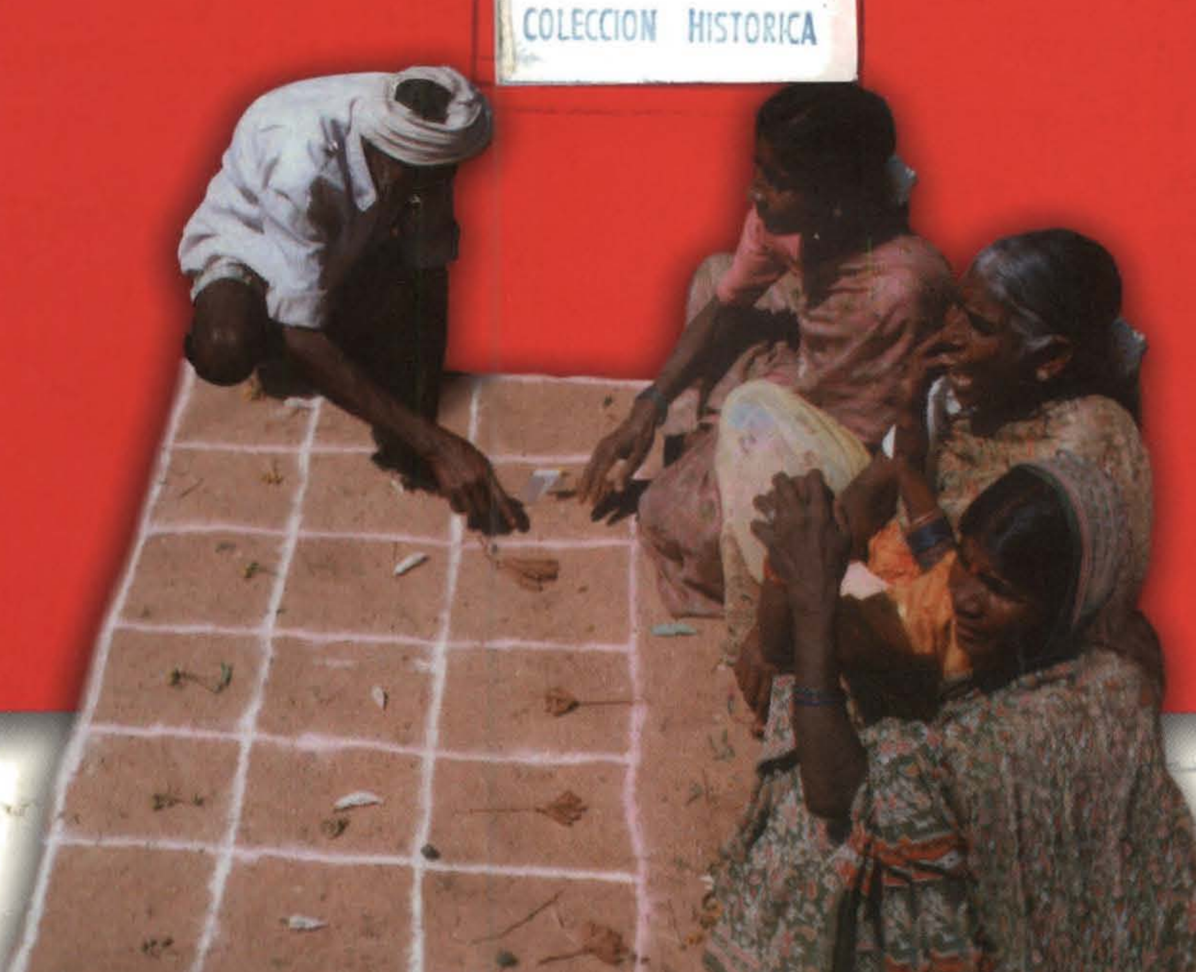
An Exchange of Experiences from South and South East Asia

Proceedings of the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement



PRGA IDRC CANADA DFID Plant Sciences Research Programme DDS LI-BIRD IPGRI ICARDA

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Introduction

In the past 10 to 15 years participatory plant breeding (PPB) has captured the interest and curiosity of a growing number of development practitioners and agricultural scientists. Its main appeal has been its promise to improve the chronically low adoption rates of new crop varieties developed by the research community to alleviate food scarcity, poverty, and natural-resource decline in developing countries. By bringing the formal breeding process closer to farmers and combining disciplines such as plant genetics, pathology, entomology, anthropology, economics, marketing, etc., with traditional farmer knowledge, PPB has facilitated the creation of more "relevant" varieties. However, other equally significant goals can drive the development of PPB programs, for instance, the desire to empower farming communities, which gain greater control of breeding and seed supplies, to enhance biodiversity and germplasm conservation, and to develop adapted germplasm for especially disadvantaged user groups (e.g., women, poor farmers).

From May 1–5, 2000, over 100 scientists, farmers, development practitioners, and community organizers from 7 South and Southeast Asian countries (with Jordan and Samoa added in for good measure) met in Pokhara, Nepal, to discuss PPB methodologies, strategies, actors, environments, and impacts. The objectives of this symposium were to exchange and compare the diversity of experiences with PPB in the region, to identify gaps in the research to data, and to network South and Southeast Asian institutional plant breeders, farmers, and others who are using participatory methodologies. The symposium was also an opportunity to further discuss and contribute to the working document *Guidelines for PPB*... drafted in a 1997 expert consultation and refined in subsequent meetings and electronic discussions within the Plant Breeding Working Group of the CGIAR Systemwide Program on Participatory Research and Gender Analysis (PRGA).

The symposium had two parallel programs—one for scientists and the other for farmers—which came together at different points in the four days through formal presentations, working-group discussions, and impromptu evening sessions. The aims were to encourage interactions within groups and well as between them. Farmers and plant breeders contributed from the west and central regions of Nepal and three dispersed regions of India (Uttar Pradesh, Hyderabad, and Rajasthan) with the result that discussions were variously conducted in English, Hindi, Nepali, and Bengali. Exchanges were generally intense, informative, illuminating, and—occasionally—conflictive, yet managed to cross the linguistic, philosophical, and methodological divides effectively.

These proceedings are but one product—and a critical one—of the four-day seminar. Several field programs developed directly from new collaborative relationships established at the meeting, as did an increased understanding of the mutual contributions that institutional plant breeders and farmer plant breeders can make to sustaining and enhancing the farming communities' contribution to agriculture.

The strength of the workshop rested largely on the range of co-hosts and in the dynamic work of their partners. Special acknowledgements go to the Nepal Agricultural Research Council, which launched the workshop, and to the diverse regional networks, which came together for four days to compare, contrast, and debate appropriate goals, approaches, and methods to use for effective participatory plant breeding.

Co-hosts

The System-wide Program on Participatory Research and Gender Analysis (PRGA)
The International Development Research Center (IDRC)
The Department for International Development (DFID)
Using Diversity Network (UD)
South Asia Network for Food, Ecology and Culture (SANFEC)
Deccan Development Society (DDS)
Local Initiatives for Biodiversity Research and Development (LI-BIRD)
The Eastern Himalayan Network
The International Plant Genetic Resources Institute (IPGRI)

Inaugural Address

Mr. Dhruva Joshy

Participants and Ladies and Gentlemen,

It is, indeed, a great pleasure for me to be associated with the inauguration of the *International Symposium on Participatory Plant Breeding for South and Southeast Asia* being held in Nepal.

I wish to express my sincere gratitude to the organizing committee of this symposium for the invitation extended to me to deliver an inaugural address in this opening ceremony, which, to my mind, is of special importance, since Nepal is the birthplace of participatory plant breeding (PPB) as a methodology used in plant breeding.

First of all, I would like to thank the organizer for choosing beautiful Pokhara valley as the venue for this symposium. I would like to welcome you to Pokhara, the valley of eight lakes, the custodians of wild rice and 70 rice landraces, and the place known for its natural beauty with the majestic Annapurna Himalayan range in the background and for its great ethnic and cultural diversity. Annapurna Conservation Area and the study site of in situ conservation of agrobiodiversity are also in this valley.

In the present paradigm of sustainable agricultural development initiatives, conservation of agricultural biodiversity is the cornerstone of sustainable production and of local and national food security. Seed is the first link in a sustainable food chain of the human kind. In Nepal, still about 80%–90% of farmers' seed demand is met by the informal seed sector for the majority of crops. In this system, farmers produce their own seeds on their own farms, or obtain seed via exchange or purchase from other farmers, relatives, or local traders. Participatory plant breeding has its primary attraction in this system as it has tremendous potential to address the needs of farmers, particularly in the developing countries of the region. It takes us closer to marginal areas; it helps us to harness the potential of many minor and neglected crops; and most important, it addresses the livelihood needs of poor people and helps to alleviate poverty.

Evidence shows that the conventional plant breeding of the Green Revolution has yielded good results in the more favorable agricultural systems. Most low-resource farmers in marginal areas, however, have not benefitted from these modern cultivars as expected. As an alternative for these areas, participatory approaches to crop improvement and selection have been initiated with good results. It is quite appreciable that the CGIAR system has recognized this gap and institutionalized the PRGA program to assess and develop methodologies on participatory plant breeding.

The Nepal Agricultural Research Council (NARC) is aware and very supportive of such initiatives on participatory approaches to crop improvement. I am proud to mention that we are the first national agricultural research system to release a product of PPB, the Machhapuchre-3, a rice variety for rainfed lowland areas of mid-altitude (1300–2000 m) in 1996. This variety was bred by the breeders of the Nepal Agricultural Research Council and later selected and tested by farmers from Chhomrong and Ghandruk villages under the guidance of scientists from Lumle Agricultural Research Centre. Local Initiatives for Biodiversity, Research and Development (LI-BIRD) is playing an important role in scaling up the products and approaches of these PPB initiatives to wider areas. I

Mr. Dhruva Joshy is executive director of the Nepal Agricultural Research Council (NARC).

am pleased to hear that some of the farmers of these communities are participating in this workshop to share their experiences. There is now substantial evidence that farmers maintain and improve their landraces through a continuous process of selection. I am sure we can hear many such examples from Bangladesh, India, Nepal, and other countries in this symposium.

A major challenge in modern plant breeding is to devise appropriate ways to address the problems of resource-poor farmers in marginal environments who have often contributed important genetic diversity to the formal system with little benefit in return. In countries like Nepal where ecosystems, farming systems, and user preferences are so diverse and complex, participatory plant breeding can consolidate the impact of institutional plant breeding. This is not an expensive approach, but our plant breeders need a flexible mind-set to try new methods and approaches. If this happens, it may provide an opportunity, no less important than that offered by biotechnology, to solve the food-security problem of the country to a certain extent.

For sustainable agriculture, increasingly uniform crops may be more vulnerable to pests and diseases. We have had recent examples of BPH damage in the *terai* region of Nepal. I heard that many participatory approaches to crop improvement have been initiated in both high-potential and marginal areas of this region, including Nepal, and some interesting results are emerging. I believed that participatory varietal selection and PPB can deploy new diversity to combat new pests and diseases and that participatory research will lead to rapid extension of the technologies. New genetic materials reach farmers' hands quickly. If the material is good, farmers take care of it, as they have maintained many landraces such as Másuli rice over the years, and, hence, it will remain in the informal system.

Distinguished Guests, Ladies, and Gentlemen,

Nepal Agricultural Research Council has assigned a high priority to conservation and sustainable utilization of agrobiodiversity. Both, ex situ and in situ conservation strategies are being adopted in the national research system. The gene bank maintains nearly 10,000 accessions of 60 crop species at low temperature and low humidity. Nepal is the probable homeland of the Asian cultivated rice *Oryza sativa.* Wild species, namely, *Qrjza nivara, O. rufipogon, O. granulata,* and *O. officinalis,* are distributed in different parts of the country. *O. rufipogon* is available in the various lakes of Pokhara. To allow the evolutionary process to proceed, in situ conservation provides a unique opportunity in the natural habitat.

May I take this opportunity to mention a few words about enhancing partnerships in agricultural research between nongovernmental organizations (NGOs) and NARC. NARC has now started to initiate partnerships in research with NGOs and the private sector and is keen to support capable NGOs in participatory approaches. I am also pleased to inform this August gathering that NARC, LI-BIRD, and the International Plant Genetic Resources Institute (IPGRI) have jointly developed a PPB program in three in situ sites in Nepal with the objective of assessing PPB as a strategy for on-farm conservation and productive gains. Needless to say, the sharing of our field experiences from across the globe will bring further refinement of these methodologies in the future.

While speaking of subsistence farmers and biodiversity relationships, these custodians of genetic diversity are still maintaining crop diversity and varietal diversity within species, in spite of the threats of erosion. This has been possible because of the result of cultural practices and local knowledge systems built through the input of millions of unknown and invisible farmers. Indigenous knowledge has been overlooked in the past but is increasingly being acknowledged as a cornerstone for sustainable development. The value of indigenous knowledge systems has become ever more important in our diverse mountain system where people live in great ecological, biological, and cultural diversity.

It would not be out of place to mention the liberalization policy the country is following. This has prompted NARC to look into the issues of trade-related intellectual property rights (TRIPR) under the General Agreement on Tariffs and Trade (GATT). The World Trade Organization (WTO), under the TRIPR agreement, requires member countries to provide legal protection to plant varieties. As in many developing countries, protection of intellectual property rights (IPR) has not been taken seriously in the process of technology generation in Nepal. I believe the symposium will provide us some suggestions for dealing with the changing scenario of globalization with respect to IPR. What will be the impact of IPR on biodiversity? How will IPR handle the issues involving the varieties developed by PPB? What will be the consequence of high-yield adaptive terminator technology on agrobiodiversity? These are some of the issues that need answers in response to the globalization of agriculture.

Today various forces are at work—population pressures, a desire for a better quality of life, urbanization, and the availability of modern technologies—which have started a chain reaction in the transformation of mountain agriculture. It is widespread. The unfortunate outcome of this process, observed during the past few decades, is a negative impact on native agricultural biodiversity. Therefore, ways have to be found to contain and reverse this trend.

We need to be realistic, as resources are limited. We need to understand what needs to be preserved and do the best we can. Ways must be found to motivate farmers to maintain farm biodiversity; I believe PPB is one approach we can look forward to.

While conventional institutional efforts for the conservation of agricultural biodiversity must continue, it is equally important to find innovative ways of maintaining in situ crop conservation. Local initiatives, people's participation, and combining conservation with use are some of the important concepts for developing appropriate approaches that can combine agricultural biodiversity with sustainable agriculture development. PPB appears to carry lots of promises in this regard but we still need to develop our critical mass of researchers.

I am sure this is exactly what this meeting is also going to discuss. Over the next five days, I very much hope that each of you will be able to benefit from the sharing of combined knowledge and experiences in this field. This meeting is especially unique as I was told that farmers from various countries have also assembled here to share their wisdom and insights. The most interesting change is that plant breeders and researchers are here to learn from them. NARC will follow the outcomes of the symposium with much interest.

Finally, I would like to thank once again the PRGA and other cosponsors for inviting me and NARC scientists to participate in this meeting. I hope the weather will be kind over the next week or so, particularly on the field-trip days.

I am looking forward to the outcome of your productive deliberations over the next five days and wish you a very fruitful and pleasant stay in Pokhara and Nepal.

Thank you. *Dhanyabad.*

Participatory Plant Breeding: A Framework for Analyzing Diverse Approaches

L. Sperling, J.A. Ashby, M.E. Smith, E. Weltzien, and S. McGuire

Abstract

Participatory plant breeding (PPB) is a relatively new approach to germplasm development. Overview summaries of cases to date show that most PPB programs were begun within the last 10 years, whether located in public-sector or nongovernment (NGO) crop-improvement programs. Some have argued that commercial, private-sector, plant breeding has long been client-driven, or "participatory." However, when PPB is used to reach poor client groups, to breed for high-stress or heterogeneous conditions, and to incorporate diverse, specialized client preferences, the result is a fundamental change in the way plant genetic resources are managed by formal breeding programs and farmers.

This paper outlines a framework for relating different participatory plant-breeding approaches to different outcomes and impacts. Based on a detailed analysis of 65 case studies of programs and projects involving PPB, it suggests some of the wide variability of PPB programs and lays out key variables that are crucial for discriminating among PPB approaches. These include the institutional context, the bio-social environment, the kind of participation achieved, and the goals set for the PPB work. It is only when these variables are clearly described that practitioners can start to link the type of PPB employed (method and organizational forms) with the type of impact achieved. Such clarity is essential if PPB is also to have the scientific and organizational foundations necessary to judge its utility for a given objective.

Introduction

Participatory plant breeding (PPB) is a relatively new approach to germplasm development. Overview summaries of cases to date (Weltzien/Smith et al. 2000; McGuire et al. 1999) show that most PPB programs were begun within the last 10 years, whether located in public-sector or non-government (NGO) crop-improvement programs,. Although some have argued that commercial, private-sector, plant breeding has long been client-driven, or "participatory" (Dr. Don Duvick, personal communication), PPB, when used to reach poor client groups, to breed for high-stress or heterogeneous conditions, and to incorporate diverse, specialized client preferences results in a fundamental change in the way plant genetic resources are managed by formal breeding programs and farmers.

This article aims to set up a framework for relating different participatory plant-breeding approaches to outcomes and impacts. Based on a detailed analysis of 65 case studies of programs and projects involving PPB (Weltzien/Smith et al. 2000; McGuire, Manicad, and Sperling 1999; Hecht 2000), it suggests some of the wide variability of PPB programs and lays out the key variables that are crucial for discriminating among PPB approaches. These include the institutional context, the bio-social environment, the kind of participation achieved and the goals set for the PPB work. It is only when these variables are clearly described that practitioners can start to link the type of PPB employed (method and organizational forms) with the type of impact achieved. Such clarity is

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We thank B. Sthapit for providing useful insights on this framework.

essential if PPB is also to have the scientific and organizational foundations necessary to judge its utility for a given objective.

The institutional context

One of the most important differences among approaches to participatory plant breeding is institutional, in the sense (following North 1990) of the rules for behavior, the norms and values, and the incentives that govern how farmers and scientists share the responsibilities, work, and benefits of a joint plant-breeding effort. The key institutional difference lies in the obligations that determine the locus of control or decision making about the objectives of the plant breeding and the kind of results and data required to support these objectives. We distinguish two main institutional approaches: one when farmers join in breeding experiments that have been initiated by formal breeding programs, which we term formal-led PPB, and the other when scientists seek to support farmers' own systems of breeding, varietal selection, and seed maintenance, which we call *farmer-led* PPB. The incentive structure and the rights and obligations that characterize these two approaches can be expressed in different types of organizational arrangements.

Formal-led PPB

Formal-led PPB has certain unique institutional characteristics. Researchers run formal-led PPB programs and invite farmer participation in formal research. Researchers have an obligation and often a priority objective to feed information back to the formal research sector, which means that the scientific standards of replicability and validity of results must be met. PPB is expected to complement the formal-sector research system, e.g., either refining breeding strategies so that specific environments and varietal preferences are addressed or reorienting priorities. Generally, formal-led PPB programs also involve strong linkages to formal systems for variety release and seed production. Finally, scientists involved in formal-led programs are usually expected by the scientific community to extrapolate their methods, if not the varieties *per se*, beyond the individual community with which they work. They often need to show what the advantages of PPB are, compared to formal breeding approaches (Weltzien/Smith et al. 2000).

Farmer-led PPB

Researchers or other professionals involved in farmer-led programs are expected to facilitate a process in which farmers establish the breeding objectives. Farmers bear the main responsibility for and, often, the costs of conducting experiments and selecting materials for seed multiplication and dissemination. Researchers are expected to take a support role in this process. The objective of farmer-led PPB is to develop varieties or populations that suit specific local environments and local preferences; any broader applicability beyond local circumstances is fortuitous. Farmer-led PPB, with a few exceptions, tends to work for a specific client group or groups that have no obligation either to feed information back for wider geographical extrapolation or to feed products such as varieties into external formal systems (McGuire, Manicad, and Sperling 1999).

It is important not to confuse the scale of a PPB effort (i.e., the size of the program or the extent of its geographical coverage) with the institutional approach. The fact that PPB is carried out at the village or local level does not mean that it is, *ipso facto,* farmer-led. Case-study analysis indicates that there is a very wide range of collaborative arrangements in PPB carried out at the local or village level (PRGA 1999), some of which can be described as using a farmer-led institutional approach; others are instead controlled by representatives of outside agencies, albeit small-scale ones like local NGOs. Since most PPB is still experimental and most initiatives in their early stages are conducted in a few sites, it is not yet clear whether there is an inherent difference in potential scale between the formal-led and farmer-led approaches.

Bio-social environment of PPB

Two types of parameters have proved heuristic for characterizing the environments in which PPB programs take place.[1] The first of these is the type of *agroecological environment* in which PPB programs develop. This has been plotted along a crop-specific scale, ranging from high stress to low stress, based on actual versus expected yields, coupled with an index for incidence of crop failure (thus combining yield level and stability) (figure 1) (Weltzien/Smith et al. 2000). Agroecological environments potentially range from those that are primarily subsistence-oriented and

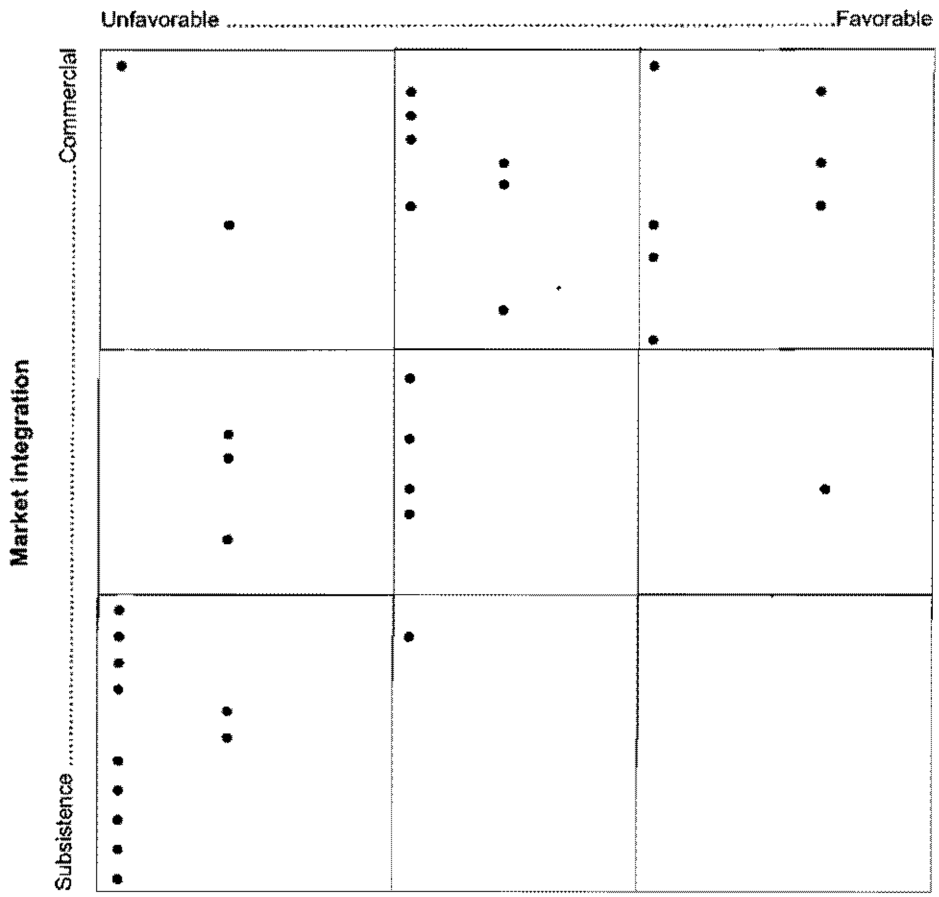

Figure 1. The distribution of participatory plant breeding cases by type of environmnet (For case identification, see Weltzien/Smith et al. 1999; for an extensive description of each case, see McGuire et al. 1999 and Weltzien/Smith et al. 1999.)

1. This characterization has been done in collaboration with the Plant Breeding Working Group of the PRGA. This group embraces about 150 plant breeders, social scientists, development personnel, grassroots activists, and geneticists from a wide range of public- and private-sector institutions, both North and South. The common link between members is a methodological interest in PPB.

highly unstable, implying that farmers' crop choices are governed by their own adaptive and preference needs, to systems in which crop production is very controlled and largely driven by the needs and preferences of urban consumers and/or commercial processors.

The second parameter suggests the broad *economic environment* of PPB; that is, the degree of "homogeneous demand versus heterogeneous demand" for varieties. Plotting was based on a nominal scale of 1 to 10, according to the "leniency/narrowness of varietal characteristics demanded by end-users" and the similarity/discordance between varieties used for home consumption and for sale (Weltzien/Smith et al. 2000). At the higher end (for example, 8, 9), the environment tends to correspond to a high degree of homogeneity in product, often favoring a narrow range of grain, taste, and cooking types. Such a high degree of uniformity/homogeneity is often associated with an economic environment where farmers are producing for highly specialized markets.

Because conventional breeding has been less effective in difficult environments and in reaching farmers with few resources, some plant breeders consider PPB as most appropriate for high-stress/ marginal environments, where agriculture is low-input. This would confirm the rationale for testing participatory approaches that are often site-specific. Analysis of actual PPB cases, however, shows a more complex picture (figure 1). Not all PPB is concentrated in high-stress environments with low-input agriculture. An unexpectedly large number of PPB programs are being initiated in intermediate areas where agroclimatic stress is less severe. On the whole, these are cases where quality concerns, such as meeting end-user preferences, are the paramount challenge (Weltzien/Smith et al. 2000), e.g., see cases of PROINPA work in Bolivia and CIAT/CIALS in Colombia). PPB programs are also becoming more common in the favorable or so-called "Green-Revolution" areas. Here, PPB approaches are being explored to help increase varietal diversity and to enable farming communities to have greater control over their breeding and seed supply (McGuire et al. 1999).

Participation and PPB

Participation is a term with a number of different connotations, and it is essential to be clear about what the separate dimensions of participation are, which together define what we call its *quality*. With respect to the "quality of participation" in PPB, it is useful to identify three different dimensions:

- stage of participation
- degree of participation
- actors' roles in participation

When researchers describe "participation" in PPB programs, they are generally referring to the stage of the breeding cycle at which farmers are involved. It is usually fair to say that the earlier user participation occurs in the breeding process, the more opportunity users are given to influence the objectives, breeding strategy, and final outcome. But the extent to which users can realize this opportunity depends on the *degree* of participation.

The third dimension of participation is the specific role taken by researchers, farmers, or others. *Role* refers to the function performed: for example, management or providing information or field labor.

3. **Information-giving role—Providing information on varietal preferences, plant types, or desired traits to be maintained or introduced:**
   Farmers can offer key insights into the trade-offs they are willing to make among characteristics in designing the desired plant ideotype. Farmers often have strong preferences that greatly shape adoption and which need to be integrated into potential varietal entries.

4. **Trainer/skill-builder role**—While this role is often associated with researcher input (and can be key for empowering farmers to continue generating breeding materials themselves), farmers can also play a central role in skill building through farmer-to-farmer training and farmer-to-researcher training.

5. **Field laborer role—Providing labor:**
   Farmer labor may be needed when formal research cannot select with available resources. In all cases, farmers often do the routine land preparation, weeding, etc.

6. **Input supply role—Providing land for "realistic" bio-physical sites:**
   Formal breeders sometimes have greater success by selecting directly in target environments. To do this, they may use actual farmers' fields in the same way they use more standard experimental stations—as researcher-designed and -managed testing sites.

7. **Providing landrace or farmer material used for further breeding work:**
   There is also a key role played by farmers in providing germplasm to the breeding process. While formal breeding approaches have used this farmer resource extensively, it has often been done without involving farmers specifically in the process of choosing germplasm, or in the subsequent processes of evaluation and selection. In some PPB cases, farmers have explicitly generated new base material for a shared breeding program by making or facilitating crosses between chosen parents. Whether they are directly involved or whether farmer germplasm is used with direct farmer advice, the outcome of the programs should recognize farmers' contributions when attributing any property rights to the finished materials.

Roles 5, 6, and 7, in isolation or as farmer-only roles in a program, do not make a program *participatory*. There probably isn't a breeding program in the world, or at least, in the developing world, that does not use skilled farmers as laborers. There is also a good deal of on-farm testing, where farmers provide land and other resources. For a program to be participatory, it has to be linked to some degree of real decision making (i.e., roles 1 through 4).

Goals of PPB

Over the last decade, PPB has been applied as a crop-improvement strategy primarily in response to the need for impact in noncommercial crops and in very unpredictable, stressed production environments. However, a range of other goals has also been defined within PPB programs: for instance, enhancing biodiversity and germplasm conservation, developing adapted germplasm for especially disadvantaged user groups (e.g., women, poor farmers), and making breeding programs more cost-efficient, particularly through decentralization of programs that target more niches. Table 1 lists the broad goals around which PPB programs have been designed and some indicators that can be used to track whether these goals are being met.

Close analysis of the set of PPB cases shows that some goals are explicit and often attained (for instance, production increase), while others are poorly articulated and usually not addressed unless

Table 1. Potential PPB Program Goals and Possible Indicators for Montioring Progress towards Them

PPB Goals	Possible Indicators	Comments
Production gains (includes quality increments, higher value products)	• yield increases, stability • faster uptake • wider diffusion • benefits gained through higher market value of product (income generated) • better identification of farmer-preferred quality traits, such as taste, etc. • better performance of genetic material in worst conditions	The production edge of PPB may monitored in 'normal' years and also when conditions are variable
Biodiversity enhancement/ Germplasm conservation	• communities get wider access to germplasm • communities get wider access to information/related knowledge • more intravarietal diversity • more intervarietal diversity • compatibility of new materials with existing ones (less varietal replacement; more compatibility with landraces) • targeting of more micro-niches	An objective may be to manage 'a pool' of diversity versus 'a variety' Efforts might be aimed at enlarging 'useful' diversity: that is, putting emphasis particularly on those traits that farmers value and are eager to maintain and promote Strategies that encourage diversity both in space and time can be devised
Effective targeting of user needs	• greater inclusion (of different kinds of users) relating to access and benefits • higher degree of farmers' satisfaction • broader range of users reached • reaching of the most marginal (particularly women and the poor)	
Cost-efficiencies	• reduced research costs in relation to impact gained, e.g., acceptable varieties identified faster, fewer research dead-ends • more opportunities for cost-sharing in research • less-expensive means for diffusing varieties	This criterion is most applicable to formal-led PPB
Capacity building and knowledge generation for farming communities and the formal research and development (R&D) sectors	• improvement of links to strengthen farmers' access to sources of material and information • changing relations/attitudes between communities and formal research systems • enhanced farmer capacity to breed more accurately (if needed) • enhanced formal breeder understanding of the complexity of traits desired by farmers and of the site-specific exigencies • extensive knowledge dissemination: helping farmers become more aware of the normal system, e.g., letting them see (and judge) genebanks • extensive knowledge dissemination: helping the formal system understand the nuances of farmer breeding and seed systems so as to more effectively plan joint work	This sharpened capability to breed may be part of a larger process of empowerment

Stage of participation

After having agreed that joint farmer-researcher collaboration in plant breeding is desirable, and having set the overall goals of the research (e.g., enhancing biodiversity, building farmers' skills, increasing production), there are five stages that emerge, often cyclically (modified from Schnell 1982):

1. setting breeding targets
2. generating (or accessing) variation through crossing (or using collections)
3. selecting segregating populations
4. variety testing and characterization
5. interacting with seed systems (release, popularization/marketing/diffusion, seed production, distribution)

PPB may incorporate farmer input at various steps (especially at stages 1 to 4 in the list above), where it is not found in traditional breeding schemes. The order of these processes may also be significantly shuffled: e.g., breeders start at stage 4 alongside farmers before solidifying stage 1, so that an iterative rather than a linear research process is followed, with researchers, extensionists, farmers, traders, or other users taking different roles in each stage. In many cases, the stages at which farmers participate or at which formal breeders participate evolves as the program develops and as the understanding (and appreciation) of each others' skills and priorities increases.

From examining the stages of farmer involvement in the 65 cases, we observed that farmer participation can occur at various times, depending on the crop, parent materials, target region, researcher capacity to assimilate farmer criteria, farmer capacity to handle different types of materials, traits of interest, and scale of the breeding program/number of materials to be screened. The stage at which farmer participation is first introduced to a conventional breeding program can lead to changes in the program's objectives or breeding strategy, or even in its organization.

Degree of participation[2]

To look at the degree of farmer participation, we draw from a consultation meeting of the systemwide initiative on Participatory Research and Gender Analysis (PRGA) in September 1998, in Quito (Lilja, Ashby, and Sperling 2000). The degrees of participation were conceived as being in the form of a wheel, which could evolve through time and according to the stage of involvement. The potential degrees of participation embraced the full range from manipulative, passive, contractual, consultative, collaborative and collegial through to farmer- or community-initiated.

In practice, three degrees of participation are generally found in PPB programs:

- *consultative*: information is sought from farmers and, sometimes, from other clients of the breeding program
- *collaborative*: there is task sharing between researchers and breeders, along lines determined by the formal research program

2. In illustrating the concept of *degree*, we draw from a more formal-led perspective. However, the classification of degree might equally be sketched from a farmer-led community perspective, i.e., the various degrees to which others (scientists, development personnel) have been brought into community-driven PPB work.

- *collegial*: researchers support a farmer-initiated, farmer–managed program that is accountable in a direct way to the farmers and other client groups with a stake in the results of the germplasm development

Within the global review of PPB programs (McGuire, Manicad, and Sperling 1999; Weltzien/Smith et al. 2000), the most frequently observed degree of participation has been consultative (followed by collaborative) and this takes place at the very first stage of defining breeding targets (e.g., what is the farmers' plant ideotype—what characteristics do they most value). Farmer-initiated work sometimes occurs at the later stages of formal-led PPB, usually at the very last stage of seed multiplication, distribution, and popularization. Farmer-initiated activities are also occasionally carried out within PPB programs to support and strengthen farmers' local varietal selection, in situ conservation of germplasm, seed multiplication, and distribution (McGuire, Manicad, and Sperling, 1999; Weltzien/Smith et al. 2000). If we separate out the later stages of variety testing on-farm and the multiplication and distribution of seed, we find that farmers are rarely involved in the PPB process in true sharing or decision-making roles.

Few of the cases analyzed have experimented with collegial participation involving a significant devolution of responsibility to farmers. This may be because a good number of the cases are still testing approaches. There are as yet very few guidelines drawn from experiences with the degree of devolution to farmers that can be achieved in a research program that seeks to maintain certain standards of data quality affecting replicability and validity of results. Programs aimed more towards immediate developmental goals in specific locales might be expected to devolve more rapidly.

Roles

The participation of farmers and researchers in participatory plant breeding may have them taking on a variety of different roles or functions (irrespective of stage and degree). However, in most cases analyzed, the way in which researchers worked with farmers was not clearly described, making it difficult to discern the links between specific outcomes and the stage of the breeding process in which participation is implemented, the degree of participation, and the roles performed by researchers and farmers.

Based on the PPB cases analyzed, we identified the following roles taken on by farmers (note that a parallel list might be devised for the researchers):

1. **Management role—Providing technical leadership:**
   Farmers can take on a major role in matching specific varieties to specific environmental niches and uses.
   Farmers can interpret local GxE interactions, as well as varietal performance through time and in different locations.
   In farmer-led PPB, community specialists may lead and manage the breeding work itself. Cases like this occur especially in the minor crops in very remote areas, where formal research does not have a strong presence, and in PPB programs where community empowerment is an important goal.

2. **Management role—Providing key social organizational leadership:**
   Farmers' groups and their organizational arrangements, such as cooperatives, often provide the key vehicles through which PPB can unfold efficiently. Without such organizational forms, on-farm testing could lack representative sites, and seed multiplication and distribution could be inadequate or even completely lacking.

Table 1. Potential PPB Program Goals and Possible Indicators for Montioring Progress towards Them (Continued)

PPB Goals	Possible Indicators	Comments
Empowerment, particularly of farming communities	• changes in types of participation, in relationship between partners, e.g., depth of recognition of farmers' own breeding within this activity • changing priorities or needs, e.g., farmers have equal voice in setting the joint breeding agenda; changes in patterns of decision making • changes in access to and control over germplasm and information	This is a significant challenge to develop indicators of empowerment. It implies a shared conceptual frame-work among partners of what 'empowerment' looks like and indications of which changes in status are positive or negative
Institutional and organizational innovation	• identification of sustainable ways to decentralize • identification of greater range of institutional partners • clarification of strategies for scaling up process of PPB • identification of options for moving and scaling up the products of PPB	
Breeding program and seed policy modifications for expansion and institutionalization of PPB	• recognition of farmer varietal assessment/acceptability as a key condition of release • formal release of site-specific materials • support to localized seed-multiplication and -distribution enterprises • strengthening and support to informal/local farmer seed systems	

they are built into the research design (for instance, reaching specialized interest groups). Case-study analysis also suggests that many goals are not obviously compatible (for instance, biodiversity enhancement and reaching the poorest farmers). The trade-offs among goals are one of the areas where a good deal more structured or focused work needs to be pursued within the PPB field.

Partners usually have to accept trade-offs in reaching certain goals, so it is important at the very beginning of a PPB collaboration for those concerned—scientists, farmers, development/NGO personnel—to explicitly discuss primary and secondary goals, and the minimum agreed-upon outcomes for which collaborators are aiming.

Practical example

The framework presented here can be useful for classifying different PPB approaches and for linking different types of PPB to specific hypotheses developing within the PPB field. The hypothesis we have chosen to examine below is one of the more popular and accepted of the PPB findings.

In what is quickly becoming a classic PPB article, Witcombe et al. (1996) recommend a progression from working with stabilized materials (what they call participatory varietal selection, or PVS) to variable materials (PPB). The authors state that "Participatory Plant Breeding (PPB), in which farmers select from segregating material, is a logical extension of participatory varietal selection. However, the first choice should be PVS since PPB is more resource-consuming. . . ." (Witcombe et al. 1996:450). Certainly, the statement is elegant in its simplicity. But is this progression valid across the full range of PPB practice?

We do not mean to critique the "PVS-to-PPB" proposition, which has proven useful to many practitioners, but rather, we wish to illustrate that this proposition proves useful (or holds true) for a specific set of conditions.[3] While Witcombe et al. (1996) do not explicitly describe their own PPB context, using the framework variables given above, it can be roughly characterized as follows: their work is situated within more formal-led institutions and they aim for official release of the varieties identified. Their primary goal is one of production increase, and much of their base materials consist of modern varieties (MVs). Their PVS/PPB methods model does not seem to be restricted to any particular environmental or commercial context; indeed, the authors have done innovative work in both lower- and higher-stress areas. Finally, within this PVS/PPB methods model, the role of farmers has generally focused on giving preference to feedback by screening materials within scientist-controlled programs.

Within a program, with a strong or *sole* focus on production results, using a classic "development-oriented" or "modernizing" framework, does the PVS-to-PPB progression hold? Probably yes. This PVS-to-PPB model is becoming increasingly popular, particularly among the national agricultural research systems (NARS) that usually share such classic breeding goals. For example, the work of the West African Rice Development Association (WARDA) with 17 NARS in West Africa starts with PVS and will move to PPB only in more demanding situations (Dr. Monty Jones, personal communication).

3. We recognize that PPB and PVS can be points along a continuum, and practitioners sometimes use those terms, as we do with farmer-led and formal-led PPB, as conceptual tools (Dr. Bhuwon Sthapit, personal communication). However, *programs* often focus on a particular starting point and progression, with PVS too often identified as the given mode for initial participatory efforts.

Would the PVS-to-PPB progression rule hold equally well if germplasm conservation were the goal? Probably not. In the model presented above, materials in PVS tend to be stabilized MVs, with only a few cultivars presented to farmers. The PVS-to-PPB progression rule would probably not hold either if the goal were empowerment or capacity building among farming communities. The farmers' role in the PVS-to-PPB progression is to provide advice only at later stages; skill-building is very limited, if addressed at all.

Across the full range of PPB practice, we see different institutions taking different starting points, and progressing in different ways, according to their goals and contexts. If PPB is to develop as a predictive approach—one where approaches that are appropriate for the working context and for the desired outcomes are explicitly chosen—it needs to analyze experiences and results in terms of their contexts (by institutional setting, goal, environment, and participation type).

Clearer discussion of these contexts in PPB documentation can help probe the effectiveness of analytical frameworks such as the one we propose. Only then can we move the approach forward in more than anecdotal ways and start to link the specific PPB approaches in specific contexts with the precise impacts achieved.

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Participatory Varietal Selection in High-Potential Production Systems

J.R. Witcombe

Abstract

This paper reviews some of the participatory research in high-potential production systems on participatory varietal selection in high-potential production systems. This collaborative research is conducted by the Centre for Arid Zone Studies, UK; Local Initiatives in Biodiversity Research and Development (LI-BIRD), Nepal; the Gramin Vikas Trust, India; and the Punjab Agricultural University, India.

The justification for participatory research on varietal selection in marginal areas is reviewed and then compared to the needs of high-potential production systems (HPPSs). Some of the more significant findings on participatory varietal selection (PVS) in HPPSs are summarized and the roles of decentralization and participation in the research are reviewed. Participatory methods can increase the efficiency of formal breeding programs and in HPPSs they have a great potential for contributing to higher and more stable food production.

Why farmer participatory research is advocated in marginal areas

Participatory research in marginal areas can be used to empower farmers and promote development in farmers' communities (e.g., Sperling 1996; Ashby et al. 1996). It can also be used to increase the efficiency of formal breeding programs in producing and popularizing varieties appropriate for resource-poor farmers. Research funded by the Department for International Development (DFID) Plant Sciences Research Program has concentrated on improving efficiency, although benefits in empowering farmers are achieved coincidentally to this process. Increasing breeding efficiency helps meet the goal of the research: the improvement of the livelihoods of poor people.

An extensive analysis of the testing of varieties in India for marginal areas revealed weaknesses in the formal testing system that reduced the chances that varieties released for marginal areas would meet farmers' needs (Witcombe et al. 1998b). The failure of the system is evidenced by, e.g., the rejection of many varieties by farmers, who did not adopt them, and the rapid and high adoption by farmers of nonreleased varieties, such as Mashuri rice, that had been rejected in the formal testing system (Maurya 1989). Most important, farmers in marginal areas often continue to grow landraces and have only adopted modern varieties to a limited extent (figure 1). Resource-poor farmers in marginal areas, where yields are appreciably lower, are benefitting less from modern varieties than farmers in more favored regions.

The deficiencies in the system of trials that is used to test varieties is one of the causes of this low adoption in marginal areas. An analysis of any multilocational trials from several crops in India over a number of years showed the following:

- The trial sites were located according to the available research infrastructure and often poorly represented the major areas in which the crop was grown (Packwood et al. 1998). Sometimes the trials were divided into zones but these were so large that they included diverse environ-

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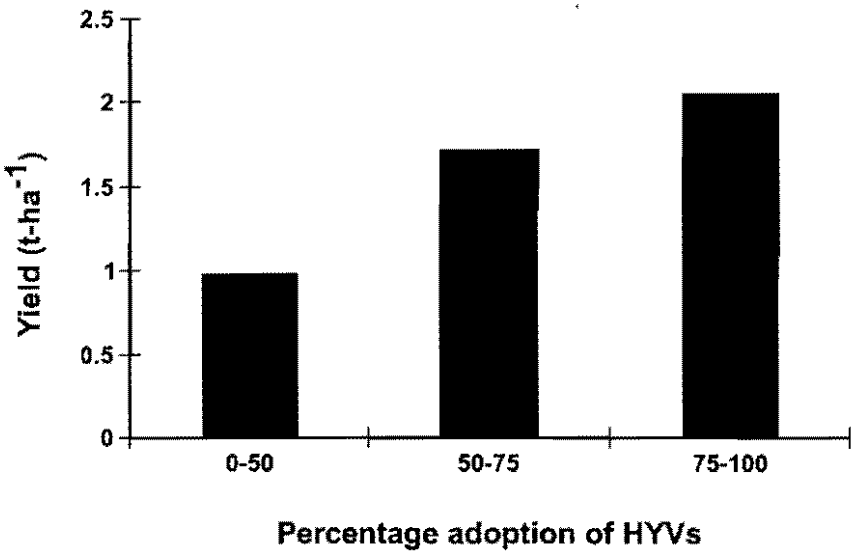

Figure 1. Mean yield of rice in 149 districts in six states, categorized by three levels of adoption of high-yielding varieties (Witcombe et al. 1998a)

ments. This could not be overcome by further division into smaller agroecological zones as there were too few trial sites to do this. Some of the agroecological zones would not be represented at all and others would have only a single trial site.

- The trials poorly represented the growing conditions in farmers' fields. The environments in which the trials were conducted were too favorable and the trials had too high a level of purchased inputs applied to them. For example, an analysis of sorghum trials in 1989 showed that the average yield of the trials was over three times the yields achieved by farmers in the districts in which the trials were conducted (figure 2). This analysis is typical of the many that were made (Packwood et al. 1998). A more recent example is the direct-sown early rice trial of 1999. The average yield over 10 sites was 2.6 t ha^{-1} and the highest yield was 4.1 t ha^{-1}. Compare this to the average yields of less than 1 t ha^{-1} obtained by poor farmers in upland conditions in the states of Bihar, West Bengal, and Orissa. This difference is far too large to be explained simply as a result of higher potential of the new varieties in the trial, and mainly results from a more favorable environment on the research stations than on farmers' fields.
- The reliability of the trials was poor. Many trials are rejected because they have high coefficients of variation (which tends to be correlated with nonsignificant between-entry variances). In part, this is because the plot sizes are small and nearly all trials have only three replicates. Individual trials poorly predict the overall performance of genotypes in the multilocational trial—the correlation coefficient, r^2, between the yields of the entries in any one trial site and the trial mean across all locations is usually low. This certainly reflects error, i.e., uncontrolled variation, in the trials but it also indicates the possibility of high specific adaptation of genotypes to sites or groups of sites. Such specific adaptation, of course, cannot be exploited when selection is exerted for overall performance across locations.
- The allocation of resources to entries at different stages of testing was inefficient. In theory, the resources (a product of the number of trials, replicates, and plot size) allocated to the entries in each year of testing should be equal. However, many more resources are spent on

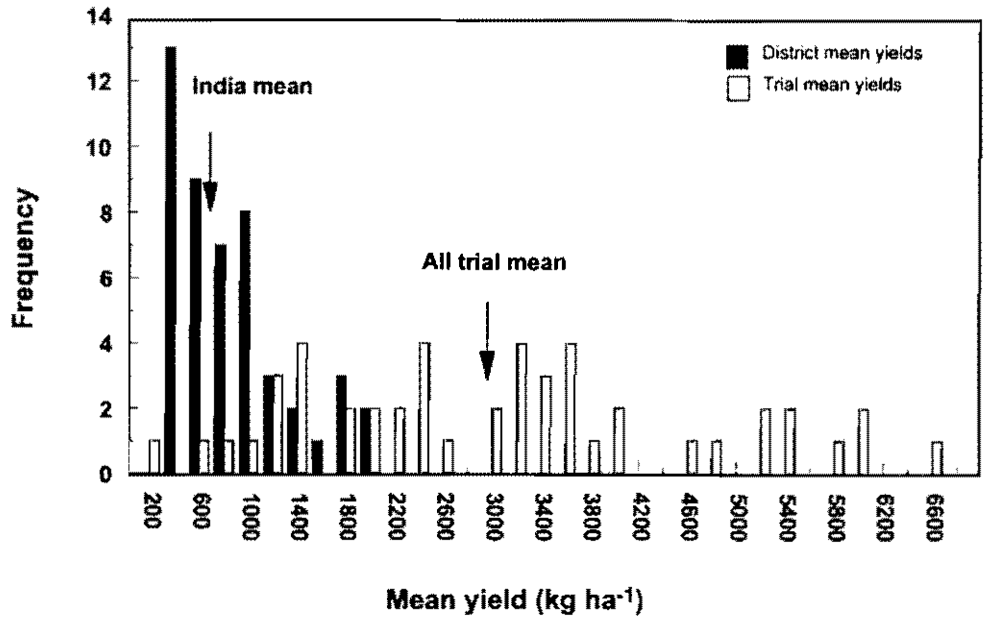

Figure 2. Comparison of yields in the All-India Coordinated Sorghum Improvement Project trials and in the districts in which these trials were conducted, 1989 (Packwood et al. 1998)

testing the least important entries—those in the first year of the trials—than the more important entries undergoing the second or third year of testing (Witcombe et al. 1998c).

- The trials did not allow selection of specifically adapted varieties . For example, earliness is extremely important in marginal areas because it allows the escape of end-of-season drought. (Earliness is prized by farmers in HPPSs as well because it increases the possible options in the cropping system and gives more time for the timely sowing of the following crop.) However, analysis of many trials showed that in nearly all there was selection against early- and later-maturing entries (Witcombe et al. 1998c). In selecting for wide adaptation, i.e., the entries that yield best on average, there is selection for mediocrity in flowering time (figure 3).
- The selection system to promote entries from one trial stage to the next did not allow a trade-off between different traits. The promotion criteria are heavily biased towards grain yield, and little or no consideration is given to other traits, such as early maturity, stover yield, and grain quality. Only if an entry survives three years in the trial can other traits be taken into account when it is considered for release. Traits other than yield will have been ignored in the earlier stages of promotion—initial to advanced trial, or promotion to a second year of testing in an advanced trial. Hence, in practice, varieties with advantages in non-yield traits can only be selected if they have a yield advantage in the first two years of testing (Witcombe et al. 1998c).

In summary, in marginal areas, the following disadvantages of multilocational trials were seen:

- Trial sites poorly represented the crop area.
- Trial sites poorly represented farmers' fields.
- Trials were unreliable.
- Resources were allocated inefficiently between varieties in different years of testing.
- Selection for wide adaptation selected against specific adaptation.
- The selection criteria used rarely allowed trade-offs between traits.

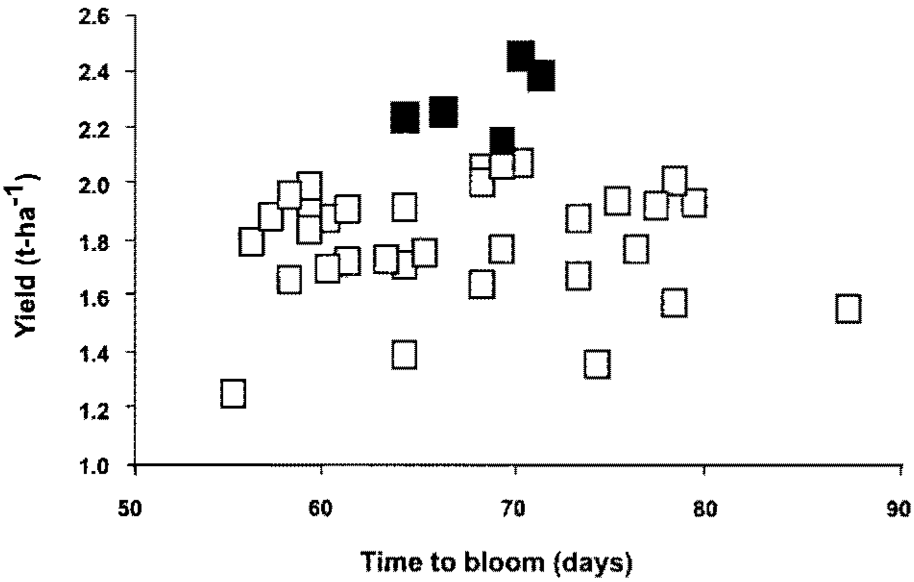

Figure 3. Time to bloom and yield of entries in the very early, direct-sown rice trial of the All-India Coordinated Rice Improvement Project of 1993 (The four highest yielding entries are all of intermediate flowering time; early-flowering entries are eliminated.)

Trials for favorable areas share the disadvantages of trials for marginal ones

Although it is not the perceived wisdom, the drawbacks described for trials targeted at marginal agricultural environments are shared with those targeted at high-potential production systems (HPPSs).

There are very few trials to represent the often extremely large areas of high-potential production systems. For example, in state-level trials there are only four trial sites for rice in the Indian Punjab to represent a rice area of about 2.2 million hectares and only two sites in the All-India coordinated trials. The Punjab does not represent a single target environment; there are marked differences in adoption of varieties by farmers from district to district; however, not all of the districts are represented in the formal trial system.

High-potential production systems are not uniform (Witcombe 1999) but have great physical and socioeconomic diversity. Physical variation is often related to the cost and availability of irrigation water that can be supplied predominantly by tube well in some areas and by canal in others. Variation in soil and land type is significant. For example, in rice there are niches, such as more waterlogged areas, where long-duration rice is required (figure 4). In contrast, in some areas short-duration varieties are needed either because of physical variation (limited water) or temporal variation (a need to harvest the crop early for timely sowing of the following crop).

Unlike marginal areas, the disparity in the level of inputs on the research station trials and farmers' fields is indeed much less and this is not a major reason why trials poorly represent farmers' fields in HPPSs. However, unlike marginal areas where the planting date used by both researchers and farmers is dictated by significant rainfall events, there can be a large disparity between the sowing dates of farmers and the sowing dates of research station trials. Coordinated research trials require a

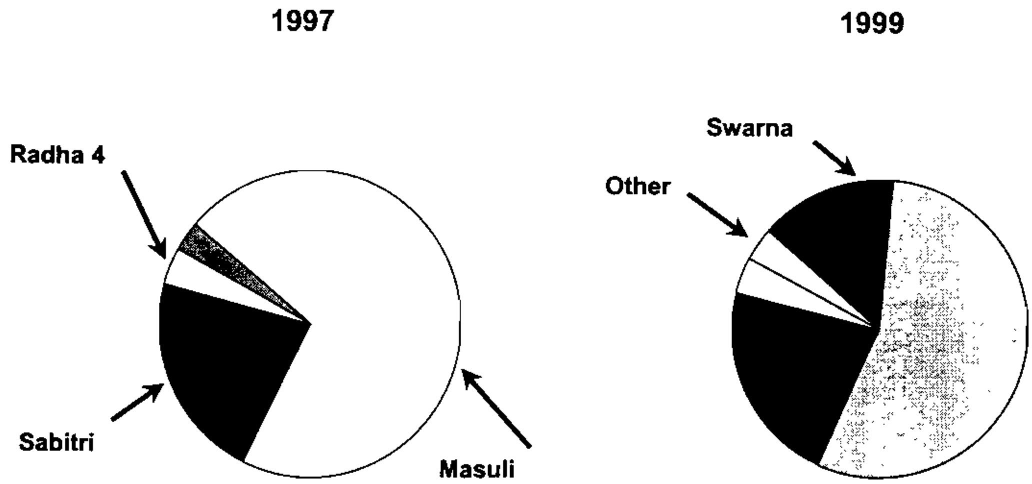

Figure 4. The adoption of Swarna, a late-maturing variety for wetter areas, in a village in Chitwan, Nepal, after two seasons (data from K.D. Joshi, LI-BIRD)

great deal of organization to assemble and redistribute the seed to the trial sites. Hence, it is common in a crop such as rice, where the seed is produced in the off-season just before the main season trials, for the trials to be sown later rather than earlier in the season. Apart from the practical difficulty of representing earlier sowing dates, the low number of trial sites means that the range of planting dates used by farmers cannot be represented. For example, both the sowing and transplanting of rice extend over a three-week period in Lunawada District, Gujarat (figure 5). It is a practical impossibility to have all these sowing dates in a formal trial system, yet significant interactions between sowing date and variety occur.

Trials in HPPSs, although more reliable than those in marginal areas because of the existence of irrigation and more uniform land, can still suffer from high experimental error because of small plot sizes and limited replication.

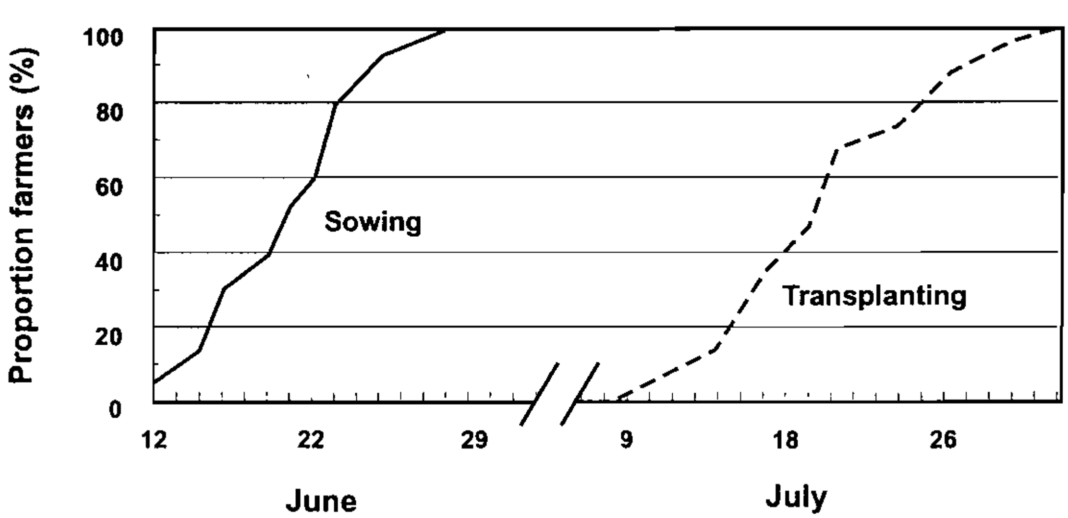

Figure 5. Sowing and transplanting dates of rice in Lunawada District, Gujarat (Virk et al., this volume)

The deficiencies in resource allocation, described for trials in marginal areas, are caused by the promotion criteria used. These criteria are used independently of the targeted production system, so resource allocation is just as poor in trials for HPPSs as in those for marginal areas.

In trials for HPPSs, the trade-off between multiple traits is no better than in trials targeted at marginal areas. The value of shorter-duration crops is insufficiently recognized in the trial system for HPPSs where selection is almost entirely for yield and division of the trials by maturity class is lacking or inadequate. Early maturity can allow another crop to be grown during a year, either a cash crop or a green-manure crop, and it can spread demands for labor at sowing, transplanting or harvest time. Trade-offs between yield and other important traits (e.g., fodder yield or grain quality) also receive insufficient attention.

What are the roles of participation and decentralization in PVS?

The deficiencies identified in the multilocational trial system can be removed by radically modifying the design of the multilocational trials without significantly increasing farmer participation. Alternatively, the problems can be addressed by introducing a major component of participatory varietal testing (Witcombe and Virk, forthcoming). This raises the question as to whether modifications to the design of the trial system, all of which result in decentralization, are simpler and cheaper than employing participatory approaches.

The six problem areas identified in the multilocational testing are examined to see if redesigning the trials by decentralization or increased farmer participation is the most efficient solution. Both decentralization and participation help to solve these problems because they can do the following:

1. allow trial sites to better represent the crop area
2. allow better representation of the environments in farmers' fields
3. increase the reliability of the trials
4. allocate resources more efficiently between varieties in different years of testing
5. allow varieties to be selected for specific adaptations
6. allow trade-offs between traits

In the first five of these, decentralization or participation can provide a solution mainly by allowing more replication, particularly replication that increases the number of test sites. Adding more researcher-managed test sites in a decentralized testing program is expensive. Adding farmers in a participatory testing program is cheaper because there are many farmers who are willing to collaborate with minimal cost.

These six issues are considered in more detail below.

1. **Allow trial sites to better represent the crop area**
   Trials can be modified to better represent the target areas (or, indeed, the niches within areas) by having more trials divided into more zones and types. However, clearly many more formal trials would be needed to do this and the increase would consume many more resources. Participation provides a more cost-effective solution. Moreover, the participation of farmers does not just allow varieties to be tested in more niches, it helps to identify them.

2. **Allow better representation of the environments in farmers' fields**
   The formal trial system can be modified to reduce purchased inputs to farmers' levels. After surveying farmers' cultivation practices, more realistic management can be adopted in

research-station trials. However, only participatory methods, which allow many farmers to be sampled, can realistically account for the range of management practices and sowing dates found in farmers' fields. Replication across sites is the key to representing the diversity of the environments of farmers' fields, and participatory methods would appear to be the only cost-effective way of achieving the amount of replication required.

3. **Increase the reliability of the trials**
The overall reliability of a multilocational trial can be increased by increasing the number of sites, the number of replicates at each site, the size of plots, or any combination of these. Of the three components, the number of sites is the most critical. The number of formal testing sites that can be controlled and managed by scientists can be increased but at considerable expense in both requirements for infrastructure and running costs. Increasing trial sites is cheaper with participatory methods because farmers are interested in participating in varietal trials without any financial incentive other than the provision of seed free of cost. The major costs are then for data collection. Qualitative data are "scientific," analyzable, and more cheaply collected than quantitative data. Hence, if breeders and release committees were prepared to accept qualitative data on yield and other traits, rather than the current insistence on quantitative data, the costs of this data collection would be considerably reduced.

4. **Allocate resources more efficiently between varieties in different years of testing**
Participatory approaches, because of the quantities of seed required, would concentrate on more advanced entries, which would automatically correct the imbalance that concentrates too many resources on varieties that are at an early stage of testing. With PVS, the number of sites, i.e., farmers' fields, in which a variety is tested can easily and systematically be increased as a variety is promoted through the testing stages.

5. **Allow varieties to be selected for specific adaptations**
The higher the number of trial sites, the more accurately selection can be targeted to niches—either physical or socioeconomic. This allows specific adaptations to be exploited, as was seen for the example of Swarna rice in Nepal. Although a higher number of trial sites in the formal system would allow the selection of more specifically adapted varieties, it is a more expensive alternative to increased participation.

6. **Allow trade-offs between traits**
It is certainly feasible to introduce a trade-off between traits in a formal trial system after consultative participation that determines the traits that farmers consider important and how farmers trade them off. Trials can then be split according to farmer-important traits, e.g., trials for high grain yield, high stover yield, and dual-purpose varieties for grain and stover. Selection indices can also be constructed to allow the promotion of a greater range of varietal types in any trial. These methods, however, are complex and require traits to have standard weightings even though they differ from farmer to farmer and from season to season. Collaborative participation that allows farmers to decide overall which variety or varieties they prefer is a simpler and more effective solution.

Six issues have been considered in this comparison of the roles of decentralization and participation. However, there is a seventh important issue that only participation addresses.

7. **Participation promotes the speed of adoption of preferred varieties**
   No matter how decentralized a breeding program and its varietal testing system, if it does not involve farmers, it cannot directly promote adoption. Only participation can do this.

Conclusions on PVS in HPPSs

Other papers in these proceedings will attest to the efficiency of PVS in more favorable agricultural environments (Virk et al., this volume; Malhi et al., this volume; Joshi and Witcombe, this volume). It is highly effective and has been demonstrated to achieve the following:

- Identify and promote varieties that were not recommended for the area in which the PVS was done (this means that the recommendation domains of many varieties that are adapted to HPPSs are too small)
- Increase varietal biodiversity (more varieties are adopted because farmers, when given choices, can identify varieties for niches)
- Promote acceptable recommended varieties (recommended varieties are adopted more quickly in villages where PVS is done than in control villages)
- Identify recommended varieties that are either not accepted by farmers or are poorly accepted

However, PVS has certain limitations. It is dependent on a seed supply to start the PVS trials, and often the seed of released varieties is surprisingly difficult to obtain. When nonrecommended varieties are identified, the seed supply limits the speed of their adoption. The success of a PVS program depends on other external factors such as the timing and success of recent releases in the target area. PVS is much less likely to be considered successful when introduced varieties compete against a very recently released variety that is liked by farmers than when, perhaps for more than a decade, there has been no significant change in the variety grown. PVS is also dependent on pre-existing varieties. If there are no suitable varieties among those currently available, then it will not succeed. In contrast, PPB approaches that generate new variability do not suffer from this limitation. In participatory approaches in maize and rice breeding in marginal areas (Goyal et al., this volume; Kumar et al., this volume), 30% gains in yield were obtained over the best varieties—about three times the rate of genetic gain using conventional methods. Success in HPPSs is yet to be demonstrated but research in this area is underway (Witcombe et al., this volume).

Participatory varietal selection in HPPSs is much more difficult to justify to scientists and policymakers than it is in marginal areas where the need for and success of a different approach was evident. The need was clear from a lack of adoption of new varieties and the success of PVS has been convincingly demonstrated by many (e.g., Sperling 1996; Witcombe et al. 1999). PVS in high-potential production areas is new research from which results are only just emerging. It is an alternative to an entrenched system that can justifiably claim success—the adoption of modern varieties is, after all, almost universal in HPPSs. However, this success does not necessarily equal efficiency—a 100% adoption of modern varieties can be achieved with or without extensive participation. However, could participatory methods be more cost-effective, produce better varieties, and create and maintain greater varietal biodiversity in farmers' fields? The theoretical basis as to why this might be so has been presented here, and the evidence to justify this theoretical assumption is emerging.

It is extremely important for these issues to be thoroughly explored. HPPSs produce most of the world's food. If the production increases from PVS of 10%-40% found so far in these production systems were to be widely replicated, this would have a considerable impact on improving food security and would directly, and indirectly, greatly benefit the poor.

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Enhancing Biodiversity and Production through Participatory Plant Breeding: Setting Breeding Goals

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Abstract

Participatory plant breeding (PPB) is one of the on-farm conservation strategies designed to maintain or enhance the level of landrace genetic diversity deployed on-farm. The global in situ project aims to strengthen the skills and knowledge of local communities in locating and understanding the value of landraces, and also monitoring genetic erosion. Participation by farmers and informal sectors in decentralized testing of materials can result in much greater diversity in the fields of collaborating farmers, as well as providing a broader range of varietal choices and adoption. Germplasm exchange between farmers and farmers' selection criteria can also contribute to and enhance on-farm conservation and biodiversity. Within the project, "Strengthening the Scientific Basis of in situ Conservation of Agricultural Biodiversity," supported by the International Plant Genetic Resources Institute (IPGRI), case studies of rice were made in Nepal on consolidating the roles of farmer participation in PPB and seed-exchange processes. Participatory methods, such as diversity fairs, diversity blocks, and community biodiversity registers, were used to understand the value of local diversity and also to strengthen the roles of farmers and informal sectors in the local crop-development process. PPB programs in Nepal are designed to investigate (1) whether farmers' cultivars *per se* can be conserved, (2) if PPB has contributed to the enhancement of biodiversity in terms of a broader genetic base that provides benefits to the community, and (3) if genetic improvement was been achieved without loss of genetic diversity. This paper describes preliminary results of understanding genetic divergence in terms of the use value of local biodiversity and the participatory methods used to select landrace parents. Methodological constraints of participatory approaches in setting breeding goals in the context of biodiversity enhancement and production objectives in biodiversity rich areas are discussed. The paper also documents how the needs of farmers and objectives of biodiversity enhancement can be integrated during the setting of breeding goals and supplying useful genetic diversity by bringing new, restoring old, and generating new genetic diversity (local x exotic) in the agroecosystem in three eco-sites of Nepal.

Keywords: Participation, PPB, PVS, rice, biodiversity, in situ (on-farm) conservation, diversity fairs, diversity block, community biodiversity register, diversity deployment

Introduction

Participatory plant breeding (PPB) has been proposed as a strategy to enhance on-farm conservation through use (Eyzaguirre and Iwanaga 1996; Jarvis and Hodgkin 1997; Jarvis, Sthapit, and Sears 2000) and thereby conserve the processes of evolution and adaptation of crops to their environments (Altieri and Merrick 1987; Brush 1991). PPB and on-farm conservation have a common goal: both approaches encourage farmers to continue selecting and managing local crop populations. Sperling (2000) reviewed the goals of 40 PPB case studies worldwide in which only a few cases addressed the objectives of enhancing biodiversity on-farm. Most PPB programs aim to improve research efficiency and productivity for the target environment and often do not have a transparent goal-setting process (Weltzien/Smith, Meitzner, and Sperling 2000). Consolidating the role of farmers in setting breeding goals and selecting segregating or variable materials in the process of planting, managing, harvesting, processing, consuming, and marketing their crops, PPB offers

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farmers the opportunity to continue to select and manage local crop populations to better their livelihoods and income. By definition, PPB involves decentralization of the breeding process from research station to farmers' fields, but it also includes significant farmer participation (Witcombe et al. 1996). With increasing levels of farmer participation and decentralized testing, PPB can enhance the deployment of genetic diversity and also broaden the base of landrace populations in a sustainable manner. Increased varietal diversity deployed among farmers' fields as well as within them is the key to reducing vulnerability to diseases and pests (Zhou et al. 2000). The process also ensures farmers better access and control of acceptable germplasm (McGuire, Manicad, and Sperling 1999).

Both PPB[1] and participatory varietal selection (PVS[2]) are likely to have a negative impact on the diversity of landraces. Both methods are intended to change the structure of local crop populations to make them competitive with other available options that could totally replace the existing diversity of local landraces (Witcombe et al. 1996; Brown and Young 2000). Nevertheless, PPB is likely to be more beneficial for conservation goals because it works with variable, segregating materials that are derived from or similar to materials already in the local farming system (Brush 1999: 288). In contrast, PVS is likely to be negative for conservation goals because it is based on replacement of local populations with new and less variable ones from breeding programs (Witcombe et al. 1996). It is therefore important to distinguish between the processes of PVS and PPB if one of the purposes of PPB is to enhance biodiversity and production. There are concerns that PPB products may replace diverse local crop populations, and new alleles or combinations are expected to increase at the expense of other alleles, which that may well disappear. Brush (1999: 288) advocates that as better alleles or combinations arise and enjoy selective advantages, other less useful alleles thereby become less competitive and decline. This is the cost of evolutionary substitution and the price paid for allowing evolution to continue.

Therefore, it is assumed that in situ conservation and PPB strategies fail to preserve all biodiversity at the gene level. Although it may not prevent a reduction in genetic variability, it certainly limits the amount and rate of genetic erosion. There is limited published literature that has monitored the products of PPB over the long term. Sthapit (1998) monitored the spread of PPB products and their impact on landraces for seven years. The impact of PPB was reported as positive in terms of biodiversity enhancement and production in high-altitude areas of Nepal where rice varietal diversity was limited because of chilling temperatures and associated disease complexes (Sthapit, Joshi, and Witcombe 1996; Sthapit et al. 1998). PPB tends to enhance biodiversity in potential high-yield areas as well, where diversity has already been reduced by the rapid spread of modern cultivars (Witcombe 1999). However, the impact of PPB in biodiverse areas is not yet well documented in the literature. The factors that most influence how genetic improvement affects biodiversity are the production system (marginal, heterogeneous, or high potential), the degree of farmer participation employed in plant breeding (centralized or decentralized participatory methods), and the breeding methods employed (narrow or broad genetic base).

The Global In Situ Project[3] of the International Plant Genetic Resources Institute (IPGRI) has initiated PPB programs in selected countries and crops to examine such concerns. The goals of PPB can

1. PPB is defined as the "selection by farmers of genotypes from genetically variable, segregating materials" (Witcombe et al. 1996).
2. PVS is the selection of fixed lines (released, advanced lines, or landraces) by farmers in their target environments using their own selection criteria (Joshi and Witcombe 1996).
3. The project, "Strengthening the Scientific Basis of *in Situ* Conservation of Agrobiodiversity On-Farm," is globally coordinated by IPGRI, Rome, with three objectives: (a) understanding the scientific framework of farmers' decision-making processes in

include improving and conserving germplasm, broadening the base of the population, enhancing germplasm (pre-breeding), increasing options and access to a wider range of germplasm to provide greater opportunities to low-income farmers, empowering local farming communities, and increasing self-reliance. Not all goals will be addressed by the Global In Situ Project, but enhancing biodiversity and production is the central concern, with strengthening the capacity of farming communities in in situ conservation and utilization.

Research questions

Before PPB is accepted as a strategy for on-farm conservation, the following research questions need to be answered:

- Can farmer cultivars, *per se*, be conserved in situ?
- Can PPB contribute to the enhancement and conservation of landrace diversity in situ and provide benefits to the community?
- Can genetic improvement be achieved without loss of genetic diversity?

This paper presents preliminary results from the PPB program in three in situ sites of Nepal —Talium, Jumla (2000 m), Begnas, Kaski (600–1400 m), and Kochorwa, Bara (80–100 m)— based on the objectives of enhancing biodiversity and production. The methodological constraints of participatory approaches in setting breeding goals in the context of biodiversity enhancement and production objectives in biodiverse areas have been discussed. The paper also documents (1) how the needs of farmers and can be integrated with the objectives of biodiversity enhancement when breeding goals are set and (2) how useful genetic diversity can be developed by bringing in new, restoring old, and generating new genetic diversity (local x exotic) in the agroecosystems of the three eco-sites in Nepal.

Materials and methods

Study sites and priority crops

Three contrasting physiographic regions were selected to represent the high-mountain, middle-hill, and low altitudes of crop production in Nepal (table 1). The Jumla valley is remote, with basically subsistence-oriented traditional farming systems. It has a unique range of crop varieties finely adapted to local conditions. The area is a transitional zone between valley bottoms (where a winter cereal is followed by a summer crop) and higher elevations (where only one crop can be obtained). Most crop varieties are landraces except for few introduced vegetable and fruit crops. The valley is known for its cold-tolerant Jumli marshi rice, which is the only variety grown at the highest altitude of the world (Shahi and Heu 1979). Finger millet, barley, buckwheat, and cucumbers are other important crops in the valley.

The second site, Begnas village is situated in the Pokhara valley of the Kaski district, a middle-mountain ecosystem in Nepal. The Pokhara valley is known for high-quality rice in the western hills of Nepal. It is characterized by a number of lakes, broad alluvial valleys, isolated hills, terraced

on-farm management of crop diversity, (b) strengthening national capacity to plan and implement *in situ* conservation, and (c) broadening the use of agrobiodiversity. The nine countries involved in the project are Burkina Faso, Ethiopia, Nepal, Vietnam, Peru, Mexico, Morocco, Turkey, and Hungary (Jarvis and Hodgkin 1997).

Table 1. Contrasting Site Characteristics of IPGRI's in Situ Project, Nepal

Site	Agroecological characteristics	Socioeconomic characteristics	Human managed	Landrace diversity	Level of technical and market intervention	Type of partners
Talium, Jumla	High mountain with valley bottom (2200–3000 m) 866 mm/annum Arctic to cool temperate Calcaric cambisol, utric cambisol, utric fluvisol 8 indigenous land-use systems	Mixed ethnicity: 55% Chettri Population size=4570 Out-migration =25% Total cropping area =258ha Average farm size= 0.33 ha Total households=759 No of parcels =18.9±0.9 Food sufficiency (months) =7.5±0.3	Fertilizer for MV =0 kg Fertilizer for local= 87±25 kg (14) Compost =19.2–30.1 t/ha Area under rice MV=0	Rice = 21 Millet= 12 Taro=1 Cucumber=13 Barley=5 Buckwheat=6	Imperfect market Poor access to technologies and inputs No road network	NARC, LI-BIRD, NGO and DoA
Begnas, Kaski	Middle mountain with valley bottoms (600–1400m) 3979 mm/annum Subtropical to temperate Dystrict luvisol, systrict campisol, luthic regisol, flurisol 6 indigenous land-use systems	Mixed ethnicity: 53% Brahmin Population size=6070 Out-migration =7% Total cropping area =363ha Average farm size= 0.65 ha Total households=759 No of parcels =5.2±0.3 Food sufficiency (months) =8.3±0.3	Fertilizer for MV =120±41 kg (65) Fertilizer for local= 54±5 kg (93) Compost=1.34-5.72t/ha Area under rice MV=0.2±0.02 (90)	Rice =63 (6) Millet=24 Taro=24 Cucumber=14 Sponge gourd=13	Intermediate market situation Medium access to technologies and inputs Fair weather road and average market	LI-BIRD, NGO, NARC, and DoA
Kachorwa, Bara	Lowland *terai* plains (80–90 m) 1515 mm/annum Subtropical Utric cambisol, eutric luvisol 6 indigenous land-use systems	Mixed ethnicity: 64% Chettri Population size=5891 Out-migration = very little Total cropping area =627 ha Average farm size= 0.74 ha Total households=914 No of parcels =4.0±0.2 Food sufficiency (months) =7.4±0.3	Fertilizer for MV =147±5.4kg (192) Fertilizer for local= 127±9 kg (78) Compost used Area under rice MV=0.7ha (184)	Rice =33 (20) Millet=6 Taro=? Cucumber=4 Sponge gourd=16 Pigeon pea=5	Good market and road access Good access to inputs and technologies HYPP system	NARC, LI-BIRD, NGO and DoA

farming, and meandering streams. Farming systems based on rice and maize-finger millet are the two important production ecosystems. For the study, rice, finger millet, taro, sponge gourds, and cucumbers were identified as priority crop species.

The third site, Kochorwa, is situated in the Bara district of Nepal and lies on the fertile strip of Indo-Gangetic plain (100–200 m) on the southern frontier bordering India. The production potential is high, and farmers have adequate access to inputs and technologies. The rice-wheat-legume system is the basic cropping system of the region, and both irrigated and rain-fed systems occur in the communities. Rice, pigeon pea, finger millet, sponge gourds, and cucumbers were identified as priority crop species for the study. In Nepal, a total of eight crops (namely, rice, barley, buckwheat, finger millet, taro, sponge gourds, pigeon pea, and cucumbers) were identified for studies of in situ crop conservation. Rice is used as a case study for this paper, with a particular example from Begnas village because it maintains the highest number of rice varieties among the selected three eco-sites.

The three sites discussed above were selected by a national multidisciplinary team, based on predetermined criteria and indicators (Rijal et al. 1998; Paudel et al. 1998; Sherchand et al. 1998). The following selection criteria and indicators were used:

- diversity at the agroecosystem, species, and variety level
- rich intra-species diversity
- diversity in agroecology
- socioeconomic and sociocultural diversity
- importance of target crops for livelihood strategies
- landrace under threat and genetic erosion
- farmers' knowledge and skills in seed selection and management
- community interest and cooperation
- local research capacity and facilities available
- accessibility of the site
- contrasting market opportunities and/or opportunities for improvement

The major characteristics of the sites are summarized in table 2. The sites are significantly different in terms of agroecological and socioeconomic considerations. Though sites have some similarity in family size, other parameters differ in terms of average farm size, level of food sufficiency, education of respondents, and access to information sources. The sites also differed in terms of farm characteristics: size of land holding, land parcels, land-tenure systems, and irrigated area. The level of external inputs applied to crops varied between sites and farms, providing contrasting conditions of human-managed ecosystems.

Institutional settings

The institutional context is a bit unique in the case of in situ conservation because it demands multi-institutional and multidisciplinary research and development efforts. The project's strategy is to promote on-farm conservation by strengthening the relationship of formal institutions with farmers and local-level institutions. The Nepal Agricultural Research Council (NARC) has the public-sector mandate for the conservation and utilization of plant genetic resources (PGR) and is jointly working with the Local Initiative for Biodiversity, Research and Development (LI-BIRD), a nongovernmental organization (NGO) experienced in participatory approaches to crop improvement and genetic-resource management. Their aim is to build the capacity of local farmers' groups

Table 2. Comparative Socioeconomic Characteristics of Three *in Situ* Study Sites in Nepal, 1999

Ecosite	Total HH #	Sample HH#	Average rice farm size (ha)	Average area under rice land-race (ha)	No of field parcels/ HH	Average family size (No/HH)	Average food sufficiency months	Average cultivable farm (all types) (ha)
Talium, Jumla (2240–3000m)	759	180	0.13±0.2	0.13±0	18.9±0.9	6.0±0.2	7.5±0.3	0.33 (179)
Begnas, Kaski (600-1400m)	941	206	0.51±0.3	0.36±0.02	5.2±0.3	6.5±0.2	8.3±0.3	0.65 (195)
Kachorwa, Bara (80-90m)	914	202	0.71±0.1	0.30±0.03	4.0±0.2	6.5±0.2	7.4±0.3	0.74 (187)

Source: Rana et al. (2000).
Note: HH=Household.

and community-based organizations (CBOs) to implement on-farm conservation activities (Upadhaya and Subedi 2000). The Department of Agriculture and farming communities were also represented during the PPB planning process.

Stakeholders' meeting

A series of brain-storming sessions were organized to internalize the PPB approach in the national crop-breeding strategy. A primary stakeholders' meeting was held in April 1998 to develop a PPB process for on-farm conservation (table 3). Plant breeders from the public sector as well as NGOs participated in the process with the representatives from Department of Agriculture and farmers. The roles of farmers, NGOs, and the national agricultural research system (NARS) were agreed upon for four fundamental breeding steps: (1) setting goals, (2) generating new diversity, (3) selection, and (4) variety release and seed dissemination (Joshi et al. 2000: table 3). Modes of participation, as defined by Biggs (1989), may vary with specific breeding steps. Table 3 shows the steps of participatory plant breeding and the roles of the various participants. The measurement of PPB impact on biodiversity enhancement is the result of technical consultations with IPGRI staff and technical advisors.

Processes of participatory plant breeding

The PPB steps used in the project are listed below:

- locating agroecosystems and identifying interested communities
- organizing diversity fairs for locating crop genetic resources and local knowledge
- understanding local crop diversity
- monitoring diversity through a community biodiversity register[4] (CBR)
- developing options for adding benefits
- setting breeding goals for PPB
- agreeing on roles among stakeholders in breeding the process
- selection of diversity
- strengthening farmers' seed system for rapid diffusion

4. The CBR is a record, kept in a register book or electronic format by community members or local institutions, of all landraces in a community, including information on their custodians, passport data (e.g., agromorphological characteristics, agroecological characteristics), and cultural use or significance. A CBR aims to monitor genetic diversity at the community level and to encourage local communities to develop their own on-farm conservation strategy (Sthapit, Sajise and Jarvis 2000).

Table 3. Steps Used in the PPB Process under the in Situ Project in Nepal

PPB process	Mode of participation	Tools	Participation: Farmer	Breeder	Institution
A. Setting breeding goals					
Categorization of landraces based on area coverage and number of households		Mean values for different variables	*	***	LI-BIRD NARC
Validation of landraces	Consultative	focus-group discussion	***	*	LI-BIRD NARC
Preference ranking for identifying landrace parent	Consultative	focus-group discussion	*	***	LI-BIRD NARC
Documentation of positive and negative traits	Consultative	focus-group discussion	*	***	LI-BIRD NARC
Matrix ranking to identify traits for improvement	Consultative	focus-group discussion	*	***	LI-BIRD NARC
Finalization of landrace parent and exotic parent	Collaborative	focus-group discussion	***	**	LI-BIRD NARC
Selection of participating farmers	Collaborative	farmer network analysis	***	**	LI-BIRD NARC
B. Creating diversity		Crossing	*	***	NARC LI-BIRD
Growing F_1 lines	Contractual	space planting of all F_1 seeds	*	***	LI-BIRD NARC
Orientation to staff and participant farmers	Collaborative	village-level workshop	*	***	LI-BIRD NARC
Advancing heterogeneous bulk using equal seed-descent method	Consultative	negative selection	*	***	LI-BIRD NARC
C. Selection					
Screening early-segregating lines against abiotic stresses		field testing under farmers' management	***	**	LI-BIRD NARC
Screening early-segregating lines against biotic stresses		controlled-condition study	**	***	NARC
On-farm site selection for testing	Collegiate	Farmers' judgment	***	**	LI-BIRD NARC
Selection within and between populations	Collaborative	Farmers' judgment, farm walk	***	**	LI-BIRD NARC
Post-harvest evaluation	Collaborative	survey	***	**	LI-BIRD NARC
D. Seed diffusion					
Farmer-to-farmer seed flow	Collegiate	monitoring	**	***	LI-BIRD NARC
Variety release	Collaborative	proposal	*	***	NARC

Continued on next page

Table 3. Steps Used in the PPB Process under the in Situ Project in Nepal (Continued)

PPB process	Mode of participation	Tools	Participation: Farmer	Breeder	Institution
***E. Impact of PPB*[1]**					
Baseline information on genetic diversity on-farm to measure number of varietal choices available to farmers and their geographic pattern (domain)	Collaborative	Inventory of farmer-named and exotic cultivars and list of their uses	***	**	CBOs LI-BIRD NARC
Time-series information to measure the change of GD over time at village and community levels	PhD research	CBR Sample survey Effective number of landraces	*	***	LI-BIRD NARC
Pedigree analysis to detect the level of allelic richness and the level of polymorphism for genetic markers	PhD research	Molecular marker Average, weighted and temporal diversity estimates	*	***	LI-BIRD NARC
Need for monitoring diversity of use-values, e.g., local adaptation, uses for local cuisine, religious & cultural rituals, fodder value, etc.	Collaborative	Focus-group discussion List of farmers' selection criteria	**	***	LI-BIRD NARC
Assessment of productivity and sustainability of the system	Collaborative	Participatory project evaluation	***	*	LI-BIRD NARC
Linking with national breeding and ex situ conservation strategy	Consultative	Number of landraces used as parents in national breeding Collection of locally rare landraces	*	***	LI-BIRD NARC
Impact on cropping systems/landraces that are not chosen for improvement by PPB	Collaborative	CBR	***	**	LI-BIRD NARC

Source: Adapted and modified from Joshi et al. (1999).
Note: CBR=community biodiversity register.
* Passive role.
** Subordinate role.
***Lead role.
1. Impact of PPB is not the product of the participatory planning process.

The first step was to locate ecosystems and communities that harbor good biodiversity with local knowledge and interest. Multidisciplinary research teams assessed local situations using participatory tools to locate diversity, the community's interest, and the local capacity of community-based organizations for participating in participatory crop improvement. In 1997, a diversity fair[5] was organized in all three locations in Nepal in order to sensitize communities about crop genetic resources, to locate diversity and custodians of diversity, and to understand the value of landrace diversity in the context of the local food culture, market forces, and socioeconomic and agroecological settings. The materials collected from the diversity fairs were displayed in farmers' fields as a diversity block[6] to measure the morphological diversity structure within landrace popu-

5. A diversity fair is a display of local crop diversity through competition at village level (Rijal et al. 2000).
6. A diversity block is a participatory research technique to characterize local landraces under conditions of typical farmer management. Germplasm to be grown in the diversity block may be selected from materials displayed in diversity fairs or from community members' seed stocks. Farmers using traditional practices manage the crops, while farmers and scientists monitor the plants to observe and record agromorphological characteristics. Diversity blocks can be used to select parent plants and sources of seed for the crossing program (Sthapit, Sajise, and Jarvis 2000).

lations and also to analyze preferred and undesirable traits. Male and female farmers representing all socioeconomic strata participated in this activity. Participatory methods, such as diversity fairs, diversity blocks, and community biodiversity registers, were used to understand the use value of local crop populations and to assess the richness in the use value of existing diversity.

Amount of genetic diversity

The genetic diversity in farmers' fields was measured by the number of farmer-named and exotic varieties, the number of farming households growing each variety, and the area covered by each variety. A baseline survey and participatory tools such as the diversity fair and CBR[7] were used to collect the data and validate the information. Participatory rural appraisals (PRAs) and diversity fairs are quick methods for assess biodiversity in situ. CBRs provide a complete census of biodiversity at the community level.

Distribution of genetic diversity

Baseline household (HH) surveys were carried out on a sample of 180 to 200 households per site, depending upon the variability of agroecological and socioeconomic factors (Rana et al. 2000). Data were collected for each cultivar on HH features, farm characteristics, the status of cultivars (growing environment, area, and productivity), preferred and undesirable traits, along with use value, including medicinal and religious/cultural values, if any. An SPSS Data Entry module was used for data entry and SPSS/PC and MINITAB were used for statistical analysis.

Understanding the value of local crop diversity

This is a key step before participatory goal setting is initiated. The CBR provides a list of farmer-named cultivars and their use value at the community level. Based on the baseline survey data and CBR, farmers' varieties can be placed into four broad categories in terms of area cultivated and the number of farmers maintaining them in order to understand the relative importance of specific landraces:

1. landraces grown in large areas[8] (wide) by many farming households (common)
2. landraces grown in large areas (wide) by a few farming households (rare)
3. landraces grown in small areas (local) by many farming households (common)
4. landraces grown in small areas (local) by a few farming households (rare)

This kind of broad distribution analysis helps to understand why some landraces are grown in a small area by many farmers whereas some landraces occupy a large area but are grown by few farmers. It is very important to understand the pattern of such distribution and the reasons for such decision making by farmers.

Setting breeding goals

The dilemma project members faced before initiating the process of PPB was where to start? On all varieties? Those in high demand in the market or those maintained by only a few farmers in small areas? Or those grown by many farmers in larger areas?

7. After the diversity fair in Nepal, local communities were motivated to keep an inventory of farmers' varieties, including rare and endangered cultivars. This record is being maintained in the community biodiversity register.
8. For example, at Begnas, 63 rice landraces were reported in the baseline study (n= 206 households). The average area under rice varieties was 1.22 ha, maintained on average by 11 households. These figures were used to categorize area (> 1.2 ha = a large area and < 1.2 ha = a small area) and frequency (> 11 = many HH and < 11 = few HH). The size of area and HH number differed in the Jumla and Bara sites.

It was not known which particular group of farmer-named varieties was important from a conservation angle. However, it was not possible to include all the landraces for PPB, therefore it became necessary to categorize them on some obvious criteria. Since there was no previous literature available to guide this process, the team decided to categorize the rice landraces into four cells, based on the average area covered and the average number of households growing them. This was planned in such a way that at least one representative variety from each cell would be included in the crossing program.

A consultative participatory mode was used to assess the needs of farmers and the project goal. Focus-group discussions (FGDs), attended both by men and women farmers, were organized at the Kachorwa, Bara, and Begnas, Kaski, sites with the objective of identifying landrace parents for PPB. Farmers from across socioeconomic strata and gender were consulted in the FGDs to select the landraces for participatory plant breeding. Participatory approaches were used to select at least one landrace per cell for parents. Listed farmer-named cultivars were analyzed using preference matrix ranking (Guerrero, Ashby and Gracia 1993) for preferred and undesirable traits in order to identify traits that needed improvement. The third step was to identify the best landraces from the four cells using preference matrix ranking. During discussion, the preferred traits of the landrace parents were documented, while the traits that needed improvement were thoroughly analyzed using ordinary ranking or paired matrix-ranking methods. Finally, landrace parents preferred by farmers for the PPB program were short-listed to represent each cell. A relatively large number of landraces were selected from the cell with both large diversity and area. The exotic parent was then identified looking at the traits to be improved in an individual landrace, as well as adaptability of the exotic variety in the area and other farmer-preferred traits. Finally a cross-combination for each of the sites (Bara and Kaski) was finalized by the team.

Results and Discussion

Amount of diversity

Farmer-named varieties are a practical indicator of genetic diversity in farmers' fields. However, it is assumed that there is some degree of inconsistency in farmers' naming and/or distinguishing traits. Table 4 summarizes the number of farmer-named cultivars of rice, barley, finger millet, buckwheat, taro, sponge gourds, cucumbers, and pigeon peas across three study sites in Nepal. Only the data on rice are considered in this paper for further analysis.

The middle-mountain ecosystem at the Kaski ecosite harbored the highest number of rice cultivars (69), followed by Bara with 53, and Jumla with 21. The farmer-named cultivars at these sites were characterized to find out their genetic distinctiveness. The diversity of micro-satellite markers in random subset samples of landraces showed uniqueness in the cultivars. Therefore, the number of farmer-named cultivars can be considered as a measure of genetic diversity on-farm. Some landraces particularly adapted to heterogeneous areas tended to vary between subpopulations, as evident from molecular characterizations of Jetho budho, Basmati, and Gurdi (Bajracharya et al. 2000).

We found that several landrace populations share a common name but farmers distinguished them by their specific morphotypes and uses (table 5).

Most farmer-named cultivars of self- and clonal breeding crops have a high degree of consistency in their names and farmers' distinguishing traits (Bajracharya et al. 2000). We also found variation

Table 4. The Amount of Genetic Diversity and Its Distribution in Three Eco-Sites of Nepal, 1999

Ecosite	# Farmer-named variety	# modern variety	Consistency of farmer-named variety and distinctiveness	Area under crop (ha)	Average area under landrace (ha)	Average area under modern variety (ha)
Rice						
Talium, Jumla (2240-3000m)	21	0	Medium	80.6	0.13	0
Begnas, Kaski (600-1400m)	63	6	High	363.4	0.36±0.02	0.2±0.02
Kachorwa, Bara (80-90m)	33	20	High	718.4	0.3±0.03	0.7±0.05
Finger millet						
Talium, Jumla	12	0	High	34.7	0.04±0.01	0
Begnas, Kaski	24	0	High	133.4	2.2±0.03	0
Kachorwa, Bara	6	0	High	small	0.04±0.03	0
Taro						
Talium, Jumla	1	0	High	HG	NA	0
Begnas, Kaski	24	0	High	HG	0.001-0.03	0
Kachorwa, Bara	1	0	High	HG	NA	0
Cucumber						
Talium, Jumla	13	0	Medium	HG	NA	0
Begnas, Kaski	14	NA	Medium	HG	NA	0
Kachorwa, Bara	4	NA	Medium	HG	NA	0
Sponge gourd						
Talium, Jumla	0	0	NA	HG	0	0
Begnas, Kaski	13	0	Medium	HG	NA	0
Kachorwa, Bara	16	0	Medium	HG	NA	0
Barley						
Talium, Jumla	5	0	High	119.7	0.07±0.01	0
Buckwheat						
Talium, Jumla	6	0	High	9.8	0.04 ±0.01	0
Pigeon pea						
Kachorwa, Bara	5	0	High	Bund planting	0.21±0.02	0

Source: Rana et al. (2000).
HG= home garden (few plants).
NA= Not available.

within farmer-named cultivars (table 5). Work on molecular and agromorphological characterization is in progress to address problems of consistency in names; however, the list of farmer-named cultivars can be considered a basic unit of diversity on-farm, used by farmers as a management tool.

Distribution of rice diversity and use value

Figure 1 illustrates the extent and distribution of rice diversity from the Begnas eco-site. It helps to understand the importance of each farmer-named cultivar and the value of genetic diversity.

Table 5. Examples of Farmer-Named Landrace Populations and Farmer-Named Cultivars within the Landrace, Kaski Site, Nepal

Landrace population	Distinguishing traits	Farmer-named cultivars	Translation
Gurdi	*Gurdi* type of grain is distinguished by small grain with black apiculus color, medium-quality grain, adapted to hills	1. Seto gurdi	White gurdi
		2. Naulo gurdi	New gurdi
		3. Kathe gurdi	Foothills gurdi
		4. Lahare gurdi	Clustered gurdi
		5. Ganjale gurdi	Maskara eye shaped
		6. Kalo gurdi	Black gurdi
		7. Sano gurdi	Small gurdi
		8. Thulo gurdi	Big gurdi
Jhinuwa	*Jhinuwa* group of rice is distinguished by fine black grain and known for cooking quality—such as aroma and softness of cooked rice	1. Kalo jhinuwa	Black fine grain
		2. Chobo jhinuwa	
		3. Tarkaya jhinuwa	
		4. Pahenle jhinuwa	Yellow fine grain
		5. Tunde jhinuwa	Awned fine grain
		6. Kalo tunde jhinuwa	Black-awned fine grain
		7. Lamo jhinuwa	Long fine grain
		8. Seto jhinuwa	White fine grain
		9. Masino jhinuwa	Fine grain
		10. Jhinuwa basmati	Scented fine grain
Jemeli	*Jemeli* group of rice is distinguished by medium-coarse and long type rice	1. Pakhe jemeli	Foothills, medium-coarse grain
		2. Dhabe jemeli	Adapted to swampy area
Ghaiya	*Ghaiya* group of rice is distinguished for its ecological adaptation to direct-seeded upland rice	1. Seto ghaiya	White upland direct-seeded rice
		2. Rato ghaiya	Red upland direct-seeded rice
		3. Bicharo ghaiya	
		4. Gurdi ghaiya	
		5. Jire ghaiya	
		6. Chobo	
		7. Jhayali rato ghaiya	
		8. Kunchhali ghaiya	Upland direct-seeded rice from Kunchha
		9. Katuse ghaiya	
		10. Lahare ghaiya	Clustered upland rice
		11. Masino ghaiya	Fine grain upland
		12. Kanajire ghaiya	

(Continued on next page)

Table 5. Examples of Farmer-Named Landrace Populations and Farmer-Named Cultivars within the Landrace, Kaski Site, Nepal (Continued)

Landrace population	Distinguishing traits	Farmer-named cultivars	Translation
Anadi	*Anadi* group of rice is distinguished for its glutinous rice, coarse grain, and broad leaf	1. Seto anadi	White sticky rice
		2. Rato anadi	Red sticky rice
		3. Dudhe anadi	Milky sticky rice
Madhise		1. Thulo madhise	Big rice from *terai*
		2. Sano madhise	Small rice from *terai*
		3. Naulo madhise	New rice from *terai*
Bayerni	Bayerni rice is distinguished for its high-quality, aromatic, and black-seeded fine grain	1. Junge bayerni	Awned bayerni
		2. Kalo bayerni	Black bayerni
		3. Bayerni jhimuwa	Bayerni fine grain

Landraces grown in large areas by many households. It is interesting to note that only 13% of the landraces were grown in large areas (> 1.2 ha) by many households (> 11). Only eight farmer-named cultivars were found in this cell. They are used for four major purposes: subsistence, commercial, local adaptation, and quality. Table 6 illustrates the comparative value of local landraces and their bad traits as perceived by farmers. We found some contradictions in farmers' perceptions of good and bad traits and, therefore, only frequently reported information is included in order to avoid such bias.

Ekle, Kathe gurdi, Thulo gurdi, and Madhise are relatively high-yielding landraces adapted to high-yield-potential areas of the study site. Mansuli and Radha-7 are the only two modern cultivars common in the area. Farmers use grains of these varieties for subsistence purpose, whereas landraces such as Jetho budho and Pahenle are grown to meet market demand. These varieties are basically sold at the farm gate because of their high market price, based on their good cooking qualities. Resource-poor farmers in Begnas have allocated a large portion of their rice fields to Jetho budho (0.24 ha ±0.11) and Pahenle (0.20±0.14 cf. 0.14±0.14 ha).

Through interviews, it was found that these farmers sell highly priced rice in the market and buy modern varieties for their own consumption. In contrast, resource-rich farmers and farmers in the medium wealth category grow modern rice (Masuli) in larger areas than do the resource-poor farmers. It is assumed that these farmers have good access to land with a high yield potential and have the capacity to purchase the inputs required for modern cultivars. In this category, 43 farming households also grow Mansara, which covers 14.3% of the area for this category. Mansara is specifically adapted to poor soils and low-input management. The faith in Mansara is safe as long as farmers do not find competitive options. This variety tends to be grown by resource-poor farmers; however, its adaptive traits may be useful for future crop improvement for marginal lands. No farmer wants to improve this variety because of its low quality and poor straw and grain yield. From the conservation perspective, the question is whether these types of cultivars should be considered for PPB since many resource-poor farmers in large areas grow them. Or should we concentrate on locally common landraces such as Pahenle, Ekle, and Jetho budho to address the needs of many farming households? Farmers proposed Pahenle, Ekle, and Thulo gurdi for participatory improve-

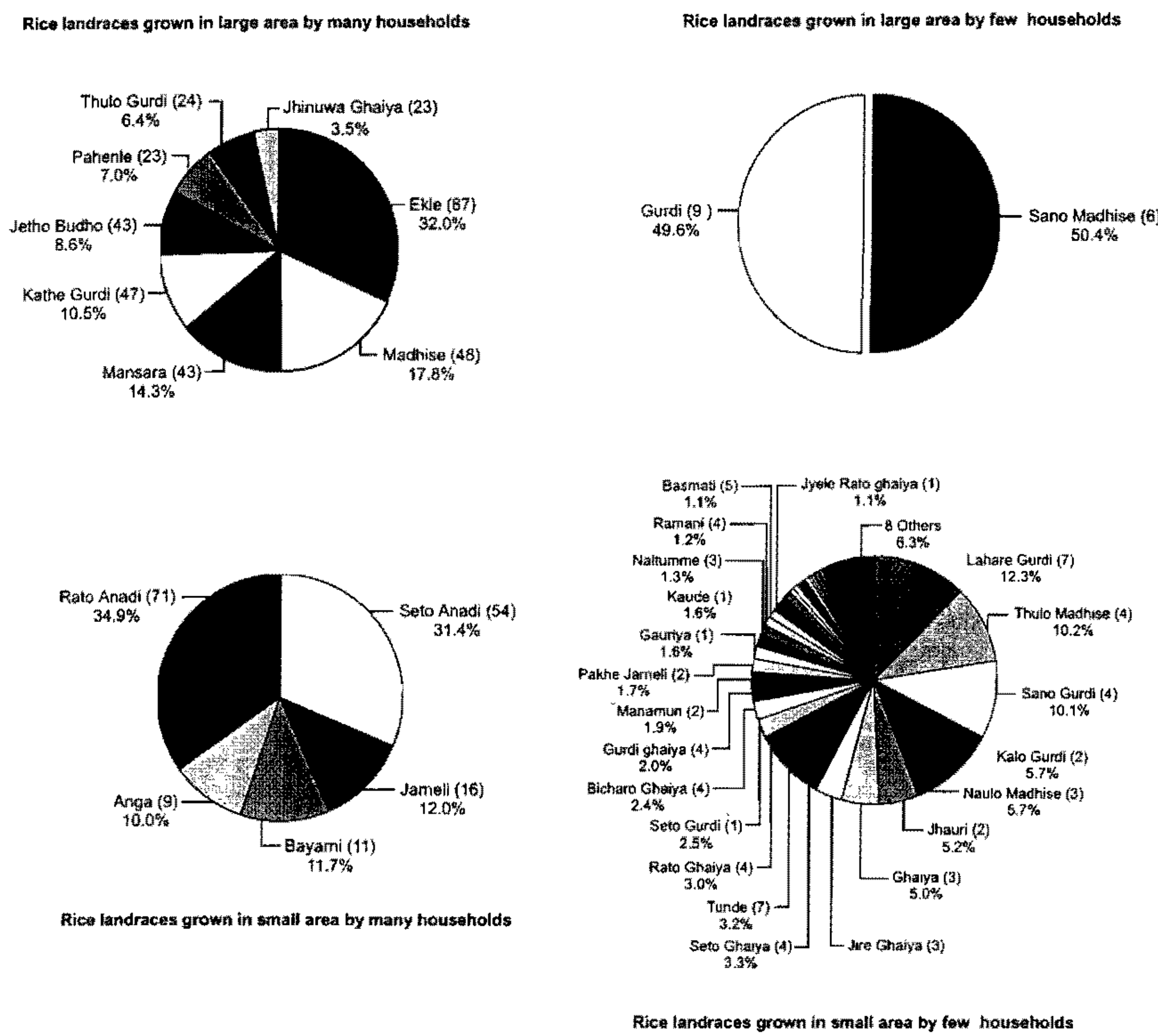

Figure 1. Categorization of rice landraces of Begnas, Kaski, based on area and number of farmers growing them (figures in parenthesis represent number of households)

ment, whereas Mansara was selected for adaptive traits. Jetho budho was selected for landrace enhancement because it is more competitive to other available options.

Landraces grown in large areas by a few farmers. There are very few cases in this category (figure 1). In Begnas, Gurdi and Sano madhise are the only two landraces found, whereas in Jumla and Bara, none was identified. These cultivars are grown for home consumption and are more tolerant to storage pests. Sano madhise is perceived as good for better rice yield and soft straw for animals (table 7). Farmers perceived that Gurdi is valued for multiple positive traits, such as good taste, long straw, low input response, and better milling recovery. Farmers selected Gurdi for a PPB parent.

Landraces grown in small areas by many farmers. Figure 1 shows that few rice varieties are found in this category. Most landraces in this cell have a special value in local food culture. Landraces with religious and cultural significance are likely to be maintained in small patches for local

Table 6. Comparative Use-Value of Rice Landraces Grown in Large Areas by Many Households

Farmer-named cultivars	HH #	Ecosystem	Major use	Use-value and constraints perceived by farmers	Undesired traits perceived by farmers
Ekle	87	Irrigated HYP 800-1000m	Subsistence	Good taste (97) Long straw (87) Good milling recovery (60)	High water demanding (43) Prone to insects in storage (35) High nutrient demanding (36) Late maturity (27)
Madhise	48	Irrigated HYP 600-900m	Subsistence	Good taste (48) Good milling recovery (19) Good yield potential (17)	Poor straw yield (21) Requires more water (12) & nutrients (11)
Kathe gurdi	47	*Tari* LYP 900-1400m	Subsistence	Adapted to low-input rainfed conditions (45) Good taste (36) Early maturity (21)	Poor straw yield (23) Low yield (6) Poor milling recovery (5)
Mansara	43	Rainfed *tari* LYP 900-1400m	Adapted to poor land and low-input conditions	Early maturing (23) Adapted to very poor soil and low-input conditions (17)	Poor taste (22) Poor straw yield (22) Poor milling recovery (17)
Jetho budho	43	Irrigated *tari* HYP 600-900m	Commercial	Good-quality aroma/softness (74) High price (22) Quality straw for mats (8)	High-input demanding (9) Low yield (6)
Thulo gurdi	24	Irrigated *tari* HYP 800-1100m	Subsistence	Good taste (36) Milling recovery (17) Good straw yield (22)	Demanding for water & nutrients (18) Low yield (3)
Pahenle	23	Irrigated lowland HYP 600-800m	Commercial	Good quality with aroma (30) High market price (13) Good straw yield and quality (12)	Low yield (4) Insect diseases (2) Water demanding (20)
Jhinuwa ghaiya	23	Tari LYP 800-1200m	Adapted to upland poor soil	Good taste among *ghaiya* (15) Market price (5) Straw value (4)	Nutrient demanding (6) Poor milling recovery (4) Poor straw yield (3)
Mansuli	59	Irrigated HYP 100-700m	Subsistence plus commercial Modern variety	Good taste (50) High yield (40) Milling recovery (25) Earliness (11) Adapted to warm water (14)	Poor straw yield and quality (24) More input demanding (36)

Note: Figures in parentheses indicate number of respondents in survey. Only top three frequencies of positive and negative traits were considered as perceived value of each variety.
Tari = indigenous classification of land types, upland rainfed rice ecosystem.
HYP= High-yield-potential areas.
LYP= Low-yield-potential areas.

use. Rato and Seto anadi are such examples from Begnas (table 8), whereas Sathi is used in Bara. They are sticky, glutinous rice used in preparing for local cuisine[9] during special festivals. The area under Anadi is the same across wealth categories (0.01 to 0.02 ha per HH). About 66% of the area

9. Several local cuisines are prepared from anadi, for example, *latte, siraula, puwa,* and *chiura. Latte* is cooked in *ghee* and eaten in a special Hindu festival, whereas *siraula* is puffed rice. *Puwa* is rice flour cooked in *ghee. Chiura* is prepared after boiling and pounding paddy rice until it is flat. This can be stored for long periods and used as a snack with several kinds of vegetables, pickles, and meat. Farmers and customers appreciate the quality differences in recipes according to varieties.

under this category falls to this variety. The question here is, As long as food culture is conserved, do we need to use PPB to conserve and use these kinds of landraces? Yield improvement and better marketing may add to the value of these cultivars and, consequently, many farmers may increase the area they plant to them.

Anga is grown for medicinal purposes in very poor soils, whereas Bayerni and Jerneli are very high-quality, low-yielding landraces specially grown in small areas for household consumption on festivals and for special guests. These types of rice are difficult to find in the market. The survey also showed that resource-rich farmers of the community conserve such special crop genetic resources. The value of such landraces is well understood but farmers maintain them in small areas

Table 7. Comparative Use-Value of Rice Landraces Grown in Large Areas (> 1.2 ha) by Few Households (< 6 HH) in Begnas Village, Kaski Ecosite, Nepal

Farmer-named cultivars	HH #	Ecosystem	Major use	Use-value and constraints perceived by farmers	Undesired traits perceived by farmers
Sano madhise	6	Tari/irrigated HYP 700-1100m	Subsistence	High yield (3)	Poor straw yield (3)
Gurdi	9	Irrigated HYP 800-1200m	Subsistence	Adapted to low-input conditions (5) Relatively good taste (5) Good milling recovery (4) Good straw value in terms of yield (3)	Poor yield (2)

Source: Baseline survey, 1999.
Note: Figures in parentheses indicate number of respondents in survey. Only top three frequencies of positive and negative traits were considered as perceived value of each variety.
Tari = indigenous classification of land types, upland rainfed rice ecosystem.

for specific domestic uses. Their small population size may lead to genetic drift. Does PPB have the scope to increase their productivity so that useful alleles from the Bayerni, Jerneli, and Anga populations are maintained? If the crop-improvement program is successful in incorporating good quality with yield advancements, will PPB products replace the diversity of other landraces that are not chosen for improvement? Farmers value Anga for its multiple traits and it has been crossed with NR 10291-6-1 for better yield. Landrace enhancements for Beyerni and Jerneli have also been suggested for improving yield.

Landraces grown in small areas by few farmers. In all sites, the majority of farmer-named cultivars fall into this category. In Begnas alone, out of 63 landraces grown, 48 landraces were maintained by only a few farmers in small patches of about 0.5 ha (figure 1). We need to understand why farmers grow so many landraces in small patches, as well as when and where they grow them and how they maintain and use them at the local level (table 9). Except for a few, the majority of landraces are maintained in small areas scattered in fragmented plots. This group of cultivars falls into locally rare materials, which should receive priority for ex situ conservation. Of 48 cultivars, 24 farmer-named cultivars were maintained by virtually a single household and can be defined as endangered. Should these be improved by PPB? Or are they candidates for a genebank before they disappear from the community? Do these varieties have specific genetic value? Or are farmers maintaining them because they do not have any better options? Or are they selected from locally common landrace populations? If so, should they be candidates for PPB?

Table 8. Comparative Use-Value of Rice Landraces Grown in Small Areas (< 0.5 Ha) by Many Households (> 11 HH) in Begnas Village, Kaski Ecosite, Nepal

Farmer-named cultivars	HH #	Ecosystem	Major use	Use-value and constraints perceived by farmers	Undesired traits perceived by farmers
Rato anadi	71	Irrigated; *dhab* HYP 700-900m	Food culture	Good for latte recipe (56) Medicinal value (59) Good for many local recipes such as sirula (35), khatte (17), puwa (16), tote (12), chiura (5)	Poor milling recovery (20) High input requirement (15) Low yield (10)
Seto anadi	54	Irrigated; *dhab* HYP 700-900m	Food culture	Good for sticky latte rice (47) Good for many local recipes such as sirula (42), khatte (22), tote (7), chiura (5), puwa (1)	Coarse grain (6)
Jemeli	16	Rainfed *tari/dhab* 600-900m	High-quality rice for home consumption	Adapted to low-input rainfed conditions (45) Good taste (36) Early maturity (21)	Low yield (3) Poor milling recovery (2) Input demanding (2)
Bayami	11	*Tari* HYP 700-1000m	Quality aromatic rice for home consumption	Good quality rice: aroma, softness (22) Medicinal value (5) Good for mats (7)	Low yield (6) High input demanding (6)
Anga	9	Unirrigated *tari* LYP 1000-1400m	Medicinal use	Adapted to very poor soil and rainfed plots (9) Medicinal value (5) Good fodder	Poor taste (6) Low yield (3) Red rice (6) Traits similar to wild rice (3)

Source: Baseline survey, 1999.
Note: Figures in parentheses indicate number of respondents in survey. Only top three frequencies of positive and negative traits were considered as perceived value of each variety.
Tari=upland rainfed rice ecosystem.
Dhab= permanent waterlogged ecosystem.

Table 9 illustrates the use value of minor varieties from the Begnas site. For example, Sano gurdi is valued for its moth tolerance in on-farm storage, whereas Biramphool[10] and Ramani are kept for their excellent cooking quality. These varieties are, however, low yielding and special skills are needed for cooking them in the traditional *kasaudi* (a thick, round, nickel pot for slow cooking on the fire). The introduction of rice and pressure cookers has replaced old cooking practices and skills and has also slowly reduced the demand for these varieties.

Naltume is a niche-specific variety adapted to shaded areas. Tunde is concentrated in drought-prone plots. Many Jerneli and Bayerni types are maintained for multiple quality traits despite their low yields. More case studies may be needed for varieties that are conserved without special value. The challenge is to identify the special genetic value of these rare landraces and find ways to assist the continued selection of local landraces that conserves the evolutionary process of landrace diversity. Traditional knowledge about such cultivars is limited, as few farmers maintain them.

In the PPB program, farmers decided to select Biramphool for its high-quality traits, whereas Naulo madishe was selected for its local adaptation to rainfed conditions. Biramphool will be crossed with another modern aromatic rice with better plant stature. Naulo madhise is crossed with IR 36 to incorporate its good yield potential (table 9).

10. The survey showed that two resource-rich farmers conserved this variety in an area of 0.30 ha. This variety is highly valued for its aromatic quality, which is controlled by a single gene.

Table 9. Comparative Use-Value of Rice Landraces Grown in Small Areas (< 0.5 ha) by Few Households (< 6 HH) in Begnas Village, Kaski Ecosite, Nepal

Farmer-named cultivars	HH #	Ecosystem	Perceived use-value by farmers	Perceived negative traits by farmers
1. Lahare gurdi	7	*Tari dhab* 800-1000m	Good taste (8), long straw (8), good milling recovery (4), adapted to cold water	Requires more water (3) Late maturity (2) Nutrient demanding (2)
2. Thulo madhise	4	*Tari* 600-900m	Good straw yield (4), good taste (3), adapted to marginal lands (3), better milling recovery	Late maturity Insect pest problems Sterility
3. Sano gurdi	5	*Tari*/irrigated 700-1000m	Adapted to rainfed conditions, adapted to shaded area, milling recovery, good taste	Low yield
4. Naulo Madhise	3	*Tari*/irrigated 600-900m	Long straw (5), drought-tolerant	High input demanding (2)
5. Kalo gurdi	2	*Tari*/irrigated 900-1400m	Long straw, good taste, adapted to shaded area	Difficult to thresh, prone to false smut, high input demanding
6. Jhauri	2	*Tari*/irrigated 900-1400m	Drought-tolerant, low input requirement, early, medicinal value, good for beaten rice, long straw	Poor taste
7. Ghaiya	3	*Tari* upland 700-1300m	Medicinal value (2), drought-tolerant, suitable for inter-crop with maize, early, good for *puwa*	Low yield (2) Leaf roller problem
8. Tunde	7	*Tari*/irrigated 800-1200m	Drought-tolerant	
9. Rato ghaiya	5	*Tari* upland 700-1300m	Supplement rice need before main rice harvested, good taste, early, good for beaten rice	Bad quality and taste, low straw yield, leaf roller problem
10. Seto gurdi	1	*Tari* upland 800-1200m	Tolerance to moths, good milling recovery	
11. Bicharo ghaiya	4	*Tari* 600-900m	Good for beaten rice, medicinal value, adapted to marginal land	low yielding, less milling recovery, coarse grain (2)
12. Gurdi ghaiya	5	*Tari*/irrigated 900-1400m	Quality straw for mat making, medicinal value	Difficult to thresh, low milling recovery
13. Manamuri	2	*Tari*/irrigated 800-1200m	Better adapted to low-input agriculture, easy to thresh, medicinal value	Low yield
14. Pakhe jerneli	2	*Tari* 800-1200m	Medicinal value (3), good for *latte* (2), *siraula, tote;* lodging-tolerant; good taste, aroma; long straw; low input; early	Low milling recovery
15. Gauuriya	1	*Tari* 900-1000m	Good taste, fine grain, high yield, good milling recovery, adapted to sandy soil, long panicle with awns	Late maturity, awned grains
16. Kaude	1	*Tari* 600-900m	Easy to thresh	
17. Naltume	3	*Tari*/shaded area 800-1200m	Good taste (3), good for shaded area (2), early, lodging- and shattering-tolerant, more milling recovery	Low straw yield
18. Dhabe jerneli	3	*Tari* 600-900m	Good taste (4), aroma, good for *latte*, long straw	Poor milling recovery, nutrient demanding

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Table 9. Comparative Use-Value of Rice Landraces Grown in Small Areas (< 0.5 ha) by Few Households (< 6 HH) in Begnas Village, Kaski Ecosite, Nepal (Continued)

Farmer-named cultivars	HH #	Ecosystem	Perceived use-value by farmers	Perceived negative traits by farmers
19. Ramani	5	Irrigated 800-850m	Good quality (11) with aroma, long straw (4), less prone to insect pests	Late, low yield, poor-quality straw
20. Jire ghaiya	2	*Tari* 600-900m	Adapted to upland *tari*	No special traits
21. Kalo jhinuwa	5	Rainfed *tari*/irrigated 800-1000m	Good quality (12), good straw quality (8), aroma (3), good for *khatte*, adapted to water logging, shaded areas	Low yield, late, difficult threshing
22. Kaude anadi	4	*Dhab*/irrigated 700-900m	Medicinal value (3), good for *latte* (2), *siraula*, *tote*, lodging-tolerant	
23. Jhinuwa	2	*Tari*/irrigated 800-1000m	Good quality, medicinal value, good for *puwa*, adapted to shaded area, low input requirement	
24. Thapachini	2	*Tari* 600-1000m	Good for *khatte*, adapted to marginal lands, good for beaten rice	Poor taste
25. Jhayali rato ghaiya	1	*Tari* 600-900m	Yield, supplement need of rice before main crop harvest	Poor taste, high shattering
26. Mala	1		Good for beaten rice, medicinal value, early maturity	Poor taste, high water demanding
27. Kunchali ghaiya	1	*Tari* 600-900m	Adapted to rainfed, early maturity, better milling recovery, good yield	
28. Lame	1	*Dhab*	Adapted to swampy land, good taste, aroma	
29. Kanchhi mansuli	1	Irrigated	Good yield, adapted to shaded area, long straw	
30. Kanajire ghaiya	1	*Tari* 700-1000m	Adapted to rainfed, green straw	Poor taste, prone to rodent damage
31. Katuse ghaiya	1	*Tari* 700-1000m	Adapted to rainfed	Poor taste, prone to rodent damage, shattering, etc.
32. Lahare ghaiya	1	*Tari* 700-1000m	Adapted to rainfed	Prone to water logging
33. Masino ghaiya	1	*Tari* 700-1000m	Fine-grain upland rice with no special quality	Low straw quality and yield
34. Masino jhinuwa	1	*Tari* 700-1000m	Fine grain, long straw, good taste	Poor yield
35. Seto jhinuwa	1	*Tari* 700-1000m	Good quality, good milling recovery, long straw, aroma	Poor straw quality, high input demanding, prone to rodent damage
36. Barmali	1	*Tari* 700-1000m	High yield, long straw	Poor milling recovery, poor eating quality, high input demanding
37. Chobo	1	*Tari* 700-1000m	Good for *puwa*, more production	Nutrient demanding
38. Jhinuwa basmati	1	Rainfed *tari* 800-1000m	Good taste, good milling recovery, long straw, aroma, long fine grain	Late maturity, awns

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Table 9. Comparative Use-Value of Rice Landraces Grown in Small Areas (< 0.5 ha) by Few Households (< 6 HH) in Begnas Village, Kaski Ecosite, Nepal (Continued)

Farmer-named cultivars	HH #	Ecosystem	Perceived use-value by farmers	Perceived negative traits by farmers
39. Juge bayemi	1	Irrigated 900m	Good taste, good milling recovery, long straw, aroma, long grain	Low yield, awns
40. Kalo bayemi	1	*Tari* 700-1000m	Good yield, aroma, good milling recovery, long panicle, black grain green rice	Low yield
41. Kalo tunde jhinuwa	1	*Tari* 900-1100m	Good taste, aroma, medicinal value, long panicle, good milling recovery	Low yield
42. Rate	1	*Tari* HYP 1000-1400m	Good taste, good milling recovery, high grain panicle	Threshing difficulty
43. Pakhe rameni	1	Tari 800-900m	Good taste, aroma, long straw, high tillering	Poor straw quality, low milling recovery
44. Seto bayemi	1	*Tari* 700-1000m	Good taste, good milling recovery, long straw, less shattering	High input demanding, prone to leaf roller attack
45. Bayemi jhinuwa	1	*Dhab* 800-1000m	Good quality, good milling recovery, long straw, aroma	High input demanding
46. Biramphool		*Dhab*/irrigated 700-800m	Good quality rice (6), aroma, long straw	Low yield, difficult to thresh
47. Basmati	5	Rainfed *tari* 800-1000m	Good quality (11), long straw (7), milling recovery (5)	Low yield

Note: Figures in parentheses indicate number of respondents in survey. Only top three frequencies of positive and negative traits were considered as perceived value of each variety.
Dhab=swampy, waterlogged rice ecosystem.
Tari=upland rainfed ecosystem.
Upland=dry-seeded, rainfed upland ecosystem.

Developing options for adding benefits. Two options were used in adding benefits: the first on adding benefits through participatory plant breeding and seed networks and the second on adding benefits through public awareness, better processing, marketing, and policy incentives (Sthapit, Sajise, and Jarvis 2000). The first option is to seek improved quality, disease resistance, high yield, better taste, and other preferred traits through breeding, seed networks, and modified farming systems. The second option includes adding value to crop resources so that the demand for the material or some derived product may be increased. These diverse options will emerge when the community, researchers, and developmental institutions are directly involved to monitor local crop diversity using CBRs and to link with crop-improvement, seed, and market networks for adding benefits on local resources. Table 10 illustrates a few examples of options for adding value.

Setting breeding goals and selecting landrace parents for PPB. Parents can be selected on the basis of either (1) the evaluation of parents or (2) the evaluation of their progeny. Participatory methods help greatly when selection is made on the basis of parental evaluation. The aim is to select parents that are as unrelated as possible, have complementary attributes, and will contribute towards the ideal genotype. In PPB, at least one of the parents should be adapted to the target environment and have traits that farmers like. The best way of identifying such a parent is by understanding the importance of crop diversity or through participatory varietal selection, which allows a wide

Table 10. Some Cases of Value-Addition Strategies Used in Begnas, Nepal

Strategy for adding benefits	Local crop diversity (location-specific example)	Value addition
Developing new products from popular recipe	Taro corms from Hattipau Samdi millet	Finger-millet pizza of Samdi kodo New recipe of taro masura from corm
Enhancing germplasm *per se*	Jetho budho	New productive seed
Better processing and marketing of local products for niche markets	Anadi rice Biramphool rice	Quality processing and packaging to supply to supermarkets
Enhancing skill of farmers for seed production	Basaune ghiraula (aromatic, high-quality variety of sponge gourd maintained by group of farmers)	Skill improvement of farmer groups in seed production of sponge gourds Linking with seed markets
Improving access to materials and information by sharing benefits	Taro landraces Sponge gourds Upland rice	Exchange of knowledge and materials
Linking markets with food culture and tourism industries	Local cuisine of typical local varieties Food fairs	Promotion of local products in conference Training in local and big hotels

range of germplasm to be evaluated by farmers in their own fields. This germplasm can include local landraces, recommended cultivars, and introduced varieties. A variety selected through PVS or one that is a common local landrace is an ideal parent (it has local adaptation and traits that farmers prefer) for which other parents with complementary traits must be found.

In Begnas village, a total of 12 landraces were selected for PPB parents. Participatory approaches were used to consolidate the farmers' role in setting breeding goals. The following steps were employed: understanding local diversity, understanding the importance of landraces, community interests, technical feasibility, and use value (genetic, socioeconomic, and ecological benefits). Table 11 shows comparative preferred traits as well as traits farmers would like to improve through the participatory crop-improvement process. Criteria for such selections include farmers' preferences, known value of specific or multiple traits, locally common, locally rare, widely common, and widely rare. The Mansara landrace was added by breeders because it possesses specific adaptive traits for low-input conditions. This landrace is basically grown and maintained by resource-poor farmers. It is interesting to note that nobody suggested improving Mansara, and the question arose as to whether participatory approaches lack methods to encompass all the concerns of farmers and conservation issues. Biramphool is included for its highly prized quality and aroma. It is assumed that by involving farmers in selection and evaluation, the process of genetic erosion of landraces can be slowed if the locally adapted landraces are used as parents in the breeding program and if landraces are made more competitive with the options available in the market (Sthapit and Jarvis 1999; Jarvis and Hodgkin 2000). Sthapit, Joshi, and Witcombe (1996) have shown that by utilizing farmers' varieties and knowledge, acceptable varieties can be bred that are competitive to the released cultivars, and biodiversity at the village level can be maintained (Sthapit et al. 1998).

Selection of exotic parents for PPB. Exotic parents were selected on the basis of plant breeders' knowledge of current breeding materials, the participatory variety-selection program, and multi-locational trials of the national as well as LI-BIRD's PCI programs (table 11). Cross-combinations

Table 11. Comparative Preferred and Undesired Traits of Landraces Selected for PPB, 1998

Female parent	Valued traits	Negative traits to be improved	Male parent
Kaski			
Aanga	• Grows well in dry, marginal, and upland areas • Has medicinal value • soaked rice regarded as coolant in case of heat stress; straw has similar effect on animals	• Improve yield • Increase panicle length • Increase straw yield	NR 10291-6-1
Biramphool	• Fine grain • Aromatic rice • Adapted to *dhab* areas • Good eating quality • Adapted to low hill valley	• Increase panicle length • Improve yield • Reduce sterility	Himali
Ekle	• High yield potential • Tall plant height • High tillering • Good eating quality • Adapted to hillside	• Improve grain density • Improve aptability to warm water • Improve drought tolerance • Reduce crop duration	Khumal-4
Jetho budho	• Cooking quality and taste • Straw quality • Col -water tolerance	• Improve yield • Improve blast disease tolerance • Improve lodging tolerance	Pusa basmati
Mansara	• Adapted to low-input conditions • Rainfed and poor soils	• Improve yield • Improve taste	Khumal-4
Naulo madhise	• Easy for threshing • Grows well under rainfed conditions • Adapted to low hill valley	• Reduce sterility • Poor eating quality • Not responsive to fertilizer	IR36
Pahele	• Very good eating quality • Fetches premium price in the market • Good yield potential • Good straw yield • Health promoter: increases stamina of all age groups of people • Grows well even in moderate fertility and partially irrigated conditions • Adapted to valley bottom	• Improve resistance to stem borer • Improve resistance to blast disease • Improve grain density • Improve resistance to leaf folder • Improve fertilizer responsiveness • Reduce lodging in low-lying areas • Improve resistance to panicle brittleness	Sabitri
Sano gurdi	• Good eating quality • High milling recovery • Soft straw	• Improve tillering • Reduce sterility	Khumal-6
Thulo gurdi	• Tall plant height • Suitable for mat making • Good eating quality of old stock of rice • Good yield potential • Adapted to hillside	• Increase tillering ability • Increase yield potential • Improve responsiveness to fertilizers	NR 10286-20-3-3

Continued on next page

Table 11. Comparative Preferred and Undesired Traits of Landraces Selected for PPB, 1998 (Continued)

Female parent	Valued traits	Negative traits to be improved	Male parent
Bara			
Dudhe saro	• Good eating quality • High market price • Reasonably good yield	• Reduce plant height with improvement in lodging traits • Improve fertilizer responsiveness • Improve tillering ability	Pant 10 BG 1442
Nakhi saro	• Good eating quality • Reasonably good yield	• Improve plant height with improvement in lodging trait • Improve fertilizer responsiveness • Improve yield potential	IR36 Chiate-2
Rato basmati	• Aromatic • Very good eating quality • Fetches premium price in the market	• Reduce plant height • Improve tillering ability • Improve resistance to insects, e.g., stem borer, brown plant hopper, and to disease, e.g., blast	Basmati 385 Sabitri
Lanjhi	• Good eating quality • High market price	• Reduce plant height • Increase panicle length • Improve harvest index • Improve resistance to insect pests and diseases • Incorporate aroma	IR64 KIII
Mansara	• Good eating quality • Fetches premium price	• Reduce plant height • Improve yield • Improve grain quality • Improve resistance to insect pests and diseases	IR64 Rampur mansuli

Source: Joshi et al. (2000).

were carefully chosen to improve bad traits of landraces. These crosses have been made and F_2 generations are being evaluated on-site. Generations will be advanced using the equal-descent method, and heterogeneous fixed materials will be distributed to participating farmers for further selection.

Conclusions

If crop genetic resources are going to be conserved on-farm, it must happen as a spin-off of farmers' productive (development) activities. This means that conservation must be put into the context of development. It is assumed that PPB could contribute to the achievement of development goals and farmers' needs. At the same time, PPB could strengthen the process of on-farm conservation by securing the survival of genetic resources and enhancing biodiversity on-farm, as well as increasing productivity. PPB has the potential to educate humankind (farmers, local politicians, development workers, researchers, and policymakers) about the need for in situ conservation of local crop diversity. At the community level, farmers select their own seed and also exchange, barter, purchase, or hunt new seed from other farmers, relatives, or local traders. This informal seed system harbors relatively large amounts of genetic diversity. It has elements of crop conservation, crop development, and seed supply. Institutional breeders, however, rely on genebanks and exchange pre-breeding materials[11] with international agricultural research centers, whereas local breeders and farmers can rely on the products of PPB as a source of new genetic variation. PPB, therefore, could generate considerable farmer interest in in situ conservation. The PPB process could be a *de facto* interface between germplasm enhancement and utilization.

This case study demonstrates that the farming community could be motivated to participate in developing PPB processes, understanding the value of local crop diversity, and choosing preferred traits and landrace parents for PPB crossing programs. Choosing breeding goals with participatory methods may conflict with conservation goals; therefore, the choice of parents and number of crosses to be made should vary, based on the diversity of uses farmers are looking for. The categorization of local diversity by area covered and the number of growers for each cultivar is helpful for participatory goal setting. Farmers also see the value of maintaining the community biodiversity register because it helps to develop local conservation strategies.

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Cultivating the Landscape: Enhancing the Context for Plant Improvement

Farhad Mazhar and Daniel Buckles

Abstract

The role of uncultivated plants in local food systems of Bengal is discussed, along with the concept of 'weed.' The authors describe the significance of uncultivated plants in local religious and social systems and their role in the broader context of crop improvement.

Bethua shak (*Chenopodium album* L. of the family Chinopodiaceae)[1] is not a cultivated plant in Bengal, but it's hard to imagine the rural cuisine of Bengal without this vegetable. It is an important leafy vegetable just like any cultivated cabbage or spinach. Its secure position in the food system of Bangladesh can easily be traced through many songs and stories, such as the *bhawaia* from North Bengal. There are few Bangladeshi who have not heard or are aware of the song.

Not long ago, the *bethua* was available in plenty. It used to grow along with winter crops in every field of potato, mustard, or lentil. Farmers considered it a partner crop and part of the total yield of a plot. It was not just consumed by the poor or during stress conditions when food was not readily available. Rather, it was an integral part of the food culture of Bengal.[2]

Consider, for example, the typical Bengali literary epics like "Monosha Mongol" and note what Sanaka, the wife of Chand Sawdagar, is cooking. The major place is given to the vegetables that are uncultivated. One by one she cooks 10 *shaks*, or uncultivated leafy vegetables, including the leaves of *chalta, bethua shak, gima shak, kumra shak*, etc. These are cooked as delicacies, as the supreme expression of her art of cuisine. Also see "Padma Puran" where Tarakasundai is cooking for Lakshmindar. She cooks *nalita shak, gima shak, kumra shak, helencha*, banana flower, and many others. The author says that if he lists all the food items the book will be too long and the poems may fail to describe the subtle elements of the plants and the art of cooking. This old literature clearly indicates that this knowledge belonged to a highly refined and sophisticated rural cuisine, despite deep class and gender differentiations.

In areas of contemporary intensive agriculture, *bethua* is no longer available, or if it is, rural people don't collect it because consuming it would mean consuming the pesticides applied to the field. Yet *bethua* and other uncultivated plants are still an important source of food for the poorest of the poor in the ecologically degraded rural areas of Bengal, once the high points of agrobiodiversity and local knowledge systems. It is clear from what research has been undertaken that the poor and the marginal populations retain the culinary art, knowledge, and skill that took hundreds of years to evolve. This article suggests that we recognize this vital context in our work with communities and when trying to improve crops.

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1. In English *bethua* is known as lamb's-quarters, fathen, dog's tooth grass, goosefoot, etc. A close relative of this plant is *chandan bethua*, or betho (*Chenopodium ambrosioides Linn*). Another local name for this relative is chapali ghash. This is also an important source of uncultivated food for rural people, particularly under stressed conditions. *Shak* is the Bengali term for leafy green.
2. Although we have mostly drawn from our work in Bangladesh, we use the term "Bengal" to include the communities of West Bengal, India, as well, when we believe that similarities exist for cultural and historical reasons.

The concept of weed

Bethua is just one example from the long list of uncultivated vegetables used as food by rural communities in Bangladesh. The same is true of *helencha* (*harkuch*), *Enhydra fluctuaans* (Compositae); *kanaibanshi* (spider wort) *Commelina benghalensis* (Commelinaceae); *kantanote* (spiny pigweed, prickly amaranth), *Amaranthus spinosus*, Fam. Amaranthaceae; *dheki shak* (fern), *Dryopteris filiz-mus* (L.) Schott, Fam. Polypodiaceae; *shaknote* (pigweed, green amaranth) *Amaranthus viridis* L., Fam. Amaranthaceae; *malancha* or *heicha* (alligator weed) *Alternanthera philoxeroides* (Mart) griseb., Fam. Amaranthaceae. These are all leafy vegetables important in rural diets, but none of them are cultivated. Others are used as medicine. For example, the common plant *lazzaboti*, the "touch-me-not" legume, is extremely important in the lives of rural women. Almost all women know how to use it to treat leucorrhoea, a common gynecological problem.

To further highlight the cultural context, consider as well the special role of a particular plant in the life of a child growing up in the rural areas of Bangladesh. Imagine the plant known as *foshka begun* (*Physalis heterophylla* nees.) and its role in babysitting baby brothers. The older sister picks the soft green fruit of *foshka begun* and presses it against her brothers' forehead to make soft, funny sounds to keep him amused. The relationship built by the plant between the brother and sister has been ritualized in the ceremony called *bhai fota*. Sisters use the flower to make a stamp on the forehead of the brothers on a particular day of Bengal's calendar, using sandalwood paste. This is an example of how conservation of a plant having no economic use plays a role in cementing and celebrating the relationship between people.

Strikingly, *bethua* is classified as a "weed" by Bangladeshi scientists.[3] While it is true that communities identify plants that they do not want in their fields, there is no notion of "weeds" in the Bangla language in the sense that the plants are completely useless or absolutely unwanted. The term *agacha* is used by farmers to refer to plants that are not intended for cultivation, but not to imply that the plants must be totally removed from cultivated fields. The farmer's perspective reflects the ecological, historical, cultural, and spiritual dimensions of agriculture. First of all, each and every being is part of a living reality, with a "place" in the order of the world that constitutes the community. Declaring a plant a "weed" implies that the life experience with that plant is also useless. Keeping these places in the order of the world secured is the first condition by which human communities ensure the conservation of plants, whether they satisfy an immediate need or not. Second, there are always specific individual and community needs different plants can fulfil. Different plants are recognized by different people for collection, or domesticated to meet the needs of human beings and other life forms. What are seen by some agricultural scientists as "weeds" actually make up part of the "harvest" from a piece of land. Equally, there are the needs of animals, birds, and other life forms that use plants that have no direct use to human beings. Third, the human relationship with plants is not static. There are multiple experiments going on with plants within communities in a dynamic relationship. These experiments are not undertaken simply to meet the functional needs of the community. They may be undertaken out of intellectual curiosity, as symbolic inspiration for spiritual and cultural experience, or for ethical reasons, since many communities believe that taking care of plant and animal life forms is a way to seek the meaning of human existence or communion with God. Finally, the notion of "weed" has no technical validity. We now understand from ecology that under most conditions, all plants in agricultural fields play a role in

3. The book *Weeds of Bangladesh* (Karim and Kabir 1995) published by the Bangla Academy lists *bethua* as a weed in agricultural fields, without even mentioning its role in Bengali culture and cuisine.

the recycling and conservation of nutrients and soil moisture. For example, farmers may opt to leave plants undisturbed in the soil during certain stages of crop development to avoid losses of soil moisture that would result from uprooting. In terms of agricultural practice, these plants are managed, not destroyed.

The dynamics of local food systems

The general point raised by the *bethua* illustration is that the boundary between cultivated and uncultivated plants is continuously blurred and redrawn. Botany and zoology, through the taxonomic classification of plants, animals, and aquatic species, have contributed enormously to our understanding of the diversity of life forms in nature. The introduction of an ethnological perspective to these disciplines has added scientific sensitivity to the depth of knowledge held by local and indigenous peoples regarding the characteristics, habitat, and multiple uses of these life forms, as well as non-Western systems of nomenclature and classification. The sharp focus of this perspective on species diversity is a strength because the biological distinctions and the local knowledge of these distinctions enriches our understanding of nature. However, this focus is also a weakness because it overemphasizes the distinction between nature and culture and reinforces the misleading notion of "wilderness" and "wild food." Science is now realizing that both historically and in the contemporary age, few environments and species evolve completely independently of human influence and management. In many settings the forests, savannas, and other landscapes have developed in coevolutionary relationships with human beings. Species that at one time were considered "wild" are now recognized as having been carefully nurtured by people (Leimar Price 1997; CGIAR 1999). This observation tells us that there is no clear division between "domesticated" and "wild" species. It also has a political dimension because it forces us to recognize both the intellectual and material rights local peoples have to all of the resources in the environment where they live and work—and those, such as sacred areas, that they manage through cultural means and practices.

The dichotomy of the domesticated and the wild contributes as well to the misleading notion that agricultural communities are based solely on the production and consumption of a few "staple" foods. While it is often assumed that between seven and 30 crops provide the largest proportion of the world's food, recent analysis suggests that the importance of staple crops in a community's food system is greatly overestimated (Scoones, Melnyk, and Pretty 1992). Research by Christine and Robert Prescott-Allen (1983) suggests that 90% of the world's plant food supply is provided by 103 species. Furthermore, it is now recognized that "partner species" to cultivated crops play a critical role in food and livelihood security, similar to that of semidomesticated livestock, not only during times of stress but as regular sources of nutrition as well.

Understanding the contributions of uncultivated food to food security is crucial to reframing the debate around food production in the context of diverse and dynamic local food systems. One dimension of these systems is the way in which the informal rules, customs, and social and institutional hierarchies within communities and the cultural practices of communities regulate local access to the biological resources of the community for food. These common property regimes are especially vital to the rural poor who depend upon access to common lands and bodies of water for the uncultivated plants, animals, and fish they need for food.

Another dimension of local food systems is that the dominant farming practices have an enormous influence on the availability and safety of uncultivated foods. The extensive use of pesticides to grow a single crop such as rice destroys not only the leafy greens in the field but also the plants along field edges and pathways and the fish in the nearby bodies of water, where pesticide residues end up. Widespread mono-cropping also has a negative impact on the availability of uncultivated food, both indirectly through the associated reliance on pesticides and directly through the homogenization of agricultural lands (single-tillage practices, rooting depth, microenvironments, etc.). This suggests that the appropriate level for understanding food systems is the community landscape, not the individual field, backyard, or plant species. Simply by protecting village lands from pesticides and enclosing common lands, an enormous resource in uncultivated foods is also protected. Such a strategy might be called "cultivating the landscape," in contrast to the limited perspective of "cultivating species" commonly applied to programs seeking to promote the use of a particular crop or plant in backyard gardens or agricultural fields.

The production of plants for food not only means cultivation but also recreating the production conditions for plants, both cultivated and uncultivated. Uncultivated plants are not "wild," as though they were left unattended or without any implicit or explicit community management. Rather, they belong to the community landscape, not simply as a material entity, but also as a cultural entity, from which communities draw their food and construct social relations. The horizon of the community landscape is like a spectrum or a continuum. At any one spot there are always surprises of nature: a plant that had no direct use yesterday suddenly becomes part of cuisine, an element of a concoction for medicine, a spice, or what not. In another bright location there are plants ready to be used as food, if necessary, during famine, flood, or conditions of stress. The cultivated plants indeed occupy the narrowest place in the diverse richness of this spectrum. Most important, there is no meaning in the unwarranted contradiction, antagonism, or dichotomy between cultivated and uncultivated plants, because both are equally crucial, important, and useful. The ingenuity of a community lies in continuously redrawing the margins in the context of their day-to-day struggle for livelihood, taking into account different ecological and socioeconomic conditions.

Enhancing the context for crop improvement

Our general argument in this paper is that the context for crop improvement is broad and must be enhanced through the practice of crop improvement. This perspective builds on and goes beyond recent constructive critiques of the conventional theory and practice of crop improvement, critiques that have pointed out two main issues:

1. Modern plant breeding focuses essentially on achieving the genetic potential for grain yield in a single variety of a single crop, in exchange for or against total biomass production and the multiple uses of plants.
2. Formally trained scientists are considered the only legitimate producers of knowledge and technology, while farmers are considered the receivers, consumers, or market for their products.

The critique has helped shape the concept of participatory plant breeding and its efforts to recognize the broader potential of farmers' seed systems and to involve farmers in formal research. While the development of the concept is constructive, the new approach has not been able to go beyond the context used to frame the theory and practice of plant breeding. Despite the critique, participatory approaches still focus on the outputs of a single crop and, typically, of so-called "major crops" such as rice, wheat, maize, barley, beans, pearl millet, and chickpea. This focus has several important negative implications. First, it marginalizes the question of the diversity of plant genetic resources. Conceptually, the notion of a single, improved species is flawed because implicitly all other plants, and even other varieties of a species, are reclassified as "weeds." This bias can all too easily be used to justify the use of destructive technologies and practices in the name of the introduced plant. The promotion across the globe of monocultural farming practices for a handful of commodity crops is a manifestation of this technical bias, and antithetical to the principles expressed in the Convention on Biological Diversity.

Second, the focus on single species of a single crop contradicts the overarching goals of crop improvement. Crop improvement programs typically state in their general goals that they seek to improve the livelihoods of the poor, but this goal is immediately lost by the brutal narrowing down of the plant breeding focus and definition of "improvement." Improved in what sense? In the community landscape different plants have different uses. One is not inferior to another. A paddy variety may produce a few kilos less rice in the field but provide the straw needed for livestock or for house construction. A high-yielding variety is not an "improved" variety compared to the one producing more good-quality fodder. A village woman in Bangladesh would never consider a variety of gourd or pumpkin "improved" if she can not pluck the leaves day-to-day for use as a leafy vegetable, no matter how big the pumpkin becomes. Clearly, improved livelihoods for the poor will not develop unless a wide range of plant genetic resources, including landraces and wild relatives of crops and uncultivated plants, are available in the community landscape.

Plant breeding is useful only in so far as it contributes to a qualitatively better life and environment, as well as joyful social and ecological relationships. The introduction of a single, improved species must therefore be assessed and justified in this broader context. This implies that the contribution of a crop be assessed against existing cultivated and uncultivated plants in terms of its contribution to the total harvest from a particular ecosystem and to the regenerative capacity of the ecosystem. At a minimum, the frameworks and research protocols of crop improvement must consider the existing production potential of the whole agro-ecosystem of the farming communities where work on crop improvement will be undertaken, including the needs of fisherfolk and others related to the farm environment. More specifically, the protocol must identify and recognize the value of the harvested products of the community landscape, including uncultivated plants and foods, so that actions in the name of plant improvement do not undermine these food sources and the diversity of plant genetic resources in farmers' fields and community lands.

The knowledge context

The public sector has traditionally had a strong role in crop improvement, mobilizing a wide range of skills, infrastructure, and capacity. However, this work and its potential are at grave risk of withering away because of several international trends. First, funding for public-sector research has declined dramatically everywhere in the world, as governments seek ways to control spending and as private-sector plant breeding grows stronger. Second, plant breeding is increasingly dependent upon technologies and knowledge systems that are expensive and largely controlled by the private sector. For example, in North America and Europe, virtually all plant breeding relies heavily on proprietary technologies controlled by the private sector, or through partnerships of the private sector with universities. Both of these trends have created a serious crisis in public-sector plant breeding, at a time when marginal farmers really need its support. One way out of this crisis is to redefine the nature of the collaboration between farmers and scientists and strengthen the institutional basis for collaboration.

The framework of the community landscape as the context for plant improvement theory and practice helps move beyond the flawed understanding of the process of knowledge creation that underlies and confines both conventional and participatory approaches to plant breeding. While in both approaches farmers participate at various levels and at particular times, it is taken for granted that professionally trained scientists are the main researchers. Scientists determine the research need and protocol and ultimately take credit for improving a crop or breeding a new variety. Farmers are not recognized as authentic producers of knowledge and technology. Rather, the involvement of farmers is treated mainly as a means to ensure the quality of the research product, particularly when testing and selecting varieties. Farmers' involvement is considered necessary for the promotion or marketing of the new variety.

Recognition of the broader context in which crop improvement takes place allows for a more balanced and realistic understanding of the contribution of farmers to knowledge production. Farming communities are engaged in a wide range of actions such as seed conservation, seed management and seed exchange that contribute to crop improvement. They are also engaged in particular farming practices such as mixed cropping that contribute to crop improvement by increasing inter-species diversity in farmers' fields and creating environments where intraspecies traits such as pest resistance are expressed and valued. Through these actions, communities regenerate the conditions of the agroecosystem, including their agricultural knowledge and other social and cultural dimensions.

Recognition of the context for crop improvement, and of the validity of the farmer's contribution of knowledge within this context, opens the mind to the constructive discussion of the primary roles of farmers and scientists and the nature of collaboration among them. Discussions of this nature are urgently needed, so that the current vulnerabilities of communities can be identified and communities can gain from collaboration with scientists.

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The Broader Institutional Context of Participatory Plant Breeding in the Changing Agricultural and Natural Resources R&D System in Nepal

Stephen Biggs and Devendra Gauchan

Abstract

In the past, many of the debates concerning participatory plant breeding (PPB) have concentrated on the differences between PPB and conventional plant breeding (CPB). In this paper, it is argued that the emphasize on the differences between PPB and CPB has led to (1) a perception of differences where in fact they do not exist, (2) a lack of acknowledgement of the complementary nature of different activities in participative technology development, (3) a lack of acknowledgement of other participatory-research and technology-diffusion activities taking place in the same locations, (4) a lack of emphasis on looking at legitimate concerns of science and technology policy. This preoccupation with simple notions of differences in the debates has resulted in a lack of knowledge sharing, a lack of available scarce resources, and an inadequate analysis of the institutionalization of PPB processes. This paper concludes that some of the PPB debates are about smaller issues and that major issues of science and technology policy need to come onto the agenda in the future.

In order to go forward, the authors suggest placing the debates in a broader institutional context where actors are seen to be playing many roles when participating in arguments about the pros and cons of PPB and CPB. It is proposed that those who are knowledgeable in this area look beyond their own organizational, funding, or other interests and help promote the development of broad-based institutional structures in research and development that mobilize and effectively use the wide range of research resources in Nepal and allow access to funds and scientific resources outside of the country. The paper illustrates the argument by using case-study materials from recent experiences in Nepal.

Introduction

We write this paper from the perspective of two people who are actively involved in promoting participatory approaches to technology generation and development. We are both socioeconomists and have experience of being part of plant breeding programs. However, neither of us is currently involved in day-to-day activities concerned with plant breeding. This paper attempts to reflect our views on some of the participatory plant breeding (PPB) activities and debates going on around us at the present time in Nepal. While we run the risk of being uninformed on some of the current literature, or not aware of some the points of the debate, we feel that our perceptions could be useful to those who are more closely engaged in these debates. By taking this broader institutional view of the role of different actors, we hope to show how the way issues, problems, constraints, etc., are described and presented by different actors not only reflects the way those people see things from their perspective, but also how the language used in the debates and the way the discourse is conducted opens up or narrows down the room for maneuver for exploring possible options for moving forward in policy and practice.[1] We argue that some of the preoccupation in the debate with defining simple dichotomous differences has resulted in a lack of adequate analysis of the complexity of the

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1. For a fuller description of this type of analysis in agricultural and rural-development planning practice, see Clay and Schaffer (1984) and Apthorpe and Gasper (1996). Recent analysis on mainstreaming gender analysis into agricultural research practice has focused on similar issues (Locke and Okali 1999).

issues involved, a lack of sharing of resources, and inadequate attention to long-term, sustainable "institutionalization" of PPB concerns in the broader national research and development (R&D) system.

We feel quite strongly that some of the concerns in the PPB debates are about smaller issues, and that major issues of science and technology policy are being neglected. The human resources in Nepal in public-sector research institutions and in the private and nongovernmental organization (NGO) sectors (including farmers and other rural people) are too small to be diverted to the consideration of minor issues. The major issue for research policy in Nepal is to address the diverse technological needs of various clients in the face of ever-changing socioeconomic and institutional environments. The best use needs to be made of the funds and human resources available in Nepal and from outside.

We are concerned that the nature of the current debates and behavior of some of the actors in plant breeding may not be helping the development of a flexible, strong, and cost-effective agricultural and natural resource research system in Nepal. The way different participants in the PPB debates are characterizing their own position and that of others does not seem conducive to addressing these larger issues. So there is a policy imperative behind the argument in this paper. Hopefully, if the arguments of this paper are at least partially accepted, we shall see more policy support for new types of fora, new alliances, and coalitions of actors for collaborative efforts in participatory plant breeding and participative technology development in general.

Changing institutional context of agricultural and natural resources R&D systems

The Nepali agricultural and natural resource research system, like many other research systems in low-income countries, is going through a period of great upheaval and structural change (Gauchan, Joshi, and Biggs 2000; Byerlee 1998; Hall et al. 2000). These changes include new research actors, such as NGOs, emerging as reliable research providers; farmer groups and associations becoming more vocal and increasing their capabilities to conduct research; major funders of research (the national planning commission and foreign donors) changing their funding strategies and procedures—sometimes to encourage a plurality in research and extension provisioning—using competitive funding as an instrument of policy intervention; a greater emphasis on log frames and other project-cycle methods for research funding and management; more emphasis on transparency and accountability in research processes; expectations of systematic, broad-based "impact" analysis of research activities; the demands and implications of future membership of the World Trade Organisation (WTO); the rapid, but very patchy, spread of modern information technology in the R&D system; developments in biotechnology; and the continued integration into the national agricultural research system of two well-established stations that previously had exclusive long-term special funding from a single donor. These are just some of the major changes taking place that are having a profound effect on the R&D system.

It is often recognized that Nepal has a very rich and diverse set of agroclimatic and natural-resource conditions, which have led to great and ever-changing biodiversity. It is also recognized that the changing cultural, political, and socioeconomic conditions in Nepal are very complex, and generalities such as the notion that Nepal is a Hindu state are highly contested (Bista 1991;Gurung 1998). However, it is not so often recognized that the institutions of research and development are also very complex and are always changing. To some extent, the lack of appreciation of the complexity of the R&D system has been a result of the preoccupations of the government, foreign donors, and the Consultative Group on International Agricultural Research (CGIAR) with research in the public domain. While they directed attention at only part of the overall R&D system, they created a perception that the public sector was not just part of the overall R&D system, but that it was, for all intents and purposes, *the* research system. Some of the major challenges for those who influence R&D policy and for R&D practitioners now is to drop this old model and use an alternative model that sees technological and institutional innovations as coming from multiple sources (Biggs 1990).[2] While innovations from farmer experimentation, informal R&D, and indigenous technical knowledge have been recognized as a source of innovation for many years,[3] there has been less recognition of the existence and role of innovations from other parts of national R&D systems, for example, parts of the private/NGO sector, universities, etc. It is in this context—where attention is now being given to a far wider range of institutional actors in the R&D system—that we move onto the advocacy and practice of PPB in Nepal.

Recent advocacy and promotion of participatory plant breeding

Advocacy for the greater involvement of farmers in plant-breeding research

According to Sperling and Ashby (1997), "The greater involvement of farmers in formal breeding research programs is a development only in the last 10 years." Some of the key features of PPB as given by these writers are that (1) PPB has to be client driven, (2) the focus is on the development of prototypes, rather than finished products, (3) the major responsibility for adaptive testing should be devolved to farmers, (4) accountability should be shared.

It appears that one of the key issues here is the "greater involvement" of farmers in the R&D process. The problem with such a definition is that it is difficult to delineate boundaries and isolate what we mean by the *greater involvement* of PPB researchers as opposed to CPB researchers. This statement is clearly not true for many past conventional plant breeding programs where there was a very high degree of farmer participation through control over the R&D process. The development of improved wheat varieties might be seen as part of a conventional plant-breeding program; however, the Senora Valley, where Norman Borlaug and his Mexican colleagues worked, is an example of breeders having had a very high degree of interaction with local farmers that continued for many years (Biggs and Smith 1998). In India, the interaction between Punjabi farmers and the local R&D capability was very high. In fact the farmers of the Punjab had great influence over the setting of high wheat prices and the high subsidization of many inputs. This represents very high involvement of farmers in the overall R&D process. The record of the development of commercial crops under colonial regimes in low-income countries also shows that farmers had great control over the technology-generation process and were often highly involved with the practice of science. Our own work has brought us in contact with "conventional" breeders who for many years have had very close ongoing interactions with farmers and also distributed prerelease materials to farmers to get their reactions and feedback. Even in IRRI, many rice breeders knew that farmers (sometimes in

2. Hall et al. (2000) address these issues in the context of agricultural R&D in India. They use as a conceptual framework the "national systems of innovation" (NSI) from the work of Freeman and others.
3. For example, see Richards (1994) and Okali, Sumberg, and Farrington (1997), Chambers and Howes (1979), Biggs (1980). The recognition of innovations from farmers did not, of course, mean that these were recognized or used by the earlier public-sector–dominated R&D systems. Some early analysis of the contributions and roles of the NGO sector in the national R&D system can be found in Farrington and Biggs (1990) and Farrington et al. (1993).

their role as technicians on the research station or farmers who visited the station) were taking a whole range of materials off the station and growing them locally.[4] However, the nature and pattern of participation was often neither planned nor systematic.

In some cases, then, we are not talking about anything that is new to plant breeders, but looking more closely at different types of participation and how different mechanisms for participation were/are institutionalized in practice in different institutional contexts. Certainly some "conventional" breeders would have no problem with the four principles listed above and would welcome structures, measures, incentives, etc., that would support the implementation of those principles. This takes us to a major R&D policy issue concerning the rewards and institutions of science, rather than arguing over what is old or new in breeding.

Some preoccupations in the current plant breeding debates

Preoccupation with simple dichotomous differences

The last 10 years versus everything before that. It seems that one of the preoccupations of the current debate is to create simple two-way, dichotomous differences in situations where such either/or classifications neither help in our understanding of past plant-breeding processes nor in bringing different groups to work together in the future. For example, we have on the one hand, the "old" conventional, traditional, classical approaches to plant breeding, and on the other hand, the "new" participative, process, holistic approaches. A "them-and-us" mentality is being established: you can belong to one camp or the other. The search for common ground is not on the agenda, nor is the notion that both camps could be "right," or that important complementarities exist.[5]

Even when it is said that involving farmers in formal breeding research programs started only 10 years ago, we are creating a dichotomy between the last decade and the time before that. This dichotomy does not encourage us to explore and understand the way different components of PPB were used in different situations in different ways before the last decade. While it may be true that conventional approaches have been promoted by the CGIAR system and parts of national research systems, and it is only recently that the CG system and some major bilateral donors are funding work of this type,[6] the CG system is only part of international systems and the mainstream may only be part of national research systems. What is new to some may not be new to others. The reason for making this point is that some of those who are now part of the new advocacy might prefer to see themselves as joining a long tradition of dissident/innovative plant breeders rather than as part of a new approach that started only 10 years ago.[7]

4. For details see an unreleased but highly circulated "grey literature" report by Ruth Goodell (early 1980s) on the extent of IRRI materials that had spread in this way.

5. It is interesting to see that the use of simple dichotomies is also seen as a major problem in participatory evaluations (Hammeijer, Waters-Bayer, and Bayer 1999). The CARE (1998) publication on participatory crop variety selection places emphasis on the differences, rather than the complimentary nature, of some R&D activities.

6. For a review of recent projects in this area, see Weltzien/Smith et al. (2000) and McGuire, Manicad, and Sperling (1999). Details of international collaboration in this area are also given in Sthapit, Joshi, and Witcombe (1996); Gauchan, Subedi, and Shrestha (1999); Jarvis, Sthapit, and Sears (2000); Witcombe, Virk, and Farrington (1998).

7. In the late 1970s in Uttar Pradesh, there was an "on-farm" program involving several universities to develop composite varieties and relevant agronomy practices for farmers with high farmer involvement. At the same time, a report by a very experienced maize breeder involved in a Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) regional network was stopped because it outlined the alternative approach to maize crop improvement that was being tried. Deep controversy is not new to plant-breeding practitioners.

Farmer-led or formal-led research. Another dichotomy in the literature is the difference between "farmer-led research" as opposed to "formal-led research" (Weltzien et al. 2000; McGuire, Manicad, and Sperling 1999). This distinction worries us on a number of scores. First, this is a sort of contradiction of terms. If there is respect for the different knowledge that farmer and researchers bring to a discussion, then each party recognizes that there are things the other party does not know. Each party has to trust that the judgments being made by the other party are in good faith. In farmer-led research, farmers have to trust the "relevance and safeness" of the exotic materials being suggested by the researcher. Yes, the farmer may decide to use that new variety; however, if that variety has come, say, from research processes using modern biotechnology methods, the farmer will have to trust the information about those processes that the scientists have provided. A different, equally qualified researcher from the formal system, but with different scientific judgments on genetically modified organisms, might have given the farmers different advice and farmers might have made different choices. Clearly, the information scientists give affects the path taken by farmers even in the farmer-led approach. Terms such as *farmer-managed* or *formal-managed* research might better represent the difference that is being searched for here. However, even if that change is useful, we may have the situation (if PPB is like other types of participatory technology-development processes) where there is always fluidity in the process. What started off as farmer managed might become formal managed and vice versa.

A second concern centers on the notion that it is useful to separate farmer-led from formal-led research. There is considerable evidence to show that new technology is often developed and promoted by formal and informal alliances/coalitions/partnerships.[8] Those involved in participatory plant breeding projects in Nepal confirm this view.[9] This is also the pattern of cooperation that is emerging in a sustainable soil-management program in Nepal (Subedi and Bajracharya 2000). The problem, then, with farmer- or formal-led difference is that it places emphasis on a simple difference, rather than helping us to look at and understand the way alliances/partnerships were formed with different actors playing complementary roles. To place the emphasis on who "led" the process might be misguided if one were interested in a broader-based institutional analysis of what happened and why. As to the formation of alliances/partnerships in the future, farmer-led or formal-led classifications might well hinder rather than help in the promotion of collaborative activities.

A third problem centers around the notion that farmer-led PPB is in any sense a new phenomena and that ways forward might be based mainly on the experience from recent projects that have promoted farmer-led PPB. Our reaction comes partly because Nepal and India have a very long open boarder along the Tarai, which for all practical purposes cannot be regulated regarding the flow of germplasm. Farmers cross from one side to the other and select materials in a truly participative manner. This has been going on for generations and continues very actively today. Some farmers (perhaps with and without formal training in science) even go to some of the big agricultural universities in India to seek advice and obtain new varieties. We would call these activities "farmer-led initiatives." They are very common and have resulted in the spread of improved materials in Nepal from India and vice versa. We would suggest that this source of information on innovative farmer-led PPB should be used as much for understanding the past and for guiding future technology and institutional policy as more recent "project-inspired" initiatives in this area.

8. See Tendler (1993) and Biggs and Smith (1998).
9. See Sthapit and Joshi (1998). This was also a strong view expressed to us by Dr. Anil Subedi, the director of LI-BIRD, one of the major NGOs involved in PPB in Nepal (Subedi 2000).

Participatory crop improvement versus conventional crop improvement. A recent new term to be promoted by some of the dominant actors in this area is *participatory crop improvement* (PCI), which by implication is differentiated from conventional crop improvement (CCI). The term enables nongenetic technological options, such as integrated soil fertility management, integrated pest management, irrigation, mechanization, and post-harvest technology, to be taken on board. For those who have worked in India, this term has resonance with the All India Crop Improvement Programs. Experiences with the practice of those programs as planned approaches to science have been very mixed and their periods of higher or lower usefulness can only be understood if one looks at the broader macroeconomic policy context and the institutional context of science and technology at the time (Rajeswari 1995). A closer examination of the activities of those programs would show different types of participation of farmers, NGOs (both local and international, such as the Rockefeller and Ford Foundations, CIMMYT, etc.), public-sector researchers and development agencies, and other actors in different arenas at different moments in time. A detailed institutional analysis of those networks/partnerships/coalitions would be interesting for informing future policy in the area of integrated crop improvement policy.

However, the point that is being made here is that a new simple dichotomy is being introduced: PCI programs on the one hand and CCI programs on the other. We feel that this simple approach will neither help us understand the past nor provide a good framework for addressing the complexities of developing partnerships/linkages, etc., where some parts of the "old" conventional approaches might be relevant to "new" participatory approaches. From a participatory perspective, one of the most difficult problems of getting different groups of researchers (both social and natural scientists) to participate and work together is as likely to be as difficult for the new PCI programs as it was for the CCI programs.

Narrow definition of participation

A further characteristic of the current debate is to define "participation" in a very narrow way.[10] Participation appears to concentrate mainly on only two sets of actors: "researchers" (plant breeders) and "users" (farmers). There appears to be little analysis of relationships within these two groups, e.g., gender analysis as regards the significance of the relationships between men and women of different ages within the user or researcher groups is little analyzed in some PPB programs. We mentioned earlier the difficulties of getting different groups of researchers to participate together in R&D, and there is plenty of literature on this subject.[11]

However, for contemporary analysis of participatory issues, we have to take into account the relationships between different actors in the private and public sectors. This has special importance if one is concerned with the actual practice of R&D as well as "implementation" and "institutionalization" issues. Whether a plant breeder trained in formal scientific methods is in the private sector (e.g., a farmer or a seed merchant in a private breeding company), in the public sector, in the NGO sector, or part of a donor project, etc., will in most situations have great significance for any debate concerning the usefulness and spread of PPB. In most situations, the history of specific actors and the history of the institutions will also be of significance. A narrow discussion about relationships between researchers and farmers, with little or no serious analysis of these broader institutional

10. In this paper we do not address the issue of how different community/village level actors perceive the enterprise/project being undertaken by researchers. For a salutary article which demonstrates that the "outsider" will always be viewed in ways that that outsider may not want, see Burghart, (1994).
11. See for example Merrill-Sands, et al, (1991); Byerlee, Triomphe and Sebillotte.

issues may well be diverting us away from some of the more important topics of contemporary research policy. It is interesting to reflect that there is never any situation in R&D where there is no participation. There is always participation by definition, as R&D is a social process. It is the nature of the participation that deserves analysis.

We would argue that the use of simple dichotomies and the narrowness of the PPB debate have been some of the reasons why major policy issues in this area have not been addressed[12]: issues such as the sharing of information and the mobilization of national R&D human resources (in whatever institutional location) to address national R&D problems. In addition, there are legitimate concerns about CPB programs that need addressing by the promoters of PPB.

Legitimate concerns of CPB programs

There are five important concerns about conventional breeding programs in their resistance to accept and adopt PPB principles and practices in Nepal. They are (1) fear of vulnerability of genetic materials to disease/pest epidemics when they are promoted in the early stages of breeding, (2) concerns for wide agroecological adaptation of the genetic materials, which prolongs involvement of farmers in the early stages, (3) requirements for a regulatory framework for variety release and seed production and promotion, such as distinctive, uniform, and stability (DUS) characteristics, (4) inadequate knowledge on the part of participating farmers about the future genetic performance of materials, (5) the nature of partnerships and ownership of the participatory technology-development process.

Reasons for the narrowness of the debate and the fragmentation of activities

Before continuing, it is worth exploring some of the reasons for the apparent narrowness of the plant-breeding debate and the lack of concerns with broader national research policy issues.

Demands of the project cycle

One of the reasons is the demand of current funders to see the "impact" of "their" projects. The project cycle, with its associated methods and techniques of log frames, reviews, and monitoring and evaluation (M&E) activities sometimes leads to the creation of differences, for project purposes. In competitive situations, differences may also be created in order to secure funds. *Differences* are created categories, which in some ways are created for reasons related to the project cycle rather than to helping apply science to problems. One of the reasons for the idea that PPB is "new" comes from the need for funders to fund "new" ideas that can be tried and experimented with before being multiplied and promoted more generally. This makes a far more exciting project for a funder to support than a project that suggests it is trying to change the balance between different alternative approaches and methods in a broad-based crop-improvement strategy. The former makes claims of

12. The type of debates mentioned above have led to situations in Nepal for example where PPB projects have been critical of CPB, but failed to point out that many of the useful varieties used in participatory program came from CPB programs. On one occasion, an eminent plant breeder connected with a major CGIAR center, visited the country to work with an NGO on PPB. However, even though the center had had for many years worked in partnership with the relevant public sector plant breeding programs, the visitor did not contact the public sector program.. This was in part due to the separation between PPB and CPB. This approach in our view, does not encourage new creative partnerships.

clean-cut separations and dichotomies, which many reviewing such projects know are based on many unsustainable assumptions. In the present context, some of the ways PPB projects are being drawn up and described as separable from other parts of the R&D system are not necessarily leading to the better use of scarce resources in Nepal.[13]

Social status and institutional location of researchers

The second set of reasons for some the activities concerning PPB in Nepal concern the history, experiences, seniority, and status of people in different parts of the overall research-and-technology promotion system. While many scientists subscribe to an ideal model of science where there is a free flow of information and ideas, the way science actually takes place in any situation is affected a great deal by the social attributes of the actors involved. In its most obvious form, these things are reflected by who gets invited to meetings, what makes up the formal and informal agenda, and the authority of the meetings to have "recommendations" "implemented." The reasons for the demise of the strong NARC farming systems division and the current locations of the old staff of the two British-funded stations in Nepal are important institutional determinants for the nature of the current discourse concerning the pros and cons of PPB.

Path dependence

A third important determinant affecting the nature of the present activities and discourse concerns the "path dependence" of scientific debates (Hogg 2000). It is very hard for organizations to change, especially if they are part of, or are linked to, established bureaucracies or traditions in the way they do things. This is not only for technical research priorities but also the institutional mechanisms for managing research and establishing linkages with other actors. In the current context of PPB in Nepal, it is very challenging for the Nepal Agricultural Research Council (NARC) to consider the possibility of developing new partnerships with the private sector/NGOs for plant breeding and the on-farm testing of a wide range of materials where farmers and NGOs can have a major say in decision making (Sthapit, Gauchan and Rana 1996). Issues of path dependence are also key features for explaining some of the behavior of different parts of the CGIAR system and other international actors.

Some of the consequences of the battles within the plant-breeding fraternity about what is or is not PPB, PCI, or CPB and who should or should not be doing what, are that important policy issues are not being addressed and scarce human resources in Nepal are not being well used. Opportunities to have policy debates and actions on such things as a strategy for future rice research in Nepal, using all known professional expertise whether in the public or private/farmer/NGO sector, are being missed. Some of this is due to the narrowness of the PPB debate and the associated behavior of the actors involved.

Participatory technology development activities in Nepal

We have suggested that some of the international and local plant-breeding debates have been narrow and parochial in their orientation. We now briefly describe some of the history of broad-based

13. There has been a lot written about the way different actors use concepts of logframes, cost/benefit analysis, the project cycle, etc., for different purposes in general development practice. For example, see Gasper (1997), Wood (1998), Biggs (1997), Apthorpe and Gasper (1996), Clay and Schaffer (1984), Horton and Mackay (1999), Biggs and Matsaert (1999), Grimble and Wellard (1997).

participatory technology development (PTD) activities in Nepal and some PTD work taking place now. There is a paradox here. While the PPB debates appear to be narrow, there is plenty of historical evidence to show that there has been, and there continues to be, a wide range of PTD activities taking place in Nepal. In many ways Nepal is an international leader in the PTD field, as evidenced, for example, by its being the first country to formally release a variety from a PPB program, as well as the fact that it is the home of the *samuhik bhraman*, the traveling PRA technique used by senior researchers to interact with farmers.

The historical record

There is a long history of PTD in Nepal. Some of the earliest work in low-income public-sector agricultural research organizations took place here (Gauchan and Yokoyama 1999; Kayastha, Mathema, and Rood 1989). This started in the 1970s with the cropping-system project based in the agronomy division of the national agricultural research system in Khumaltar. This grew to its height in the mid-1980s when there was a large, fully functioning multidisciplinary farming systems division with farming systems research (FSR) sites in many locations. In addition to this, there were two well-funded autonomous agricultural research stations in the hills supported by the British government that had active PTD programs. One of these stations had a PPB program. While the outcomes of these programs were sometimes mixed as regards the involvement of poorer farmers, effective feedback to researchers, etc.,[14] the point is that many of the principles being suggested in these early PPT programs are common to the "new" PPB/PCI approaches. It would appear that some of the institutional lessons from this historical experience are not being taken up in the current debates on PPB.

For those interested in the "institutionalization" of participatory approaches, the establishment and then total decline of the farming systems division in NARC, and its replacement by a traditional technology-transfer outreach unit (mainly concerned with varietal testing) must be a salutary lesson. During the same time, NARC's social science capacity to support PTD and conduct research policy analysis also declined drastically. Whether institutional capacity is developed and is sustained depends on the social context of science. There is nothing linear or straightforward in capacity development. Not only is there this long history of agricultural PTD in Nepal, but there is also a long tradition of PTD in a wide range of other technology sectors. Many of the publications of the Intermediate Technology Development Group (ITDG) give evidence to this long history. In the irrigation sector, Nepal's research work on participatory irrigation management has made major contributions to the applied and theoretical literature on institutions and common property management.[15]

It is interesting to read some of the chapters in the proceedings of the third and fourth NARC outreach workshops (Acharya, Lang, and Karki 1996; Acharya 1998) to see that a great deal had been learned about strengthening PTD approaches and the problems that might be expected. Some of this experience was with PPB taking place in the two relatively autonomous British-funded hill stations at Lumle and Pakhribas.[16] Chapters in those proceedings also covered such issues as the potential role of NGOs and institutional linkages in the overall R&D system. This type of institutional issue is important. What can or cannot be done to implement different ideas, methods, techniques of PPB depends very much on the institutional context in which scientists work. Some of the current

14. See Kayastha, Mathema, and Rood (1989).
15. For example, see Martin and Yoder (1988).
16. See Sthapit, Gauchan, and Rana (1996), Gurung et al. (1996), and Dhital, Subedi, and Shrestha (1996).

actors in the PPB debate are the same ones who were involved in earlier years. What is puzzling to observe, is that it is as if these earlier, broader-based and more institutionally aware pieces of analysis did not exist. Certainly, with the current emphasis on a "new" approach and "new" manuals, the reader is encouraged to think that some of the issues are new, while in fact they are well known in Nepal.

The current range of PTD activities by many different actors

Not only does Nepal have this rich historical background of participatory approaches to research in topics far wider than plant breeding, but there is a great deal of PTD now taking place inside and outside of the public-sector research system, which could inform the debates in plant breeding (Gauchan, Joshi, and Biggs 2000). This includes a participatory varietal selection (PVS) program for fodder, involving 3500 farmers in 10 districts in Nepal and farmers asking researchers in NARC for specific varieties of exotic goats to cross with their own local breeds. Many of these programs do not think that what they are doing is extraordinary, or needs a special project, let alone that it should be the subject of much-heated debate to show that what they are doing is different from other parts of their R&D activities.[17]

In addition to these activities, there is the continuing and very extensive PPB practice of farmers going to India to select and being back a whole range of cereal, horticultural, and other varieties. This activity includes not only farmers, but also a range of other actors such as agricultural veterinarians and other rural entrepreneurs who seek out new pesticides, fertilizers, and other agricultural inputs. A serious challenge for Nepali and Indian researchers and policymakers is how to keep up with this two-way flow of technology, how to learn lessons for science, and if necessary and feasible, how to regulate it.

Ways forward

We have argued that from our perspective, some of the PPB debates in the international and local literature appear rather narrow and are not addressing broader R&D policy issues.[18] From a Nepal perspective, it would also appear that some of the debates have not taken adequate account of the great wealth of past knowledge (published and unpublished) on PPB/PTD in Nepal, nor does it appear to reflect an awareness of the large amount of PPB/PTD research being conducted by a range of different R&D actors at the present time. In the light of this, we suggest a number of ways forward in the Nepal context. These are ways forward that place emphasis on the institutional issues of how the national system can integrate and use the R&D capacity of many diverse actors.

New forums for research policy debates

The agricultural and natural resource R&D system in Nepal is rapidly changing. There are new research and extension providers emerging and old actors are changing their roles. The sources and conditions of research funding are also changing, with an emphasis more on transparency and the

17. It is interesting to note that there are important areas of breeding (for example, in the fisheries sector) where there is very little systematic research, the term breeding being used to denote the multiplication of fingerlings. It is possible that some of the knowledge and experience of those engaged in the PPB/CPB debates could be better redirected towards strengthening fisheries breeding.

18. A very notable exception to this is the PPB code of practice guidelines being developed by the CGIAR Systemwide Participatory Research and Gender Analysis Program (Weltzien/Smith, Meitzner, and Sperling 2000). There are many ethical and legal issues concerning access to information, patents, etc., that have been neglected in the past and need serious policy analysis.

efficiency of the overall R&D system. In the light of these changes, it would appear that one of the new types of institutions needed in the PPB area are *national* forums where issues of importance to national policy can be discussed.[19] Participants need to include knowledgeable researchers, not only from the public sector but also now from the private/NGO and university sectors. Research funders will also need to be involved, as funders increasingly need to be recognized as one of the stakeholders in a particular research endeavor. In the particular area of plant breeding, seed-release legislation, and regulatory systems, the national forum will have to include the major NGOs working in this area and in the growing private sector. The knowledge and capacity of these sectors has to be used for policy purposes. At the regional level and for specific technologies (e.g., a regional research station or a rice commodity-improvement program), forums will also have to be established. The legitimate concerns of different actors can then be discussed. The strengthening of such forums would also help to reduce the chances that the competition for funds (and the demands of the project cycle) becomes the major determinant for directing research activities.

New institutional partnerships and coalitions

A second and related new direction concerns the formation of new institutional partnerships, alliances, and coalitions. In the past such projects as the in situ agrobiodiversity project involving a formal agreement between NARC, Local Initiatives for Biodiversity Research and Development (LI-BIRD, a large local research-based NGO), and IPGRI were an exception.[20] However, it is now being recognized that such partnerships are the best way forward in using scarce national and international research resources. At the national level, it is clear that public-sector R&D agencies are changing policies to encourage their staff to work collaboratively with the NGO/private/university sectors and also to enhance linkages among public-sector institutions.[21] The challenge in this is how to develop and implement genuine partnerships. At one level, this will involve learning new management skills, but at another level, it will also involve a respect for the knowledge, skills, and roles of a wide range of multiple actors in the R&D system. Many of the institutional innovations needed for going forward are already being developed "informally" and sometimes formally in multiple locations in Nepal. Some of these innovations might be useful to other countries and international agencies.

Conclusions

For years researchers in Nepal (whether with or without formal training in science) have been developing technology relevant for different niches in the country. In recent years the achievements of formal science have been recorded in various ways. However, the informal activities of research-minded farmers have continued to play a major role in R&D processes (as evident in the spread of improved varieties selected by farmers), but these informal activities have not had the support of the formal research process for technology generation and promotion. By the same token, there are innovative researchers in the formal system who are developing new plant-breeding procedures and new institutional structures for the practice of science. Some of these innovations involve new types of partnerships with many local and international actors. This type of innovative practice is

19. See Roling (1990) for the importance of platforms, forums, and other similar institutional mechanisms for discourse in agricultural R&D. For similar discussions on development nodes and networks in rural-development projects, see Alsop and Farrington (1998).
20. Interestingly, this included a PPB component, participation of "conventional" plant breeders and concerns with gender analysis.
21. See Gauchan, Joshi, and Biggs (2000), the proceedings of the 5th National Outreach Workshop and the report of the Committee on Research and Development Linkages prepared for the July meeting of the NARC Board.

not new to science. The practice of science always involves the flow of information between different groups of people. However, because science is a social process, there are always people and interest groups who, for one reason or another, want to control the flow of information in different ways. Some of the reasons for this have been discussed in this paper.

One of the biggest challenges for researchers and research funders at present is to find ways of strengthening the overall R&D system in Nepal. In this process, international actors can play a role. However, the involvement of international actors should be questioned if (1) they encourage the creation and use of unhelpful dichotomies, where a more careful analysis is needed and (2) Nepal is seen as a location for experiments or international research programs that are owned in any meaningful sense by others—and Nepal is seen as being at the end of a "top-down" R&D system.

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Participatory Plant Breeding in Diverse Production Environments and Institutional Settings: Experience of a Nepalese NGO

A. Subedi, K.D. Joshi, R.B. Rana, and M. Subedi

Abstract

This paper provides an overview of participatory plant-breeding (PPB) programs implemented by LI-BIRD in different environments and institutional settings in an attempt to address various breeding goals, such as productivity increase, research efficiency, biodiversity enhancement and on-farm conservation, users' needs, capacity building, and policy changes. It draws lessons from these experiences and raises some concerns about strengthening PPB in the future.

Background

In the 1960s and '70s, some developing countries saw a profound impact on crop production from plant breeding. Modern varieties developed from the breeding programs were seen as one of the main ways to achieve food security. Based on these experiences and research strategies, formal research systems in developing countries were gradually strengthened according to the Green-Revolution model and supported infrastructure, human-resource development, and finance. Several technologies (based on external inputs) were generated, aimed mainly at wider adaptability and uniformity and for high-production environments. However, it gradually became evident that adoption of these technologies by the farming communities has been low. For the vast majority of small-scale farmers, living particularly in marginal and heterogeneous production environments, the benefits from these technologies have not been realized. At the same time, their needs and problems have not been appropriately addressed. On the other hand, a large number of farmers have been dependant on their own skills and knowledge as well as resources to improve their crops to suit their own environments and resource base. This process of local crop development is still an important institution of crop breeding in most marginal environments (Hardon and Boef 1993). This again has to be fully recognized if efficiency in crop breeding is to be improved.

In realization of these concerns, therefore, some researchers moved into participatory plant breeding (PPB) and used their own approaches and methodological processes as they worked without any institutional support (Hardon 1996). However, the usefulness of PPB is yet to be realized. It is being considered parallel to and competing for resources with the conventional breeding system. This view may be because of the lack of realization that it is complementary, the lack of enough empirical evidence to demonstrate the advantages of PPB, and the lack of opportunities for interested researchers to work in participatory approaches to strengthen farming communities in local crop development. However, this is now changing since the number of researchers and institutions involved in participatory plant breeding is growing—70 cases have already been recorded (Sperling 2000). In this context, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), a Nepalese nongovernmental organization (NGO), is one of the few institutions that has been involved in participatory research in the region since late 1995.[1]

The authors are all with Local Initiatives for Biodiversity Research and Development (LI-BIRD) in Nepal.

1. LI-BIRD professionals have been involved in PPB since the early 1990s at Lumle Agricultural Research Centre (LARC), a British-funded project in the western hills of Nepal.

In Nepal, consultative PPB[2] was used in breeding high-altitude rice. The decentralized testing of cold-tolerant rice was initiated in 1985 by Lumle Agricultural Research Centre (LARC) in the village of Chhomrong (2200 m). This later evolved into a consultative PPB activity, leading to collaborative PPB while developing a white peri-carped rice variety (Sthapit, Joshi, and Witcombe 1996; Sthapit and Subedi 2000; Witcombe et al. 1996). In this process, farmers were consulted for developing farmer-preferred, cold-tolerant rice varieties resistant to sheath brown-rot disease (ShBR).[3] Starting with the monitoring of the spread of PPB products, LI-BIRD has undertaken several programs using approaches based on participatory varietal selection (PVS) and PPB in different production and institutional environments.

This paper provides an overview of PPB programs implemented by LI-BIRD in different production environments and institutional settings. It then draws upon some lessons from these experiences. The PPB cases discussed here attempt to address various breeding goals, such as increasing productivity and research efficiency, enhancing biodiversity and on-farm conservation, and recognizing users' needs, capacity building, and policy changes.

PPB and production environments

PPB, by definition, assumes decentralized testing and evaluation in various production environments. Successful PPB case studies have often been reported from marginal environments (PRGA 1999; Ceccarelli, Grando, and Booth 1996; Sperling and Scheidegger 1996; Sthapit, Joshi, and Witcombe 1996). Consequently, it is widely perceived that PPB is useful only in marginal environments rather than in favorable environments. However, Hardon (1996) argues that farmers in better-endowed environments may also benefit from participatory plant breeding, for some of the same reasons as in marginal environments. In recent years, therefore, a large number of PPB programs are being initiated in intermediate areas where agroclimatic stresses are less severe (Weltzien/Smith, Meitzner, and Sperling 1999). In this context, LI-BIRD is one of the pioneering institutions to undertake PPB programs in diverse environments, including high-potential production systems (HPPS). Figure 1 shows the distribution of LI-BIRD's PPB projects (including PVS) across market and biophysical environments.

It is often assumed that high-potential production systems are uniform, more market-oriented, and well served by formal research for technological options and that, therefore, there is no need for participatory crop improvement. The preliminary findings from four PPB projects implemented in areas representing commercial and high-production systems indicate that there are diverse niche conditions within HPPS that need different locally adapted varieties, with different users' preferences (Joshi et al. 1998; Joshi et al. 1999a; Rana et al. 1999). Participatory methods such as PVS and informal research and development (IRD) have also been found effective (DTZ Peida 1999; Joshi et al. 1997).

2. There seem to be different definitions of PPB. In its broadest sense, PPB ranges from decentralized breeding controlled by plant breeders to various degrees of farmer involvement in the breeding process (Hardon 1996). PPB includes both PVS and PPB. PVS is the selection of fixed lines in the target environment by farmers using their own selection criteria (Joshi and Witcombe 1996). PPB is the selection of segregating materials by farmers in the target environment (Witcombe et al. 1996; Sthapit, Joshi, and Witcombe 1996). According to PRGA (1999), PPB includes not just the actual mixing of plant genes to produce new traits but all the joint efforts of farmers and trained researchers to improve and move germplasm into the field.
3. Sheath brown-rot disease is caused by *Pseudomonas fuscovaginae*.

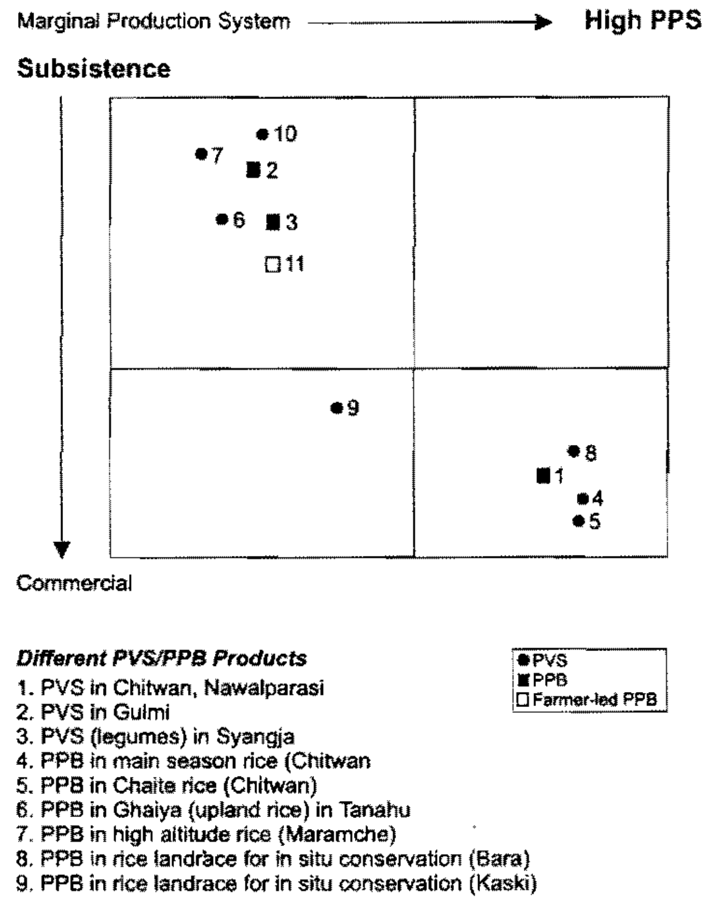

Figure 1. Distribution of LI-BIRD's PVS/PPB by production environment

PPB and breeding goals/objectives

Increasing productivity is obviously an important breeding goal. Beyond this, PPB is aimed at achieving other goals, such as improving research efficiency, addressing diverse users' needs, enhancing agrobiodiversity, building local capacity in local crop development and on-farm conservation, and influencing policy changes for farmer involvement in formal breeding processes. LI-BIRD's PPB projects have also been aimed at achieving most of these goals through specific breeding objectives (table 1).

PPB and participation

PPB assumes that the participation of primary stakeholders (i.e., farmers) is beneficial for farmers, themselves. Different PPB programs include varying degrees of participation of researchers and farmers (PRGA 1999; Ceccarelli, Grando, and Booth 1996; Sperling, Loevinsohn, and Ntabomvra 1993; Sperling 2000; Sthapit, Joshi, and Witcombe 1996; Subedi, Rana, and Joshi 1997; Subedi and Joshi 1998; Witcombe et al. 1996). But mode of participation, as defined by Biggs (1989), may vary according to the stages of the PPB process: setting breeding objectives; creating or providing variability, selection and evaluation within and between populations; and dissemination (Sthapit

Table 1. PPB and Breeding Goals and Objectives in LI-BIRD Programs

PPB projects	PPB goals	Specific breeding objectives
1. PPB in rice (Chaite and main-season rice in HPPS, Chitwan) (This also includes mutation breeding)	• Productivity increase • Research efficiency • Biodiversity enhancement • Policy change	• Developing of varieties for low water regime • Improving Masuli rice for disease tolerance and yield • Eliminating awns and increase height in Pusa basmati rice • Improving grain quality of IR44595 • Improve CH-45 for disease tolerance; increased seed dormancy in yield
2. PPB in rice landrace (in situ crop conservation project: marginal to HPPS of Jumla, Kaski, Bara)	• Biodiversity enhancement • On-farm conservation • Farmers' capacity building • Policy change	• On-farm conservation of rice landraces through value addition • Improvement for locally important traits in common landraces in Kaski, Bara, and Jumla sites
3. PPB in upland Ghaiya rice (marginal/tar, Tanahu)	• Productivity increase • Biodiversity enhancement • Users' needs/preferences • Policy change	• Diversity deployment • Drought tolerance in upland rice (Ghaiya) in marginal/tar condition
4. Farmer-led maize PPB (marginal, Gulmi)	• Farmers' capacity building • Users' needs/preferences • Productivity increase • Biodiversity enhancement • On-farm conservation	• Addressing lodging problem on Thulo piyanlo landrace of maize • Diversity deployment
5. PPB in high-altitude rice (marginal, high-altitude village of Maramche, Kaski)	• Farmers' capacity building • Users' needs/preferences • Productivity increase	• Addressing shattering problem in PPB product (M-3 rice) • Developing cold-tolerant, farmer-accepted variety

and Jarvis 1999). However, the success of PPB requires quality participation from different actors during the breeding process, from the conceptual and problem/need-diagnosis stage to diffusion of PPB products, by blending their comparative advantages. Three dimensions of participation determine the quality of participation: stage, degree, and roles/nature of participation (Weltzien/Smith, Meitzner, and Sperling 1999). The nature of participation would also depend on the type of crop (self/open-pollinated or vegetatively propagated) and the capacity, willingness, and commitment of the participants—individuals and institutions alike (Subedi et al. 2000).

LI-BIRD is carrying out various PPB projects in collaboration and partnership with different institutions at local, national, and international levels. Participation among the institutions is mainly collaborative, while it is contractual from the funding agencies. But the mode of participation between researchers and farmers ranges from consultative to collegiate in different stages of the breeding process (table 2).

LI-BIRD is aware of the importance of the participation of farmers, researchers, and other users in terms of their input into decision making at different stages, as appropriate. The degree to which farmers or other users who participate influence or make decisions about the process at any given stage, is an important dimension for the quality of participation (Weltzien/Smith, Meitzner, and Sperling 1999). To illustrate the degree of participation of farmers and researchers, the case of setting breeding objectives is taken as an example (table 3).

Table 2. Comparative Modes of Participation among Institutions and among Researchers and Farmers

PPB projects	Institutions	Mode of participation between institutions	Mode of participation between farmers and researchers at different breeding stages[a]
1. PPB in chaite and main season rice including mutation breeding (HPPS, Chitwan)	PSP/DFID[b] CAZ/UWB, UK LI-BIRD	Collaborative	1. Consultative 2. Contractual 3. Collaborative 4. Collaborative
2. PPB in rice landrace (in situ crop-conservation project: marginal to HPPS of Jumla, Kaski, Bara)	NEDA[b] IPGRI NARC LI-BIRD CBOs	Collaborative	1. Collaborative 2. X 3. Collaborative 4. Collaborative
3. PPB in upland Ghaiya rice (marginal/tar, Tanahu)	Sainsbury Family Trust,[b] UK CAZ/UWB, UK LI-BIRD	Collaborative	1. Consultative 2. X 3. Collaborative 4. Collaborative
4. Farmer-led maize PPB (marginal, Gulmi)	CGIAR SWP-PRGA[b] LI-BIRD NMRP/NARC FRC	Collaborative	1. Collaborative leading to collegiate 2. Collaborative leading to collegiate 3. Collegiate 4. Collegiate
5. PPB in high-altitude rice (marginal high-altitude of Maramche, Kaski)	LI-BIRD[c] CBOs	Collaborative	1. Collegiate 2. Collaborative 3. Collaborative 4. Collegiate

a. Numbers 1 to 4 represent the breeding stages of the PPB cycle: 1=setting breeding objectives, 2=creating variability, 3=selection, and 4=dissemination.
b. Funding agencies.
c. LI-BIRD's internal resources as well as direct involvement.

Lessons and issues

The following major experiences and issues are drawn from the work of various PPB projects carried out by LI-BIRD.

Emerging breeding objectives resulting from participation

Setting breeding goals/objectives is a continuous and cyclic process. New problems may be realized during the PPB process. The new breeding objective to address the problem of shattering in a PPB product, Machhepuchhre-3 (M-3) rice, can be taken as an example of how new breeding objectives may arise while working with farming communities. During the monitoring of the spread of M-3, the first variety developed through PPB in Nepal, men and women farmers of Chhomrong, Ghandruk, Maramche, and several other high-altitude villages in the western hills of Nepal, provided strong feedback about the problem of shattering in M-3. Hence, the breeding objective was

Table 3. Participation of Farmers and Researchers in Setting Breeding Objectives

Specific breeding objectives	Breeding objectives set by	How breeding objectives are set(degree of participation)	Stage of involvement
• Developing of varieties for low water regime • Improving Masuli rice for disease tolerance and yield • Eliminating awns and increasing height in Pusa basmati rice • Improving grain quality of IR44595 • Improving CH-45 for disease tolerance, increased seed dormancy in yield	Researchers and Farmers	Experience from PCI research activities along with farmers' information on pests and diseases	Crop monitoring of PVS activities Market survey
• On-farm conservation of rice landraces through value addition • Improvement for locally important traits in common landraces in Kaski, Bara, and Jumla sites	Farmers and Breeders	Farmers compared traits of different landraces, identified, prioritized the traits to be improved and conserved, followed by selection of specific landraces as parents while researchers selected which MVs to be used as male parents for addressing the desired traits	PPB field-level planning of activities
• Drought tolerance in upland rice (Ghaiya) in tar condition • Diversity deployment	Farmers and Researchers	PRA exercises	Pre-project period during diagnostic stage
• Addressing lodging problem on Thulo piyanlo landrace of maize • Diversity deployment	Farmers	Initial objective set by researchers for cultivar deployment and introduction during the project design was changed by farmers after field activities were initiated, particularly during goal-setting exercise	Initial stage of project implementation
• Addressing shattering problem in PPB product (M-3 rice) • Developing cold-tolerant, farmer-accepted variety	Farmers	Feedback from farmers who adopted the variety and experienced shattering problem	Monitoring of varietal spread

set to improve M-3 using mutation breeding. Similarly, consultative participation involving mill owners as the users (reaffirmed by farmers in Chitwan) led to breeding work to improve Pusa basmati rice[4] for awn reduction, and other varieties for market purposes (e.g., taste and price).

The breeding of high-altitude rice in Chhomrong demonstrated that women farmers were the main goal setters for the development of white-colored rice from the red peri-carped Chhomrong dhan (Sthapit, Joshi, and Witcombe 1996). Farmers of in situ sites at Kaski and Bara actively collaborated in setting breeding objectives and identifying landrace parents (table 3). Women and men

4. Adoption of Pusa basmati was low despite its high market price. A market survey indicated that mill owners did not want to mill Pusa basmati because of its long awn, which needs special adjustment of the milling device. The need for an awnless Pusa basmati with good flavor and aroma was thus realized.

farmers were instrumental in redefining the breeding objectives for maize in Gulmi (table 3), while in certain other cases, however, breeders had more say in setting breeding objectives, which were later verified with the farming communities (e.g., *chaite* and main-season rice in HPPS).

These examples indicate that the participation of farmers and researchers in different circumstances and stages is important if the right opportunity to influence breeding is to be captured. This requires continuous collaboration and commitment from those involved.

Diverse production environments within HPPS

LI-BIRD's experience shows that diverse, niche environments and different user choices do exist in the HPPS. For example, the Chitwan valley (150–250 m) of Nepal is considered a high-potential production system. However, through a series of PVS and IRD[5] activities in a participatory crop-improvement project in Chitwan valley, it was found that Chitwan has different production environments for rice: low-lying swampy, rain-fed, partially irrigated, and well-irrigated areas. Variations in soil fertility and farmers' preferences also exist in these areas. Different technologies are needed for these conditions. In such circumstances, participatory crop improvement approaches have also been effective (DTZ Peida 1999), justifying the belief that PPB should not be limited to marginal production systems only (Witcombe 1999).

Diversity through PPB

As formal breeding systems aim for wider adaptability and uniform varieties, the promotion of uniform varietal technologies may reduce diversity. In HPPS, where a modern variety is widely grown (e.g., CH-45, a variety of *Chaite* rice grown in 98% of the project area), PPB has the potential to increase biodiversity (Joshi et al. 1998; Witcombe et al. 2000). Hence, PPB creates diversity, and this would help create sustainable production systems.

Participation

The breeding process involves the participation of farmers (women and men) and researchers at different stages of PPB for different purposes. Depending on the objective and nature of the work, the mode of participation may vary from one stage to another in the same PPB project (table 3). For quality participation, it is also important to establish and agree upon the roles and responsibilities of different actors/partners. LI-BIRD has experienced that having such an arrangement, even with grassroots organizations, actually enhances the participation of all those involved. Annex 'A' shows an agreement on various tasks between LI-BIRD and two community-based organizations, while annex 'B' shows those agreements between farmers and researchers (the Nepal Agricultural Research Council and LI-BIRD). An analysis of the strengths and weaknesses of the participating institutions also helps identify areas for capacity or skill building for the respective institutions, researchers, and farmers. Such kinds of partnership are increasingly becoming important in the context of developing a critical mass of researchers and sharing resources for PPB.

5. Informal research and development (IRD) is an informal and simple method of testing, choosing, and multiplying seeds of choice for development (Joshi and Sthapit 1990). IRD, first used at Lumle Agricultural Research Centre in Nepal, is now increasingly being used for variety testing and dissemination in marginal and high-potential environments in Nepal and India (Joshi et al. 1998).

Concerns about the institutionalization of PPB

Participatory plant breeding is considered to be parallel to the formal breeding system and is also viewed as competing for the same resources. Most formal-sector researchers/breeders have yet to realize PPB's importance and its potential for addressing food security. These may be some of the concerns limiting the institutionalization of the approach. For the institutionalization of PPB and its wider use as a complementary approach, it is necessary for PPB practitioners and advocates to make greater efforts to influence policymakers in the national research system and funding agencies. This may also require more collaborative PPB projects for different environments and crops. Exposing researchers to participatory approaches to crop improvement will also be necessary.

Concerns about the seed regulatory framework

It is not likely that all the PPB materials will satisfy the distinct (D), uniformity (U), and stability (S) requirements, which is essential for formal release.[6] There are concerns that the seed regulatory system must be flexible to allow PPB products, such as farmers' varieties or landraces, to be recognized for further dissemination. However, in the context of a poor seed-supply system in the formal sector (less than 10% of the national seed demand is met by the formal system) and with farmers depending mainly on their own seed systems (i.e., informal seed-supply systems), the question may be asked whether it is necessary for PPB products to go through the seed regulatory framework, and also whether it would be commercially feasible to deal with a large number of varietal requirements for location-specific PPB products.

Concerns about pests and diseases

A general criticism of PPB materials is that they are prone to pests and diseases because they are not put through a disease-screening process as materials in conventional breeding programs are. It is, of course, important that care should be taken for any new material to be tested under any breeding program. But it may not hold true that only PPB products are subject to such problems. Experience has shown that even formally released varieties that have passed through a rigorous screening process may also succumb to pests and diseases within a short period after release. Instead, it can be argued that as PPB creates diversity and the products are locally adapted, the problem of pests and diseases in PPB products may be less serious than in a pure-line variety developed by conventional breeding. In modern farming, a single-crop variety is usually grown alone. In contrast, the genetic heterogeneity created by PPB may provide greater disease suppression when used over large areas. Zhou et al. (2000) demonstrated significant reduction of blast disease due to diversification of rice varieties in China. Nevertheless, it is still important to find ways of ensuring a minimum of pest and disease problems in PPB materials. To this end, LI-BIRD initiated a collaborative project with the National Rice Research Program (NRRP) and National Maize Research Program (NMRP) of Nepal Agricultural Research Council (NARC) for disease screening and field monitoring of PPB lines.

Conclusions

Participatory Plant Breeding is still an evolving approach. Since different PPB cases indicate substantial variations (Sperling 2000), it is not surprising to find differences among PPB practitioners

6. For a variety to be eligible for formal release, it has to be distinct (D), uniform (U), and stable (S), criteria that a PPB product may not be able to meet.

regarding its terminology, concepts, approaches, and methodologies. These will have to be refined over time from the experiences and the work done so far, as well as through more PPB programs and projects in the future in different production and breeding systems and in different socioeconomic and institutional settings. This also warrants more collaboration and partnerships as well as institutionalization in national agricultural research systems. Training courses and orientation programs must also be designed to develop human resources in this area of research and development.

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Annex A. Roles and Responsibilities Agreed between LI-BIRD, Pragatisheel Yuba Club, and Srijansheel Mothers' Group on Various Tasks in PPB Process (for High-Altitude Rice)

Tasks	Roles/Responsibilities		
	Srijansheel Mothers' Group	Pragatisheel Yuba Club	LI-BIRD
1. Preference ranking	1	1	2
2. Management of new materials			
2.1. Selection of landraces for PPB	1	1	2
2.2. Identification of MVs for PPB	2	2	1
2.3. Segregating lines	-	-	1
3. Farmers and plot selection	1	1	2
4. Interculture operations	1	1	-
5. Crop management	1	1	-
6. Field visits	2	1	3
7. Variety/plant selection	1	1	2
8. Harvesting of selected lines/plants	1	1	2
8.2. Assessment for shattering	1	1	3
8.3. Drying/storing	1	1	-
8.4. Yield estimation	1	2	-
8.5. Assessing line for milling	1	2	-
8.6. Taste assessment	1	2	-
8.7. Final selection	1	1	2
9. Monitoring spread	3	2	1
10. Record keeping of progress	2	1	3
11. Skill-transfer hands-on training	2	2	1
12. Call for meeting/consultation	1	2	3

Source: Letter of agreement between LI-BIRD and Maramche CBOs, December 1998.
Note: Roles are given in order of priority (i.e., 1 = leading role, etc.).

Annex B. Roles and Responsibilities of Farmers and Researchers on Various Tasks in PPB Processes (In Situ Crop Conservation Project), April 1999

Tasks	Participation		
	Farmer	Researcher*	Institution*
Categorization of landraces	***	**	NARC*** NARC**
Validation of landraces	***	**	LI-BIRD*** NARC**
Preference ranking for parent identification	***	**	LI-BIRD*** NARC**
Documentation of positive and negative traits	***	**	LI-BIRD*** NARC**
Matrix ranking for trait improvement	***	**	LI-BIRD*** NARC**
Goal setting with farmers (landrace parent)	***	**	LI-BIRD*** NARC**
Farmer selection	***	**	LI-BIRD*** NARC**
Creating diversity	**	***	LI-BIRD*** NARC**
Growing F_1 lines	**	***	LI-BIRD*** NARC**
Orientation to staff and participant farmer	**	***	LI-BIRD*** NARC**
Site selection	***	**	LI-BIRD*** NARC**
Screening segregating lines against abiotic stresses	***	**	LI-BIRD*** NARC**
Screening segregating lines against biotic stresses	**	***	NARC***

Source: Joshi et al. (2000).
Note: **=Subordinate role; *** = Lead responsibility.

Landrace Renaissance in the Mountains: Experiences of the *Beej Bachao Andolan* in the Garhwal Himalayan Region, India

Vir Singh and Vijay Jardhari

Abstract

The development of on-farm conservation of agrobiodiversity is of particular significance in inaccessible, fragile, and risk-ridden mountain areas, such as the Garhwal Himalayan Region in India. Having experienced the negative impact of conventional institution-led breeding programs (that neglect farmers and their knowledge systems), the farmers in the mountains of Garhwal launched the *Beej Bachao Andolan*—the Save Seed Movement. The main objectives of this movement are to save the seeds of the landraces the farmers have developed over several generations of selection and to strengthen and restore sustainable organic systems of farming.

The farmers are doing their own experimentation on the landraces in the Henwal Valley of Garhwal and comparing the results with the formal-led demonstrations of high-yielding varieties (HYVs). Many of the landraces produce more foodgrains than the HYVs do; straw-grain ratios and recovery percentages of most of the landraces are also considerably higher than those of the HYVs propagated under conventional interventions in the region. The landraces are sturdier and lees vulnerable, requiring no use of expensive external inputs, which has reduced the risks of crop failure.

The Save Seed Movement is an outstanding example of how farmers themselves can become involved in conservation of genetic resources, revive their once lost landraces, put them to sustainable use and challenge the modern systems of plant breeding. On-farm conservation of landraces and cultural practices involving farmer-led breeding programs provides a strong basis for sustainability in mountain agriculture. Mountain farmers have always been aggressive plant breeders. Their knowledge and rich experiences should be taken advantage of in evolving new programs of participatory plant breeding in the region.

Introduction

Conservation of genetic resources and species in farmers' fields (or in situ conservation) has received increased attention in recent years. National parks, zoos, and nature reserves are needed more than the current system of seed banks if sustainable agricultural systems are to be maintained (Partap 1996). On-farm conservation in farmers' fields promotes an evolutionary process of recombination of useful genes from wild relatives and cultigenes with widely grown landraces under changing conditions (Sthapit and Joshi 1996). On-farm conservation of genetic resources is of special significance for the Himalayan mountain areas, such as Garhwal in India, where there is a high degree of inaccessibility, fragility, and risks, and where farmers have little political awareness.

The traditional knowledge system of a farming community is built upon cultural practices interwoven around agroecological resources. Cultural practices include preservation, cultivation, and utilization of biodiversity. If in situ conservation practices are squeezed out of mountain agriculture and farmers are instead made dependent on germplasm developed through modern breeding techniques by public institutions and seed companies, the traditional knowledge and means of livelihood that have evolved over long periods of trial and error would be severely threatened.

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In situ conservation and farmers' access to and control over germplasm go hand-in-hand. If biodiversity were the potential source of sustainability, on-farm conservation of crop species and genetic resources must be the inevitable process to realize sustainability in marginal areas like mountains. Farmers are at the center stage of agrobiodiversity management. If farmers' rights are to be safeguarded and their independence is to be ensured, on-farm conservation of germplasm must remain in the hands of farmers. In situ conservation is also a way to keep the negative effects of Green-Revolution-type agriculture at bay, including the possible extinction of valuable landraces.

Keeping in mind these deeper issues and concerns, farmers in the Henwal Valley of Garhwal Himalayas started a *Beej Bachao Andolan* (Save Seed Movement). By saving the traditional seeds and landraces, along with in situ conservation of biodiversity, this kind of initiative brings positive changes to local agricultural systems, leading to ecologically sound, self-reliant, and sustainable agriculture. It also empowers farmers with seeds, which are the most potent symbols of their power and independence. Conserving landraces and biodiversity, along with empowering farmers, are the main targets of the *Beej Bachao Andolan* (BBA). Those active in the movement are trying their best to reintroduce seeds that were lost when the so-called high-yielding varieties (HYVs) produced by institution-led research were introduced. Farmers are reviving ecologically regenerative farming practices by improving the common property resource base, mainly the forest ecosystems.

This paper attempts to present the experiences of the *Beej Bachao Andolan,* which is, in fact, a landrace renaissance in which mountain farmers are the sole motive power. This story might help to stimulate farmers and pro-farmer organizations in other areas of the world to establish this sort of conservation and development effort, with farmers at the heart of it.

A historical perspective

Garhwal is a part of the Uttarakhand Himalayan area in India, which was once a unique repository of biodiversity in its forests, grasslands, and farmlands, including a variety of unique landraces. This has been reflected in the foods and folk culture of the area. Mountain people have been relatively prosperous; unique landraces have contributed to their prosperity in a big way. Quoting Walton's findings of the 19th Century, Bahuguna (1989) writes, "The Hill man [is] indeed specially blessed by the presence in almost every jungle of fruits, vegetables, and roots to help him over a period of moderate scarcity."

The prosperity of the region in the past is also evident from oral history and written documents: "The people were well off and they used to export wheat, rice, coarse grains, oil seeds, ginger, saffron, herbs, walnut, handmade paper, copper rods, musk, honey, ghee, woolen clothes, cows, bulls, ponies, etc., in the markets of foothills and imported only *gur* (molasses) and cotton cloth" (Bahuguna 1989). Lt. Col. Pitcher, who was appointed to inquire into the conditions of the lower classes, reported in 1838, " The peasants of Garhwal and Kumaon are better off than the peasants in any parts of the world, who neither live in such well-built houses, nor are so well-dressed as the peasants of Kumaon (Bahuguna 1989).

This richness of Garhwal's agriculture was clearly evident right up to the end of the first half of the twentieth century. The picture has now reversed entirely, largely due to external development and complete neglect of local perspectives. The type of agricultural development associated with the Green Revolution began in relatively fertile irrigated valleys, leading to the management of monocultures of a few HYVs of just two cereal crops. These required liberal use of chemical inputs (fertilizers and pesticides), for which lot of incentives and subsidies were provided to the farmers of the area. The HYVs of many crops also spread to rain-fed upland areas, which led to the reduction of the large number of landraces the region was famous for.

Beej Bachao Andolan: The genesis

The fertile valleys in Garhwal Himalayas witnessed a near genetic wipeout in agriculture. By the mid-1980s, large areas of irrigated flatlands were occupied by only two crops—wheat and rice—and only a few varieties of these crops. A considerable proportion of arable land in the upper rain-fed areas had come under cultivation of introduced white-seeded soybeans. A majority of farmers had switched over to "improved" cultivation practices using recommended chemical fertilizers and synthetic pesticides, and were heavily reliant on external "expertise." This almost completely transformed the mountain valleys, which were virtually converted into an experimental ground for government-sponsored agencies. These agencies conducted their experiments and demonstrations and distributed chemical inputs, "tested" seeds of modern varieties, and "improved" tools and implements to the farmers.

It was only a matter of time until this genetic uniformity was struck by disaster in the form of an unprecedented drought during 1987–88 and by pest epidemics in the two following years. The modern crops had a very narrow genetic base and were badly damaged; the farmers experienced the worst days in their lives.

To confront the crisis of genetic vulnerability, the farmers in the Henwal Valley of Garhwal began collecting indigenous seeds, which had almost disappeared from the accessible fertile valleys. Initially, they collected seeds of 10 local rice varieties from remote rural areas not affected by changes in technology and reintroduced them in their fields. These local varieties exhibited remarkable performances. The pest epidemic recurred during this crop season, but it hit only the modern crop cultivars. The reintroduced landraces remained undamaged.

The next year, more farmers in the Henwal Valley opted for indigenous varieties. Seeds of the landraces produced during the first year were distributed to other farmers in the valley. After strenuous efforts, 35 indigenous varieties of rice were collected during the second year and were all raised on farms. Nearly 60 percent of the total area of the valley was covered by the reintroduced landraces that year.

During the third year, a total of 110 landraces of rice were reintroduced, and the genetic diversity in rice increased dramatically. Nearly 90 percent of the cultivated area in the valley came under landraces. In the fourth year, the total number of local varieties went up to 126 and the year after, 130. Experiencing the wonderful performance of the landraces, the farmers of the valley launched the *Beej Bachao Andolan,* (BBA) which has now spread its roots throughout the whole of Garhwal.

The BBA searches, collects, reintroduces, tests, distributes, and popularizes all available local varieties of mountain crops. So far, it has reintroduced 300 genetically distinct varieties of rice, about 200 varieties of kidney beans, 12 of amaranth, and so on, in the Henwal Valley alone. The number of landraces reappearing in the once genetically transformed valleys is increasing year by year. Free exchange of seed within the community—the life-line of traditional mountain agriculture—has also been revived. BBA is witnessing a landrace renaissance in the mountains. Superb landraces, once lost to the so-called HYVs, are becoming an increasingly potent symbol of farmers' self-respect, self-reliance, and independence.

Impact of modern varieties—farmers' perspective

In transforming agriculture, seed has been the most potent weapon in the hands of the external development agencies, including multinational corporations. Along with a variety of chemicals, alien cultivation practices also came with the new "miracle" seeds. This gradually undermined farmers' traditional wisdom and innovativeness. A vicious cycle of dependence on market and development agencies for new seed varieties, chemical inputs, and technological know-how started in the region.

Because of the inevitable dwarf characteristic and narrow straw-grain ratio of the HYVs, they provide considerably less fodder compared to their long-stalked traditional counterparts. The quality of fodder provided is also inferior. The dwarf varieties have thus led to a severe shortage of the fodder and manure that are always badly needed by the livestock-dependent communities of the mountains. In addition, when there is a fodder shortage, the workload of women farmers increases (Singh 1992).

Monocultures with a narrow genetic base are extremely vulnerable to epidemics and unfavorable weather conditions. The seeds of HYVs cannot even be stored in houses without chemical treatment. They are thus a potential source of environmental pollution and health hazards. Indiscriminate use of chemical fertilizers and pesticides also reduce soil fauna and flora and severely affect the health of soil ecosystems.

Seeds have always been regarded as a common property resource by farming communities in the mountains. Free exchange of seeds within mountain communities has been one of the most outstanding features of agriculture. Under transformed agriculture involving new seeds and external inputs, seeds cease to be a common property resource, as does their free flow among farmers. Seeds are now a private resource of big corporations or public organizations. Patents and intellectual property rights, etc., are the means to treat vital seeds as weapons of a newly emerging biological imperialism.

Superb landraces

Rice in the Himalayan mountains was once a natural treasure of genetic diversity. In this region rice can be grown successfully up to an altitude of 2000 meters. Himalayan valleys are especially well known for the special varieties of rice that grow there. Traditional rice varieties, like *hansraj, ramjawan, kanguri, bagwai, gorakhpuri, basmati, thapachini, jhumkya*, etc., thrive in lowland areas, while *chawaria, mujil, jhailda, lekmal, kallao, almunji, chwatu*, etc., grow well in upland rain-fed areas and at high altitudes. Some of varieties can even be grown close to glaciers. Some varieties demand more water, some less, and some need no irrigation at all. The productivity of rain-fed rice varieties is comparable with that of irrigated ones. Such rare, hardy, and sturdy varieties would hardly be found in the plain areas anywhere in the world.

HYVs cannot match traditional varieties in their palatability, or, perhaps, nutritive value. Due to chemical applications, HYVs can pose a potential risk to human health and disturb the natural food chain. The taste and distinctive aroma of some traditional rice varieties, e.g., Indian *basmati*, are known throughout the world. Many rice varieties in the mountains, e.g., *kafalya, kallao, ghyasu*, and *ramjawan* are comparable to *basmati*.

All landraces are known for their characteristic size; the shape and size of ears; color, shape and size of seeds; palatability; aroma; cooking quality, etc. In addition, *lathmar* and *jhailda* are free from splitting problems. They are generally planted in areas prone to hailstorms. Even wild animals cannot harm them because the ears of the plants bear awns. Some landraces are also of high medicinal value; for example, *kafalya* is used to cure leukorrhea and many other gynecological problems.

The *baranaaja* culture: Diversity is prosperity

A cropping pattern based on intermixing finger millet, locally known as *baranaaja*, is a symbol of prosperity in the region. *Baranaaja* literally means "12 food grains." The adage "diversity is prosperity" holds well from the perspective of mountain agriculture. Finger millet is intercropped with as many as 12, and sometimes even more, other food grains. Amaranth, buckwheat, kidney beans, horse gram, black soybean, black gram, green gram, cowpea, adjuki bean, sorghum, and *cleome* are the main crops intermixed with the base crop of finger millet. *Baranaaja* provides a unique example of how a mountain farmer cultivates diversity. Marginal and small farmers inhabiting the mountains manage agrobiodiversity in such a way that they can harvest the maximum number of food items from the minimum amount of land. The degree of agrobiodiversity is directly proportional to the level of their (food) security, and *baranaaja* is the core of their (agri)culture.

The main result of conventional interventions in agriculture is to replace the unique *baranaaja* culture with monocultures of white-seeded soybeans. Soybeans as a cash crop is projected as a panacea for the land-based economy of the mountains. This crop was introduced recently as one of the packages of the Green Revolution and is said to be a source of protein, milk, and oil. Soybean, in fact, has never been an ingredient of local diets, nor has it fetched more money for the farmers. Farmers who switched to soybean cultivation from *baranaaja* generally barter their produce for salt or rice. Unlike all major mountain crops, soybeans do not provide fodder for livestock, which has contributed to fodder problems in the area.

Realizing the potential dangers to local agrobiodiversity, the majority of local farmers have given up raising soybeans at the expense of the unique *baranaaja*. BBA, with the help of farmers has been successful in reviving the *baranaaja* culture, to the joy of mountain communities.

Ecological regeneration of common property resources

The mountain farming systems typical of Garhwal comprise forests, cropland, livestock, and households as four organically linked components (or subsystems). No input from outside the system is required. This traditional system is "closed," and self-containment is one of its most essential features. Forest biomass flows into cropland (cultivated land) in the form of organic manure via the agency of livestock. Crop biomass is recycled into cropland through livestock and human beings.

This farming system is altogether different from the one operating in the plains under Green-Revolution agricultural practices. In the latter, organic linkages among components are virtually missing. Forests are almost absent. Almost all the necessary inputs are supplied from outside. The forests and grasslands in the mountains, on the other hand, are managed as common property resources, with cropland continuously receiving a subsidy from them. Such a unique farming system could be termed a "nature-subsidized, solar-powered agroecosystem." Green-Revolution agriculture, on the other hand, is a "fossil-fuel–subsidized, solar-powered agroecosystem" in which petroleum-based inputs (chemical fertilizers, pesticides, and machines powered by fossil fuels) are inevitably used.

Common property resources play the most vital role in providing ecological integrity to mountain agriculture. Biodiversity in these areas has enormous bearing on agrobiodiversity. Ecological regeneration and enrichment of diversity in these areas is also a focal point of BBA. Plentiful biomass harvests, especially of fodder and fuel wood, from common property resources have strengthened organic linkages among the components of farming system, infusing health into the whole farming system. Cropping systems are more fragile than forest ecosystems. If there is crop failure due to an erratic weather cycle, for example, common property resources can fill much of the requirement for food. They also ease pressure on croplands. In their absence, more and more areas would have to be cultivated, which would exact a heavy cost from the ecological balance in the region.

Common property resources also play a significant role in enhancing food security. Villagers in Garhwal have access to at least 127 different food-providing plants. Many of these food plants occur in areas that are common property resources. People incorporate 23 wild fruits, flowers, and buds and 14 wild vegetables in their diets. These uncultivated foods complement the cultivated ones. Foods obtainable from uncultivated common property resource areas often have very high nutritive value. Many of these have medicinal value as well. At least 100 more plant varieties that occur naturally in uncultivated areas are exploited as fodder for livestock and thus become part of human nutrition through milk and milk products.

When looking at the food spectrum of prehistoric humans, we come to know that they embraced at least 1500 species of plants, while over 500 vegetables were utilized by ancient civilizations. However, in contemporary times, human nutrition is based on no more than 30 plants, with three crops—wheat, rice, and maize—accounting for 75 percent of our cereal consumption (SAM 1984).

It can clearly be inferred from this that human societies have been moving steadily towards a state of food poverty based on the decline of food diversity. The state of food diversity is grimmer in agriculturally transformed areas deluged by high-yielding, fertilizer-dependent varieties of food grains. In these Green-Revolution areas only a few species of plants with a limited number of varieties remain the sole source of human nutrition. There is no mention of and no debate about uncultivated foods. In urban mountain areas, where the public distribution system is the only way to feed people, most of nutritional requirements are met by *dal-bhat* (pulses and rice). But the plates of rural mountain people are piled with delicious and diverse foods thanks to the enormous biodiversity flourishing in their forests and agroecosystems.

Because of the continued neglect of common property resources in policies and planning, however, considerable ecological damage has been witnessed in these areas over the last few decades. BBA took stock of this situation and designed concrete strategies for ecological regeneration. *Van suraksha samiti* (forest protection committees) have been formed. Inspired by the Chipko Movement, the village youths involved in these committees have taken on the task of regenerating the rapidly depleted forests. Overgrazing of the common property resources by cattle and ovine species is not allowed. Only hand-lopping (no cutting with sickles) of oak leaves is permitted. Oak forests represent the natural climax vegetation of the Middle Himalayas, playing a very specific role in soil and water conservation and microclimate maintenance. These forests are especially protected from overexploitation. Only dry branches and twigs can be removed for firewood. The committee's sanctions are to be followed by all. BBA has enhanced the biodiversity of the common property resources through massive plantings of food-yielding trees. These trees have begun bearing fruit and contributing to food security.

As a result of this community management, village residents in the Henwal Valley of Garhwal are now obtaining fuel, fodder, and several kinds of wild foods (fruits, flowers, buds, vegetables, seeds, honey, etc.), along with cultivated fruits, from the common property resource areas—free of cost on sustained basis. Water springs have been rescued and these supply clean drinking water to villagers. The reappearance of several wild animals—boars, bears, leopards, etc.—indicates that the ecological balance is being restored. Farmers are getting plentiful natural subsidies in the form of forest biomass, water for irrigation, etc., for agriculture, and the impact on agronomic yields in cropland is visible.

Farmers' Experimentation

BBA keeps records of the performance of all the landraces. BBA farmers also do their own informal experimentation on the landraces. The performance of all the landraces is compared with the so-called HYVs demonstrated by external development agencies. All the traits of vital socioeconomic importance, rather than just grain yields, are taken into consideration. The results of one such experiment conducted in Jardhargaon of the Henwal Valley are presented in table 1. In their experimentation, farmers do not apply any statistical design, but they do take into consideration more traits and factors than an agricultural scientist would conventionally do. Some of the interesting observations are listed below.

- The average yield of 27 landraces (40.00 q per ha) was significantly higher than the yields of five HYVs (28.00 q per ha).
- *Thapachini*, a widely adopted landrace, gave the highest grain yield (54.00 q per ha).
- *Jhumkya, khushboo, agariya, lathmar, kali mukhri, basmati nagni, lalmati, congressi, nailchamya, rekhalya,* and *rikhwa* also gave impressive yields.
- Most of the landraces attain maturity earlier than HYVs.
- The average recovery percentage of landraces (72 percent) was significantly higher than that of HYVs (60 percent).
- The average grain-husk ratio of landraces (2.6:1.0) was wider than that of HYVs (1.5:1.0).
- Straw-grain ratios of most of the landraces (1.4:1.0 to 2.3:1.0) are higher than those of HYVs (1.1: to 1.6:1.0), thus supplying more fodder, a critical produce, no less important for livestock production in the region.
- Yields of the landraces are fairly sustainable. This has been observed for more than a decade in the Henwal Valley of Garhwal.
- More yields with low inputs (zero external input) indicate the high-energy efficiency in landraces.
- Landraces show considerable tolerance to diseases and pest infestation, and some of them can thrive well under rain-fed conditions, thus exhibiting the unique trait of drought tolerance. HYVs, on the other hand, are vulnerable to several sorts of pests and cannot grow under rain-fed conditions.
- In addition to organic manure, HYVs usually require external inputs (chemical fertilizers and dreaded pesticides); hence, their cultivation contributes to environmental pollution and

Table 1. Performance of Some Landraces and High-Yielding Varieties of Rice in a Village of the Garhwal Himalayas, India

Name of Landrace/ HYV	*Production (q per ha)*		**Straw-Grain Ratio**	***Plant Height, (cm)***	**Days of Maturity**
	Grain	*Straw*			
Landraces					
Thapachini	54.00	96.00	1.8	140	140
Khushboo	49.00	80.00	1.6	125	145
Kali Mukhri	46.00	80.00	1.7	122	145
Agaria	49.00	78.00	1.6	125	145
Kanguri	38.00	54.00	1.4	115	120
Lalmati	45.00	64.00	1.4	120	140
Rikhwa	43.00	64.00	1.5	125	130
Jhumkya	50.00	80.00	1.6	130	140
palphaBasmati Nagni	45.00	88.00	2.0	135	150
Utauli	36.00	64.00	1.8	118	145
Bangoi	40.00	65.00	1.6	125	140
Congressi	45.00	104.00	2.3	126	145
Anjana	29.00	48.00	1.7	125	145
Gajraj	33.00	48.00	1.5	126	150
Ghyasu	37.00	72.00	1.9	135	150
Lathmar	47.00	65.00	1.4	115	150
Rekhlya	43.00	70.00	1.6	120	140
Gorakhpuri	36.00	65.00	1.8	135	120
Hansraj	33.00	75.00	2.3	130	160
Bhagwandas	33.00	58.00	1.8	125	135
Nyuri	35.00	60.00	1.7	110	120
Palyopar	36.00	66.00	1.8	120	140
Basmati Doon	32.00	55.00	1.7	125	150
Nailchamya	43.00	72.00	1.7	120	145
Chawarya	32.00	60.00	1.9	122	135
Luakat	37.00	60.00	1.6	130	145
Ramjawan	33.00	57.00	1.7	125	130
High-Yielding Varieties					
Kasturi	24.00	34.00	1.4	85	150
Pant Dhan – 6	30.00	40.00	1.3	72	155
Saket – 4	41.00	64.00	1.6	72	165
Pant Dhan –11	30.00	40.00	1.3	80	160
Govind	17.00	18.00	1.1	85	155

Note: Landraces were grown at the farm of a BBA farmer, while HYVs were the demonstrations of an agricultural university near the same farm. Organic manure was applied to all the plots at the rate of 250 q per ha. HYVs, in addition, were also provided with recommended doses of chemical fertilizers and pesticides.

health hazards, whereas the landraces thrive under organic culture, ensuring environmental quality.

- Landraces not only satisfy people's hunger and contribute to food security, but they are also used in many rituals. All through the history of Indian civilization, these landraces have been used as symbols of religion and culture.
- The social acceptability of landraces is very high.

Regular features of the movement include organizing meetings to review the progress of the BBA and occasional walking trips, along with seed fairs and participation in museums, fairs, etc., in urban areas. These have been considered necessary for creating awareness in the community. The relentless search in remote and poorly accessible areas for the collection of more and more seeds of landrace varieties exhibiting unique characteristics goes along with the awareness-raising activities. An inventory of the unique traits of landraces is made with the help of farmers in remote areas, and oral histories relating to their cultivation are recorded. BBA has also prepared a biodiversity register for elaborating the characteristics of individual landraces.

Seeds of the local varieties of crops, such as rice, kidney beans, black soybeans, several local pulses, amaranth, etc., can now be found for sale in urban markets, indicating their increasing economic value in the market. Landraces, in fact, are fetching handsome returns for some of the families in the area. Many varieties of the crops grown only in the mountain areas are known for their special food and medicinal values and have great export potential.

Future Implications

Traditional systems of management and ecological knowledge have been the vital means by which mountain communities have evolved richly diverse food-production and livelihood systems. Traditional knowledge develops from the natural process of adaptation and, unlike conventional scientific knowledge, it is moral, ethical, aesthetic, intuitive, theosophical, compassionate, and holistic, resulting in a diverse local and bioregional economy.

One thing that seems certain is that in the historical process of agricultural development, farmers have always sought to enhance the level of biodiversity. When they opt out of following the biodiversity-destructive ways of the Green Revolution, they return to the biodiversity-based agriculture they have tested over millennia. Farmers in the Garhwal Himalayas, through BBA, are doing this.

Diversity in agricultural crops, landraces, and their wild relatives in the Indian Himalayas have been maintained by farmers for centuries. In India, the endemic species inhabit two areas for the most part: approximately 4,200 species are found in the Himalayas and 2,600 in the peninsular region. In the Indian Himalayas, crop diversity is related to eight groups of crops and 71 species. As a result of the selection pressure exercised within the species by locals over the millennia, enormous diversity has evolved in the form of local landraces (Pant 1998). Too much emphasis on HYVs has led to the extinction of several landraces during recent decades. People's movements, like the BBA, would help remove such extinction scenarios from the mountains.

The efforts of BBA are noteworthy in that they have revived the cultivation of unique landraces and cropping systems, promoted on-farm conservation of genetic resources, enhanced biodiversity in forests and agroecosystems, and encouraged the growth of organic farming based on the principles of a living soil, biodiversity-complexity, and cyclic flow patterns. The success of BBA suggests that it is possible to combine diversity, productivity, and livelihood security in future agricultural policy.

Since many of the local landraces exhibit unique properties—like taste, aroma, essential amino acids, high calcium content, medicinal (Ayurvedic) value, and the like—they can have very high market value in the plains and can bring in handsome returns to local farmers. A mountain-friendly agricultural policy can play a pivotal role in this regard. Prices should be decided on the basis of the characteristic properties the produce possesses. Mountain agriculture, in fact, should be dictated by the principle of value, rather than volume. Value rather than volume should also be the main concern of the agrarian economy of the mountains and other marginal areas harboring unique biodiversity in their ecological niches.

When agrobiodiversity is managed and controlled by farming communities, it is virtually regarded as a common property resource. Conservation of plant and animal genes should be seen as an aspect of management of the common property resource. It should, therefore, be seen as a fundamental duty of both institutions and farmers to conserve biological and genetic resources. BBA reminds us this moral obligation.

A farmers' movement, rather than just farmers' participation or farmers' involvement, is the most radical approach towards realizing the most desirable change in a system. This approach itself takes care of any bias and lack of institutional mechanisms for change. It also reverses negative change into positive. By creating local gene pools through large-scale farmers' movements, on-farm management (conservation and sustainable use) of genetic resources will also help marginal farming communities, like those of the mountains, to remain impervious to the global politics surrounding control of the world's gene pools.

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Empowering Farmers through Participatory Plant Breeding: An Initiative of the Green Foundation

Vanaja Ramprasad and Shibu M P

Abstract

In the so-called *difficult environments*, institutional plant breeding appears to be a failure, mainly because breeding is directed at increasing yields in more favorable environments. Although the improved varieties have broad adaptability, under varied marginal environments, they do not express their yield potential or they do not satisfy other user requirements. In any environment, the potential of a plant is controlled by the interaction of its genetic composition with the environment. This involves adaptation of the plant to both physical environments (climate, soil, abiotic and biotic stress) and the socioeconomic environment (user concerns, consumers' preferences, economic status, markets, etc.). After the introduction of high-yielding varieties and hybrids during the Green Revolution in India, hundreds of landraces and indigenous varieties have become extinct or on the verge of extinction, largely because they have not been considered economical to grow under the present market economy.

Despite this, small-scale farmers in marginal environments continue to grow a mixture of crops and varieties as a buffer against temporal and spatial variation to cope with stress factors. It has been a time-tested practice by farmers to continue to select their next generation of seeds, thereby modifying the genetic characteristics of the crops. Tapping into this practice and empowering farmers to improve their crops has now come to be referred to as "participatory plant breeding."

Conservation of plant genetic resources has been initiated by the Green Foundation, working in the dryland regions of South India. As a means of empowering farmers, the Green Foundation has conserved several varieties of staple food crops, like finger millet and rice, on-farm. Using the genepool available to them, farmers have selected varieties, based on a set of criteria, for varietal purification, as a first step towards participatory plant breeding. This paper describes the process of varietal selection for improvement of local cultivars and the upgrading of farmers' skills as independent seed producers.

Introduction

Indigenous seed practices encompass practically all aspects of crop production, since seed saving is an integral part of cropping activities in indigenous systems. Farmers engaged in the production and multiplication of quality seeds deal with asexual propagation, land preparation and soil management, seed and seedling preparation and care, crop and pest management, flowering induction, the enhancement of seed quantity and quality, crop improvement, harvesting or collection, seed processing, storage, and genetic conservation (Fernandez 1994).

The holistic understanding of cropping in semi-arid areas has lent support to the conservation of diversity in various parts of the country. In the last few decades, there have been dramatic changes in Indian agriculture. The advent of the Green Revolution in the mid-1960s has been a major threat to India's vast genetic diversity. Intercropping has been replaced by monocropping, and as a result, food production is perched on narrow genetic diversity. The erosion of agricultural biodiversity threatens the long-term stability and sustainability of Indian agriculture in the following ways:

- It erodes the genetic base on which scientists are dependant for crop breeding.
- A monocrop of high-yielding varieties (HYVs) does not provide adequate insurance against failures caused by natural calamities.

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Need to revive biodiversity

A considerable amount of the genetic material that has been maintained by farmers over several years is now no longer available to the farmers. The ex situ collections play an important role in preserving germplasm under freezing conditions but they have their own limitations, like cost and loss of viability during storage. This limits the natural course of evolution, since the environmental conditions to which crops are constantly adapting cannot be recreated in a refrigerated gene bank.

It is in this context that a plant-genetic-resources conservation program was introduced in 1992, to ultimately create a village-based community seed bank. Since then, the program has gone through the stages of collection, multiplication, monitoring, evaluation, and farmers' participation in selection, rating, and distribution of varieties.

The profile of the area

Thally block, in the State of Tamil Nadu, and Kanakapura, in the state of Karnataka, are semiarid, with an annual rainfall of 700–900 mm. The Green Foundation works in the dry-land regions lying between these two administrative regions—Tamil Nadu and Karnataka. Seed conservation work extends across 85 villages, involving more than 500 farmers. The agricultural scene paints a bleak picture. The combination of illiteracy, poor infrastructure, poverty, and small land holdings on the one hand and changing agricultural practices and market pressures on the other have rendered agriculture very vulnerable for the farmers of the area. More than 85 percent of the cultivated area comes under rain-fed dry-land. Changing rainfall patterns have affected the improved varieties introduced in the area. Yet the area also represents a rich source of biodiversity, which is on the verge of extinction. It is against this backdrop that the Green Foundation has initiated a genetic resource conservation program.

The major food crops of this region are finger millet and dryland paddy, followed by wetland paddy, pulses, sorghum, maize, oilseeds, vegetables, and other minor millets. Many of the indigenous varieties have been reintroduced with low-input agriculture since 1993, when the foundation started its work in the area. Table1 gives the details of the collections between 1995 and 1999. In 1998 an attempt was made to upgrade local varieties through a process of participatory varietal selection, and as an initial step, *ragi* (finger millet) and rice crops were selected.

Earlier practices recall cultivation of four seasonal crops such as *gingelly* in the pre-monsoon season; groundnuts, paddy during early monsoon; *ragi*, pulses in the monsoon season; and horse gram in the post-monsoon period.

Changes in climatic variations have had an impact on the rainfall pattern and, as a consequence, have affected different crops in different ways. Intercropping has been popular as a traditional practice, although many farmers have shifted to the improved varieties of finger millet, leading to erosion of traditional ones. The program of seed conservation has widened the choice of finger millet varieties for farmers (figure 1).

The focus of the program was not only to widen the choice of varieties but also to increase yields by improving the quality of seeds. The on-farm conservation program, with nearly 34 indigenous varieties of finger millet and 38 varieties of wetland and dry-land paddies provides the basic materials for the participatory plant breeding (PPB) process.

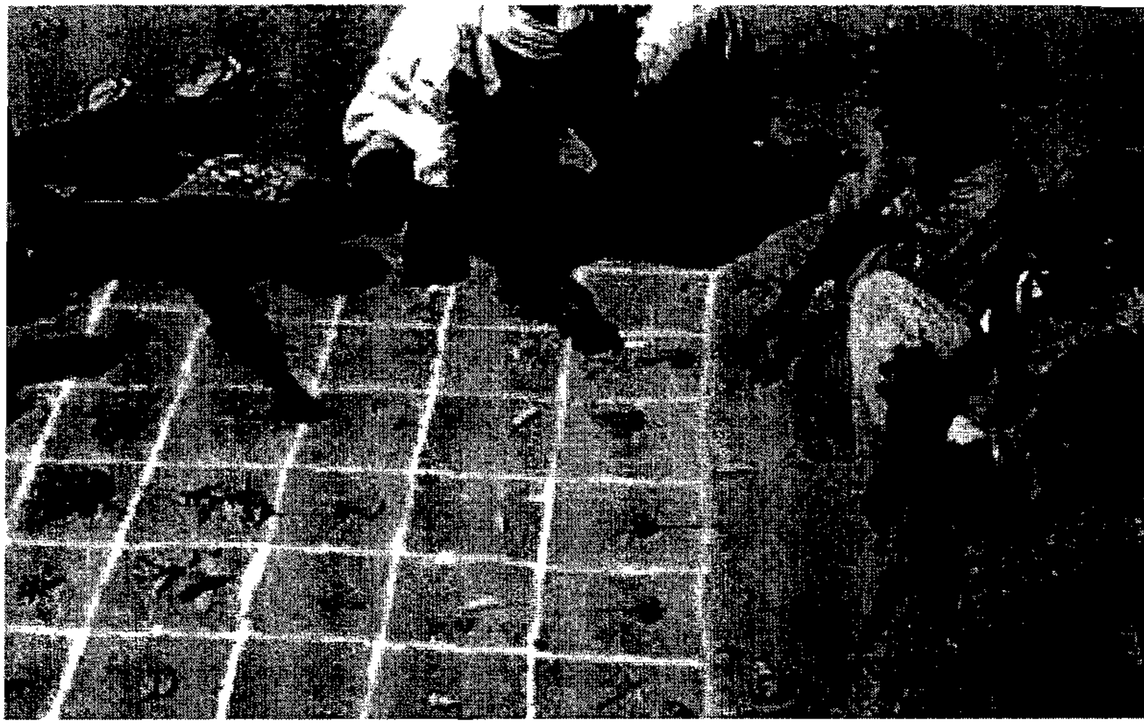

Figure 1. Participatory varietal selection of finger millet

Table 1. Collections of Indigenous Varieties and On-Farm Conservation between 1995 and 1999

	No. of varieties at conservation center		No. of varieties with farmers	
CROPS	1995	1999	1995	1999
Finger millet	21	68	6	34
Upland paddy	20	36	5	22
Wetland paddy	12	46	5	16
Pearl millet	3	13	3	5
Sorghum	4	15	3	5
Maize	3	8	1	3
Little millet	4	11	2	5
Foxtail millet	4	12	2	6
Kodo millet	1	1	0	1
Proso millet	1	2	1	2
Vegetables	24	68	23	53
Oil seeds	7	14	4	13
Pulses	12	38	8	26

The concept of PPB

To ensure household food security and optimize productivity under available conditions, which are highly resource-constrained farming environments, the farming community continuously relies on diversity of crops and crop species. The efficiency of formal breeding lines or improved cultivars has remained largely confined to favorable environments and high-input conditions. Decentralized breeding approaches have been started in Western Asia and the Near East (Ceccarelli et al. 1994), Central Africa (Sperling, Loevinsohn, and Ntabomurra 1993; Voss 1992), and West Africa (Jusu 1995). Farmer-based breeding is an important strategy for maintaining and using genetic diversity in agriculture as part of a multilateral system for conserving plant genetic resources (PGR) by making a wider range of genetic material available to farmers, directly as well as through the use of a broader genetic base in formal breeding (Eyzaguirre and Iwanaga 1995), by developing plant varieties suitable for resource-poor farmers in marginal areas, and by creating incentives for in situ conservation of PGR (Cooper, Engels, and Frison 1994).

Although agricultural universities and private-sector organizations are releasing a number of varieties, the farming community has continued to maintain their own varieties. Although advances are being made to decentralize the varietal evaluation process for incorporated traits, breeders have not risked making selections under the non-uniform conditions typical of a small and marginal farmer. Even today a number of farmers prefer their varieties and reject modern varieties because of the probability of low yields and crop failures in unfavorable environments. Besides it is also realized that the use of inputs such as fertilizers, pesticides, and chemicals for weed control is uneconomical and risky for resource-poor farmers.

As a process of decentralizing the formal and conventional breeding system, PPB approaches were developed with the involvement of farmers. PPB is more likely to produce farmer-acceptable products or varieties, particularly for marginal environments, as in our context. It also has a greater effect on increasing biodiversity, though its impact may be limited to smaller areas as acknowledged by authors like Witcombe et al. (1966).

The approach

There are many improvement programs that involve farmer participation, with different degrees of participation for breeding, identifying improved cultivars, or upgrading landraces. One participatory approach is being varietal selection, which broadly aims at purifying the seed material—a precursor to the plant-breeding program.

In the initiatives of our program, the concept of PPB has been employed in three broad areas: (1) crop improvement, (2) conservation of biodiversity, and (3) empowerment of farmers. Here, crop improvement involves informal varietal breeding under variable environments using traditional varieties. As described by Witcombe et al. (1996), the first phase of PPB starts with the identification of farmer-preferred traits in a particular variety.

Identification of farmer-preferred traits and cultivars

Alternative approaches for identifying cultivars that are acceptable to resource-poor farmers have been suggested and tried by a number of researchers. Maurya, Bottrall, and Farrington (1998) tested advanced lines of rice cultivars in villages in Uttar Pradesh, India, and successfully identified superior material that was preferred by farmers. The first step in a successful participatory varietal-selection program involves identifying farmers' needs in a variety of crops. The farmers' requirements can be identified using several methods (Joshi and Witcombe 1996), such as participatory rural appraisals, examination of farmers' crops around harvest time by providing a pool of genetic materials in a demonstration plot, and comparative evaluation on the farm.

A similar set of methodologies was adopted to identify farmers' needs over a variety. With an on-farm conservation program around, farmers had a number of choices to select some varieties suited to their requirements. Rural appraisals were made to assess both qualitative and quantitative characteristics (figure 2).

After identifying farmer's requirements, three indigenous varieties of finger millet and rice were selected for the participatory crop-improvement program. Selections from segregating populations

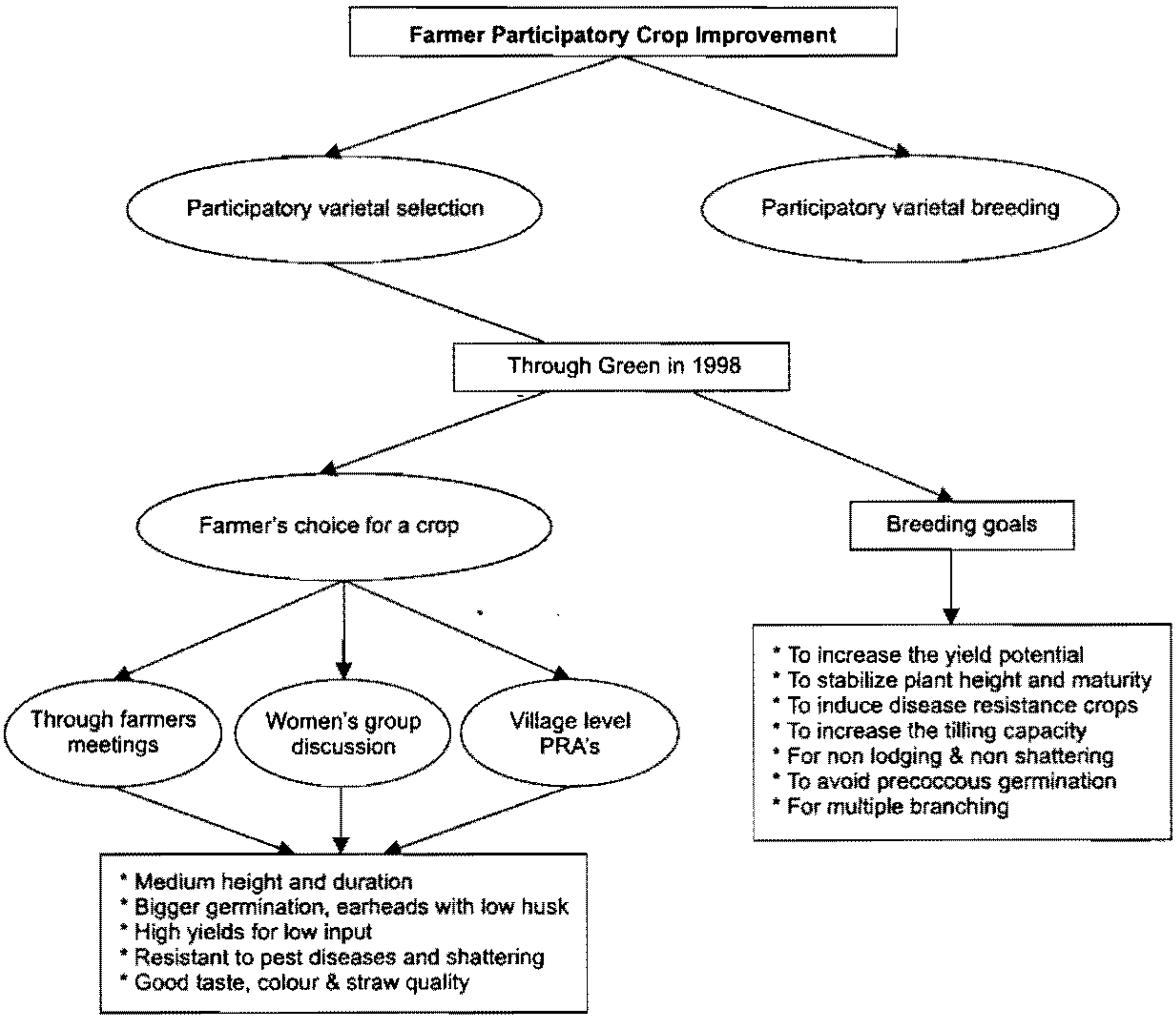

Figure 2. Assessment of farmers' criteria and setting the breeding objectives

of these varieties (table 2) were made from five different farmers across the watershed. The main emphasis in the selections was to improve genetic characteristics, such as plant height, disease and pest resistance, drought tolerance, number of leaves, and flag leaf size. A sufficient quantity of seeds (Selection 1), which can be handled by a single researcher and farmer, were collected, based on the set criteria.

The first selection of seeds from five different farmers was bulked into a single lot and divided into two halves. One half was sown in the field of a farmer who was trained to take observations along with the researcher. Another set was sown at the conservation center, where close monitoring and optimal agronomic conditions could be maintained. Adjacent to the selected seed, a control check was carried out using nonselected seed of the same variety. Close monitoring and clear data for

Table 2. Selection of Varieties

Finger millet	Rice	Major Varietal characters (for all)	Selections made for
Dodda thene	Mottaikar	Drought tolerant	Higher yields
Mandya orissa	Marudi	Nonshattering	Uniform height
Pichchakaddi	Dodda baira nellu	High fodder value	Disease resistance
		High cooking quality	High tillering
			Nonlodging, etc.

these two sets were kept during the course of plant growth. Selections were made from these populations involving more farmers for the set criteria. A sizable quantity of seeds was taken to disseminate in order to test the variety under varied agroclimatic conditions and to involve more farmers.

The second year's selection was tested at five different localities involving three new farmers and two of the old locations. Under each set of conditions, a check of the unselected population is maintained for comparison and analysis. Selections involving researcher and farmers will be made from these crops.

Various strategies in PPB depend on the selections from S_2 generations of already improved varieties, where the objective of conservation of biodiversity in farmers' fields has not been taken into account. Therefore, in this approach, selections were made from traditional varieties, and in each generation the number of farmers and villages maintaining the variety will be doubled. This provides a base for on-farm conservation of plant genetic resources.

From the S_3 population, a bulked composite set will be developed in order to have genetic variability intact, and from each individual farmer, two different sets of selections will be made for performance evaluation and to disseminate the selected indigenous variety across the farming community (figure 3).

This will be continued until the variety is stable with respect to the desired traits of selection (figure 4). The evaluation assessment will be carried out through the following:

1. Field assessment or crop assessment
2. Pedigree record analysis
3. Evaluation and appraisal by the farming community

Therefore, a participatory plant-breeding program in our context aims at the following:

1. Improving local cultivars in a participatory mode under open conditions
2. Selecting a variety for farmer-preferred traits under marginal, uncontrolled environmental conditions
3. Improving the skill base of farmers with scientific inputs, in order to empower them as an independent seed producers
4. Conserving genetic resources among many farmers under varied agroclimatic conditions
5. Maintaining a bulked composite mixture to conserve genetic variability, which will be expressed under different (genetic x environment) interactions
6. Breaking the low-yield barrier and inducing morphometric uniformity
7. Increasing the participation of farmers in post-development testing of improved varieties in order to develop an acceptable variety

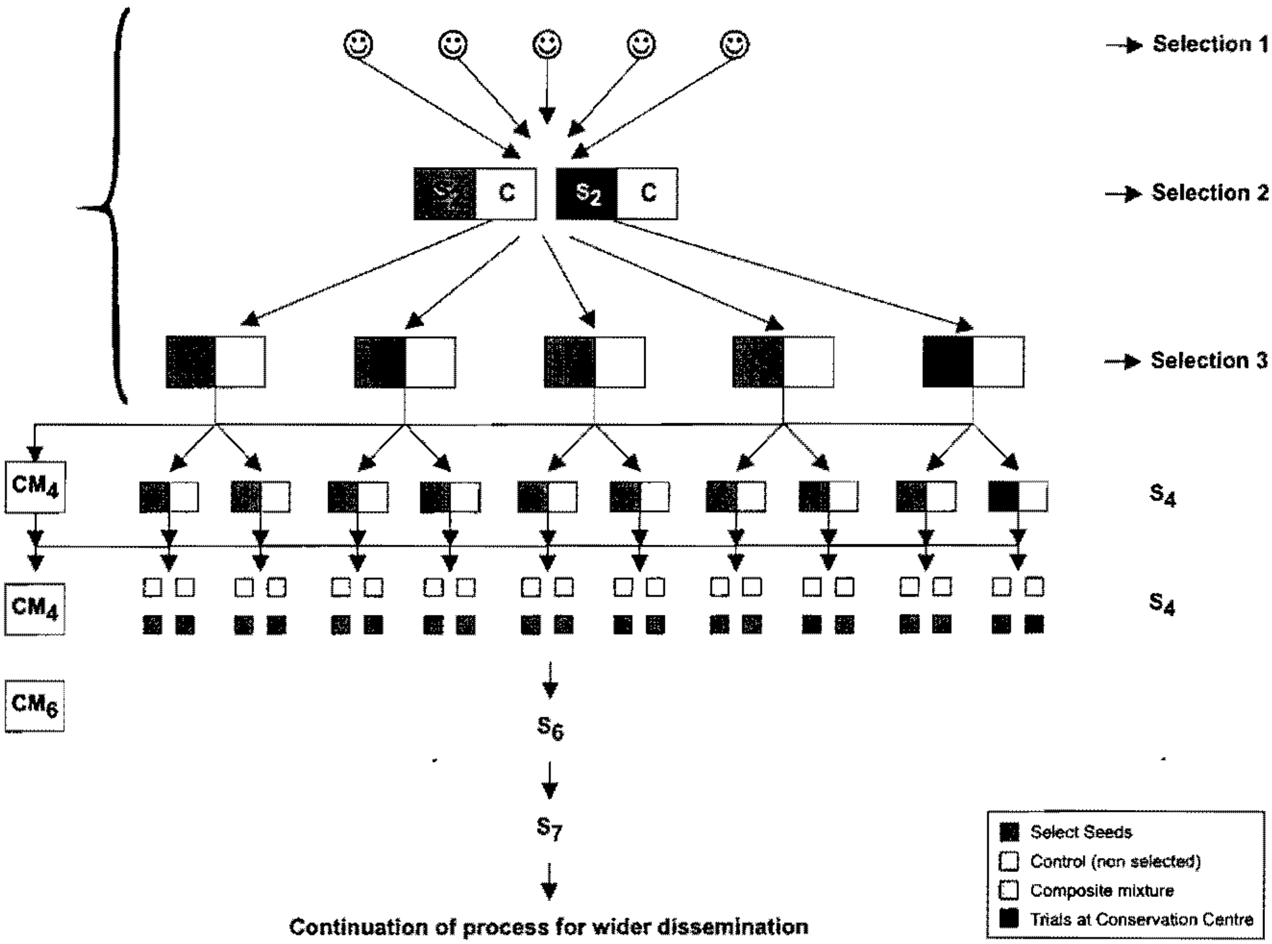

Figure 3. Diagrammatic representation indicating the model of approach

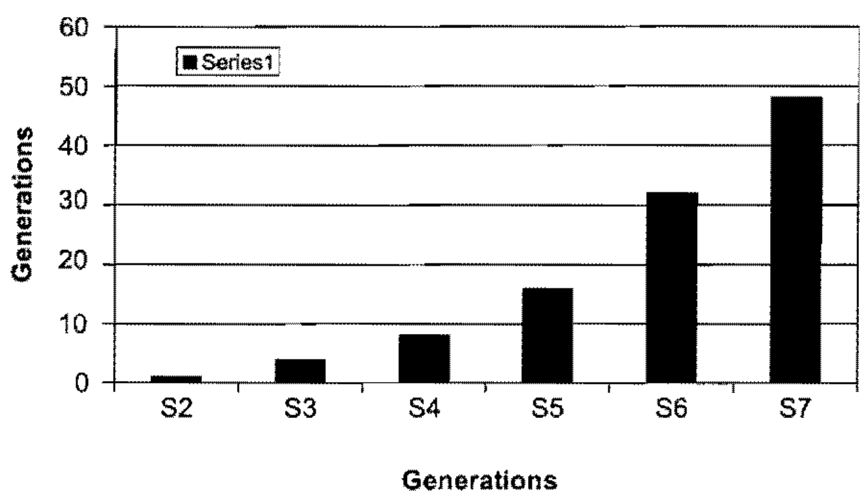

Figure 4. Dissemination of conservation-PVS program

The success of a new variety depends on the number of farmers' criteria being incorporated into the breeding lines and its value with respect to its environmental interactions.

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Rethinking the Participatory Paradigm in Plant Breeding: A Nonbreeder's Perspective

Bishnu Raj Upreti

Abstract

This paper attempts to highlight the fact that it is time to critically rethink the use of the participatory paradigm in research and development. The notion of participation is not only highly debated but also heavily misused and abused in research and development discourses. Rhetorically, almost all documents of government, research organizations, INGOs, and NGOs impressively use such terms as beneficiaries' participation, participatory approach, use of indigenous knowledge, bottom-up planning, etc. But in reality, they themselves control the participatory process by imposing their criteria, conditions, and regulations. The global as well as Nepalese experiences in participatory approaches in both research and development show that the commitment and confidence of local people is not gained at the desired level. The participation of beneficiaries in the research and development process is not only a means but also an end that empowers people. Participation has to focus on contributing, influencing, sharing, and redistributing power, resources, benefits, and knowledge. Therefore, the essence of the participatory process lies in helping people to make their own decisions and to take responsibility for their own welfare. This perspective has profound implications for choosing approaches and methodologies for participatory plant breeding. New challenges in plant breeding are posed by genetic engineering, biotechnology, globalization, patenting, and a profit-oriented focus. There is increasing evidence that scientists have a strong egocentric involvement in their innovations, which is often in conflict with the tremendous knowledge and experience of local people. Hence, it is time to rethink the participatory paradigm in research and development and develop a new professionalism to address the newly emerging challenges.

Introduction

The term *participation* in research and development (R&D) is becoming devalued (Farrington 1998) and even abused, partly in response to donor pressure (much of which is rhetoric) and partly as a fashion without substance. Participation is also a notion that has been hotly debated among its practitioners and used as a means to achieve the objectives of projects and programs (Narayan 1995). But in this paper, I am conceptualizing participation and participatory approaches in the broader context as both a means and an end. In this conceptualization, *participation* is a 'multi-dimensional, dynamic process of contributing, influencing, sharing, or redistributing power and of control, resources, benefits, knowledge, and skills to be gained through beneficiaries' involvement in decision making.' Therefore, participation is a voluntary process by which people, especially the disadvantaged (in income, gender, ethnicity, education, etc.) influence or control decisions regarding plant breeding that affect them. As a non-plant-breeder, I am visualizing participatory plant breeding (PPB) from this framework. There are different levels of participation, ranging from passive participation (farmers participate in activities decided unilaterally by PPB professionals), participation in information giving (farmers answer questions posed by PPB professionals), participation by consultation (PPB professionals consult farmers and listen their views), participation for material incentives (farmers participate to obtain mini-kits given by PPB professionals, to be involved in farmers' field trials, etc.), functional participation (farmers participate in the predetermined functional requirements of PPB professionals), interactive participation (joint analysis with farmers to make action plans and mobilize local institutions, using interdisciplinary methodologies

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that seek multiple perspectives) and self-mobilization (farmers take initiatives themselves in plant breeding) (Pretty et al. 1995).

Participatory processes have certain characteristics: they integrate community mobilization for PPB planning and action based on equal an partnership between farmers and researchers; they aim at strengthening farmers' problem-solving, planning, and management abilities; they promote farmers' capacity to develop appropriate new technologies; they encourage resource-poor farmers to learn through experimentation, building on their knowledge and practices (action and reflection); they recognize that all farmers are not the same—with conflicts and differences in interest, power, and capabilities. Farmers participate when they realize that the benefits of participation outweigh the costs. So the pertinent question is, Do such PPB practices provide benefits to farmers? In the context of PPB, different modes of participation can be discussed, ranging from contractual (PPB professionals contract farmers to provide physical resources such as land, germplasm, or indigenous knowledge) to consultative (PPB professionals consult farmers about their problems and then develop solutions) to collaborative (PPB professionals and farmers collaborate as partners in the breeding process) to collegial (PPB professionals work to strengthen farmers' breeding systems) (Pretty et al. 1995). When we talk about participatory processes, we have to be clear about which mode and level of participation are relevant at a particular stage of PPB.

The essence of PPB needs to be looked at from two levels:

- First, within the PPB process, Who initiates research? Whose research agendas are used? Whose needs are being met? Who directs and controls the PPB process? What is the bottom line of PPB? Does PPB specifically focus on poor and rural women as key players in managing plant genetic resources (PGR), post-harvest processing, and the nutrition of children.
- Second, on broader global challenges: Does PPB work on equity and poverty issues? Does PPB focus on the empowerment of marginal, resource-poor farmers to improve their position in society? Does PPB have the capacity to deal with the threats posed by globalization and the abuse of advancements made in the field of biotechnology in exploiting the poor farmers of developing countries? How does PPB deal with increasing bio-piracy? How does PPB deal with growing starvation and famine? In my opinion, these are some of the pertinent questions that need to be critically considered in promoting PPB.

In this paper, I attempt to examine the essence, opportunities, minimum conditions, and threats to PPB from the non-plant-breeder's perspective and pose some critical questions to promote discussion and debate to improve the performance of PPB. This paper is divided into three sections. The first section introduced paper and its outline. The second section raises issues related to PPB, i.e., How participatory is PPB? What are its approaches and methodologies? Who defines participation and who initiates it? What scale and level of participation is involved in PPB? What is the policy context and institutional framework for PPB? What are the threats to PPB from genetic engineering biotechnology, and globalization. It argues that PPB has increasingly shifted to the control of commercial interests. A discussion is presented on the need to integrate the social and technical sciences to promote PPB. And finally, the third section concludes that there is not only great scope for promoting real PPB but there are also big challenges.

Issues raised

The common categorization of plant breeding into farmer-led and formal-led PPB is problematic because in either case farmers, especially poor farmers, are involved in the initiatives of breeders. Furthermore, the formal-led PPB is limited by organizational conditions, criteria, and obligations. It develops separate regimes and widens the gap between them. The dichotomy is vague and confusing if real poor and marginalized farmers are to be targeted. In the philosophy of participation, no one leads but both collaborate to achieve common objectives. Therefore, the challenges for professionals working in PPB are how to achieve collaborative participation to meet the needs of poor and marginal farmers, how to negotiate or cope with the commercial exploitation of PPB, how to sacrifice the personal benefits of breeders that are ensured through patenting and the International Convention for the Protection of New Varieties of Plants (UPOV),[1] and how to share these benefits with poor farmers. In the following section I will briefly discuss these issues.

Essence of PPB

Genetic diversity in agriculture enables farmers to select varieties of plants that are best adapted to a changing environment and economic and social pressures. Access to such diversity is vital for securing current and future agricultural production and food security. In this context, the need for PPB is enhanced by a growing realization that conventional plant breeding has been unable to address the crop requirements for the 1.5 billion food-deficit people of the world (PRGA 1999). The socioeconomic and agroecological conditions of farmers are complex, diverse, and risk-prone, and the conventional breeding approach based on unidirectional breeder- and lab-centered work is unlikely to address the complex problems of resource-poor farmers. PPB is an alternate approach that closely engages farmers through diagnosis, experimentation, and dissemination and systematically includes farmers' knowledge, skills, and preferences in the process (PRGA 1999). PPB helps to increase understanding of the conditions, the opportunities, and the constraints farmers face and to build on that. Therefore, PPB will be adaptable, locally owned, and sustainable.

I believe that PPB, in its current changing context, needs to be seen from a broader perspective, which encompasses relationships among plants, animals, microorganisms, soil, and water within particular social, cultural, and ecological systems, as well as the contribution of PPB to local food security and the empowerment of marginal farmers. Therefore, tradition, culture, indigenous knowledge should be important elements of PPB. PPB should not only aim to increase productivity but it should also be targeted to bridge the gap between farmers and the formal RD sector, empowering farming communities, contributing to modifying agricultural policies in general (and seed and breeding policies in particular), and documenting indigenous knowledge and skills. PPB should not be limited to enhancing genetic diversity alone, but it should also be expanded to conserve the diversity of the ecological system, of the farming system, of species, and of output (Shiva et al. 1995) as well as of the sociocultural system. In reality, are these aims fulfilled by PPB? If not, why not? What are the bottlenecks? It is time to rethink these issues. In this paper I am discussing these issues from the perspective of food security, globalization, the abuse of genetic engineering and biotechnology, and the empowerment of poor and marginal farmers. We have a bitter example of Green-Revolution-type development where the gap between rich and poor was widened (Shiva et al. 1995). Breeders have developed varieties of crops that are suitable to mid-income and rich

1. The purpose of UPOV is to ensure that the breeder of a new plant variety is recognized and protected for a given period of time under intellectual property rights. The member states of UPOV grant such rights under their national legislation, in accordance with the provisions of the UPOV convention.

farmers, not to resource-poor farmers. PPB needs to be able to provide benefits to poor farmers in order to secure their meaningful participation.

The extinction of seed varieties, the erosion of genetic diversity, and the abuse of the rapid advancement of genetic engineering and biotechnology to create genetic uniformity and vulnerability are the major threats to food security and the survival of resource-poor farmers. Increasingly, the native varieties upon which the survival of many poor farmers is based, are becoming inaccessible or being replaced. This poses severe challenges for PPB, exemplified by the following statement of Mr. Tuleshwor Rajbansi, farmer from Jhodahat, Morang District:

Before 15 years, we used to grow more than 8 different varieties of rice as: Doshara, Dumsi, Panidhan, Agahani, Basmati, Mota, Birimphul, Rajbhog, etc. At least there were different 7-8 small heaps in our field while harvesting. But now we grow only two varieties of rice as Mansuli and Kanchhi Mansuli. We have to buy seed from market. We lost all our local varieties. We buy most of the vegetables' seeds that we grow in our field from the market. I prefer to grow local varieties which are cheap and delicious to eat. But it is very difficult to find seed.

LI-BIRD research findings also show that several varieties of vegetables are on the verge of extinction in Nepal (Rana, Joshi, and Lohar 1998).

How participatory is PPB?

In the existing PPB, the role of farmers is no more than that of contractual participation, as they provide germplasm to breeders and seed companies to keep in gene banks. But such gene banks fail to conserve genetic diversity because of scientific flaws and technical and political inadequacies (Shiva et al. 1995). In conventional plant breeding, farmers are merely the suppliers of genetic materials, based on the hope of future use. Farmers are commonly kept at a distance from the breeding process and only considered as consumers of the product, i.e., the seed. The farmer-breeder link is still linear and top-down.

In recent years, plant breeding has radically shifted from the conventional domain to genetic engineering and biotechnology and has been unexpectedly manipulated for commercial interests. Therefore, it is time to critically assess which groups of farmers are involved in PPB and which are benefitting from PPB. Generally, the farmers who are consulted by breeders are from the middle and higher economic strata; they are not the backward and marginalized resource-poor farmers. Farmers from middle and higher economic classes are more articulate, better able to invest in the breeding process, have a greater risk-bearing capacity, and are more capable of dealing with breeders (by expressing their ideas and responding to requests for information). They are therefore involved in PPB and getting benefits from it. The argument I have often heard is the inability of poor farmers to carry out PPB activities. However, the major unexpressed reasons for limiting the participation of these farmers—or excluding them altogether—are their inability to offer good facilities for lodging and food for R&D professionals, poor environmental hygiene, language differences, cultural biases, geographical biases (their concentration in accessible areas), etc.

Many R&D professionals rhetorically use the participatory paradigm as a ready-made solution to improve the livelihood of extremely poor farmers without considering underlying principles of participation and local dynamics and conditions. Such interventions not only create social tensions and conflicts, but they also abuse the essence of participatory discourses in R&D. Participation engenders financial, social, physical, and psychological costs as well as benefits. Furthermore, PPB professionals also exploit the financial resources obtained from donors in the name of PPB for personal benefits (e.g., higher studies, training abroad, higher salaries, etc.). Many professionals working in R&D still lack the appropriate knowledge and skills to facilitate participatory processes. Considering this, how does PPB contribute to improving the livelihood of poor farmers, enhancing food security, and empowering marginal farmers?

I realized that the existing PPB approach limits itself to a functional type of participation where farmers are merely involved in a breeding agenda set by the PPB professionals, not to the extent of their empowerment.

Opportunities

There are several global and local opportunities to promote PPB. Among them the following two are important.

Convention on biodiversity as a broader framework for PPB. A decision reached at Rio de Janeiro in 1992 by signatories to the Convention on Bio-Diversity (CBD) established that genetic resources (seeds) are no longer "the common heritage of mankind" but fall under the sovereignty of individual countries. The CBD legally binds member countries to conserve genetic resources and farmers' rights (Chaudhary 1999). The threats posed to biodiversity, the environment at large, and human health by globalization and the new genetic engineering and biotechnology are major concerns under the CBD (TWN 1998). The preamble of the CBD, Indent 9, regarding precautionary principles states that "where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimise such threats." Article 8(g) of the CBD, dealing with in situ conservation, obliges contracting parties to "establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from bio-technology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also [into] account the risk to human health." Article 8(h) requires parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species." Article 8 (j) of the CBD addresses the knowledge, innovations, and practices of indigenous and local communities embodying traditional lifestyles relevant to the conservation and sustainable use of biological diversity (Ho 1998). Therefore, CBD is supportive and provides a promotional regulatory framework to enhance PPB.

Civil society awareness and NGO initiatives. Civil-society movements to promote PPB, to conserve biodiversity, and to minimize the negative impact of globalization emerging and gaining momentum. The protests at the World Trade Organization meeting in Seattle and the meeting of the United Nations Conference on Trade and Development (UNCTAD) in Bangkok, and the *Navdhnya* and *Beej Banchao* movements in India are examples of civil awareness. Likewise, several nongovernmental organizations, farmers groups, and activists are increasingly working towards PGR conservation and the protection of farmers' rights through lobbying and advocacy. Some NGOs are even strongly emerging to promote PPB. LI-BIRD in Nepal is an example of such an initiative.

Conditions

In order to promote PPB at the national level, some minimum favorable conditions need to exist. Some of these are briefly discussed as follows:

Conducive policy context and supportive institutional and regulatory frameworks. Is the national policy context conducive to the promotion of PPB and are institutional and regulatory frameworks supportive enough? This is the major question to be debated and discussed in the present context. The conducive policy context and supportive institutional and regulatory frameworks are essential to materializing, promoting, and scaling up PPB to increase people's livelihoods and have a broader impact on resource-poor farmers. The regulatory measures have great bearing on PPB—how supportive they are to promoting PPB and how strong they are to protect farmers' rights and to prevent bio-piracy, genetic erosion, monopoly of transnational seed companies, etc. It is essential to develop the institutional capacity, relationship with farmers, and research-institutions to create an environment favorable to promoting PPB. Decentralized management structures and effective mechanisms for sharing and disseminating information, as well as systems for regular monitoring, evaluation, feedback, and feed-forward are important characteristics of institutions that can and will support and promote PPB. However, policymakers, planners, and senior managers of agricultural research have yet to realize the importance of PPB, at least in Nepal. For example, in Nepal there is neither clear policy on PPB nor any interest or concern from policymakers and politicians. Similarly, neither there is regulation on the import or informal entry into the country of genetically modified or terminator seeds that can have a negative impact on the local seed-management system and which can contribute to genetic erosion. Nepalese laws and regulations are either silent or unclear about genetically modified crops, patenting, bio-piracy, CBD, or farmers' rights (Timsina 2000).

New professionalism to improve PPB performance. Since PPB itself is an integration of social and technical sciences, it is essential to develop a new professionalism with an adequate understanding of the importance of both sciences. Shared cognition and intention, along with appropriate institutions are essential ingredients to an interactive design that views people as participants, not as object that can be instrumentally and strategically manipulated (Roling 2000). So far, the egocentric attitudes of natural and social scientists, and their lack of knowledge and skills in participatory processes, have restricted collaboration not only in participatory R&D activities but also in developing this new, integrated professionalism. PPB not only deals with technical issues of genetics, plant breeding, entomology, and plant pathology but it also combines the perspective of economics, sociology, anthropology, farm management, etc., to social issues like the attitude and behavior of farmers; their economic, social, and cultural conditions for adaptation of PPB outcomes; local knowledge and information about the characteristics of particular plants and varieties, etc. One can not assume that the goals of PPB are the goals of farmers. At this juncture, there is a gap between social and natural scientists that could be bridged by developing a new, integrated professionalism through appropriate training, sharing, and experimentation.

It is increasingly realized that the "delivery" of science-based innovations like plant varieties to farmers does not work (Roling 2000). This approach was attempted by the Green-Revolution model but failed to reduce the gap between rich and poor, which increased instead. Therefore, a new approach is essential in order to develop effective action according to the objectives, expectations, priorities, and knowledge of farmers. It is time to integrate hard, positivist-objectivist, biophysical science with soft, participatory, constructivist social science to deal with PPB, which imparts knowledge, skills, and a change in the attitude of scientists (both social and biophysical), and to work in a collaborative and complementary way to improve the performance of PPB. One important characteristic of a successful professional, whether breeder or social scientist who works with communities, is the learning attitude and communication skills. One of the major constraints observed in PPB is the lack of internalizing the role and importance of integrated professionalism. Changing from an ethnocentric, own-discipline bias to accommodation of multidisciplinarity—shifting perspectives and feeling from "we are the master and, therefore, part of the solution and they are the lay person and therefore part of the problem" to "we both are learners and collaborators"—is another challenge to be internalized by PPB professionals. Attitudinal differences between two groups of scientists are due to different kinds and levels of knowledge, orientation, background, professional bias, and experience. Therefore, balancing recognition and exploring latent conflict is essential to increasing commitment, collaboration, and interdisciplinarity.

Potential threats to PPB

In this section, the effect of globalization, intellectual property rights, UPOV, genetic engineering and biotechnology, and bio-piracy is presented from the PPB perspective. The dominant reductionist scientific world view of the West and its inventions like genetic engineering and biotechnology is causing suffering, widening poverty, and destroying earth (Ho 1998). International agricultural trade does not benefit the poor because it is based on the monitory interests of transnational and multinational companies. Rather, it is severely threatening farmers' rights to seed and plant genetic resources (Action Aid 1999). It is increasingly accepted that genetic engineering, in general, and patenting of genetic resources, in particular, have a potentially negative impact on resource-poor farmers. Studies have shown that the liberalization of global trade is not only exerting enormous pressure on resource-poor agriculture and marginalizing poor and small farmers, but it is also promoting starvation and the erosion of agricultural biodiversity and indigenous knowledge (Action Aid 1999). Transnational and multinational agribusiness corporations are benefitting from globalization and the liberalization of trade at the cost of inequality, hunger, and the threatened survival of resource-poor farmers of developing countries like Nepal.

Threats to PPB by genetic engineering and biotechnology. In the field of breeding, genetic engineering and biotechnology is a departure from the conventional breeding induced by industrialized countries. The sole motive of these innovations is to monopolize global agriculture and maximize profit (Ghale and Upreti 2000). Genetic engineering is widely touted by the giant biotech industries of the developed countries as the cure for world hunger. Their argument is that genetic engineering and biotechnology will help to restore a healthy environment, prevent further degradation of plant genetic resources, and globally provide more choices and opportunities. It is assumed that hunger is due to lack of food. But that is a simple and incorrect analysis of world hunger. The fundamental cause of hunger is not lack of food but a whole range of things from unjust and inequitable political and economic structures to ecological degradation for maximization profit to the marginalization of poor people (Ghale and Upreti 2000). Even some ecological economists argue that hunger is the inevitable result of globalization and the free-market economy.

Genetic engineering and biotechnology have been directed solely at meeting the commercial interests of a few giant food producers and processors in industrialized countries. Genetic engineering and biotechnology bypass the natural reproduction process because they horizontally transfer genes from one individual to another, as compared to vertical transfer from parents to offspring. These horizontal gene transfers not only spoil genetic diversity but also raise ethical questions (for example, human gene transfer to pigs, sheep, or bacteria). Transgenic plants are generally resistant to broad-spectrum herbicides, which cause acute and chromic toxicity and have a negative impact on biodiversity (ESRE 1999). Similarly, intervention in agriculture through genetic engineering and biotechnology reinforce existing social structures, maximize monopolistic profits, and intensify agricultural practices, which will lead to widespread environmental destruction and ecological imbalance.

Intellectual property rights, the Union for the Protection of Plant Varieties, and PPB. Intellectual property rights (IPR), plant breeders' right, and patents[2] as a regulatory arrangement introduced in the field of breeding to universalize the command and control of most developed countries has not provided protection to public interests in developing countries (Ghale 1999). How do breeders and other professionals working in the field of PPB perceive plant breeders' rights as embodied in the UPOV convention, which strongly centralizes the plant breeding (TWN 1996)? Which options do breeders involved in PPB prefer in IPR protection—protection through patents of protection *sui generis*[3] or open?

Due to the UPOV convention, the trade-related intellectual property rights (TRIPs), and genetic engineering and biotechnology, the control over plant breeding and seed is shifting from farmers to giant multinational seed companies. In this context, do participatory plant breeders advocate farmers' rights to use, produce, multiply, share, exchange, sell, modify seed, and plant genetic materials freely? The restrictions imposed by IPR infringe on farmers' rights. UPOV claims that the implementation of the new plant variety protection (PVP) arrangement stimulates protection of the environment and conservation of biodiversity and stability of food availability. That is only a nightmare and misleading (GRAIN 1999) because the uniformity criterion specified for PVP by UPOV tends to destroy diversity and enhance genetic erosion. If PPB practitioners realize this, then the fundamental shift from conventional PPB to PPB led by advocacy and lobbying is essential. This is probably too hard for the breeders. Another ethical question related to PPB is the IPR issue. PPB builds directly on farmers' knowledge and germplasm to select and develop crop varieties. Therefore, the ownership rights, access, benefits, and control of such varieties needs to be held by farmers instead of breeders. But does this happen in reality?

Threats to PPB from globalization. Technological advancement and the international expansion of trade and commerce have fundamentally shifted the focus on plant breeding. Global competitiveness is emerging as a determinant of plant breeding. The World Trade Organization (WTO), through its TRIPs arrangement and patenting of life forms, is posing new challenges and eroding the scope of self-supporting PPB. In the developed world, local seed saving is increasingly considered as a barrier to trade and commerce, and provisions are being imposed on farmers to pay royalties to plant breeders and companies. Globalization, through WTO and other similar arrangements, is forcing a radical change, not only on the setting of agricultural research but also by pressurizing member countries to change their legal, regulatory, and fiscal policies. In the case of plant breeding, the development of genetically modified foods and terminator technology by giant multinational agro-biotech companies like Monsanto, Novartis, and DuPont are examples of threats to PPB.

As the global market becomes more liberal, there is a countervailing trend to privatize knowledge and agricultural innovations for commercial profit (Action Aid 1999). Under TRIPs, if farmers use patented seed, they will be forced to pay royalties to the patentee if they keep seed to re-sow in the following years. Giant bio-tech companies are using local knowledge on the properties of plants to identify "useful" genes. They then patent the gene and its use. As a consequence, farmers in the country of origin have to buy it back and pay royalties. For example, neem trees from India and Nepal, basmati rice from India, and jasmine rice from Thailand are patented by Monsanto-like

2. A patent is a form of intellectual property protection that gives a monopoly right to exploit an invention for a period of 17 to 20 years. Article 27.3b of TRIPS requires developing countries to allow companies to take out patents on the products and processes of biotechnology. This article also demands that countries supply either patent protection or an effective sui generis (a unique intellectual property system for a specific good or process).
3. *Sui generis* is a Latin phrase commonly used in the IPR debate, which means "of its own kind."

companies. By placing the control of germplasm in the hands of the most powerful corporate bodies in global agriculture, the social, political, and economic structures that underpin poverty and hunger will continue to flourish (Action Aid 1999).

The open-market economy, free trade, and economic liberalization are the basic premises of WTO, in which patenting and IPR are the most controversial issues related to agriculture. Article 27.3 (b) of the TRIPs agreement does not recognize the right of local communities to their indigenous knowledge and agricultural practices. This article forces members to protect their rights to genetic resources for food and agriculture (GRAIN 1999). The commercialization of terminator technology, a genetically engineered trait that causes crop seeds to become sterile at harvest time, is posing another threat around the world (GRAIN 1999). The majority of the international and transnational life science companies are not only ignoring basic ethics and values but are also destroying indigenous knowledge, technologies, and practices for the sole aim of profit (UvA 1999). Therefore, excluding agricultural biodiversity and plant genetic resources from the patent protection within TRIPs 27.3 (b) and the protection of farmers' rights is essential to minimizing the negative effect of the TRIPs agreement on the livelihood of resource-poor farmers. In reality, the relationship between intellectual rights on life forms and the conservation and sustainable use of biodiversity is highly contentious (GRAIN 1999).

Bio-piracy as an emerging threat. Bio-piracy is another threat emerging from patent arrangements and TRIP. Bio-piracy from developing countries to patent innovation and earn money is on the increase. Recent seed-related research in Nepal has shown that bio-piracy is rapidly increasing in that country (Timsina 2000). The research report states that the germplasm of buck-wheat (*Fagopyrum spp.),* barley (*Hordeum spp.*), chuche karela (*Momordica spp.*), wild rice varieties containing nitrogen-fixing bacteria (*Oryza spp.*), several herbal medicinal plants, and colocacia were taken from Nepal without permission by Japanese, German, and American researchers working in and or visiting the country. Nepalese breeders and NGO workers supported them in this bio-piracy.

Conclusion

It is time to rethink the approaches, methodologies, and focus of PPB to address changing global challenges and to raise the livelihood of resource-poor farmers. As a people-centered approach, PPB has to work in the spirit of conventional plant breeding, which seeks to promote the establishment of a sovereign community and indigenous rights to plant genetic resources. TRIPs/WTO, UPOV/ plant-variety protection, genetic engineering and biotechnology, and bio-piracy are becoming increasingly serious threats to PPB, food security, indigenous knowledge, and conservation of biodiversity. Corporate control of seed and plant genetic resources is creating inequalities. To minimize these adverse effects, it is essential for PPB to take the initiative in developing a germplasm-sharing network among farmers, PPB practitioners, and civil society, by establishing in situ seed banks as a common property resource, promoting the exchange of indigenous knowledge, registering seed and plant genetic resources at the community level, strengthening the management capacity of farmers for plant genetic resources, recognizing farmers' innovations, etc.

Since the last decade, PPB has been widely advocated by donor-supported research centers rather than poor farmers. Much of the discussion on PPB has been rhetoric, venturing into professional debate among the believers of PPB. Some practical efforts have been made to promote PPB, but they have been limited to a small-scale, disorganized, and mechanistic use of a few participatory tools such as PRA, on-farm trials, and farmer groups in a superficial level. Not much attention has been given to empowering farmers and increasing their livelihood. Therefore, a substantial reform in existing PPB—through the development of new professionalism and ideas, frameworks, and methodologies, particularly by engaging in collaborative action—is essential if PPB is to address the globally emerging challenges in plant breeding. Experiences over the last decade suggest that plant breeding approaches are donor driven, operating under the broad conceptual framework and financial conditions imposed by donors, which are, therefore, more rhetoric than "real participation" to empower a weaker section of society. The lack of communication and facilitation skills, conducive policy measures, and supportive institutional and regulatory frameworks in national agricultural research systems, combined with the egocentricity of breeders and social scientists and a sectoral approach, are some of the major bottlenecks to promoting a PPB that aims to use participation both as an end and a means. The scaling-up, institutionalizing, simplifying (demystification of prevailing jargon and rhetoric), empowering of farmers, managing change, reorienting training, coping with globalization and TRIPs/patenting, and developing a new professionalism are some of the major areas to be improved in order to reform the existing PPB.

The only way to cope with the threat of genetic engineering and biotechnology at the global level is to work in line with the Convention on Bio-Diversity, an international treaty that has been signed by more than 160 member states of the United Nations. This convention provides an international legal framework for the conservation of biological diversity, including access to and exchange of genetic materials and biodiversity prospecting.

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Adding Benefits to Local Crop Diversity as a Sustainable Means of On-Farm Conservation: A Case Study of an in Situ Project from Nepal

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Abstract

Effective management and conservation of genetic resources on-farm takes place where the genetic resources are valued and used to meet the needs of local communities. The in situ conservation project supported by the International Plant Genetic Resources Institute (IPGRI) in Nepal recognizes that farmers maintain local crop genetic resources if they remain competitive with other options or have value for special use. It has been demonstrated that community participation can be strengthened by sensitizing the farming community and consumers through public awareness, by developing markets for local products or providing market incentives, by improving the farmer's varieties and adding benefits through policy incentives. A variety of innovative and participatory initiatives to increase the value and benefits of landraces for farmers has been identified, and three strategic options in adding benefits were used in this study. Option 1—participatory plant breeding, seed networks, and grassroots strengthening—seeks to improve quality, disease resistance, high yield, better taste, and other preferred traits through technical means, including seed networks and participatory plant breeding. Option 2—non-market and non-breeding—includes creating awareness and sensitizing communities through educational means. Option 3—market methods—works through improved markets and information. Tools like diversity fairs, diversity blocks, and community biodiversity registers (CBRs) have been found effective in consolidating the roles of the farming community in the conservation process. This paper documents some processes using diversity fairs and CBRs that demonstrated how various options for adding benefits could be developed, tested, and linked with market networks.

Introduction

The goal of in situ conservation is to encourage farmers to continue to select and manage local crop populations (Brush 1999). In situ conservation aims to conserve not only genes themselves but also the farming systems and agroecosystems that produce and maintain genetic diversity (Eyzaguirre and Iwanaga 1996). Effective management and conservation of genetic resources on-farm takes place where the genetic resources are valued and used to meet the needs of local communities. The in situ conservation project supported by the International Plant Genetic Resources Institute (IPGRI) in Nepal recognizes that farmers maintain local crop genetic resources if they remain competitive with other options or if they have value for special uses. Jarvis and Hodgkin (1997, 1999), Sthapit and Jarvis (1999), and Brush (1999) suggest that one method to encourage farmers to continue to select and manage local crop populations is to increase the value of local and diverse crop populations to farmers who might otherwise stop growing them. In this paper, we concentrate on

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The in situ conservation project is implemented in partnership in Nepal between the Nepal Agriculture Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD), and the International Plant Genetic Resources Institute (IPGRI). The authors wish to extend their gratitude to IPGRI and the PPB symposium organizers for giving us this opportunity to share our experiences globally.

the contribution of various options to add benefits that help maintain and maximize the genetic diversity within the total crop gene pool.

The Nepal project has developed a variety of innovative and participatory methods to increase the value and benefits of landraces for farmers and society. Benefits may be sociocultural, economic, ecological, or genetic and may apply to farmers, communities, or society as a whole. This requires an in-depth understanding of the value of local crop diversity and potential ways of adding value and market networks. Brush (1999) identified three types of value in local crop diversity: direct, indirect, and optional.

This paper documents some case studies on options for adding benefit, carried out in three study sites: Jumla (2200m), Kaski (1200m), and Bara (85m) in Nepal.

Understanding the direct value of local cultivars and information sharing

Direct values refer to the harvest and uses of crop varieties as a part of a subsistence, commercial, and/or industrial process. Direct values have been considered as the basis of in situ conservation. Farmers value local crop diversity in terms of local adaptation to ecological diversity , pests, and pathogens; risk management (socioeconomic); and culture, rituals and food culture. A baseline survey, diversity fair, and focus-group discussion across three eco-sites in Nepal have documented typical examples of the direct value of local crop diversity (appendix 1).

These values may vary among farmers and are influenced by such factors as wealth, land, and labor resources; proximity to market and technological information, and government policies. No single variety can satisfy the concerns of all the farmers in a village, resulting in a complex range of crop diversity being maintained.

Evidence clearly shows a varying degree of local crop diversity in Nepal. These resources have been used and categorized broadly into ecological, socioeconomic, and cultural or religious, linked with traditional food recipes. The in situ project has the challenge of developing appropriate methods that enhance their conservation on-farm.

Strategy for adding benefits

Jarvis and Hodgkin (1999) suggested that value may be added to crop genetic resources in two main ways: (1) the materials themselves may be improved or (2) the demand for the material or some product may be created or increased. In addition, nonbreeding and non-market methods are equally important as they are linked with access to information and genetic resources and creating awareness at different levels.

How can local crop diversity be improved? It is important to understand why and where local crop populations are maintained, as well as understanding what the value of particular landraces is and what the limiting factors are and what traits are not preferred. We can appreciate the farmers, contribution to biodiversity conservation, but we need to understand why some crops and varieties are grown on a larger scale by many farmers, while at the same time, a few farmers grow a few selected varieties by themselves—often in niches. Understanding the rationale behind this will assist plant breeders in seeking technical opportunities to improve the materials. In Kaski, Nepal, *Bayerni* and

Biramphul rice is grown by a few, richer, households for its high quality. In terms of yield, these varieties are not competitive with other landraces, such as *Jetho budho* and *Pahele*. It is assumed that many households may start planting *Bayerni* and *Biramphul* if these varieties are improved in terms of yield without losing their quality traits. Table 1 shows the number of landraces selected in the study sites for adding benefits to see whether landraces, per se, can be conserved by adding value.

Table 1. Setting Breeding Goals for Adding Benefits in Selected Rice Cultivars

Site	Landrace selected	Constraint	Adding benefits—PPB
Jumla	*Jumle marshi*	Low yield, chilling injury	Increase yield by select blast- and cold-tolerant cultivars
Kaski	*Anaga*	Low yield, poor grain/panicle	increased yield
	Mansara	Low yield, less response	non-lodging
	Thulo/sano gurdi	Low yield	early maturity
	Ekle	Low yield, late	improved eating quality
	Biramphul	Lodging, low yield, late	
	Pahenle	Long straw, low yield	
	Madishe	Eating quality, low yield	
Bara	*Dudhisaro*	Low yield, lodging,	grain quality
	Nakhisaro	Lodging, low yield	non-lodging
	Rato basmati	Pest BHP, low yield, blast	pest tolerance
	Lajhi	Lodging, low yield	increased yield
	Mansara	Lodging	blast tolerance

Source: Adopted from Joshi et al. (1999) and Rijal (1999).

Adding benefits through participatory plant breeding

Participatory plant breeding (PPB) can improve the materials, but the materials can also be improved by eliminating diseases and pathogens from planting materials or clones, e.g., taro, diseases in potato and citrus. Sthapit et al. (1996) have demonstrated that *Chhomrog* rice has been enhanced because its red rice grain was replaced by a white color, while cold tolerance was improved. The project is also assessing the value of landrace enhancement for those landraces that are widely grown and preferred by farming communities. Strengthening the skill of selection and exchange of enhanced materials will also assist in the process of on-farm conservation. *Jetho budho* in Kaski, *Basmati* in Bara, and Jjumli marshi in Jumla have already been identified and preliminary work has been initiated.

The most important strategy for increasing the value of local crops is to use them for a crop-improvement program. PPB covers the full range of crop improvement activities: assessing local diversity and uses, setting breeding goals, creating variability, selecting varieties from variable populations, evaluating varieties, and scaling up through farmer-to-farmer seed networks. Joshi et al. (1999) documented the detailed process of PPB to study whether PPB can be considered a strategy to enhance on-farm conservation as well as to meet the productive needs of farmers. The roles of formal plant-breeding institutions (e.g., NARC) and NGOs (e.g., LI-BIRD) have been mutually agreed upon for each key step of the PPB process. The multidisciplinary team categorized rice landraces by their distribution and frequency, as described by Joshi et al. (1999). Breeding goals for the Bara and Kaski eco-sites were developed in a participatory manner, involving breeders, socioeconomists, and farmers, to analyze the strengths and weaknesses of the landraces. In the process of selecting parents, farmers strongly felt that the preferred traits should be maintained even if inferior traits were the targets for improvement through PPB. Thus, the breeding strategy has a role to play in improving and conserving traits and characteristics that are *not* linked specifically with social, religious, or medicinal norms and beliefs or used in local recipes.

Adding benefits through nonbreeding and non-market methods

A number of participatory approaches have been used to date to increase local awareness about the importance of agro-biodiversity and to improve the flow of seed within and between communities (Rijal et al. 1999). Diversity fairs, diversity theaters, diversity songs, poetry journeys, community biodiversity registers (CBRs), and diversity blocks are some of the popular activities carried out to increase awareness and sensitize the community.

In the context of strengthening access to germplasm and information in the farming community, diversity fairs, diversity blocks, and community biodiversity registers have been identified as powerful options, which also enhance the farmers' capacity in managing their own crop genetic resources.

The diversity fair. Here, the term *diversity fair* refers to a tool used to demonstrate or display local crops along with the associated knowledge resources of an ecology, as defined by community-based organizations (CBOs). Traditionally, local seed markets and fairs constitute an important part of the informal seed exchange system in the villages. Local markets, *haat bazaar,* and "agricultural fairs" provide a good opportunity for the exchange of seeds and knowledge. In recent years, these informal systems have been threatened by outside intervention, particularly in the seed sector. As a result, indigenous knowledge associated with local genetic resources has begun to erode.

The community-organized diversity fair focuses on indigenous landraces. In Nepal, diversity fairs have been used as an entry point to raise the level of awareness about in situ crop conservation programs before more technical aspects of the project are implemented. By organizing competitions between groups of farmers, the project promote access to farmers and encourages farmers to maintain the maximum genetic diversity. The in situ project uses diversity fairs as a participatory research and development tool in Nepal. It aims at creating competitions between farmer groups on a regular basis in order to accomplish the following:

- to recognize farmers who maintain large amounts of genetic diversity and who possess a good deal of associated knowledge, to act as a source of information for others
- to locate areas of high diversity
- to identify and locate endangered landraces
- to prepare an inventory of crop genetics, along with a knowledge resource base
- to identify the main sources of the informal seed supply within the community
- to understand the value of diverse genetic resources in terms of use, economics, culture, religion, ecology, etc.
- to empower local communities to have control over their genetic resources
- to help develop a sense of ownership in the community

There are different ways of conducting diversity fairs. The in situ project aims at strengthening CBOs that conduct on-farm conservation activities with little input from outside. Initially, when CBOs were unfamiliar with the project's activities, project staff managed the fairs in partnership with them. Over time, as they have become better oriented, they organize the fair as an annual event. Sthapit and Jarvis (1999) have documented the concept and methods used, and the steps of the fair have been described by Rijal et al. (1999). There have already been five such fairs organized in Nepal, and as a result, the process has been refined over time. The fairs organized in Nepal have been successful in terms of the following:

- documenting local landraces and associated knowledge, as well as strengthening the farmer-to-farmer seed supply system
- linking outputs with research and development work
- locating the status of diversity and the custodians
- sensitizing farmers, along with the research and policy communities, on the importance of agrobiodiversity
- strengthening CBOs in on-farm conservation processes

The fairs organized through CBOs have documented equally good information, as well as increasing sample size and the number of crops. The information includes the special characteristics associated with the landraces, i.e., *huliya*, sociocultural values, ecology, and status at the community level. These sets of information can be very useful for a number of stakeholders, including breeders, ecologists, socioeconomists, and local promoters for their varied interests. The information may be shared among the farm communities and other interested parties. A very important aspect of the fair, observed in a recent fair in Begnas, Nepal, is the development of the sense of ownership in the community for the resources they have conserved for generations. Every CBO took back samples with the knowledge that they had to maintain them for future use.

The diversity block. A diversity block is a participatory research technique designed to characterize local landraces under farmers' management conditions. Landraces to be grown in the diversity block may be selected from materials from either the diversity fair or farmers' seed stocks. The crops are monitored by both farmers and scientist-promoters, and agromorphological characteristics are recorded. The diversity block has the value of enhancing public awareness at the grassroots level and making germplasm more accessible o the local community. In Nepal, the diversity block has been used to acquire farmers' indigenous knowledge about local varieties, to identify parents for breeding, and to study the population structure.

The community biodiversity register. A community biodiversity register is a record, kept on paper or in electronic form by community members. It is a register of local crop biodiversity and associated knowledge. The information maintained in the register includes landrace names, the farmers who store the seed, associated local knowledge and uses, and traditional and nontraditional passport data like agromorphological and agroecological characteristics and cultural significance. The register functions as a decentralized community gene bank (Sthapit and Jarvis 2000). CBRs have no implications for local seed exchange and storage systems; rather, it helps to improve access to information and seeds.

Updated over time, the CBR allows communities to monitor the level of genetic diversity and prevent the extinction of rare varieties, which may then be preserved ex situ. CBRs can be a practical tool to monitor genetic diversity at the village level, and if the capacity of the farming community is strengthened with institutional support, it could be a good way of developing various options to add benefits on a local or regional scale.

Strengthening seed and information networks was one of the concerns in this project, for which different strategic tools were explored. The community gene bank adopted by a few institutions, such as UBINIG in Bangladesh, was reviewed for its strengths and limitations. It was found to require additional structures to serve communities under situations of stress and risk, and may replace the local farmer-to-farmer seed-supply systems. CBR strengthens local systems was developed through review of functions complementary to in situ conservation.

Since CBR has only recently been developed, it still requires further refinement. However, it has multiple functions and is worth the effort because of its effectiveness at the grassroots level. This was discussed with farmers and CBO representatives, and their responses are summarized below:

- CBR provides an inventory of both valuable and worst crop resources.
- It strengthens sharing of information and crop seeds by improving access.
- It is useful for strengthening market and seed networks.
- It lists the status of all known crop resources, with reasons for decrease, increase, or loss.
- It is useful to R&D workers.
- It enhances the process of developing a sense of ownership for the resources held by CBOs.
- It provides descriptions of ecology and diversity with area-specific identities.

The records maintained in the CBR assists in understanding the farmer's decision-making processes as well. Thus, the CBR implemented in Nepal has guided communities in developing a sense of ownership for their resources. Whatever significance it has depends on the way it is developed and executed locally. Therefore, the potential benefits from CBR can only be realized when it is adopted with full consideration of the importance of (1) partnership with farmers, (2) periodic up-dating, (3) local control, (4) sharing information among the users/stakeholders, and (5) caution about providing access to the information to outsiders.

Both the CBR and diversity fair can be used for a number of purposes, from developing R&D bases to strengthening at the grassroots level in terms of improving access to seeds, using information in an effective manner, and assessing diversity. CBR records could provide a very useful basis for developing conservation strategies. Endangered species or landraces, for example, may be conserved ex situ. However, we are also equally concerned with the possible misuse of information, such as intellectual and farmers' rights. The community must be made aware of this kind of danger as well.

Adding benefits through market methods

The demand for materials or processed products may be increased by market methods (box 1). There are many examples of local crops (e.g., *Basmati* and *Jetho budho* rice) that have direct market value. There are many options to which farmers are not exposed. This applies to researchers, development workers, market networks, and consumers as well. Benefits can also be added to crop diversity by better processing, packaging, storage, and marketing.

Box 1. Options for Adding Benefits through Market Incentives

Adding benefits through market incentives

- Exploiting price incentives by better processing and marketing
- Creating consumer awareness of local products
- Linking market with food culture
- Linking market with eco-tourism and local cuisine
- Developing new food products using local landraces
- Adding benefits through participatory pest management (organic agriculture, green marketing)
- Improving farmers' skills on seed production of specific valuable landraces
- Appellation of local products through development of cook book of keystone crops across ethnic cultures
- Direct sale of genetic resources using IPR or contract (e.g., seed)

Source: Sthapit and Jarvis (1999).

Identifying local promoters and then linking them with local producers and markets are crucial processes. In Begnas, Nepal, a series of consultations was carried out to identify major local products that have market potential, assessing total production, price negotiations, quality control, and marketing outlets. In Nepal, the project identified local promoters like *Gunilo* and *Bandobasta* who played a catalytic role in establishing linkages between promoters and consumers with the farming community. NGOs have been involved in the project to facilitate networking. Associations of hotel and tourism, Pokhara chambers of commerce, hostels, and hospital networks have also been sensitized to use more domestic products. The impact of such networks is yet to be seen.

The project is keen to develop markets to enhance the value of local crop diversity through direct sales. Rice landraces, *Jethobudho*, aromatic sponge gourd, *Khari* in taro, and *Samdi kodo* in finger millet, are a few examples. To succeed, this initiative must also be supported by policy reforms.

Table 2. Strategic Options Employed for Adding Benefits to Local Crop Diversity through Market Methods, Case of Begnas

Crops	Varieties	Farmers' values	Indicators of assessment
Rice	*Anadi*	*Latte*, *khatte*, and *siroula* in festivals; Medicinal value	Research base recipes developed Number of grower farmers' increased Status of nutrition known Grain demand created and area under production increased Number of growers increased
	Bayami	Fine, medicinal and high quality; High quality and price	
Taro	*Khari, Khujure, Hattipow*	*Masaura*, *tandra*, corm quality; Gava	
Sponge gourd	*Basaune ghiroula*	Aroma and excellent eating quality	Quality seed produced and marketed widely
Finger millet	*Samdi kodo*	Special gruel; Possibly suitable for pizza making	Demand created locally that motivates farmers to grow

Source: Adopted from Rijal (1999).

Discussion of strategic choices for PGR conservation

The role of local crop varieties in securing food at the household level is apparent, but diversity has also been enhanced for socioeconomic reasons (Rana et al. 1999). Nepali farmers use local rice landraces for at least six specific purposes (Rijal et al. 1997). On the one hand, these deserve special value and there is less competition, so a nonbreeding strategy is appropriate. On the other hand, breeding strategies are employed to make local crops competitive with other options, particularly those that have value and benefits in terms of ecology or physical indices like yield, disease resistance, etc. For example, the best quality of *Jethobudho* is grown with cold water, as is *Phewa* and *Kundahar* of the Pokhara valley, and always fetches a higher market price than when grown in an irrigated field. The strategies employed for adding values are presented in table 3.

In niche- or ecology-specific areas where food security is the main concern, as in Jumla, farmers always go for increased yield. Low yield is associated with rice blasts, poor response, and cold injury, for which the only way of addressing the problem is through breeding methods.

Table 3. Strategic Options for Adding Benefits to Local Crop Diversity

Values	In situ strategies employed for on-farm conservation			
	Breeding	Market	Awareness	Improved access
Ecology (e.g., JB)	✔	✔	✔	✔
Genetic (yield, height, disease, etc.)	✔	✁	✔	✔
Medicinal, cultural, religious	✁	✔	✔	✔
Traditional recipes	✁	✔	✔	✔

Conclusion

Developing an in-depth understanding of the value of landraces through appropriate methods is the prime need prior to deciding on any conservation strategies. Local crop diversity can be desegregated into broad categories by value—genetic, sociocultural, medicinal, or religious—to strengthen conservation of crops in situ by the farm community. Three broader categories include market, non-market, and policy perspectives for improving direct and indirect benefits. No single strategy is perfect for addressing the goal of conservation; a combination is required.

Of the many innovative tools available, the diversity fair and community biodiversity register have been most effective in terms of documentation and sensitizing communities of farmers, researchers, promoters, and policymakers. Furthermore, these two tools are very useful in monitoring diversity along with status. Values documented through these tools can be used for R&D purposes, where researchers, promoters, and planners may benefit. They also provide a basis for breeding work in the short term as well as the longer term.

For local crop diversity with socioreligious, cultural, or economic value, strategies that strengthen information, seed, and market networks are particularly important if CGR and their products are to be promoted *per se*. The diversity of these sets of crops will be maintained as long as the local culture associated with them continues. On the other hand, for crop diversity associated with ecological and genetic traits, the breeding strategy is the right choice. Thus, for effective conservation of

CGR on-farm, a number of strategies are essential. We argue that valuable genes can be captured and conserved only when they are utilized locally for both breeding and non-breeding purposes and when there is effective local conservation.

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Appendix

Appendix 1. Comparative Value of Local Diversity of Rice, Taro, Finger Millet, and Sponge Gourds at Different Eco-Sites of Nepal

Crop/Varieties	Location/habitat	Direct value
1. Landraces with ecological benefits		
Jumli marshi in rice	Jumla (2200m)	Cold tolerance, taste, and *aadilopan*
Naltumme	Kaski (670–1400m)	Adapted to shaded areas
Mansara, Aanga, Kathe gurdi	Kaski (670–1400m)	Adapted to entirely rain-fed, low-input ecosystems
Taro: *Khari pindalu*	Kaski (670–1400m)	Compatible for intercropping with maize, etc.
Bhati, Silhat, Laltangar, Aamaghauj, Sakhar	Bara (85m)	*Dhab* (swampy land)
Nakhisaro, Rango, Sokan, Mutmur, Sotwa	Bara (85m)	*Ucha/Bhith* (upland, rain-fed)
Batsar, Lajhi	Bara (85m)	*Nicha* (low land)
2. Socioeconomic values related to specific use		
Jetho budho	Kaski (670–850m)	High quality; High price
Panhele	Kaski (670–850m)	Fine, aroma; High price
Gurdi	Kaski (670–1400m)	*Sel roti* (Nepal donut)
Anadi	Kaski (670–1100m)	Special recipe for local festivals; Not accepted for religious ceremonies
Basmati	Bara (85m)	Aroma and eating quality
3. Medicinal, cultural, food, and religious values		
Basmati, Sathi, Aanga, Lajh, Sotwa, Sokani	Bara (85m)	Religious (guest, feast, recipe)
Khera	Bara (85m)	Religious (local diets, *Karik maharaj*)
Bayarni, Anadi	Kaski (670-1900)	Medicinal (back pain, taste, recipe)
Sponge gourds: *Basaune*	Kaski (670-11200)	Aroma, taste, eating quality
Khari pindalu	Kaski (670-1400)	Special recipes: *Masaura tandra, Gava* and cormels
Dudhe	Kaski (670-1400)	Petiole for special pickle

Source: Baseline survey, PRA , diversity fair, and FGD.

Participatory Improvement of Rice Crops with Tribal Farmers in India

V. Arunachalam

Abstract

Participatory research, including participatory plant breeding (PPB), is now a recognized option for improving the livelihood security of unreached farmers. Tribal farmers in India provide an ideal group for testing the potential of participatory interventions. They live in remote areas, are intensively bound by tradition, and continue to cultivate crops using traditional practices. For instance, the sowing time of crops is often based on a particular month, with an almanac date to harvest the crop in time for its use during festive occasions. Although these traditional cultivation practices are often poorly matched with the weather, they continue because they are consonant with the habitat, soil, agroecology, and available infrastructure. Soils are relatively free from the problems of continuous chemical fertilization. Most cultivated varieties are specific landraces that carry special traits for cooking quality and taste, catering to the tribal farmers' methods of processing food. Tribal farmers live in small villages, inconveniently distant from one another, and do not have readily accessible means of producing and exchanging community seed. Traditional varieties/landraces are also not commercially competitive. Driven by poverty, the tribal farmers yield to commercial exploitation where the cultivation of landraces, local varieties, and other valuable genetic material is replaced by the cultivation of modem varieties despite the fact that they are not preferred by the tribal community. The result is a gradual erosion of precious genetic diversity, most of which is also site-specific. This situation calls urgently for preventive measures.

Jeypore tract in Orissa State is a secondary center of rice origin. Yet farmers do not realize the potential yield of the rice landraces growing there. One reason is that the traditional practices developed essentially for avoiding risks are out of tune with those needed for realizing high yields. Participatory initiatives, setting appropriate methods of cultivation based on a realistic evaluation should provide the right corrective step. This paper describes and discusses such initiatives in the Jeypore tract of Orissa.

Keywords: Tribal farmers, participatory research, rice, landraces, participatory plant breeding, India

Introduction

We describe below a situation typical of tribal farmers in India, where any option, including participatory plant breeding (PPB), has to coexist with the site constraints if it is to be feasible. Orissa state is situated in the southeast region of India between latitude 17°48' and 22°34' N and longitude 81°24' and 87°29' E. The total geographical area is approximately 156,000 km^2 and accounts for 4.74% of India's geographical area. As per the 1991 census, the state has a population of 31.66 million, of which 7.03 million (22.2%) are tribal. The tribal people consist of different ethnic groups (at least 62 were identified in a recent survey) and form three broad categories of farmers—backward, peasant-like, and semi-urbanized—based on their level of development. The backward tribes live partially in isolated pockets and practice shifting cultivation. the peasant-like farmers depend largely on sedentary cultivation, and the semi-urbanized farmers have their mainstay in settled agriculture and wage earning. But all the tribal farmers are characterized by their own traditional life-styles, ancient customs, beliefs, rituals, and sociocultural identities.

Koraput is a district in Orissa State where the economy is based predominantly on agriculture. Jeypore, previously a part of Koraput, was made a separate district in the recent past. Cultivation is carried out in Jeypore at different altitudes, ranging from 600 to 1350 feet above mean sea level.

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Usually lands situated above 900 feet are classified as upland; around 600 feet and below is low-land, and the rest is medium land.

Agricultural practices are more primitive in Jeypore than in the neighboring states. Irrigation is rarely possible, all lands are completely rain fed, and rainfall is erratic. Farmers occasionally apply farmyard manure. Rice is the most common food crop of the region. Landraces and local varieties are mostly preferred because they cater to the cooking quality and taste of the tribal people. High-yielding varieties (HYVs) are not preferred and only commercial incentives compel some farmers to grow them. Government agencies and some private organizations are the ones that encourage this. The planting and maturation of traditional varieties are timed so that their harvest coincides with the time of festivals and family rituals (table 1). The varieties are usually photosensitive and of longer duration than high-yielding varieties. A large number of farmers still practice monocropping.

Table 1. Some Valuable Land Types Cultivated by Tribal Farmers of Orissa State in India for Use in Their Religious Functions

Rice Variety	Predominant Quality	Festivals	Time of Maturity (Month)
Kalakrishna	Scented	All festivals	January
Tulsi	Scented	*Chaitra Parva*	April
Machchakanta	White slender, short grains, good taste	*Manabasa* and *Lakshmi Puja*	November
Mer	Black grains with medicinal properties	Annual ceremony of forefathers	November
Haladichudi	White slender, long grains, good taste	*Shakti Puja*	December
Deulabhoga	Bold, short grains, reddish tinge on cooking with mild scent, preferred during worship at temples	Temple deities	December

Thus we have the following basic realities in which PPB options have to be optimized:

- Tribal farmers live in villages rich in genetic diversity and occupied by one or two tribes. They are situated far away from the reach of government extension agencies.
- Farmers are highly tradition-bound socially and religiously, and would have reservations about switching to new options.
- The enhanced yields of HYVs do not attract them as much as the quality and taste of their lower-yielding landraces and local varieties, which they prefer.
- They have rich indigenous knowledge of their crop diversity but poor knowledge of modern agriculture.
- Their habitats are poorly connected by roads and are typified by poor or absent marketing facilities.
- Against this backdrop, they are vulnerable to commercial exploitation of their natural resources.
- They are ready to learn and practice profitable methods of cultivation, provided such methods can produce perceptible returns.

- Currently there is neither a feeling of strong ownership of natural resources nor any awareness of intellectual property rights.

New PPB paradigms need, therefore, to be simple and productive to promote voluntary participation. They should be cost-effective and, at best, attempt to optimize practices under existing site constraints. They should respect farmers' tastes and be consonant with their strong preferences. They should be risk-insulated and entail a low cost-benefit ratio. Complex PPB options can only be a long-term goal and should be based on short-term benefits.

The method

A number of years of work and association with farm families of several villages in the Jeypore district by the M.S. Swaminathan Research Foundation (MSSRF), based at Chennai, India, has prepared the ground for cooperative and participatory work to improve the productivity of farmer-preferred local varieties/landraces. The work plan envisaged a three-year activity module. The first year was earmarked to survey local varieties sown by farmers and to introduce organized planting of preferred varieties. The seeds of those varieties would then be distributed by MSSRF. A few farmers would be encouraged to raise the crop in their plots by their own methods. The yield data would be analyzed and a few varieties selected for further evaluation.

In the second year, the selected varieties would be grown by PPB farmers in a field design in which farmers and formal practices would be the two treatments. Data on grain yield and its components would be statistically evaluated to select the top two varieties for upland, medium land, and lowland conditions. In the third year, the selected varieties would be grown in large plots under formal technology, provided it proved superior to farmers' practices in the second year of evaluation. Varieties to be evaluated, the sites for testing their performance, and the farmers who would participate in the program would all be selected by the farmers themselves. Periodic checks on the progress of the experiments, the problems that cropped up in the execution of experiments, and related issues would be discussed in periodic PRAs with farmers, and acceptable solutions found.

Results

During the rainy season of 1998, three districts and two blocks per district were selected for upland (U), medium land (M), and lowland (L) cultivation in the Jeypore tract of Orissa State. Fourteen farmers were chosen to raise 10 upland, six medium land, and 10 lowland local races/varieties in their own plots of approximately of 80 m^2. The crop was raised using farmers' practices common in the respective areas. However, a severe cyclone at the time of crop maturity affected crop yields; the data could only be used for a relative evaluation. We devised a form to record various field activities, with which data on cost-benefits were gathered not only on the PPB plots but also on farmers' own holdings. The overall performance and characteristics of varieties were discussed in a PRA with a large number of farmers from the sites.

Only 3 U, 1 M, and 5 L varieties were selected in the PRA from the original 10 U, 6 M, and 10 L varieties tested in 1998. In consultation with the farmers, 3 U, 7 M, and 3 L varieties were added to get a total of 6 U, 8 M, and 8 L varieties for experimentation in the crop season of 1999.

To facilitate periodic visits to plots, it was decided to confine the experiment to two blocks and five villages in the Koraput district, near the MSSRF site office at Jeypore. Nine PPB farmers agreed to test the selected varieties in two test plots of 90 m^2 each. One of the test plots was divided into three replications of 30 m^2 and the selected varieties were grown in a randomized block design. The other was divided equally between varieties to be tested. They were planted unreplicated by farmers using their own traditional practices. In the replicated plots, formal methods of cultivation were introduced (box 1).

Box 1. Formal Methods Introduced to Cultivate Local Varieties and Landraces in Jeypore, India

- Preparing land and applying farmyard manure in residual moisture when the previous crop has been harvested
- Raising nursery stock in well-prepared land in rows spaced 20 cm apart with optimal moisture
- Pre-soaking seeds in water for 12 hours and selecting only those seeds that sink
- Direct seeding (in U and some M), or transplanting (in some M and L) of about 25-day-old seedlings, in rows spaced 20 cm apart, with plants at 10-cm intervals within a row
- Setting rows north-south to maximize sunlight on growing plants.

Those formal methods were developed as a result of a survey of farmer's plots grown to rice in the first year, where a number of problems were predominant (box 2).

Box 2. Problems with Rice Crops Raised under Farmers' Traditional Practices

1. Erratic rainfall, leading to the tradition of high seeding rate of about 40–60 kg/ha
2. Consequent dense plant populations that lead to yellowing and poor plant growth
3. Ill- or unprepared lands due to lack of moisture prior to the planting season, resulting in poor germination
4. Poor seedling growth, leading to severe disease and high pest incidence
5. Farmyard manure occasionally applied in small quantities during sowing, resulting in no benefit to the crop
6. Nursery plants raised in poor, most often unprepared lands with flooded rain water
7. Transplanting most often with very old seedlings, sometimes even 60 days old

Crop growth on formal and farmers' plots was evaluated in periodic PRAs with farmers. Scientists recorded data on days to flowering, number of tillers, number of panicles, number of grains per panicle, and grain and fodder yield with the help of farmers in each plot. The data were used to compute grain filling and harvest indices. Based on multivariate statistical analysis of yield and its component characteristics, the varieties were ranked on their joint performance across all traits.

The results were striking. They are summarized and shown only for the varieties common in 1998 and 1999 in table 2. The advantages of changing over to scientific methods of cultivation are obvious.

The following inferences stand out:

a. Fluctuations in the yield of varieties occurred even under traditional (farmers') methods of cultivation. For instance, the variety, *machchakanta*, was the top yielder in 1998—a year characterized by cyclonic weather and heavy rainfall. It gave low yields in 1999 under farmers' practices despite consistently good weather. In general, however, varieties responded by giving good yields under the better climatic conditions in 1999.

Table 2. Comparative Benefits of Formal Methods over Farmers' Traditional Practices of Rice Cultivation in Jeypore Tract, India

		Average Yield (k/ha)			
		1998	1999		FO/FA
Land Type	Variety		FO	FA	
Lowland	*Machchakanta*	2189	1671	1418	1.2
	Bayagunda	1755	3679	2321	1.6
	Gadakuta	13352	1524	961	1.6
	Barapanka	1643	3438	2533	1.4
	Kalachudi (*Umriachudi*)	1309	2562	2007	1.3
Medium Land	*Bodikaburi*	1261	2838	1736	1.6
Upland	*Pandakagura*	393	1188	1178	1.01
	Paradhan	562	1028	622	1.7
	Matidhan	839	1199	1133	1.06

Note: FO=Formal methods; FA=Farmers' traditional methods.

b. Yields under formal methods were consistently and significantly superior than those under farmers' methods. Lowland varieties, which gave fairly good yields under farmers' practices, responded to formal methods by giving up to 60% higher yields (table 2). One popular upland variety, *paradhan,* preferred by all farmers, had a yield advantage of 70% under formal methods. The trend of improvement was about the same for the other 13 varieties (data not shown).

c. Yield improvement using formal methods was achieved at no extra cost. Initially farmers found it difficult and time-consuming to space-plant in rows, but quite soon they saw that they could achieve higher efficiency (see d.1, below).[1]

d. Preliminary data show that the cost-benefit ratio is substantially more favorable under formal methods for the following reasons:

   1. The seeding rate is about one-fifth of that used in traditional methods (12 versus 60–65 kg/ha). Hence even row planting with uniform space between plants could become less time-consuming.
   2. Nursery seedlings produced under formal methods grew vigorously and were free from weeds, insects, and diseases.
   3. Seedlings were well and quickly established in plots because of initial seed selection and healthy nursery plants.
   4. The healthy initial stand discouraged weed competition and helped healthy crop growth without being affected by biotic stresses.
   5. Row and space planting made interculturing operations easy, where needed, and harvesting of the crop took significantly less time.
   6. The 20-cm spacing between rows proved ideal for the harvested plants to be stacked in a slanted, reinforcing standing position for the produce to dry in the sun in the field before transfer to threshing yards.

1. In a recent PRA in August 2000, farmers reported that seed placement has become more efficient and reduced the labor requirements for planting in rows.

These small but significant benefits added up to a cumulative advantage, reduced the drudgery of field operations, including weeding and harvest, and resulted in a more favorable cost-benefit ratio.

In conclusion, we learned a number of lessons, and the experiments evoked the desired response among farming families in both the experimental sites and surrounding areas.

Lessons learned

1. Situations exist which do not exactly fit a typical case for PPB. Any participatory initiative, including PPB, is a function of the target site, environment, site farmers and their traditions, practices, and social and cultural norms.
2. Participatory programs must recognize this circumscribing frame, most often rigid, within which actions must be confined.
3. Initial action plans must produce perceptible benefits in order to ensure voluntary participation.
4. When the basic constraints and opportunities for initiating participatory actions are recognized, respected, and acted upon, even farmers in difficult economic conditions will willingly participate without incentives.

Effects induced by participatory improvement initiatives

1. Farmers were clearly convinced that the traditional high seeding rate and dense planting are not the way to counter their difficult environment, harsh climate, and unpredictable yields. They have realized by their own experience the logic of the formal methods they were shown.
2. The message of formal methods of cultivation has spread so far and fast that a number of surrounding villages have started adopting the same practices, not only in rice but also in other crops, like red gram and finger millet.
3. There is a high demand from the tribal farmers for training programs in various sites to ensure proper adoption of formal methods of cultivating traditional rice varieties.
4. Farmers are willing to extend their participation to breeding productive pure lines, initiating from parents chosen from their site-specific local races and cultivars.

Thus, the experience of participatory rice improvement has been exhilarating and productive, and efforts are under way to replicate the benefits of formal methods of cultivation by initiating site-specific PPB paradigms.

CONSERVE's Experience and Work on Participatory Plant Breeding in Rice

Gilda T. Ginogaling

Abstract

In this paper CONSERVE's experiences in handling two research approaches in participatory plant breeding in rice are discussed: researcher-managed or on-station trials (OSTs) and farmer-managed trials. OSTs are done on CONSERVE's farm. CONSERVE crosses (CC) were used as materials for evaluation on-station for three filial generations before the material was given out to farmer-partners for the farmer-managed trials. All distributed segregating materials were tried in their respective fields. Activities taken on-station and in farmers' fields is assessed. Lessons on the management of on-station trials and farmer-managed trials are discussed.

Introduction

There are some organizations that conduct research on how the development of seed is improved. Some do experiments both on-station and in farmers' fields. Community-Based Native Seeds Research Center, Inc., (CONSERVE) is one of these. It was established to conduct both researcher-managed trials and on-farm field trials using rice seeds as materials. CONSERVE is an NGO established in 1992, which started as a project of the Southeast Asia Regional Institute for Community Education (SEARICE). It has a 1.7-hectare demonstration farm for field research and a space for the project office and training center. The organization is involved in the conservation and development of plant genetic resources for sustainable agriculture and food security, particularly rice and corn, in the Arakan Valley Complex that covers 35% of the total land area of the Cotabato Province in the Philippines. The Arakan Valley Complex is composed of five municipalities where farmer-partners are 60% tenant farmers and 40% landowners. The majority of them (60%) are men. Farmer-partners are organized either through people's organizations or as individual curators and indigenous people in the uplands. CONSERVE's initial activity was to collect 299 rice varieties from Cotabato and Maguindanao provinces in 1992; 389 varieties were added in 1995. Aside from rice, 42 varieties of corn, along with millet, sorghum, vegetables, and 59 varieties of unidentified cereal crops were collected. The center is maintaining local storage as a back-up of these materials.

The problems created by the Green Revolution in the 1960s through the introduction of modern varieties inspired CONSERVE to initiate a program of conservation of plant genetic resources (PGR). Over the years, farmers had mainly relied on what was being introduced by the formal system and through the local seed supply. Very few practiced seed selection from segregating materials but, many selected from mostly or almost uniform varieties. This is where the seeds for the next cropping season came from.

CONSERVE's approach to participatory plant breeding[1]

Since the project's beginning in the Arakan Valley Complex, CONSERVE has been involved in various research projects at both the center and on farmers' fields. PGR research has mostly been

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1. Participatory plant breeding (PPB) is involving farmers in the selection of genotypes from genetically variable, segregating materials (Witcombe and Joshi 1996).

linked with sustainable agriculture. Farmer-partners have taken part in the research as the evaluators and observers at the central farm's research, while at the same time, they have had their individual research projects. Program staff provide assistance and venue through training, cross visits, regular meetings, and consultations.

From this research, CONSERVE has gained experience and learned lessons, especially since it is one of the pioneering projects in the Philippines to focus on conservation and utilization of plant genetic resources. The seeds collected by CONSERVE have played a vital role in this research.

CONSERVE conducts both approaches—researcher-managed (or on-station) and farmer-managed trials—at the same time.

Researcher-managed (center-based trials)

The researcher-managed trials are conducted in the center's production farm, facilitated by program staff and later conducted by farmer-partners. Farmer-partners are invited to visit the station and identify materials that are acceptable to them, usually before harvest season.

There were 22 single crosses done by the center and coded as CONSERVE crosses (CC). Varieties crossed were mostly materials from the uplands, which were crossed with lowland rice in order to determine if the product of the cross will adapt or not. Out of these crosses, only 10 crosses survived at the first filial generation. These were planted in on-station (lowland) fields by plot, where program staff observed and evaluated the seeds. Records of the crosses and the number of selections have been kept. Distinct characteristics of the materials selected were noted, such as resistance to pests and diseases, yield (panicle length), number of tillers, height, and other agronomic characteristics. No back-up of the crossed materials has been made. After two cropping seasons, various selections were obtained and planted in the production area. Bulk selection was practiced. Program staff made the decisions involving rejecting seeds not adaptable to the center's conditions and did the selection. Before the selection at harvest time, farmers were invited to the station and took part in the evaluation of the segregating materials. Group discussions were held and criteria were obtained to provide the basis for selection. Farmer-partners also took part in the selection; they freely selected what they wanted from the segregating materials on-field. This material was simultaneously distributed to 89 farmer-partners starting in May 1995.

Breeding materials were continuously segregated and diverse characteristics were obtained. The center had difficulty managing all the materials, and the focus of the program staff was limited to keeping records of significant developments in the materials; thus, it was decided to distribute to farmer-partners. All in all, CONSERVE was able to produce 100 lines from 10 single crosses. These were distributed to increase the number of selections and to enhance participatory research by exploring the process of selection until farmers can produce a stable selection for mass production.

Lessons learned and recommendations:

- It was interesting to note that the center did not keep a back-up of those 10 crosses that might have served as good material for selection in the future. The center is maintaining short-term back-up storage of the seeds collected in the beginning of the project.
- The crosses made also provided a good learning experience—an upland variety crossed with the lowland but with the experimental plots in the lowland area. The center should have tried conducting the same experiment in the upland area to know the performance of the offspring.

- The involvement of farmer-partners in the activity was very limited since they were only involved in the later part of the research and most of the selections were done by program staff. Farmers should have been involved not only in the later part but also in the whole process so that they could learn how the research is conducted.

Farmer-managed (farmers' field trials)

Farmer-managed trials are actually conducted on an individual farmer's field. Farmers have their own way of designing the experiment, either within the farm or across farmers. The evaluation is usually informal, with their criteria providing the basis for selection.

After the segregated materials were given to the farmer-partners in the Arakan Valley Complex, project staff monitored their progress and provided assistance to them. The majority of farmers received a minimum of five breeding lines in small amounts (around 5-10 grams) to try in their respective fields. Some planted the seeds in separate plots and others planted them in a portion of their rice field. Most of the farmers who received the segregating materials were graduates of the Ecological Pest Management–Farmers' Field School (training given to farmers on a weekly basis for one cropping season of about four to five months, to give them an understanding of rice production activities using the seven dimensions of sustainable agriculture).

Farmers selected plants according to their own individual criteria. They practiced two types of selection methods: bulk and pedigree. Some farmers discarded materials, while others mass produced. As these materials expressed their characteristics under the conditions of different farmers' fields, materials were exchanged among farmers, not just within the village but to other municipalities. Selection continued even when the materials reached the mass-production stage. Farmer-breeders continuously bred, selected, and distributed their stable lines to other farmers. It happened, too, that rejected materials were passed on to other farmers, still undergoing the process of selection according to individual preference. While the flow of materials continuously moved, the process ended when the breeding lines reached the mass-production stage. The flow of genetic materials from one farmer to another is extremely fast. The farmers' efforts to explore and experiment through selection were a very good example of participatory research and how farmers can be empowered by giving them control of the seeds and the resulting exchange of seeds within the area and to other villages.

From the survey conducted by CONSERVE in 1998, a total of 19 lines out of the 57 lines originally distributed from six single crosses (CC1, CC2, CC5, CC7, CC13, and CC20) were still maintained by farmer-partners. At present, the breeding lines are widely used for mass production not only by farmer-curators but also by other farmers. CONSERVE Crosses 5 and 13 are commonly used. Selections by farmer-partners are continuously enhanced in farmers' fields, which has led to an increase in stable lines. On the other hand, it was observed that over the years, although stable lines had been identified, the number of lines has decreased as farmers continue to select and adapt the materials given to them. Their selection criteria and the adaptability of the breeding lines are based on the conditions present in their respective fields. Moreover, only a few farmers keep many selections. Usually, they only keep two to three lines, on average. Farmers who keep many selections have the capacity to manage them and lack storage facilities, leading to a diffusion of selections.

Lessons learned and recommendations:

- It was noted that farmers did not keep the original lines given to them, as the center also neglected to do. Like CONSERVE, they have lost the opportunity to go back to the mother population in order to replace the lost selections. They have kept improving the selected materials until they became stable and uniform, based on their own criteria. There are only a few farmers who have the capacity to use all of the selected materials at a time. Since labor is limiting factor, farmers have discarded those materials that are not of use to them. Storability is another factor, because of the humid conditions of the program area—seeds lose their viability in a very short time.

- Therefore, there is a need to provide farmers with support in maintaining their selections and training them how to manage their seeds to preserve longevity.

Reasons for distribution and nondistribution

In order to determine farmers' acceptance of the segregating materials distributed, the reasons for distribution and nondistribution of materials in the field were examined (table 1). In the same survey conducted by CONSERVE in 1998, it was found that 31% of the farmers distributed the segregating lines they obtained from the center to other farmers. Most of them reasoned that it was ready for mass production. Another reason was that the person who requested it was a close relative.

Table 1. Farmers' Reasons for Distribution and Nondistribution of Segregating Lines to Other Farmers, Arakan Valley Complex, Cotabato, Philippines

Distribution	Nondistribution
Relative/kin	Minimum quantity
Morpho-agronomic characteristics	Infested by rats
Ready for mass production	Tungro infested
	Not yet uniform
	Mixed
	Infested by rice bugs
	No selection done
	Milled
	Eaten by ducks
	Neighbors have the same seed

When farmer-partners did not distribute the breeding lines to other farmers, it was because they only had a minimum quantity of the material. Some said this was because of an infestation of pests, such as rats and rice bugs, that the materials were not yet uniform, that the materials were mixed, etc. Some farmers were very reluctant to distribute because of the small quantity given. In time—with further field testing, improvement, and multiplication—farmers started to appreciate and find ways to obtain, develop, and increase the quantity of good varieties.

Reasons for adoption and rejection

There are also reasons why farmers adopt or reject varieties given to them. These reasons can be agronomic, morphological, gastronomic, social/cultural, and technological (table 2). Agronomic

Table 2. Why Farmers Adopted or Rejected the Breeding Lines Distributed, Arakan Valley Complex, Cotabato, Philippines

Adoption	Rejection
Agronomic:	**Agronomic:**
• adaptable to the area	• cannot adapt to the area
• resistance to lodging	• susceptible to lodging
• resistance to pests and diseases	• susceptible to pests and diseases
• medium maturity	• maturity is not the same
• high yielding	
• early maturing	
Morphological:	**Morphological:**
• long panicle	• discouraged by the segregation
• medium height	• height (tall)
• shiny seeds	• late maturing
• thin (lemma and palea)	
• good tillering ability	
• filled grains	
Gastronomic:	**Gastronomic:**
• good eating quality	• eating quality is not good
• aromatic	
• glutinous/oily	
Social/cultural:	**Social/cultural:**
• low cost in production	• busy with other obligations
• neighbors are encouraged	
Technology:	**Technology:**
• learn selection	• laborious

reasons include resistance of the breeding lines to pest and disease, resistance to lodging, and adaptability in the area. Adaptability was measured as having good standing performance/growth under specific environmental conditions.

Morphologically, farmers adapted breeding lines according to the length of panicle, number of productive tillers, grain characteristics, and plant height. Eating quality or palatability was also considered. Other farmers mentioned the low cost of production and knowledge gained in selection techniques as reasons for adoption.

The reasons for rejection were also classified according to agronomic, morphological, gastronomic, social/cultural, and technological. Usually farmers rejected the material because of the susceptibility of the segregating lines to lodging, while others were discouraged by non-uniform maturity or because of the height and maturity of the material. Few farmers rejected the materials for poor eating quality but others were hampered by other responsibilities and said that the activities were too laborious.

It was generally learned through the farmers' evaluation that farmers discard those materials that do not fulfill their selection criteria, especially materials that are susceptible to pests and diseases. Sometimes, however, rejection can lead to success. One of the farmer respondents rejected a selection that he then gave his neighbor. The neighbor grew the variety successfully and later multiplied the seeds for other farmers.

Conclusions

The approach initiated by CONSERVE has enhanced the farmers' capacity to develop varieties from the segregating materials distributed. Farmers' direct involvement with these materials has helped to providing access to diverse genetic materials, that has led, in turn, to opportunities for them to develop what they want from the genetic materials distributed. This approach has also helped in promoting farmers' involvement in farm-based varietial-improvement activities. In general, the approach is better if farmers are involved.

Summary

1. There are two PPB approaches initiated by CONSERVE, namely, researcher-managed or on-station trials and farmer-managed trials.
2. There were 22 single crosses made between upland and lowland rice by the center, coded as CONSERVE's crosses (CC). Ten crosses survived at the first filial generation and were planted on-station for three filial generations before distribution to farmer-partners. One hundred lines were derived and distributed to 89 farmer-partners, with a minimum of five lines per partner at 5–10 grams per line.
3. All the segregating lines given to farmer-partners were grown in their own fields. Two methods of selection were practiced: bulk and pedigree.
4. Nineteen lines distributed from six single crosses (CC1, CC2, CC5, CC7, CC13, and CC20) are still maintained by the farmer-partners. CC5 and CC13 are the most common. In their fields, farmer-partners keep two to three lines, on average. Farmers who maintained many lines have a greater capacity to manage and store them, resulting in diffusion of selections.
5. Selections are continuously enhanced in farmers' fields, leading to an increase in stable lines, but as this happens, the number of lines in the farmer's fields decreases. Farmer's selection criteria and the adaptability of the segregating materials contribute to this.
6. Farmers distribute selections for reasons such as readiness of the selection for mass production and requests for materials from close relatives. Reasons for nondistribution were because of the small quantity of materials, infestation by pests and diseases, the materials were not yet uniform, they were mixed, etc.
7. Farmer-partners adapted the segregating materials distributed for resistance to pests and disease, resistance to lodging, and adaptability in the area. Some adapted length of panicle, number of productive tillers, grain characteristics, and plant height.

8. Reasons for rejecting materials were due to susceptibility of the segregating materials to lodging, non-uniformity, and maturity. Some farmers felt that the activities were laborious and conflicted with other responsibilities.

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Enhancing Farmers' Participation in Plant Breeding: Community Biodiversity Development and Conservation Program (CBDC), Bohol Project, Philippines

Hidelisa M. de Ramos

Abstract

The Community Biodiversity Development and Conservation Program (CBDC) is a global undertaking aimed at halting or minimizing genetic erosion and strengthening the farmers' role in on-farm conservation and development of plant genetic resources (PGR). It also aims to seek ways on how the formal and informal sectors can complement each other in on-farm conservation and development. In this paper, the project's general approach is illustrated in a case study on rice, conducted in Bohol, Philippines. The objectives of the study were to increase the genetic diversity of rice planted by farmers and to determine farmers' criteria for evaluating and selecting rice. Genetic materials were distributed to farmer-partners, evaluated by farmers, and subsequently exchanged within the community through the local exchange system. Workshops were conducted every season to identify researchable areas and to design field experiments. Community workshops were also held to analyze research results and identify new problems for the next season. Farmers decided which varieties or technology to adopt after each season, based on their observations and evaluation of the on-farm research. The study documented the results of two types of farmers' evaluation of the varieties.

Introduction

Farmers have traditionally exchanged and shared seeds among themselves. Seed sharing and exchange enable farmers to evaluate and select new crop varieties that suit their needs and preferences and adapt to specific environmental conditions in their fields (Berg 1994). Farmers are therefore able to continually produce diverse crop varieties that are specifically adapted to local needs and conditions.

However, when the Green Revolution started in the 1960s, the conservation and development of crop varieties were mainly taken over by agricultural research centers (Berg 1994). For instance, the International Rice Research Institute (IRRI) developed new varieties of rice that displaced many of the traditional varieties. Formal breeding programs not only displaced local varieties but also much of the farmers' role in crop conservation and development (Salazar n.d.).

Formal breeding programs differ from farmers' methods of developing new varieties. Breeders set breeding objectives with broad rather than specific adaptability in mind (Berg 1994). This means that the new varieties are designed to adapt to a wide range of field conditions. High yield is the top consideration for breeders, while farmers consider yield along with other characteristics deemed important, such as aroma and eating quality.

Furthermore, breeders produce new varieties in very favorable environments. Varietal trials are carried out in fields that are highly fertile and highly seeded (Atlin and Frey 1989), where optimum amounts of fertilizers are applied. The new varieties, however, perform differently in farmers' fields where conditions are more variable and management practices are different.

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This project is implemented by the Southeast Asia Regional Institute for Community Education (SEARICE), a regional NGO working on issues about access and control of plant genetic resources (PGR) and farmers' rights, and currently implementing community-based PGR projects in Southeast Asia.

Ceccarelli (1989) states that direct selection of varieties in the target environment is an efficient breeding strategy since this will produce varieties that satisfy specific farmers' needs and conditions better. This calls for a decentralized and participatory breeding approach where farmers are involved in the development and selection of new varieties. Participatory breeding will generate greater crop diversity in farmers' fields that can meet the diverse needs and conditions of farmers.

Approaches and methods in on-farm research

The Community Biodiversity Development and Conservation Program (CBDC) is a global undertaking aimed at halting or minimizing genetic erosion and strengthening the farmers' role in on-farm conservation and development of plant genetic resources (PGR). It also aims to seek ways on how the formal and informal sectors can complement each other in on-farm conservation and development.

The Southeast Asia Regional Institute for Community Education (SEARICE) is implementing the CBDC project in Bohol, Philippines. It started in 1994 and focuses on conservation and development of rice, corn, and root crops, such as cassava, sweet potato, and yam (*Dioscorea alata*). The project's general approach in conducting participatory on-farm research is shown in figure 1. The project, together with farmer-partners in the community, conduct workshops every season to identify researchable areas and to design experiments to be conducted in the field. On-farm research is evaluated at three levels: by the staff, by individual farmers, and by the farmers' group. Another community workshop is conducted at the end of each season to analyze research results and to identify new research problems for the succeeding season. Farmers decide which varieties or technology to adopt after each season, based on their observation and evaluation of the on-farm research.

The key players in the project's approach participatory plant breeding (PPB) and participatory varietal selection (PVS) are shown in figure 2. The genetic materials distributed by the project to farmer-partners come mainly from three sources: local communities; formal institutions, such as

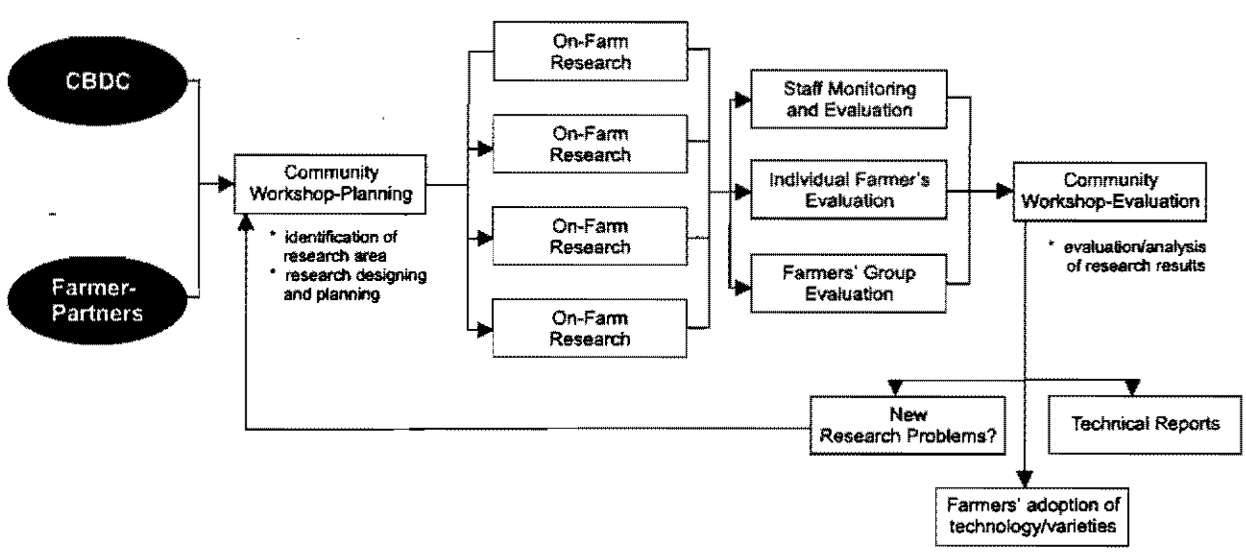

Figure 1. CBDC Bohol Project's approach in on-farm participatory research

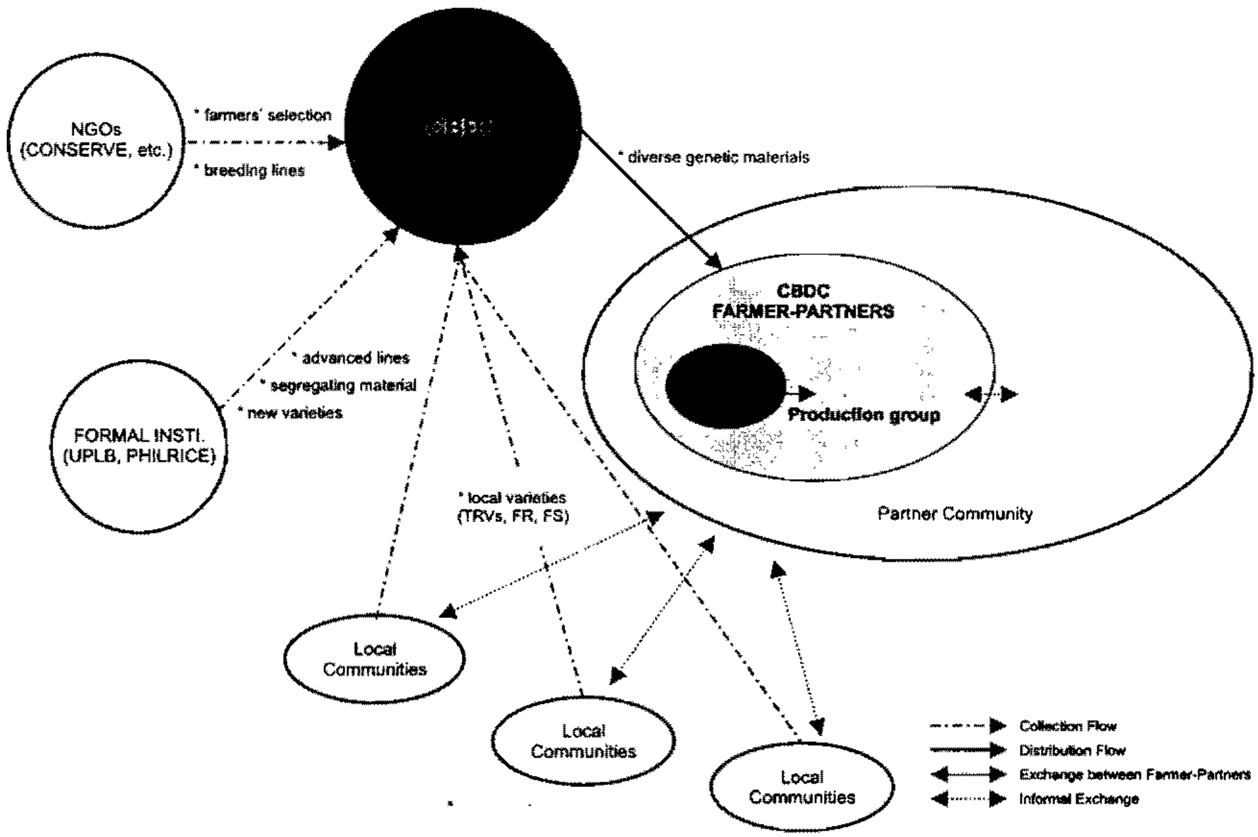

Figure 2. Key players in PPV/PVS

the University of the Philippines–Los Baños (UPLB) and the Philippine Rice Research Institute (PHILRICE); and nongovernment organizations (NGOs), like the Community-Based Native Seeds Research Center (CONSERVE). The distributed genetic materials consist of stable varieties, such as traditional varieties, farmers' selections, and formal release varieties. The project also distributes segregating lines (F1-F8) collected from NGOs and formal institutions. These genetic materials are evaluated by farmers and subsequently exchanged within the community through the local exchange system.

Methodology

The project's general approach is elaborated in a case study conducted in collaboration with the Research and Development Department of the Central Visayas State College of Agriculture, Forestry and Technology (CVSCAFT), a local institution.

Fifteen varieties of rice were distributed to 12 farmers in Zamora village in Bilar town during the second cropping season from October 1999 to March 2000 (table 1). The materials came from different sources and consisted of both white and red varieties. Boholanos are known to prefer red rice varieties. Each farmer received three varieties at 0.5 kg per variety. The farmers grew the varieties using their own management practices in combination with organic fertilization. The methods of

Table 1. Types of Varieties Distributed to Farmer-Partners

Set	Variety Name	Origin/Sources	Seedcoat color	No. of farmer recipients
1	MB	Farmers' selection from RC 10	Red	
	08	Local variety	White	3
	CC 13-3-4-3	NGO-bred and released to farmers at F3	White	
2	03	Local variety	White	
	RC 28	Formal release	White	4
	Los Baños	Local variety	White	
3	CFS-JR-06	Farmers' selection from Japanese variety	Red	
	MS 1-29	NGO/farmer-bred	White	3
	RC 4	Formal release	White	
4	66 Puwa	Farmers' selection from IR 66	Red	
	MS 2-AV	NGO/farmer-bred	White	4
	Japan	Local variety	White	
5	Ceres	Local variety	Red	
	MS 13	NGO/farmer-bred	White	3
	CC 13-3-4	NGO-bred and released to farmers at F3	White	

distribution and trial arrangements with farmers were based on lessons gained by the project in previous years of conducting on-farm experiments and studies.

The study documented the results of two types of farmers' evaluation of the varieties. In one evaluation, farmers who received the same set of varieties ranked the varieties in comparison with IR66, the most commonly planted variety in the village. Farmers ranked the varieties according to different parameters they themselves identified. Ranking in each parameter ranged from one to four, with four representing the highest preference by the farmers. In the other evaluation, the farmers participated in a field day to observe and evaluate all the varieties as standing crops. Farmers identified the varieties they preferred and the reasons for their preferences.

Objectives of the study

The objectives of the study were

1. to increase the genetic diversity of rice planted by farmers in Zamora village
2. to determine farmers' criteria for evaluating and selecting rice

Results and discussion

Farmers' preferences in a variety

Farmers identified at least 13 specific traits they look for in a variety (table 2). Their criteria are very comprehensive, ranging from percent germination to yield. Farmers evaluated the varieties from seedling stage until harvest. Yield is one of the major criteria, as shown by the identification of related traits such as big grains, long panicles, and high tillering ability. In addition to yield, maturity also matters to farmers since early maturation allows them to maintain at least two cropping seasons per year. From the evaluation results during the farmers' field day, farmers cited one addi-

Table 2. Sample Matrix Ranking of Varieties by Farmers Receiving Same Set

Preferred Traits	MB	08	CC 13-3-4-3	IR 66
1. High percent (%) germination	4	1	2	3
2. Healthy and strong seedlings	4	2	1	3
3. Panicles				
a. long	4	3	4	3
b. low % of unfilled spikelets	4	4	4	3
c. low shattering	3	4	4	3
d. heavy branching	3	3	4	4
4. Big, healthy spikelets	4	4	3	3
5. High tillering	3	4	4	4
6. Early maturing	3	3	4	4
7. Strong culm	4	4	4	3
8. Resistant to pests	4	4	4	3
9. Medium height	4	4	3	3
10. High yield	4	3	4	3
Average ranking	3.7	3.3	3.5	3.2

Note: 4 = highly preferred; 1 = least preferred.

tional criterion not identified in the matrix ranking, namely, tolerance to water logging (table 3). This criterion is significant because certain areas of the village are waterlogged. This is a good example of selection by farmers for a very specific field condition. On the other hand, formal breeding programs would be unable to capture such selection because varieties released from the formal sector are generally bred for broad adaptability.

Culture, as it relates to diversity conservation and development, is also not addressed by the formal sector. For example, Bohol farmers maintain a diversity of red rice varieties, either traditional varieties or farmer-developed varieties (table 1). Boholanos are known to prefer red rice because it is generally equated with better eating quality. Farmers also claim that they can work longer in the field after eating red rice (CBDC 1996). In fact, local red rice is priced higher in the market than local white rice. Red rice is also preferred by a number of ethnic groups in Luzon and Mindanao (Borromeo, personal communication). However, the Philippine Seed Board has not released any red rice variety since it was established in the 1950s (Borromeo, personal communication).

Increased genetic diversity

Seven of the 15 varieties distributed were replanted by the farmers who participated in the trial. Previous to the trial, farmers in Zamora were planting only three varieties (CBDC and CVSCAFT 1999). This represents a significant increase in the number of varieties planted in the community after one season.

The selected varieties have diverse qualities. Two are farmers' selections, three came from an NGO-farmer breeding program, one from the formal sector, and one is a locally adapted variety (table 4). The replanted varieties either ranked higher (in sets 1, 3, and 5) or slightly lower (in sets 2 and 4) in comparison to IR 66, the check variety.

Table 3. Result of Collective Farmers' Field Evaluation of Standing Crop

Variety name	Preferred traits	No. of farmers who preferred the variety
MS 13	Uniform hull color and absence of spots Healthy, big and many spikelets White grains Long panicle Strong culm, lodging resistant Tolerant to water logging	10
CFS-JR-06	Good panicle Healthy and big spikelets Red grains Strong culm, lodging resistant Tall	10
MS 2 – AV	Healthy and long panicles Early maturing Tolerant to leaf folder and rice bug Lodging resistant Resistant to diseases Uniform height Short height	7
MS 1-29	Healthy spikelets Many but small spikelets Uniform hull color, absence of spots Long panicle Tolerant to diseases	7
MB	Big panicles and grains Uniform hull color, absence of spots High tillering Tolerant to water logging Lodging resistant Big culm Resistant to leaf folder Tall	4
Los Baños	Many spikelets and panicles Heavy branching Tall Relatively late maturing compared to other varieties	3
66 Puwa		1

Varieties that scored high in both the field day evaluation (table 3) and the matrix ranking (table 4) had a higher rate of adoption than the other varieties with lower scores. This implies that if farmers' criteria are be taken into consideration and varietal performance is evaluated in farmers' fields using farmers' practices, then varietal adoption rates could increase considerably. This could shorten the time for a material to be evaluated and adopted by farmers. Release of a new variety in

Table 4. Summary of Matrix Ranking by Farmers According to Set

Set	Variety name	Average ranking	No. of farmers from same set replanting the variety	No. of farmers from other sets replanting the variety
1	**MB**	3.7	1	3
	08	3.3	0	0
	CC 13-3-4-3	3.5	0	0
	IR 66	3.2	local check variety	—
2	03	2.8	0	0
	RC 28	2.8	1	0
	Los Baños	2.8	0	1
	IR 66	3.4	local check variety	—
3	**CFS-JR-06**	3.2	1	0
	MS 1-29	3.7	1	1
	RC 4	2.7	0	0
	IR 66	2.8	local check variety	—
4	66 Puwa	3.7	0	0
	MS 2-AV	3.5	0	1
	Japan	3.2	0	0
	IR 66	4.0	local check variety	—
5	Ceres	3.2	0	0
	MS 13	3.7	1	4
	CC 13-3-4	only few seeds germinated	NA	NA
	IR 66	3.2	Local check variety	—
Total no. of farmers who replanted the distributed varieties			5	10

Note: Varieties in bold letters were those replanted by farmer recipients: seven varieties replanted out of 15 varieties distributed (47%).

the Philippines normally takes about eight to 10 years, starting from the selection of parent materials (Borromeo, personal communication). Moreover, with farmers' participation in varietal trials, on-farm genetic diversity can be increased almost immediately. With their experience in doing PVS, farmers can later be trained to do PPB through handling of segregating generations or actual crossing of varieties. Through PPB, farmers can produce even more specifically adapted varieties that will contribute to overall local crop genetic diversity.

Conclusions and recommendations

1. Providing diverse materials that suit farmers' criteria and conditions can enhance genetic diversity in farmers' fields.
2. PVS is a good entry point towards implementing PPB, where farmers play the central role in the development of new varieties.
3. PVS/PPB approaches should continually evolve according to local farmers' needs and conditions.
4. Feedback mechanisms between breeders and farmers should be established to ensure that appropriate materials are disseminated to farmers.

5. In providing germplasm to farmers, one should consider not only farmers' criteria but also their capacity, skills, and resources in order to determine their levels of participation.

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Developing Local Organizational Capacity for Participatory Seed Management: Experiences from the Eastern Himalayas

Barun Gurung and Prem Gurung

Abstract

This paper describes the objectives and goals of a participatory seed-management initiative that is presently being conducted in the Sankhuwasabha District of eastern Nepal as part of the Gender, Ethnicity and Agrobiodiversity Management" project. The long-term goal of the project is to develop local capacities to effectively manage existing genetic resources through the development of skills that enhance crop improvement. The research is based on an interactive methodology that emphasizes devolution through varying levels of farmer participation in the research process. Both men and women farmers are included in the project, with the requirement that they be involved in farming as a full-time subsistence activity. Specific problems faced by farmers in the area, such as out-migration of men looking for wage-work and a yearly period of food scarcity lasting as long as six months, are highlighted.

Introduction

Situated in the remote mountain regions of the eastern Himalayas, the "Gender, Ethnicity and Agrobiodiversity Management" project proposes to develop the research capabilities of selected local people in four sites: eastern Nepal, Sikkim, Bhutan, and Nagaland. The immediate objective of the project is to develop a local capacity to conduct research to better understand the causal links between ethnicity and gender and how these components affect and influence decisions related to management of agro biodiversity. However, the broader, long-term goal of the project is to develop local capacities to effectively manage existing genetic resources through the development of skills that enhance crop improvement. Within this latter context, a participatory seed management initiative is currently being implemented in one site (Nepal) with the objective of broadening the experiences gained from this process to other sites in the region.

The participatory seed management project is being conducted in three adjoining "village development committees" (VDCs), which are village-level administrative units of the Sankhuwasabha District of eastern Nepal. In broader terms, the project aims to enhance and develop new technologies for seed management in marginal mountain communities that lack access to new seed sources. The following hypotheses articulate the more specific objectives of the research project:

- The development and enhancement of seed-management technologies will occur most effectively through a process of interactive learning between indigenous and formal systems of agricultural development.
- Access to improved technologies can be most effectively sustained through community action. This necessitates the enhancement of existing technical skills for seed improvement, along with the organizational capacity of community-based organizations to ensure community access to these improved technologies.

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- Finally, the success of community action to manage development processes will depend fundamentally on the community's ability to control the processes of knowledge production, design, and implementation of actions.

The practical implications of this methodology can be summarized as the need to search for ways in which participatory research can be part of an ongoing process. Inherent to the process is the acknowledgment that power relations between researchers and the *researched* is problematic and that there is a need to develop a process of critical reflection that situates the production of knowledge and action within a specific context of a negotiated process, emphasizing community action (see also Koning and Martin 1996).

The setting

The major ethnic group inhabiting the research sites is an ethnically distinct but heterogeneous group of people known as the Rai. Together with a related group of people known as the Limbu, the Rai refer to themselves as *Kirats*, a term employed as much to unify all the various "tribes" and clans as it is a political statement employed to distinguish them from the dominant Hindu majority. Having until the recent past practiced a distinct system of communal land tenure known as *kipat*, the *Kirats* constitute one of the oldest ethnic components of the region. Yet in decades following their integration into Nepal after the "unification" in the mid-18th century, the *Kirats* have been confronted with numerous challenges to their traditional way of life. Dominant lowland influences have resulted in changes in sociocultural practices associated with traditional land-management practices and given rise to the ubiquitous rain-fed and irrigated terraces (*bari/khet*) that suit wetland paddy and other lowland crops. In the process, engineered landscapes have replaced extensive areas of forest cover where traditional swidden (slash-and-burn clearing) was practiced.

Compounding the asymmetry of historically derived center/periphery relations are constraints imposed by the harsh mountain environment. Typical of the eastern Himalayan region (see Shrestha 1989), human settlements are situated in elevations ranging from 500–2000 meters, where land-distribution patterns combine with steep slopes and shallow soil depths to severely constrain agricultural activities. The land-distribution figures of Tamku VDC (table 1), where the research sites are located, demonstrate the environmental constraints that the inhabitants are confronted with. From the total available land, only 10.6% is suitable for agriculture, and from this total arable area, 54% has slopes of 40 degrees and soil depths of not more than 20 cm (Goldsmith, 1982).

Asymmetrical center/periphery relations embedded in historical processes have contributed significantly to the present deteriorating state of local institutional capacities to negotiate and orient

Table 1. Land Classification of Tamku VDC

Agricultural lands	10.6%
Grazing lands	14.6%
Shrubs	7.8%
Deciduous forests	35.6%
Subtropical forests	10.8%
Rock ice	20.6%

Source: Khanal (1992).

development services to their benefit, especially to counter the period of food deficit that typically lasts for four to five months a year. Unable to support their subsistence needs through crop yields alone, many households have male family members migrating in increasing numbers to urban centers in search of employment, leaving women and children to manage and care for the farm. An additional outcome of prolonged periods of food deficit is the inability of households to save seeds from consumption in times of stress. This, along with deteriorating local knowledge about seed-management practices and the absence of organizational capacities to access external sources of improved seed technologies has profound implications for the long-term subsistence of households in the region. It also significantly determines the nature and type of research methodology to be adopted for particular sites.

The research process: An interactive methodology

The objectives of the project evolved in several stages of a diagnostic process that sought devolution by emphasizing community participation in increasing stages during the research process. In order to facilitate community control and ownership, the methodology was developed from the principles of problem posing, dialogue, and reflection based on the Freirean (1972, 1973, 1978) notion that community involvement in the development process can be generated through developing a critical awareness of the causes of problems. The diagnostic process involved the following steps:

1. A survey was conducted to establish the need for a participatory seed-management initiative, based on the following research themes:
   - assessing the capacity of local community-based organizations
   - determining existing patterns of food sufficiency
   - identifying appropriate crop(s) for enhancing improved seed-management strategies
   - determining factors for farmer participation through gender-differentiated varietal assessment of identified crop(s)
   - determining the source of germplasm, either in existing local varieties or through external means
2. Analysis was done through a critical examination of baseline data to determine how the problem of food deficit is contextualized by community members. That is, are problems of food deficit linked to just economic issues of subsistence or are they affected by social dynamics of decision-making? And to what extent are these embedded in the values and cultural constructs of the community? Conceptualized problems in this way necessitates posing the following questions:
   - Do the issues deal mainly with problems of subsistence, decision-making, or values?
   - Where will action most likely come from?
   - What will most effectively motivate people?
3. Problem-posing material was prepared through the development of codes, which are representations of existing problems in the form of stories, dramatized enactments, pictures, results of participatory rural appraisal (PRA), etc. Fundamental to the preparation of codes is the need to ensure that they present a scene showing a concrete experience of the problem, which is familiar to the participants.

4. Discussion was directed through an interactive workshop whereby community members participated in defining the problem of food deficit and searching for solutions. The primary objective of this process was to develop a critical awareness of the problem of food deficit through the search for potential solutions. Additionally, the process also creates a context for the community to provide comments on the research results and to define the direction of the process. The process begins with a description of codes, followed by a first analysis, which is then related to real life and followed by a deeper analysis, ending in self-reliant action planning.

Farmer participation in the research process

The degree and type of farmer participation depends principally on the objectives for participation, as well as the context, as determined by the particular stage of the process. Thus, the diagnostic phase, consisting of the survey, analysis, code preparation, and discussion, involved varying levels of farmer participation. In the survey, three members of the community and two project members comprised the research team. Clan elders and farmers selected on the basis their knowledge related to seed management were consulted about the relevance of the project. In addition, the executive body of community-based organizations were consulted to establish interest in developing a working partnership to conduct the project.

The survey was conducted to establish (1) a crop inventory, (2) to determine the needs and priorities of different groups, based on gender and wealth considerations, and (3) to identify crop for improving seed-management technology. At the same time, farmers were selected for consultation on the basis of their knowledge, financial status, and gender. The subsequent analysis of the data to develop appropriate codes was conducted in collaboration with local researchers and farmers.

The main objective of the workshop that followed was to present the codes to the larger community

Table 2. Types of Farmer Participation

	A	B	C	D
Survey		x		
Analysis		x		
Code preparation			x	
Discussion				x

Source: Adapted from Biggs (1989).
Note: A = contractual; B = consultative; C = collaborative; D = collegiate.

to understand the root causes and potential solutions to problems of food deficit in the region. The selection of community members was based on the criteria developed in prior consultation with local members of the research team. During this stage of the interface, farmers were more extensively involved in the direction of the discussion of research findings, as well as decision making to determine the level of participation in setting the agenda for future action.

User differentiation

The selection of participants was determined by the following criteria:

- demonstrated instances of innovation in seed management and knowledge of causal links between problems of food scarcity and gaps in existing seed-management practices
- gender-differentiated knowledge and gendered experiences
- farming for subsistence as a full-time subsistence activity

Innovation

The participants selected for participation in the research process demonstrated varying degrees of innovation in crop management. The type of innovations ranged from pre-harvest selection practices to post-harvest storage practices. In some instances, the practices were learned from experience gained externally, as in the case of selecting for desired traits of rice during the pre-harvest period or experimenting with new strategies as in the case of post-harvest storage of maize mixed with millet to reduce pest attack.

While post-harvest selection practices were common for crops such as maize and millet, pre-harvest selection was practiced only on paddy. One farmer, selecting specifically for larger panicles, denser grain quality, and tall height in a landrace (*punche dhan*) was successful in producing a "variety" subsequently named after him (*changkhu dhan*, literally "Changkhu's rice"). This "variety" is currently widely adopted by other farmers in the community, with Changkhu presently selecting for early maturation to coincide with the planting of winter wheat.

In seed-storage technology, some innovative farmers experiment with the leaves of a locally available plant (*bojo*) to ward off pest attacks on maize seeds. Dried leaves of this plant are placed in the bottom of the seed container and alternately in several layers approximately every three to four inches, then the container is sealed by additional leaves at the top. Sealed in September or early October, the relatively airtight spaces and the toxic nature of leaves sufficiently wards off pest attacks.

In another example, one woman farmer, noticing that millet grains were free of pests that attacked maize seeds, began mixing a handful of millet grains in the container where maize seeds were stored. This relatively simple practice was based on her observation that millet seeds were free from the pests that attacked the maize seeds that were stored in close proximity to the millet.

Knowledge and gendered experiences

In varietal assessments of maize, conducted separately between women and men farmers during the initial research phase, women and men listed different categories of preferences based on their roles and experiences. Men listed four varieties of maize, mostly modern varieties that had been introduced into the community in the last several years. Women, on the other hand, listed eight varieties, mostly landraces whose use had been discontinued in the project site but existed in the women's natal villages. Women cited fodder quality, ease in grinding, and taste as the primary criteria for their preference of landraces. Men, on the other hand, cited high yields, early maturation, resistance to drought conditions, and market prices as important in their preference for modern varieties. An additional ranking of maize varieties among farmers revealed differential knowledge and preference priorities between women and men (table 3).

Farming for subsistence

That participating farmers be involved in farming as a full-time subsistence activity was an important criteria for selection for two reasons: the first was prompted by the project need for the uninterrupted involvement of participants for two production seasons (for most farmers in the area,

Table 3. Varietal Knowledge and Preference Ranking of Maize for Men and Women

Women	Men
1. bhote' paheli	1. manakamana-1 (MV)
2. paheli	2. dhude' seti
3. dudhe' seti	3. paheli
4. bhote' seti	
5. tamlunge' seti	
6. arun-2 (MV)	
7. manakamana-1 (MV)	
8. chepti seti	

food-scarcity periods necessitated involvement in off-farm activities for supplementing household incomes); the second was because those farmers who were involved in farming as a "full-time" activity showed a greater inclination to be relatively self-sufficient in food production, even during the scarcity period. Of the nine farmer participants in Tamku VDC who were included in the "innovative" category, all claimed sufficient food security during the year and could be counted upon by other community members for food loans during periods of food deficit.

Out-migration of men to urban centers in search of employment is one of the primary strategies employed to counter food deficits. In the past, it was common for men and women to become involved in reciprocal arrangements within the community during times of food shortage. Usually this involved providing labor for wealthier farmers in return for food provisions during times of scarcity. Increasingly, however, the present trend is for the majority of young men to migrate to urban centers to work as porters for trekking companies, perform menial jobs in restaurants and hotels, or migrate to the Middle East (*arab*) through the numerous employment agencies that have sprung up in Nepalese townships.

In addition to out-migration, people also forage for a variety of forest foods (*kandamul*), although a degree of social stigma surrounds foraging activities, principally through the perceived notion that it is part of the "primitive" past.

At the household level, food-preparation strategies also play an important role in "making it last longer." Grains are boiled with excess water, creating a porridge-like consistency to increase the quantity. "Visitors and guests" during the time of scarcity are actively discouraged from visiting, though some women participants cited visiting relatives (preferably the natal home, for married women) as an option to combat food shortages.

A seasonal calendar for food production reveals a period of severe food scarcity between the months beginning in late February and lasting till early July. The relationship between food production and out-migration, especially of males to urban centers in search of employment, is directly proportional to the increasing number of female-headed households as well as the additional, "gendered" burden of farming responsibilities that this trend implies. Moreover, there was a strong relationship between decreasing food production and poor access to seed sources and deteriorating seed-saving practices. Research suggested that the deterioration of seed saving was not necessarily related to loss of knowledge but was, rather, determined to a large extent by food scarcity and the additional burden of farm households to do "other things." Increasing trends in food scarcity over the last few generations have resulted in people consuming instead of saving seed material.

Though there were many reasons for food scarcity, research demonstrated a causal relationship between decreased crop yields and the inability to manage seed, in terms of both maintaining seed purity (*saadha biyu*) and poor seed storage practices. Moreover, access to the Agriculture Input Sector (AIC), a public-sector undertaking responsible for seed supplies was difficult, since it is situated in district headquarters a day's walk from the village and using it often proves to be a difficult bureaucratic process beyond the reach of individual farmers. The consequences of low yields, the inability to maintain seed purity, and lack of access to reliable sources of new germplasm all contribute to food scarcity in Tamku.

Lessons learned: Reconceptualizing participation and knowledge

In order to address the objective of developing improved seed technologies in marginal mountain environments while emphasizing community control of the management of the process, it becomes important to conceptualize farmer participation in the research process as an instrument of empowerment. One principle way forward in this direction is to situate farmer participation in the context of local knowledge. In doing so, however, it becomes important to view knowledge, or indigenous technical knowledge, beyond common representations of its being produced as a rational response to environmental contingencies (e.g., Mathias-Mundy et al. 1991; Howes and Chambers 1980; Brokensha, Warren, and Werner 1980). Instead, it becomes important to situate indigenous technical knowledge within cultural categories of meaning, which can then become an empowering base for participation in the interface with more powerful external categories of knowledge.

The workshop discussions revealed how empirical experiences cannot be separated from cultural experience, especially in the way Rai farmers talk about food scarcity and place the phenomenon in a mythic context. Local discourse of food scarcity finds expression both in the dominant Nepali language as well as the various dialects of the Rai group. The words to describe food scarcity range from *anikal* (food shortage), *bhokmari* (to kill hunger), *mahamari* (the great killer), and *sisawa* (famine) in the Kulung dialect of the Rai. It also finds expression through simple expressions such as "*khana ko abab hunu*" (to be short of edibles), "*dhayrai/chitto bhok lagnu*" (to experience hunger pangs sooner and more frequently than normal), "*chasum na hunu*" (to lack prosperity), as well as more abstract expressions, such as in this lament in the Kulung dialect "*Etenay sisawa udanai lay tay ho wumche*" (dear friends and brothers, . . .how do we survive the *sisawa* [food shortage] this year?) or the more common instructional verse admonishing people to save seeds to combat food shortages "*Almal ma jiyu bachhaunu, Anikal ma biyu bachhaunu*" (save oneself in times of confusion, [but] save seeds in times of [food] shortage) or "*Chha geda sabai mero Chhaina geda sabai tendo*" (having seeds, all is mine, [not] having seeds, all is not mine [i.e., lost]).

In the indigenous schema, food scarcity is a condition of cultural "disorder" that has its genesis in the curse that one warring ancestor castes upon another for perceived treachery. In cultural terms, the condition becomes inevitable and requires annual propitiation of the ancestor through ritual appeasement. The myth, consisting of ancestral deeds that include the settling of present territories, serves as a metaphor for the sacred relationship that exists between the Rai and the delimited territory they occupy. Traditional Kirati notions of ethnicity cannot be separated from this relationship and are symbolized by an ancestor stone that is situated in every village and propitiated in annual agricultural ceremonies (*ca:ri*).

What such a view of knowledge implies is that by granting legitimacy to cultural epistemologies, indigenous explanations for empirical categories are not subjugated by rationalist scientific explanations and thereby become an empowering element for farmer participation. Within such a context, the transfer of technical skills to enhance seed technology neither diminishes nor disempowers indigenous systems of meaning.

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Participatory Approaches to Crop Improvement at the Community Level in Vietnam

Nguyen Ngoc De

Abstract

Crop improvement has been one of the strong, continuous programs in the Mekong Delta for major crops, especially rice. However, most breeding programs have been set and designed by breeders, neglecting the role of users: farmers and farming communities. Farmers have been the passive users, receiving finished breeding lines/varieties for their production. The dissemination process of "technology transfer" has been very slow and costly for both breeders and farmers.

The use of participatory approaches in crop improvement have ensured the involvement of farmers in the whole process or, at least, in the evaluation process. This has resulted in a better understanding and acceptability of new crop varieties generated through the breeding program.

Can Tho University, as the leading research institution for adapting participatory approaches to rice improvement, started on-farm breeding programs as early as 1975, after the war, by sending out their staff and students to work closely with farmers on crop-improvement programs. In 1994, with the inception of the Community-Based Biodiversity Development and Conservation (CBDC) project, participatory plant- breeding (PPB) and participatory varietal-selection (PVS) approaches were introduced as methods to develop and identify crop varieties specific to niche environments and farmers' preferences.

These participatory approaches are also being used in one of the study sites, Tra Cu, of the global in situ conservation project implemented in Vietnam in collaboration with the International Plant Genetic Resources Institute (IPGRI). The result has been very positive, with many promising crop varieties selected from these programs and used in larger-scale production. Farmers have been successful in segregating material selection and many farmers have become well known through these activities.

Participatory approaches are very important for crop improvement at the community level in Vietnam. PPB and PVS approaches are the key tool for crop improvement. Successful results from farmer selections have strongly proven that these approaches are right. This experience has been very useful for national crop-improvement programs.

Introduction

Crop improvement has been one of the strong, continuous programs in the Mekong Delta for major crops, especially rice and beans. However, most breeding programs have been set and designed by breeders neglecting the role of users: farmers and farming communities. Breeders have set their own breeding objectives and conducted crop-improvement programs based on their own analysis of problems and on-station research findings (COWI 1999). At the end of their breeding programs, promising breeding materials are released to farmers as so-called "technology transfer." Farmers are passive users, receiving finished breeding lines/varieties for their production. In many cases, farmers, especially the poor, refuse to try new varieties because they do not want to take the risk. Resource-rich farmers are the first to try such varieties. Participation is limited to providing a piece of land to the breeders for on-farm trials. The dissemination process of "technology transfer" has been very slow and costly for both breeders and farmers. As a result, the adoption of recommended varieties, in many cases, has been very slow, doubtful, or has even failed. Local adoption of new technologies is dependent not only on technical suitability and economic viability but also on social

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acceptance. The use of participatory approaches in crop improvement assures farmers' involvement in the whole process or, at least, in the evaluation process. This has resulted in better understanding and greater acceptability of new crop varieties generated through breeding programs.

Can Tho University, as the leading research institution for adapting participatory approaches in rice improvement, started on-farm breeding programs as early as 1975, after the war, by sending out their staff and students to work closely with farmers on crop improvement programs (Xuan et al. 1993). In 1994, with the inception of the Community Biodiversity Development and Conservation (CBDC) project, participatory plant breeding (PPB) and participatory varietal selection (PVS) were introduced as methods to develop and identify crop varieties specific to niche environments and farmers' preferences (CBDC 1996, 1997).

Witcombe and Joshi (1996) defined PPB as involving farmers in selecting genotypes from genetically variable, segregating materials and PVS as involving the selection by farmers of nonsegregating materials, characterized as products from plant-breeding programs. However, they also agreed that PPB is a logical extension of PVS. In our view, PVS is only a lower level of PPB. PPB, therefore, should be understood in its broader meaning and implications as the involvement of farmers in the whole process of plant breeding, not only the selection of segregating and nonsegregating materials. Farmers can be involved at the very beginning, when strategies and objectives are set for plant breeding, in identifying parents, making crosses (of course with training from the formal sector), and selecting both segregating and nonsegregating materials. The experiences from the CBDC project in Southeast Asia have proven that point, especially in the Mekong Delta in Vietnam and in Bohol, Philippines, for rice (CBDC 1998).

These participatory approaches are also being used at one of the study sites, Tra Cu, of the global in situ conservation project implemented in Vietnam in collaboration with the International Plant Genetic Resources Institute (IPGRI).

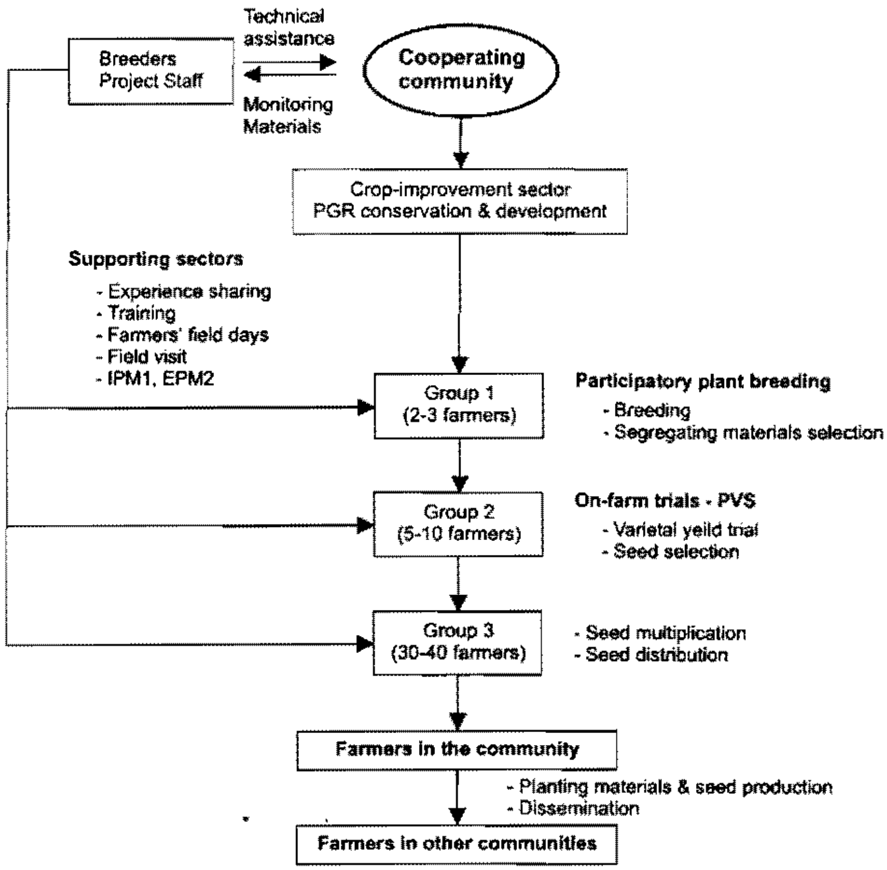
Methods used in participatory crop improvement

The participatory crop-improvement program uses PVS and/or PPB approaches, depending on farmers' varietal needs and their breeding knowledge and technical skills. The PVS approach has been used to improve local landraces and to evaluate the finished breeding materials, obtained from research institutions, on farmers' field. When varietal options available to farmers through PVS are limited or exhausted, PPB is initiated (CBDC 1998). Farmers with knowledge of and interest in breeding are involved in PPB activities, i.e., activities from crossing desired parent lines to selecting and evaluating the segregating genetic materials (De and Tin 1998). A flow diagram showing the methods used in participatory crop improvement is presented in figure 1. The methods used in implementing PPB and PVS are discussed below.

Methods used for PPB

Participatory plant breeding involves the following steps and activities.

Need assessment and selection of cooperating farmers. Community meetings are organized to identify farmers' problems and needs and to come up with suitable crop-improvement strategies and plans. A group of farmers (Group 1 farmers), with knowledge of and interest in breeding, are selected as cooperating farmers in consultation with the community. Breeding activities are then formulated and decided upon with these cooperating farmers.



Note: Group 1=Advanced farmers with good knowledge and skill in breeding.
Group 2=Farmers with good knowledge and skill in seed selection.
Group 3=Farmers with good knowledge and skill in seed production.
1. IPM=Integrated pest management.
2. EPM=Ecological pest management.

Figure 1.Community-based networking diagram for PPB and PVS

Setting breeding objectives and identifying donor parents. Breeders work closely with farmers to agree on breeding objectives. Farmers have been found to use both quantitative and qualitative criteria to determine these breeding objectives. Some of the examples of such criteria are high yield, short duration, resistance to major pests and diseases, stickiness of cooked rice, and so on. Based on the breeding objectives, breeders then assist farmers in searching for suitable donor parents for crossing. These donors may be found among the available genetic materials at the local level or from research institutions and are made available to the cooperating farmers.

Making crosses and selecting segregating materials. The Group 1 farmers are given additional training on crossing techniques and assisted in making the desired crosses. In other cases, breeders provide seeds of segregating lines at very early generations (F_2, F_3, and F_4) to the farmers for selection of desired lines based on their own criteria. Farmers have been found to handle segregating materials from generations as early as F_2. In the process, farmers apply their own crop-management practices. Based on breeding objectives, farmers observe, evaluate, and harvest the selected plants individually. This process is repeated until stable lines are obtained. For management reasons, the number of individual plants selected each season is limited, depending on farmers' capacity for seed handling and the land assigned as a breeding plot. Therefore, the genetic variation in farmers' selections is usually narrow. Only Group 1 farmers are involved in the selection process, while field operations are done with the help of other farmers in the community.

Observation test. Pure lines selected from the segregating materials are planted in observation test plots to check for adaptation and yield, with common local varieties used as local checks. Farmers compare the performance of new varieties/lines with the local check and select promising ones for further evaluation in yield trials by Group 2 farmers.

Monitoring. The Group 1 cooperating farmers take close field observations with technical assistance from breeders and agricultural extensionists. These farmers also keep records on field conditions and crop performance for later analysis in determining the suitability of the new crop varieties under selection.

Methods used for PVS

Participatory varietal selection involves the following steps and activities.

Need assessment and selection of cooperating farmers. As in PPB, community meetings are organized to identify farmers' problems and needs in relation to their current crop varieties. Farmers may want to improve their current varieties or change for promising new varieties. A separate group of farmers (Group 2 farmers), with good knowledge of and skills in seed selection and management, are also selected as cooperating farmers in consultation with the community. PVS activities are then formulated and decided upon with the cooperating farmers from both Group 1 and Group 2.

Provision of genetic materials and participatory selection. Three sources of genetic materials are used to obtain seeds for participatory selection of desired crop varieties:

- **PVS with improved local landraces.** The improvement of local landraces is done through mass as well as pure-line selection. Since the mass-selection method does not require very specialized skills, Group 2 farmers, after a simple orientation, have been able to undertake this selection. On the other hand, pure-line selection for crop improvement requires specialized skills and care on the part of the farmers. For this reason, only Group 1 farmers have been used to do pure-line selection, after adequate training and with intensive monitoring. The improved local landraces are then given to a large number of farmers within the community, as PVS materials, for their own testing and selection.
- **PVS with reintroduced local landraces.** PVS also reintroduces landraces from genebanks back to the community when local materials have been destroyed by disaster. Usually the collected local varieties from different locations within and outside of the community are evaluated in the community to give farmers more choices.
- **PVS with modern crop varieties.** Modern crop varieties from research institutions and finished products from PPB are also given to the cooperating farmers for testing their suitability under farmers' own management conditions and household requirements.

Yield trials of successful PVS varieties. The crop varieties preferred by farmers under the PVS program are then put into varietal yield trials in the community for farmers to observe directly and make selections of their choices. Common varieties in the community are used as local checks in these trials. Farmer field days are organized just before harvesting to bring farmers in the community to the trial plots for a joint evaluation of the tested varieties. Desirable varieties (usually two to three varieties) are then selected for seed multiplication.

Seed multiplication. Varieties selected by farmers from yield trials are distributed to a group of farmers (Group 3 farmers), with considerable knowledge of and interest in seed production, to multiply large quantities of seeds for use by other farmers in the community. Seed multiplication fields are closely monitored and used as final checks for large-scale production.

Monitoring. Field visits and farmer field days are the most appropriate tools for participatory monitoring and evaluation of PVS activities. Breeders, field staff, extension workers, and farmers participate in such activities. Data collection depends on farmers' objectives and includes common traits such as growth duration, plant height, tillering capacity, grain yield and quality, and tolerance to insects and diseases.

Field experiences with rice

Participatory varietal selection (PVS)

Rice is the major food crop in the Mekong Delta. PVS activities on rice have been undertaken in different forms in the Mekong Delta starting as early as the 1970s. The most common of these activities was varietal yield trials. The main objectives of the varietal yield trials were to generate farmer-preferred crop varieties and faster dissemination of these varieties. Can Tho University has been a leading research institution in initiating and implementing on-farm research activities. In the beginning, breeders and researchers cooperated with advanced farmers individually throughout the Mekong Delta (De 1997).

During the period 1975–1995, hundreds of promising rice varieties were tested in farmers' fields, and a number of varieties were identified and released. Some of these rice varieties are IR36 (later named NN3A), HT6 (NN6A), MTL30 (NN7A), HT19 (NN2B), IR42 (NN4B), MTL58 IR13240-108-2-2-3), and MTL87 (IR50404-57-2-2-3). These varieties have made great contributions to the improvement of rice production in the Mekong Delta. Many farmers, such as Mr. Hai Huu (Long An province); Mr. Hai Chung, Mr. Tu Tai, Mr. Ba Chuong (Tien Giang province); Mr. Ba Cung (An Giang province); Mr. Muoi Tuoc, Mr. Muoi Than Nong (Vinh Long province); and some others, were known as the "rice-selection kings." Farmers were also found to use pure-line selection to improve the formally released varieties for grain quality and adaptation to specific conditions in their areas. This process has, in fact, strengthened on-farm conservation of crop diversity.

Later, since 1994, with the inception of the Community Biodiversity Development and Conservation (CBDC) project, PPB and PVS have been included in their current form in the crop-improvement program. There has been a shift from dealing with advanced, individual farmers to farmer groups and farming communities (CBDC 1998). As a result, more farmers have been involved, the degree of participation has improved, and more work has been organized at the grass-roots level by communities themselves with help from many local authorities. Four farming communities used as pioneers are Nhut Ninh community (Tan Tru district, Long An province), My Thanh community (Ba Tri district, Ben Tre province), Ke Sach community (Ke Sach district, Soc Trang province), and Long Thanh community (Vinh Loi district, Bac Lieu province). The results of PVS activities in these communities are presented in tables 1 and 2.

Table 1. Number of Rice Varieties Tested and Selected from PVS Activities at Four Communities in the Mekong Delta

		Nhut Ninh		My Thanh		Ke Sach		Long Thanh	
Year		Tested	Selected	Tested	Selected	Tested	Selected	Tested	Selected
1994	TR	252	8						
	DWR	20	6						
	MR	18	4						
	HYV	5	1			5	1	22	2
1995	TR	23	3						
	HYV		1	5	4	5	3	169	16
1996	TR		1						
	MR			22	1				
	HYV	9	9	34	9	89	—[1]	9	1
1997	TR	222	2						
	MR	7	Lost[2]	32	29			25	—[1]
	HYV			20	9	16	8	20	3
1998	MR	11						12	
	HYV	12	6	18	8	19	9	24	5

Source: CBDC (1998).
Note: TR= Traditional rice; DWR= Deep-water rice; MR= Medium rice; HYV= High-yielding rice (early).
1. No data available at the time of writing.
2. Due to a typhoon at the last stage of the trial, no result was possible.

Table 2. Common Varieties Selected from PVS Activities at Four Communities in the Mekong Delta

Rice varieties	Nhut Ninh	My Thanh	Ke Sach	Long Thanh
TR	Nep Thom, Tai Nguyen, Me Huong		Tai Nguyen	
MR		MTL83, MTL124		MTL83
HYV	IR49517, IR64, MTL156, 157, MTL159, 199	IR54883, S976B, MTL138, 205	MTL99, 101, MTL142, 157, MTL164, 190, MTL199, 201, MTL202	IR64, MTL138, MTL142, 147, MTL149, 150, MTL156, 157, MTL159, 199

Source: CBDC (1998).
Note: TR= Traditional rice; DWR= Deep-water rice; MR= Medium rice; HYV= High-yielding rice (early).

Participatory plant breeding (PPB)

In the 1996/97 dry season, the project decided to start providing segregating breeding materials from 63 F_2 populations of 12 crosses made by the Rice Research Department of Can Tho University for farmer selection in the four communities listed above (table 3). The names of these crosses are L245, L246, L247, L248, L249, L250, L251, L252, L253, L254, L255, and L256. Many farmers

Table 3. Number of Segregating Populations Distributed and Selected by Four Communities from PPB Activities in the Mekong Delta, by Year

Community	Number of populations selected by generation (F_2, F_3, F_4, F_5)				Farmers' selection
	F_2	F_3	F_4	F_5	
Nhut Ninh	13	13			
My Thanh	20	8	3	1	L246-10-1-B
Ke Sach	10	4	2	1	L246-7-3-B (SiC-1) L247-1-5-B (SiC-2)
Long Thanh	20	11			
Total	63	36	5	2	

were interested in selecting individual plants from segregating populations based on their own criteria and under their own management conditions. Some of the farmer-selected varieties are now stable lines and are being tested in yield trials.

L246-7-3-B, and L247-1-5-B, the two promising farmer selections and noted by farmers as SiC-1 (Soc Trang Selection, no. 1) and SiC-2 (Soc Trang Selection, no. 2) respectively, were purified by bulk selection method after F4. Farmers in Ke Sach community (Soc Trang province) are now multiplying it for distribution among themselves. Mr. Canh is the leader of this farmers' group who has led the selection activities in this community. Similarly, L246-10-1-B, a promising line selected by farmers in My Thanh community (Ba Tri district, Ben Tre province) is also now under yield test and seed multiplication.

Besides four communities the initially selected, the PPB and PVS programs were also expanded to include other advanced, individual farmers in the Mekong Delta. One of these was Mr. Hai Triem from An Giang province, who was well-known as "farmer of the era" and was awarded the Third Labour Medal by the central government for his contribution to rice improvement.

Problems and lessons

Problems

- The low educational level of the farmers means they require more training and the adoption of PPB is slow.
- Few farmers are interested in working with breeding and selecting segregating materials. Farmers are more willing to multiply promising varieties than to select from segregating materials or make crosses.
- The number of farmers collaborating in PPB is limited, especially in pedigree selection and selection of segregating material because these are time-consuming activities.
- Agricultural policy is more favorable to commercial production than tp conserving diversity.
- Due to the fast turnover of rice varieties by farmers (every three to four seasons), it is difficult to keep their interest and get their cooperation for the entire process of selecting segregating lines, which takes time to get results.

Lessons

- Support from local authorities and organizations in term of organization, management, additional funds, and facilitation is very important.
- Cooperation with groups and communities on PPB and PVS gives better results than working only with individual farmers.
- Farmers' field schools and farmers' field days for PPB and PVS are good ways to motivate the farmers' participation at the community level.
- Farmers conserve and maintain the diversity of plant genetic resources to meet their own needs for home consumption, marketing, and adaptation to local environments and farm resources.
- Biodiversity development should be considered on a temporal and spatial basis at the level of species, crop, and agroecosystem. PPB and PVS increase plant genetic resources at the level of the gene pool and not at the level of specific varieties.
- In situ and ex situ conservation and development are complementary.
- Biodiversity in the Mekong Delta is currently under pressure but integrated farming systems and diversification of plant genetic resources could help to correct the situation.

Participatory approaches are very important for crop improvement at the community level in Vietnam and are efficient ways of achieving crop improvement at this level. PPB and PVS are the key tools for this. Successful results from farmers' selections have proven that these are the right approaches, providing a very useful lesson for national crop improvement programs.

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Using Farmer Knowledge for Participatory Sweet-Potato Variety Selection in Garut, West Java, Indonesia

Caecilia Afra Widyastuti and Minantyorini

Abstract

This paper describes trials using sweet-potato germplasm from Irian Jaya, where sweet potatoes are a staple food in the highlands. During the collection of sweet-potato germplasm, farmers' knowledge of those sweet potatoes has also been collected. Farmers' knowledge about sweet potatoes in Irian Jaya will be used as a basis for this project and includes information on yields, the use of sweet potatoes as human food or feed for livestock, and the condition of the environment.

Varieties are selected on the basis of farmers' criteria, including market orientation and table consumption: skin color, flesh color, uniformity, and other criteria. The project is also collecting information on farmers' cultivation practices, such as using high ridges in the rainy season and reducing the leaves during the growing period, as well as how to choose healthy cuttings.

Methodology

The objective of this research is not only to get a high-yielding sweet potato that is adaptable in Garut, but also to get new variety/ies with the agronomic characteristics required by different user groups (i.e., farmers, traders, consumers).

The study was set up in the village of Desakolot, Cilawu District, Garut Regency of West Java Province in a rainfed field that had been used for brick making six years before and had remained fallow for five years. The year before the trials took place, the field was planted with yambean. One week prior to planting, 150 sacks of manure were applied in order to improve the soil. This is always done in this area, especially for land has been used for brick making. This field is typical of places where sweet potatoes are grown. The nearest field to this site is planted with corn, sweet potatoes, and ginger. This neighboring field was also used for brick making, and the vigor of the plants grown on it is good. Prior to establishing the field trials, planting materials were multiplied in Cibadak, Pacet, about 3.5 hours away from Garut, since it was very dry in Garut.

A total of 64 cultivars, including five checks (BISI83, SQ27, CIP-1, Jahe, and Keleneng) were tested (the last two of the checks are well-known local cultivars in the area). There were 36 hills per plot. The date of planting was 26 February 1998.

The experimental design is a randomized complete block with three replications. The size of individual plots is 1.6 m x 3.0 m. Spacing is 80 cm between rows and 15 cm to 18 cm between hills. Harvesting is done according to the farmers' schedules.

During the harvest, we invited farmers, traders, and extensionists to select sweet potatoes based on their criteria. By using participatory tools such as flags, they walked around the trial field and chose what they liked. After that they ranked the selected varieties based on production, skin and flesh color, uniformity, skin smoothness, and general acceptance (table 1). Figure 1 shows participants ranking the selected varieties.

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Table 1. Selection Criteria and Rank of Sweet-Potato Varieties

Rank of selection	Criteria of selection	Results (in order)
I	Production	Kinta, Toweko, Lemekuara, Umakmbi, Pipombi
II	Skin color	Toweko, Pipombi, Lemekuara, Umakmbi, Kinta
III	Root shape	Umakmbi,Toweko, Kinta, Pipombi, Lemekuara
IV	Flesh color	Toweko, Umakmbi, Lemekuara, Kinta, Pipombi
V	Uniformity (shape and size)	Umakmbi, Toweko, Pipombi, Lemekuara, Kinta
VI	Skin smoothness	Toweko, Pipombi, Lemekuara, Kinta, Umakmbi
VII	General acceptance	Toweko, Umakmbi, Lemekuara, Pipombi, Kinta

Figure 1. Farmers, traders, and extensionists ranking selected sweet potatoes

Results and discussion

The experimental field was harvested on 22 August 1998, according to the farmers' schedule. No check varieties were select by farmers—not even Racik, the most popular local cultivar. Five new cultivars, i.e., W0139 (Toweko), W0331 (Kinta), W0111 (Umakmbi), W0113 (Lemekuara), and W0109B (Pipombi), were selected by the farmers, traders, and consumers (table 2). Toweko appears to be the most preferred cultivar in this area.

Farmers in Desakolot plant sweet potatoes for commercial purposes. They have several requirements, such as high yield, smoothness of skin, skin and flesh color, uniformity in shape and size, and root shape.

High yield is one important requirement for commercial purposes. The idea of "high yield" includes early maturation. Farmers prefer to plant sweet potatoes that with a high yield but they also require other criteria such as smooth skin, good skin and flesh color, etc. Table 2 shows that *Kinta,*

Table 2. Farmers' Selections from the Irian Jaya Sweet-Potato Trial

No	Accession No.	Local name	Production	Skin color	Root shape	Flesh color	Uniformity (shape and size)	Skin smoothness	General acceptance
1	W0139	Toweko	****	*****	****	*****	****	*****	*****
2	W0331	Kinta	*****	*	***	**	*	**	*
3	W0111	Umakmbi	**	**	*****	****	*****	*	****
4	W0113	Lemekuwara	***	***	*	***	**	***	***
5	W0109B	Pipombi	*	****	**	*	***	****	**

Note: Ranking is indicated on a scale from 1 to 5, where ***** indicates highly acceptable and * indicates low acceptability.

which had the highest yield was given low acceptance overall because it did not have acceptable skin color, uniformity, or skin smoothness.

Smooth skin color refers to skin that has not been damaged by weevils or nematodes and that exhibits no cracking. Skin should be thick enough to withstand peeling during transportation and to be resistant to weevils or nematodes. The smoothness of the skin has a considerable effect on the price of sweet potatoes.

Farmers always refer to good-tasting sweet potatoes as *ubi ketan* (sticky sweet potatoes) if they see a sweet potato with purple flesh. According to them, these sweet potatoes get a good price.

Toweko (W0139) was given eight flags because it meets the criteria of high yield, good skin color, uniformity in shape and size, good flesh color (dark yellow), and is suitable for fresh consumption and for snack food (*keremes*). According to farmers, the minimum price for Toweko should not be less than Rp 500. After tasting the raw *Toweko*, the farmers predicted that this cultivar would be well received in the market. The participating farmer wanted to plant Toweko 30% in the first season and increase it to 50% for the next season. They said they would plant 100% if the market could absorb that much. Two participating farmers, Haji Sumarna and Amin, will be responsible for multiplying this sweet potato as a source of planting material.

Umakmbi (W0111) was chosen with four flags because the skin is very smooth and thick, meaning it could resist weevil attacks. The flesh color is dark purple, meaning it will taste good (*ubi ketan*—sticky sweet potato), and the roots are very uniform in shape and size. With these criteria, the farmers predicted that this sweet potato would command a good price in the market. According to the farmers, they can increase the production of this variety. Farmer Unang will be responsible for multiplying this sweet potato as a source of planting material.

Kinta (W0331) was given six flags because of its high yield and purple flesh, meaning it will taste good (*ubi ketan*—sticky sweet potato). The skin is very smooth, with no evidence of nematode attack. Farmer Agus will be responsible for multiplying this sweet potato as a source of planting material.

Lemekuwara (W0113) was chosen with two flags because of its rounded shape and smooth, red skin, which mean it will be easier to sell in the market. Farmers chose this from replication III, which indicated high production. Farmer Eman will be responsible for multiplying this sweet potato as a source of planting material.

Pipombi (W0109B) was chosen with eight flags because the size is uniform, it has smooth skin color, and it can be sold fresh. Farmer Encek will be responsible for multiplying this sweet potato as a source of planting material.

Conclusions

Based on our experiences with this trial, we have formed the following conclusions:

- Using farmers' knowledge about sweet potatoes from Irian Jaya will help researchers to do preliminary selections for the trial.
- The participation of farmers in the area where the trial was set up will help in selecting sweet potatoes based on farmers' criteria, such as marketability and table consumption.
- Farmers selected sweet potatoes based on their marketability and farmers' own criteria.

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Table 3. Yield of Varieties Tested and Farmers' Ranking for Marketability

			Yield (Ton/Ha)							
			Marketable				Not marketable			
No	Accession No	Cultivar	I	II	III	X	I	II	III	X
1	W0131	Bon	0.56	0.14	1.94	0.88	1.81	1.67	0.83	1.44
2	W0194	Yaronambiri	5.83	12.5	8.47	8.93	2.36	1.39	2.92	2.22
3	W0116	Helalekue	7.08	7.08	7.22	7.13	2.92	1.11	1.94	1.99
4	W0113	Lemekuara	2.36	7.78	9.44	6.53	1.11	1.25	2.36	4.72
5	W0323	Womin	4.44	9.17	7.36	6.99	1.94	1.53	4.03	2.50
6	W0045	Poniai	5.00	6.39	6.25	5.88	2.08	2.36	1.67	2.04
7	W0061	Tinta kuning	6.81	3.61	5.00	5.14	0.14	0.69	0.97	0.60
8	W0049	Senggol	2.92	1.39	1.67	1.99	0.28	0.56	1.39	0.74
9	W0033	Sengkerengke	5.14	8.06	3.06	5.42	1.81	1.94	3.19	2.31
10	W0350	Iloka	11.11	12.22	7.50	10.28	1.11	1.25	0.97	1.11
11	W0104	Gelakue	2.36	3.61	0.28	2.08	2.08	1.39	1.67	1.71
12	W0158	Musanaken baru	15.14	10.28	2.50	9.31	5.42	3.19	3.19	3.93
13	W0220 B	Helalekue lama B	—	—	1.11	0.37	—	—	0.69	0.23
14	W0220 A	Helalekue lama A	1.25	4.44	3.47	3.05	0.14	—	0.28	0.14
15	W0008	Esipalek	—	—	0.83	0.28	—	—	0.28	0.09
16	W0124	Naulupe	5.83	11.39	5.14	7.45	2.22	0.83	1.94	1.67
17	W0204	Korwambi	—	0.69	—	0.23	0.42	—	0.14	0.19
18	W0181	Walegein	2.50	2.36	0.83	1.90	2.50	0.69	0.97	1.39
19	W0084	Kuruparambi	3.61	4.44	1.67	3.24	2.22	0.97	0.97	1.39
20	W0187	Mugulele	3.06	4.03	2.64	3.24	1.67	3.19	3.61	2.82
21	W0048	Giniagalo	7.78	5.14	3.06	5.33	1.39	0.56	0.56	0.84
22	W0139	Toweko	12.08	8.33	10.28	10.23	2.22	2.22	2.50	2.31
23	W0130	Siknimbi	4.58	7.92	1.25	4.58	0.83	0.97	1.11	0.97
24	W0197	Mukolele	5.56	4.31	3.89	4.59	1.94	2.78	2.64	2.45
25	W0223	Umakmbi	6.25	10.00	5.56	7.27	1.94	1.53	0.97	1.48
26	W0111	Umakmbi	8.19	3.33	6.25	5.92	2.22	2.22	1.81	2.08
27	W0316	Ketfelale	5.00	5.00	9.44	6.48	0.97	1.11	2.36	1.48
28	W0018	Mailongge	17.08	10.83	12.22	13.38	0.69	1.53	0.97	1.06
29	W0300	Musan	9.03	3.75	6.53	6.44	1.53	2.22	1.94	1.90
30	W0201	Gilikue	0.56	12.22	—	4.26	0.14	—	—	0.05
31	W0331	Kinta	13.19	12.22	8.61	11.34	1.67	2.22	1.81	1.90
32	W0339	Kuning	10.97	5.69	9.17	8.61	1.53	2.78	0.97	1.76
33	W0253	Yoban	4.58	4.72	5.28	4.86	1.39	2.22	1.67	1.76
34	W0041	Pusemangken	0.42	—	1.53	0.65	0.83	—	1.39	0.74

Table 3. Yield of Varieties Tested and Farmers' Ranking for Marketability (Continued)

			Yield (Ton/Ha)							
			Marketable				Not marketable			
No	Accession No	Cultivar	I	II	III	X	I	II	III	X
35	W0010	Musan	2.50	—	2.22	1.57	1.67	0.56	1.94	1.39
36	W0184	Lia-lia	8.19	9.17	7.36	8.24	2.08	2.50	2.92	2.50
37	W0125	Linggoara	4.31	1.67	1.67	2.55	0.56	1.39	0.83	0.93
38	W0241	Sahoma	11.25	8.33	10.28	9.95	1.25	1.81	0.69	1.25
39	W0280	Tuwembi	8.75	8.33	9.17	8.75	1.94	2.64	2.36	2.31
40	W0014	Kentang	7.36	8.89	4.31	6.85	1.53	1.53	1.67	1.58
41	W0141	Gelakue Putih	2.92	6.53	2.22	3.89	1.94	2.22	0.97	1.71
42	W0021	Kila	1.25	1.94	—	1.06	1.53	2.92	0.28	1.58
43	W0227	Kentang	0.83	2.50	0.97	1.43	1.11	0.56	0.97	0.88
44	W0109	Pipombi	3.06	3.47	0.28	2.27	2.92	0.97	0.69	1.53
45	W0109 B	Pipombi B	1.25	4.44	3.06	2.92	0.69	1.39	2.36	1.48
46	W0220	Helalekue Lama	5.69	9.86	5.14	6.90	4.17	2.78	1.53	2.83
47	W0134	Nasimbi	1.39	2.78	4.86	3.01	1.25	1.11	3.19	1.85
48	W0156	Soepak Baru	4.17	4.31	10.28	6.25	3.61	0.56	4.03	2.73
49	W0206 B	Andelan B	4.72	0.56	0.42	1.90	1.53	0.97	1.11	1.20
50	W0206 C	Andelan C	1.67	1.25	1.25	1.39	1.11	0.42	0.69	0.74
51	W0167	Anewun	0.83	—	—	0.28	0.56	0.28	0.42	0.42
52	W0108	Tabimbi	4.03	5.69	5.28	5.00	0.83	0.14	1.11	0.69
53	W0005	Hoboak	8.19	2.22	6.53	5.65	0.97	0.83	1.25	1.02
54	W0206 D	Andelan D	3.61	1.11	2.92	2.55	0.97	0.97	2.22	1.39
55	W0260	Mikmak	7.64	8.75	14.72	10.37	1.94	1.25	2.64	1.94
56	W0055	Mikmak	4.31	7.22	7.78	6.44	1.39	0.83	1.94	1.39
57	W0002	Mikmak	6.81	0.83	10.97	6.20	1.67	0.14	0.97	0.93
58	W0017	Wortel	6.81	4.86	1.53	4.40	1.81	0.97	1.94	1.57
59	W0039	Tinta Kuning	3.33	—	1.81	1.71	0.83	0.56	1.39	0.93
60		Bis 183	12.36	13.06	13.61	13.01	4.03	0.28	4.44	2.92
61		SQ 27	5.69	10.97	10.97	9.21	1.39	0.14	2.92	1.48
62		CIP-1	8.47	9.03	7.08	8.19	1.39	2.64	2.92	2.32
63		Jahe	1.94	9.31	9.31	6.85	1.81	2.22	1.25	1.76
64		Keleneng	2.78	4.17	8.19	5.05	1.25	1.39	4.58	2.41
65		Racik	6.11	0.42	8.33	4.95	5.42	4.58	3.33	4.44

Understanding Agroecological Domains: The Key to a Successful Participatory Plant Breeding Program

R.B. Rana, B.R. Sthapit, A. Subedi, D.K. Rijal, and P. Chaudhary

Abstract

Farmers have an intricate knowledge of their agroecological domains. The empirical evidences from Kachorwa (*terai*) and Begnas (mid-hill) sites in Nepal suggest that farmers distinguish domains for rice primarily on the basis of moisture and fertility. Farmers also differentiate the number, relative size, and specific characteristics of each domain within a given geographic area. Similarly, they allocate individual varieties/landraces to each domain, indicating that the competition between varieties/landraces occurs within the domain and that transgression of domain was rather limited. These deductions need to be verified at a wider level. A fuller understanding by researchers of specific agroecological domains is a prerequisite for them to contribute substantially in planning and executing effective participatory plant breeding (PPB) programs. Only with a sound knowledge of agroecological domains and the varietal distribution within domains can a program on diversity deployment and biodiversity conservation be effectively implemented. Likewise, justifying the cost-effectiveness of PPB, targeting research/extension activities, and measuring the contribution of PPB to food security demands a detailed understanding of agroecological domains. Simple and practical ways to illicit information on agroecological domains and associated varieties/landraces through farmers' group discussion at the village level have been suggested as a pre-project activity for PPB, which could enhance the success of PPB programs.

Introduction

The importance of agroecological domains can be found in earlier work on defining and delineating recommendation domains (RDs), which is closely associated with the farming systems research of the late 1970s (Wotowiec, Poats, and Hildebrand 1986). Initial work on RDs concentrated on a few relatively easily identifiable factors (biological variables), such as land and soil types, agro ecological zones, and crop types and management (Harrington and Tripp 1985). The exercise on RD was highly complex since the process was to identify farming households, based on the similarity in their practices, rather than farms. But the delineation of agroecological domains was much less cumbersome with rice because rice is very sensitive to changes in agroecological conditions and its adaptation is limited, as compared to some other crops such as maize. Moreover, rice is the most important cereal crop in the region, so farmers have an in-depth knowledge of rice-growing environments and varieties suitable to different agroecological domains.

The current endeavor on refining the definition of agroecological domains for rice in parts of Nepal is the case of "sharpening the focus" for better targeting of participatory plant breeding (PPB) work, including diversity deployment, conservation of landraces in different domains, and planning strategic crop management research. The methodology adopted is quite simple and can be replicated in other areas for wider use by the researchers and development workers.

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Farmers define and characterize agroecological domains

Field exercises for delineating agroecological domains have largely been influenced by the methodologies on RDs advocated by Collinson (1980), Franzel (1985), and Vaidya and Floyd (1997). They emphasized the use of secondary sources of information, followed by preliminary surveys supplemented later by a formal survey to refine the domains. However, later views on the subject hold that the refining process should take place only after researchers have a clear understanding of the variability inherent in the local farming systems (Cornick and Alberti 1985). The current study embodies the thoughts from both the methodologies for delineating domains and associated rice landraces/varieties.

In the process of delineating agroecological domains, two group meetings were organized in the Kachorwa and Begnas eco-sites. The first meeting was held with field-based staff; the second, with farmers from the project area. This was followed by a transect walk by researchers and farmer representatives to jointly validate farmers' statements. The exercise took about two days, including field visits in each site.

Interactions with field-based staff

Since field-based staff are stationed in villages, it was expected that they would have a fairly good understanding of the agroecological domains and the farming systems of their respective eco-sites. Hence, the first level of group discussions was organized in field offices, with the field officer, technical assistants, and motivators participating.

After discussions, the participants were able to come up with four major agroecological domains, mainly defined on the basis of water regimes. They also broadly classified the soil type and fertility status of soils from each domain, based on scientific knowledge of soil classification and characterization. Participants were also asked to estimate the size of each domain and place different landraces/varieties in their right domains. Estimating the relative size of each domain was straightforward because the *pokhari/man* occupied only a limited area within the eco-site. But placing each landrace/variety in its right domain proved more difficult. The team could place the majority of landraces/varieties in their domains, but the number of landraces/varieties per eco-site was too large for them to remember all the names and their right environments. The process was also complicated by the fact that some of the landraces/varieties are grown in more than one domain.

The whole process was reviewed by the participants, and once they were satisfied with the steps and outputs, the field officer was asked to facilitate the same process for the farmers' group discussion.

Group discussion with farmers

A group discussion was held with farmers with the specific objective of delineating agroecological domains. Field officers/site coordinators facilitated the discussion and the whole exercise was repeated with farmers' groups. Both female and male farmers participated in the discussion and put forward their opinions.

Farmers identified four agroecological domains within the eco-site (*ucha, samtal, nicha/khalar,* and *pokhari/man*), based on the major criteria of moisture regime and fertility status/gradient (tables 1 and 2). They could easily identify the relative size of each domain, but there were disagreements among about soil classification. Perhaps this reflected the variability of the soil types and soil fertility status in each domain. Placing landraces/variety in the domains initiated a lively

Table 1. Agroecological Domains at Kachorwa Eco-Site

Domain	Soil type	Production potential	Cultivated landraces/varieties
Ucha (bhadaiya rice cultivated on availability of water, good winter crops)	Balaute = sandy (ujar = whitish)	Low (III)	Mutmur, Sotwa, Sokan, Saro... No modern varieties grown.
Samtal (Good crop of bhadaiya rice and winter crops, aaghani rice can be grown)	Domat = Loam Balaute domat = sandy loam (whitish and brown)	High (I)	Lalka farm, Nakhi saro, Sathi, Bhadaiya Basmati, Khera, Aanga, Ujala faram, Sotwa, Sokan, Dudhi saro, Kamod, Madhumala, Basmati, Karma ... (China 4, Philips, Jiri, TV, Chandina, Sabetri...) – Modern varieties
Nicha/Khalar (Good crop of aaghani rice and medium winter crops)	Matiyar = Clay? (Piyar = Yellowish)	High (II)	Basmati, Lajhi, Mansara, Karma, Batsar, Rat rani, Faram, Kamod, Madhumala (Mansula, Sabetri, Pankaj, Nat masula, Jaya, K. Mansuli...) –Modern varieties
Pokhari/Man (can only grow aaghani rice)	Matiyar = Clay? (kalo/kariya = black)	Low (IV)	Bhati, Megraj, Silahout... No modern varieties grown.

Source: Chaudhary (2000).

Table 2. Agroecological Domains at Begnas Eco-Site

Domains	Size of domain	Productivity	Cultivated landraces/varieties
Mule khet/Bhale khet/Khule khet	I	I	Kalo Jhinuwa, Pahenlo Jhinuwa, Jhinuwa, Lamcho Jhuluwa, Sato Jhinuwa, Masino Dhaba, Jhinuwa, Adhari Jhinuwa, Lahora Gurdi,Thulo Gurdi, Seto Gurdi, Sano Lahara, Kalo Gurdi, Sano Gurdi, Gurdi,Thulo Kalo Gurdi, Bayarni, Kalo Bayarni, Seto Bayarani, Gajale Bayarni, Juge Bayarni, Seto Anadi, Rato Anadi, Sano Anadi, Dudhe Anadi, Madhese Thulo Madhese, Sano Madhese, Naulo Madhese, Dhaba Jameli, Ramani, Aapjhuta, Sano Aapjhunta, Gauwari Aakla, Sethobhudo, Rato Krishnabhog, Bhara Thapachine, Bale, Dhaba Gauwari, Masino Battisara, Kannasina, Pani Barmeli
Sim/Gaire khet	IV	II	Kalo Jhinuwa, Pahenlo Jhinuwa, Jhinuwa, Lamcho Jhinuwa, Seto Jhinuwa, Masino Jhinuwa, Tarkaya Jhinuwa, Jhugainiua, Masino Dhaba Jhinuwa, Adhani Jhinuwa, Lahara Gurdi, Thulo Gurdi, Seto Gurdi, Sano Lahara, Gajale Gurdi, Sano Gurdi, Gurdi, Thulo, Kalo Gurdi, Bayarni, Kalo Bayarni, Seto Bayarni, Gajele Bayarni, Juga Bayarni, Seto Anadi, Rato Anadi, Sano Anadi, Dudhe Anadi, Madhese Thulo Madhese, Sano Madhese, Naulo Madhese, Dhaba Jameli, Ramni, Kartike Marsi, Pahenle Marsi, Sero Marsi, Chiniya Marsi, Aapjhuta, Sano Aapjhuta,Gauwari Aakla, Naithuma Brimphul, Basmati, Chobo, Palungtare, Jyagdikhole Rato, Krishnabhog, Thapa Chine, Bale, Makikhola, Dhaba Gauwari Barmali, Zadan Masino, Battisara, Karna Jira, Pani Barmeli
Tari/Kharkheri /Tapu	II	III	Eida Jhinuwa, Phaka Jhinuwa, Kanta Gurdi, Pakha Jameli, Thuda, Pakha Thuda, Pakha Gaujari, Manamuri, Rato, Bhote, Makhi khola, Choto
Pakho tari	III	IV	Pakho Jhinuwa, Katna Gurdi, Mansara, Aagha

Source: PRA (2000).

debate among the members. However, they were able to agree upon the major domains for each landrace/variety. They also reported that some of the landraces/varieties were grown in more than one domain but the cases were limited.

In Kachorwa, of the four domains identified by the farmers, two—*ucha* and *pokhari/man*—were extreme cases (dry land and rainfed; wet-land conditions, respectively). No modern varieties were grown in these areas. Only landraces were found growing under such conditions, and the number of landraces (cultivars) was relatively small compared to other domains. *Samtal* and *nicha* represented better growing environments, with a greater number of landraces and modern varieties growing there. *Samtal* represented the major domain in terms of area. There was considerable area under *uccha* but not much area was under *nicha* and *pokahri*. Several landraces and modern varieties (MVs) were common to both *samtal* and *nicha*. These two domains were more productive in terms of crop production as well.

Similar results were found when the exercise was repeated in the Begnas eco-site under mid-hill conditions. However, the domain delineation was less clear-cut than it was in Kachorwa because several of the landraces and MVs were found in more than one domain. Here again, landraces/varieties were not repeated in more than two domains, and that in adjacent domains only. Jumping of domains by certain landraces/varieties was not observed in either of the exercises. Although several of the landraces and MVs were found in two domains, their performance was judged as best only in one domain. Based on the information generated from the discussion with farmers, it could be deduced that a landrace/variety fits best only in one domain. It exists in other domains because there is no competitive variety to replace it.

Transect walk with farmers for field verification

Having achieved a high degree of agreement between farmers and researchers in the definition of agroecological domains, it was decided to field-verify the definitions through a transect walk and to look for consistency in the field implementation. A representative group of farmers made a transect walk of the eco-site along with researchers. They identified domains and located landraces/varieties on different farms. The exercise helped in relating different agroecological domains and their characteristics with the landraces/varieties being grown there. Thus, this exercise needs to be conducted when the rice crop is mature or when the crop is standing in the field.

Development of conceptual model of agroecological domains for rice

Based on the analysis of the characteristics of different agroecological domains and the distribution of landraces/varieties within domains, an attempt to develop a conceptual model of agroecological domains for rice was made (figure 1). In the following subsections, the characteristic features of the domains have been explained. Nevertheless, the model needs verification in a larger context and further refinement for wider applicability.

Size and characteristics of domains

Local farmers can provide very reliable information on the agroecological domains for rice. Similarly, farmers can provide detailed features of each domain in terms of soil type, drainage, fertility status, production potential, cropping patterns, and so on.

The size of agroecological domains varies, with more extreme environments (domains) being relatively smaller as compared to more favorable ones. This follows normal distribution curve. How-

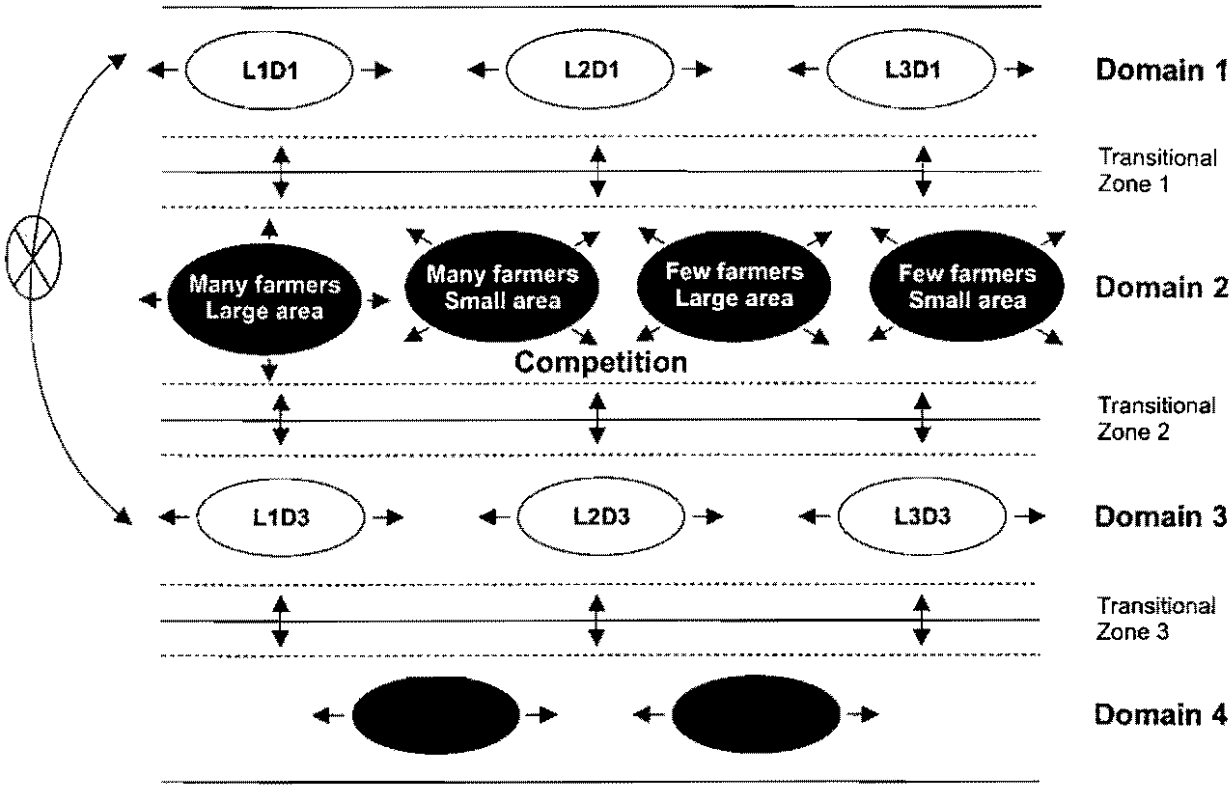

Figure 1. Conceptual model of agroecological domains

ever, depending upon the geographic location (high-potential production systems or marginal growing environments), the size of each domain will vary. For instance, in marginal environments for rice, the extreme domain will be relatively larger as compared to other domains; whereas, in favorable environments, the middle domains will be relatively larger.

Landraces/varieties distribution across domains

Until the distribution of landraces/varieties across domains, the features of domains, and the traits of cultivars are analyzed, one cannot appreciate the complexity of farmers' strategies to manage plant genetic resources to meet their multiple needs. From the analysis, it is apparent that one landrace/variety is best suited or most competitive in only one domain, though farmers might grow the same cultivar in more than one domain. This implies that the cultivar competes with other cultivars from within the domain, and that there is less competition between cultivars across domains, except when there is an overlap of cultivars. Overlap signifies the presence of transitional zones between domains, which explains the presence of landraces/varieties in two different but adjacent domains. Within domains, the area and number of households growing different landraces/varieties is explained by market forces, farmers' socioeconomic status, cultural factors, preferences for specific traits, and other abiotic and biotic factors.

Although landraces/varieties may overlap in adjacent domains, no case was registered where a landrace/variety was found in more than two domains. This suggests that landraces/varieties have very specific adaptations. In other words, it reinforces the idea that a cultivar is most competitive in only one domain.

Landraces/varieties falling within the same domain are more likely to be similar in their genetic composition as compared to landraces/varieties from dissimilar domains. The logic behind is that they have been put under similar management conditions have been selected over time for adaptation. However, this hypothesis needs to be proved from laboratory analysis of some of the samples from each domain. If it proves true, then there is a strong case, from a conservation point of view, for disaggregating genetic materials across agroecological domains. Nevertheless, this process still holds true where diversity deployment is the prime objective of the project.

Implications of agroecological domains for PPB

The distribution of landraces/varieties in different domains is the result of farmers' experimentation with those landraces/varieties over years. In other words, they are the "best fit" under farmers' management conditions. Therefore, researchers definitely need to know the characteristics of each domain, as well as the specific traits of the landraces/varieties in each domain and their distribution across domains in order to make any intervention in the present system. The analysis of agroecological domains is worth the money and time invested in collecting and analyzing the information.

Planning conservation strategies for landraces

Identifying landraces that are grown in small areas by a limited number of farmers and devising ways and means of conserving them might seem to be a straightforward task for conserving endangered landraces. Sometimes, weighted diversity, as well, might be computed for facilitating the decision-making process in choosing which landraces to focus on for conservation when there are numerous landraces falling in the endangered category. However, all these processes and steps consider the diversity of landraces at the aggregated/landscape (community) level and thus ignore the influence of agroecological domains in determining the position of landraces in different domains.

The need for micro-level analysis emerges from the fact that landraces are conditioned over years by their continued growth and selection over time in specific domains. As a result, they have developed adaptive traits, which are unique to landraces falling in that domain. Therefore, analysis of landrace diversity at the aggregated level fails to appreciate the position of landraces in specific domains, which in fact might be harboring genes of important traits. Selecting landraces from an aggregated list might exclude certain strategically important landraces from conservation.

PPB has been used as one means to conserve useful genes in landraces through crossing with modern varieties. However, there could be number of landraces within a domain that might require some form of conservation (through breeding and nonbreeding means). Understanding the features of domains and the distribution of landraces in them will facilitate decision making about selecting landraces for conservation. Failing to do this could result in selecting landraces with similar genetic traits for conservation (via PPB) from just one or two domains. This would lead to the neglect of some and overrepresentation of others.

Strategies for diversity deployment

Diversity deployment in simple term means "providing farmers with options of genetic materials to choose from." The introduction of new genetic material results in temporal disequilibrium because of competition between existing and new genetic material. The competition is for space in farmers' fields, for farm labor, for capital inputs, and so on. As time elapses, the new entrant finds its rightful place in the given environment. This is the outcome of farmers constantly trying to maintain an equilibrium (meeting farmers' objectives) in terms of stabilizing yield and production over time.

The strategy for diversity deployment must begin by analyzing the distribution of landraces/varieties across agroecological domains. Once this is done, researchers would have a clear picture of each domain, along with the distribution of landraces/varieties, and the dominance of certain cultivars against others would become evident. Researchers would also come to know the reasons for this dominance. Only then could they develop their strategy for diversity deployment. In the absence of this information, new genetic materials might fit into domains where there is not much competition. It could also happen that new genetic materials compete with each other landraces/varieties in similar domains, resulting in limited impact of diversity deployment.

Justifying PPB

The conflict between breeding varieties for wide adaptability or for niche environments will perhaps go on. (*Wide adaptability* means the domain for which the suitability of the landrace/variety is large. *Niche environment* means the domain for the given landrace/variety is limited.) In the truest sense, *wide adaptability* should encompass the ability of a cultivar to be grown in several different domains and vice versa for the niche environment. However, such is not the case.

Whatever the case, the proponents of PPB must bear in mind that the approach has to prove its worth in terms of churning out farmer-acceptable varieties efficiently on such a scale that the economic return on investment is positive. But this is possible only when researchers have a clear knowledge of the size and characteristics of the domains the new variety will fit into. In addition, they also need to know the likely existing cultivar to be replaced. Without this information, it would be rather difficult to estimate the potential adoption ceiling of PPB varieties, which implies that the estimation of economic returns at the household level is difficult. This will become an increasingly important issue in the future, when enough time has elapsed between the development and adoption/dissemination of PPB varieties and the evaluation of their impact.

Another important issue that can be addressed by analyzing agroecological domains is orienting PPB programs towards "poverty alleviation" and food security at the household level. Since resource-poor farmers mainly own marginal land, there is limited varietal choice. By conducting PPB programs using landraces from marginal environments, the chances of providing greater options in such environments is increased, which would contribute to food security, particularly in resource-poor households. Targeting PPB for equity of benefits for the resource-poor can also be justified along similar lines.

Conclusion

Agroecological delineation using key informants/farmers from the given community can be reliably done. The identified domains and the associated varieties in each domain have to be verified through a transect walk with the key informants. This exercise helps prioritize landraces/varieties in each domain based on the number of households growing them and the area covered. Using this information, a selection of landraces/varieties for PPB work could be made. Diversity deployment and conservation of certain landraces/varieties could also be planned using this information. The arguments presented here clearly indicate the need to focus PPB initiatives on marginal environments for which there are no MVs, and where, at the same time, the majority of the resource-poor dwell. This exercise has to be conducted prior to initiating PPB work in a given area. Information required to delineate agroecological domains and associated landraces/varieties can easily be gathered using key informants at the village level. It has been suggested that this exercise be incorporated as a component of PPB work.

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Listening to Farmers' Perceptions through Participatory Rice Varietal Selection: A Case Study in Villages in Eastern Uttar Pradesh, India

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Abstract

This paper presents a case study based on the findings in two villages in eastern Uttar Pradesh, India, part of a project started in 1997 to develop, test, and refine methodologies of participatory research and gender analysis as they apply to the development of new technologies in germplasm and natural resource management. The two villages occupy different agroecological areas and also differ in sociocultural characteristics. Both male and female farmers were included in the study, and details of their preferences for the rice varieties studied are presented in this paper.

Introduction

Decisions about the adoption of technology are conditional to farmers' perceptions of the performance of a new technology relative to that of the technology currently being practiced. Farmers may assess a new technology, such as an improved variety, in terms of a range of attributes, such as grain quality, straw yield, and input requirements, in addition to grain yield (Traxler and Byerlee 1993). In Orissa, eastern India, farmers indicated preference not only for the visual appearance of rice grain, but also for attributes such as cooking quality, taste, keeping quality, and straw quality (Kshirsagar, Pandey, and Bellon 1997). If farmers perceive an improved variety to be inferior to traditional varieties in terms of one or more attributes, they are unlikely to adopt such a variety (Adesina and Zinnah 1993, as cited by Kshirsagar, Pandey, and Bellon 1997). Crop improvement could potentially benefit from farmers' assessments of the relative performance of different varieties under farmer management. Information on the traits desired by farmers and their knowledge of the production system could be invaluable in setting the goals of a breeding program, delineating the target environment, identifying the parents for breeding and defining the management treatment for breeding work (Sperling et al. 1996; Eyzaguirre and Iwanaga 1996).

Varietal preferences may differ, not only between socioeconomic groups but also by gender. In a farmer-participatory breeding (FPB) project on pearl millet in the Jodhpur district, Rajasthan, India, grain yield, early availability of grain, and the ease of harvesting by hand (lower panicle number and lower plant height) were the main considerations for making selections by women. For the men, yield and quality appeared to be a stronger concern (Weltzien, Whitaker, and Anders 1996). While women have traditionally been seed selectors and managers of germplasm in low-input farming systems, scientists have not given enough attention to their local knowledge, criteria for selection, and perceptions regarding new seeds until recently. For instance, the criteria for selecting seeds, practices of animal care and food processing, and the consequent preferences for different kinds of blending various food materials are useful starting points for building on women's

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perspectives in participatory research (Gupta et al. 1996). Another example is when high labor demands for manual threshing may create incentives for women to adopt varieties that are easier to thresh (Adesina and Forson 1995). Including women in the early evaluation of varieties ensures that new seeds can be adopted rapidly. Thus, men's and women's criteria and preferences for rice varieties should be well understood and considered in plant-breeding strategies.

In March 1997, a farmer-participatory plant-breeding program for rainfed rice was developed at the International Rice Research Institute (IRRI) in collaboration with the Indian Council of Agricultural Research (ICAR). This project includes six research sites representing different rice ecosystems in eastern India. The project is under the umbrella of the CGIAR's Systemwide Initiative on Participatory Research and Gender Analysis. The goal of this initiative is to develop, test, and refine methodologies of participatory research and gender analysis as they apply to the development of new technologies in germplasm and natural resource management. This FPB project aims to test the hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently. It is also designed to identify the stages in a breeding program where farmer interfacing is optimal. The project has two components: the first is a plant-breeding component, which aims to develop and evaluate a methodology for participatory improvement of rice for heterogeneous environments, and to produce and improve adoption of material suiting farmers' needs. The second is a social-science component (including gender analysis) that aims (1) to characterize cropping systems, diversity of varieties grown, and the crop-management practices of rice farmers, (2) to analyze male and female farmers' selection criteria and their reactions to a range of cultivars and breeding lines, and (3) to enhance the capacities of national agricultural research systems (NARS) in participatory research and gender analysis in plant breeding and rice varietal selection (Courtois et al. 2000). This paper focuses on farmers' selection criteria and their reactions to a range of cultivars and breeding lines under participatory varietal selection conducted on farmers' fields.

Characteristics of the villages

The results of the socioeconomic and gender analysis in the FPB project includes only two villages (table 1): Mungeshpur in the Faizabad district and Basalatpur in the Siddathnagar district, eastern Uttar Pradesh. These sites are among the research sites under the FPB project. A similar study was conducted in the other FPB research sites in Orissa and Madhya Pradesh.

Basalatpur represents favorable (but submergence prone) lowland, rainfed areas. Mungeshpur represents shallow, submergence-prone areas that are favorably rainfed during years of low rainfall. Basalatpur and Mungeshpur have a higher proportion of lowland fields (70% and 60%, respectively) with heavier soil and good water-holding capacity. The flow of natural resources like rainwater (field hydrological conditions) throughout the season has also had a major impact on varietal selection in these villages. Farmers in Mungeshpur have more access to supplementary irrigation, which enables them to diversify into other crops, particularly vegetables and fodder crops. Only one diesel pump exists in Basalatpur and this limits crop diversification. The importance of livestock between the two villages also differs. Livestock in Mungeshpur is more important than in Basalatpur. In Mungeshpur, bullocks continue to be used for land preparation, and threshing is done manually. In contrast, land preparation and threshing in Basalatpur is mechanized with the use of tractors. The degree of market orientation is higher in Basalatpur (nearer the city) where more rice is sold.

Table 1. Village Characteristics, Basalatpur (Siddathnagar District) and Mungeshpur (Faizabad District), India, 1997

Agroecology	Basalatpur, Siddathnagar	Mungeshpur, Faizabad
	Favorable lowland	Shallow, submergence-prone, favorable rainfed during years of low rainfall
Total no. of households	140	133
Sample size for surveys	50	50
No. of male farmers	30	30
No. of female farmers	20	20
Land types (%)		
Lowland	70%	60%
Medium land	0	20%
Upland	30%	20%
Irrigation source (private pump)	1%	10%
Importance of livestock	Low	High
Degree of market orientation	High	Low

The socioeconomic characteristics of the sample households are shown in table 2. Households are classified by official social categories of caste. Muslims dominate in Basalatpur (55%), followed by scheduled and backward castes. In Mungeshpur, the backward and scheduled castes dominate (89%). The Yadavs, a subcaste of the backward caste in Mungeshpur, take care of milch animals. The majority of the farming households are owner-cultivators, and share cropping is of limited importance. Female labor participation in rice production is four times higher than that of males in Basalatpur and three-fourths in Mungesphur. There is wide disparity in terms of access to education between men and women. In general, females have lower literacy rates than men. The differences in resource endowments, socioeconomic status, importance of livestock, degree of market orientation, gender roles and responsibilities in rice production, and family size may determine the choice of rice varieties/cultivars and agronomic management practices.

Cropping systems

Rice followed by wheat + mustard is the predominant cropping pattern in all villages. In Basalatpur, wheat and oilseed are grown mainly for domestic use, but rice is grown for consumption as well as marketing. On the other hand, in Mungeshpur, rice is mainly grown for consumption because of low yields and low marketable surplus. Rice is followed by wheat + mustard, which are grown for both domestic consumption and sale. Land preparation for rice is started in June after the arrival of the monsoon. Transplanting and broadcasting are done in July; weeding, in August; and harvesting and threshing, in October to December. During the *rabi* (dry) season from November to April, crops such as wheat + mustard, peas, grams, lentils, *berseem* as green fodder, and vegetables are grown. A few farmers, who have their own irrigation sources, grow crops like mung, maize, vegetables, and green fodder during the *zaid* season (late April to June) in Mungeshpur. Growing crops during the *rabi* and *zaid* seasons is not common in Basalatpur because of the lack of irrigation facilities.

Table 2. Socioeconomic Characteristics of Sample Households, 1997

Characteristics	Basalatpur, Siddathnagar	Mungeshpur, Faizabad
Caste composition (% of households)		
Upper caste	6%	9%
Backward caste	18%	49%
Scheduled caste	21%	42%
Minority	55%	0
Area by tenure (% of households))		
Share-in	3%	0
Share-out	0	1%
Owner-cultivated	97%	99%
Labor inputs in rice (days/ha)		
Male farmers	25 days/ha (19)	45 days/ha (25)
Female farmers	105 days/ha (81)	130 days/ha (75)
Categories of farmers (%)		
Marginal (<1 ha)	68%	80%
Small (1–2 ha)	24%	16%
Large (>2 ha)	8%	4%
Ave. operational size	1.00 ha	0.70 ha
Literacy rates (%)		
Male head	72%	51%
Female head	40%	14%
Average family size	7	7

Note: Figures in parentheses are percentages of total male and female labor inputs in rice production.

The gender division of labor in rice production

The majority of the respondents belong to the lower social class, with small-sized landholdings. Females are younger and have lower literacy rates, compared to males, and have over 20 years of farming experience. The extent of female participation in rice production is high in both villages. Some tasks in rice production and postharvest operations are gender specific. Land preparation and the application of chemicals are men's responsibilities in both villages (10% of fertilizer application is done by women in Basalatpur). In Mungeshpur, women from the lower social status dominate in the work of pulling seedlings (100%), transplanting (70%), weeding (80%), applying farmyard manure (60%), harvesting (82%), and threshing (82%). In Basalatpur, more men than women participate in pulling seedlings and harvesting. Women do the transplanting of seedlings (100%) and most of the weeding (75%), with men doing most of the spraying (90%). Women are also mainly responsible for postharvest activities such as cleaning and selecting the seeds for the next season, storage, and processing rice into other food products for home consumption and for sale. They are the primary end-users of rice byproducts and biomass for livestock and other farm use. A village study in eastern India revealed that women from the lower castes provided 60% to 80% of the total labor input in rice production (Paris et al. 1996). Aside from their significant contributions in rice production, women also provide labor in non-rice crops, collect green animal fodder, and feed and tend livestock. Thus, men's and women's preferences for specific traits in rice varieties may differ, based on gender-specific roles and responsibilities. With increasing male migration to cities, women are taking on more responsibilities as farm managers, aside from their normal household and childcare responsibilities (Paris et al. 1996).

Rice varieties

Varieties grown by farmers

The rice varieties currently grown by farmers are shown in table 3. Traditional varieties are more common in Basalatpur than in Mungeshpur. Although modern varieties (MVs) show higher adoption rates in Mungeshpur, these varieties often suffer from submergence, drought, and stress at reproductive and ripening phases when the crop is planted late. Most farmers felt that traditional varieties are more tolerant to drought, submergence, pests, and diseases, while MVs performed well under irrigated conditions. The majority of the farmers indicated that they felt that MVs needed better management than traditional varieties. Modern varieties need more labor, higher levels of fertilizer, and more irrigation, but more farmers prefer to grow MVs because of their higher yields.

Table 3. Popular Rice Varieties Grown by Farmers According to Land Type

Land type	Variety	Basalatpur	Mungeshpur
Upland/midland	Traditional	Bengalia, Sarya, Kuwari Mashuri, Oriswa, Malwa	Ari, Bagri, Balbagra, Chaini
	Improved	NDR-97, Sarju-52, PNR-381	Saket-4, NDR-80, 97, 118 NDR-359, Pant-4, Pant-10, Pant-12, Sarju-52
Shallow lowland/lowland	Traditional	Kalamanak, Motibaddam, Malwa, Malasia	Bilaspuri, Indrasan
	Improved	Mashuri, Rajshree, Sambha Mashuri	Mashuri, Madhu, BKP-246, Dwarf Mashuri

Topographical adaptations

Farmers generally match varieties with their environment. For rainfed rice, this means an adaptation to the hydrological conditions of their fields. Each field position in the topo-sequence corresponds to a risk of drought or submergence. The drought risk increases from the bottom to the top of the topo-sequence, while submergence risk decreases along the same path, associated with progressively lower water depths and earlier recession of the water. This translates into different ideotypes for the different situations. Table 4 shows varietal diversity according to land type/topography. In Basalatpur, varieties such as *Bengalia, Sarya, Oriswa, Kuwari Mashuri, Malwa,* and *Ghanbhanan* are the major traditional rice cultivars grown in the uplands, and *Kalamanak, Malasia, Motibaddam,* and *Malwa* are the major varieties grown in the lowlands. Improved varieties, such as NDR-97, PNR-381, and Sarju 52 are grown in the uplands by a few farmers, but the improved variety, Mashuri, occupied more area in the lowlands. In Mungeshpur, the common local varieties grown on upland fields are *Ari, Bagri,* 90 days, *Sonia, Lalmati, Punjab, Lalbagra, Ashwani, Indrasan,* and *Bilaspuri.* The improved varieties are Saket-4, NDR-80, and NDR-118 in upland and medium fields and Sarju 52, Mashuri, and dwarf Mashuri mostly in lowland fields.

Table 4. Farmers' Perceptions of Useful Traits in Selecting Rice Varieties According to Land Type

	Mungeshpur							
	Upland		Lowland		Upland		Lowland	
Traits	Male	Female	Male	Female	Male	Female	Male	Female
Grain yield	**36.67**	**39.50**	**48.67**	**49.67**	**41.67**	**35.96**	**42.06**	**40.45**
Duration	**25.83**	**34.50**	0.67	1.00	**20.56**	**25.84**	**20.56**	**15.00**
Grain price	0.00	0.00	**15.67**	**16.00**	1.67	2.81	2.97	1.82
Resistance to abiotic stress	**8.33**	**6.70**	0.67	0.33	**6.10**	**6.18**	5.10	5.00
Biomass quality	3.33	2.50	**5.33**	**4.67**	**5.00**	2.25	**5.52**	**8.64**
Taste	1.67	0.50	**10.33**	**12.33**	2.78	2.81	2.12	3.18
Bold and pure grain	**7.67**	1.50	1.67	0.00	**4.44**	**4.49**	3.40	**5.00**
Adaptation to specific soil type	**3.33**	**3.00**	2.33	0.67	**5.00**	**4.49**	**5.52**	**6.36**
Postharvest quality	0.83	**3.00**	**6.67**	**7.67**	**0.00**	**5.06**	**0.00**	**2.27**
Resistance to biotic stress	**4.17**	2.50	1.00	1.33	3.89	1.69	4.25	3.18
Cooking characteristics	0.83	1.00	1.67	2.00	3.89	3.92	3.40	**5.00**
Response to fertilizer	2.50	1.00	2.67	1.33	5.00	2.25	4.25	1.82
Competitiveness with weeds	0.00	0.00	0.00	2.33	**0.00**	**2.25**	**0.00**	**2.27**
Resistance to lodging	1.67	0.00	2.65	0.67	0.00	0.00	0.85	0.00
Adaptation to several preparations	2.34	**4.00**	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Traits are listed in order of importance. Grain yield includes tillering, panicle length, and number of grains. Resistance to biotic stress includes resistance to pests and blast. Resistance to abiotic stress includes resistance to zinc deficiency and drought. Biomass quality includes height and quality and quantity of straw. Postharvest quality includes ease of hulling and milling recovery. Cooking characteristics include cooking time, elongation ability, aspect after cooking, and impression in the stomach.

Medium-duration fields are grown mostly in medium land. Varieties such as Sarju-52, Ashwani, NDR-359, Pant-4, -10, and -12, and Indrasan are grown on the fields that are located in between upper and lower levels of land type. Farmers of Mungeshpur prefer to grow these varieties on the these land types on the belief that they need optimum moisture during the growth period. Fields differ in agrohydrological characteristics in Basalatpur; therefore, some farmers prefer to grow medium varieties on upland fields also.

Farmers' perceptions of useful traits in varietal adoption

To determine whether there are gender differences in perceptions of useful traits in varietal adoption, we used graphic illustrations of traits. We first showed cards that illustrate useful traits in selecting rice varieties. We then asked each farmer what traits he or she consider in selecting rice varieties for specific land types—upland and lowland fields. To assess how farmers valued each trait, we asked the question, "If you had 100 *paisa*, how much would you pay for each trait? The value in *paisa* allocated to a particular trait corresponded to the importance given by the farmer. Because many traits are interrelated, we reclassified them in consultation with a plant breeder. For example, we grouped traits such as ease in hulling and milling recovery under postharvest quality. Table 2 shows the selection criteria of male and female farmers for different land types and villages.

Favorable rainfed lowlands (Basalatpur, Siddathnagar district)

In the lowland areas in Basalatpur, yield and duration are the most important traits male and female farmers consider in selection rice varieties.

In this village, the popular traditional varieties are *Bengalia, Oriswa,* and *Kuwari mashuri.* These are short-duration (90–110 days), medium-height varieties. The average yields are 2.5 tons per hectare. Farmers prefer short-duration rice varieties in the uplands because of the importance of growing early winter crops such as oilseed, linseed, pulses, peas, and potatoes. They prefer to parboil *Bengalia*; otherwise, its grains break easily. Women in Basalatpur use traditional rice varieties for making puffed rice and *churra*, beaten rice like cornflakes.. For women who continue to use the traditional method of hand-pounding rice, postharvest qualities such as ease of hulling and high milling recovery are additional useful traits. The men did not mention these. The finding that women are more concerned than men with postharvest traits and milling recovery are similar to the findings in a participatory breeding project in the high altitudes in Nepal. Sthapit, Joshi, and Witcombe (1996) also observed that women farmers are particularly skillful in assessing postharvest traits, such as milling recovery, and the cooking and eating quality of rice. They found that the evaluation scores between male and female farmers in Chhomrong village showed significant agreement. Women farmers reported that they would like to decide on variety selection after the postharvest evaluation. Consumers preferred white-grained rice to red-pericarped rice because it saves women time in milling.

In Basalatpur, both male and female farmers agreed upon the important traits for lowland rice varieties. Grain price is an important consideration for farmers here because they sell traditional varieties in the market. These, like *Kalamanak*, command a higher price because of their good taste and aroma. *Kalamanak* gives low yields of 1.5 to 2 tons per hectare. In contrast, grain price is not an important consideration in Mungeshpur because rice is mainly used for home consumption and is seldom sold in the market.

Shallow, submergence-prone uplands (Mungeshpur, Faizabad district)

In Mungeshpur, both male and female farmers agreed upon important traits in selecting varieties for the uplands. Women gave more importance to postharvest qualities and grain quality such as bold and pure grains. For the lowlands, both males and females cited better grain yield, medium duration (125-135 days), biomass, and resistance to abiotic stress as their selection criteria for lowland rice varieties. Women gave greater weight to better adaptation to specific soil types and to grain quality. Women mentioned additional useful traits for varieties in the uplands and lowlands that were not mentioned by men: competitiveness with weeds and postharvest quality. Weeds are the major problem in the uplands, particularly when rice is direct-seeded. In the lowlands, weeds are more prevalent during drought. These additional traits are related to the roles and responsibilities of female family members (e.g., hand weeding and feeding rice straw to livestock).

Farmers' evaluation of new rice genotypes grown in farmers' fields

During the 1999 monsoon season, two farmers from each of the villages of Mungeshpur and Sariyawan (rainfed neighboring village) of the Faizabad district and from Basalatpur were selected to check the performance of rice genotypes in their fields. The genotypes were (1) advanced lines from a shuttle breeding project from Uttar Pradesh, (2) released varieties, and (3) the most common local varieties. Of the 14 genotypes screened in Basalatpur, two are scented varieties (*Kamini,* which flowers in 136 days, and *Sugandha*, which flowers in 124 days). Scientists distributed the seeds through the FPB project. In this approach, breeders select the most promising lines with farmers, and farmers are given a "basket of choices," growing several genotypes in their specific environments.

Ten farmers (five women and five men) visited the individual plots and ranked the rice genotypes grown on farmers' fields past the maturity stage. Farmers were asked to rank the rice lines from 1 (excellent) to 14 or 16 (worst) on the basis of visual assessment. The rankings of the new cultivars by the farmers generated an *n* x *k* matrix, where *n* equals the lines being evaluated and *k* equals the farmers evaluating the crop performance. Kendall's Coefficient of Concordance (*W*) was used to measure the agreement in rankings among male farmers and among female farmers, and the correlation between male and female farmers' rankings. High and significant correlation values indicate close agreement on the ranking of the rice genotypes by men and women in the sample.

Tables 5a to 5d show that in the two villages, male and female evaluators were in close agreement in the ranking of the lines. The *W*s were highly significant, revealing that farmers' and breeders' rankings are often acceptable. Table 6 shows the summary of the ranking of male farmers, female farmers, and plant breeders indicating their choices. Of the 14 and 16 varieties ranked in Basalatpur and Mungeshpur, PVS 1, PVS3, PVS7, PVS9, PVS10, and PVS15 came out as the farmers' and breeders' choices in 1999. The traits of these lines are shown on table 7. During the crop season in 2000, several of these lines were compared with local check through PVS. Twenty-three farmers in two villages in Faizabad grew three rice lines, while 50 farmers in six villages in Siddathnagar grew six rice lines obtained from PVS trials.

Table 5a. Summary Ranking of Rice Genotypes in Basalatpur, Siddathnagar District, 1999

Field 1		Males(5)		Females(5)		Breeders (3)	
No.	Lines	Ave. Score	Rank	Ave. score	Rank	Ave. score	Rank
PVS1	**NDR-40032**	**2.4**	**3**	**2.6**	**2**	**3.0**	**2**
PVS2	**Kamini**	**8.4**	**8**	**8.8**	**6**	**11.3**	**12**
PVS3	**NDR-9730004**	**5.8**	**5**	**7.0**	**5**	**4.0**	**3**
PVS4	Bindili	6.4	6	8.8	6	10.3	11
PVS5	NDR-9830103	10.6	10	13.2	11	9.3	10
PVS6	Sugandha	10.8	10	7.0	5	12.0	13
PVS7	**NDR-96005**	**6.8**	**7**	**7.6**	**7**	**6.3**	**5**
PVS8	4113	14.0	11	12.4	10	14.0	14
PVS9	**NDR-9730015**	**3.0**	**2**	**1.8**	**1**	**5.3**	**4**
PVS10	**NDR-9730020**	**2.0**	**1**	**4.0**	**3**	**2.0**	**1**
PVS11	**Malasia**	**9.6**	**9**	**5.2**	**4**	**8.7**	**9**
PVS12	RAU-1308-10-11-3-1-2-4-3	8.6	11	7.4	5	6.7	6
PVS13	CN-1035-61	4.8	4	10.0	9	8.0	8
PVS14	RAU-1411-10	10.4	10	9.2	8	7.0	7
		w=.73**		w=.63**		w=.70**	

**Significant at 0.5 and .10 per cent level.

Table 5b. Summary Ranking of Rice Genotypes in Basalatpur, Siddathnagar District, 1999

Field 2		Males (5)		Females (5)		Breeders (3)	
No.	Lines	Ave. score	Rank	Ave. score	Rank	Ave. score	Rank
PVS1	**NDR-40032**	**2.2**	**2**	**3.8**	**3**	**3.3**	**4**
PVS2	**Kamini**	**7.2**	**6**	**7.8**	**7**	**10.7**	**10**
PVS3	**NDR-9730004**	**8.2**	**7**	**5.4**	**5**	**2.7**	**2**
PVS4	Bindili	5.6	4	2.6	2	11.7	11
PVS5	NDR-9830103	8.0	7	9.2	8	9.7	9
PVS6	Sugandha	6.4	5	6.2	5	9.3	8
PVS7	**NDR-96005**	**4.6**	**3**	**6.4**	**5**	**5.3**	**5**
PVS8	4113	11.0	9	12.2	10	13.3	12
PVS9	NDR-9730015	1.8	1	1.8	1	1.3	1
PVS10	**NDR-9730020**	**2.4**	**2**	**5.0**	**4**	**3.0**	**3**
PVS11	**Malasia**	**12.6**	**10**	**7.2**	**6**	**9.3**	**8**
PVS12	RAU-1308-10-11-3-1-2-4-3	13.6	11	12.2	10	7.7	7
PVS13	CN-1035-61	8.6	8	12.2	10	6.0	6
PVS14	RAU-1411-10	12.8	10	11.0	9	11.7	11
		w=.90**		w=.72**		w=31**	

**Significant at 0.5 and .10 percent level.

Table 5c. Summary Ranking of Rice Genotypes in Mungeshpur, Faizabad District, 1999

Field 1		Males (5)		Females (5)		Breeders (3)	
No.	Lines	Ave scores	Rank	Ave scores	Rank	Ave scores	Rank
PVS1	NDR-40032	3.2	3	2.6	2	1.7	1
PVS2	Kamini	15.8	16	15.2	14	15.3	16
PVS3	**NDR-9730004**	**6.6**	**6**	**6.0**	**4**	**3.0**	**2**
PVS4	NDR-9730003	10.4	13	7.2	7	3.7	3
PVS5	RAU-1308-9-3-1-10-3-4-3	8.4	8	9.0	8	13.0	13
PVS6	PSRM-1-16-48-1	13.8	15	14.8	13	14.0	13
PVS7	**NDR-9830102**	**2.9**	**1**	**1.8**	**1**	**5.7**	**5**
PVS8	NDR-9730002	9.2	10	12.6	10	7.0	8
PVS9	**NDR-9730015**	**8.0**	**7**	**6.6**	**5**	**5.0**	**4**
PVS10	**NDR-9730020**	**5.4**	**4**	**7.0**	**6**	**6.0**	**6**
PVS11	**Mashuri**	**6.6**	**5**	**10.6**	**9**	**9.7**	**10**
PVS12	RAU-1308-10-11-3-1-4-3	10.2	11	13.0	11	12.0	12
PVS13	NDR-96012	9.0	9	8.8	8	8.0	9
PVS14	RAU-1411-10	10.4	12	6.0	4	10.0	11
PVS15	NDR-9830103	3.0	2	3.4	3	6.7	7
PVS16	RAU-1400-13-200-4-6	14.0	14	13.2	12	13.3	140
			w=71**		w=.81**		w=0.79**

**Significant at 0.5 and .10 per cent level.

Table 5d. Summary Ranking of Rice Genotypes in Mungeshpur, Faizabad District, 1999

Field 2		Males (5)		Females (5)		Breeders (4)	
No	Lines	Ave scores	Rank	Ave scores	Rank	Ave scores	Rank
PVS1	NDR-40032	4.2	3	3.4	3	2.3	1
PVS2	Kamini	11.4	12	14.4	14	14.7	11
PVS3	NDR-973004	8.0	7	6.2	4	4.7	2
PVS4	NDR-973003	8.6	9	8.0	8	8.0	6
PVS5	RAU-1308-9-3-1-10-3-4-3	14	12.0	12	14.3	10	10
PVS6	PSRM-1-16-48-1	12.8	13	11.8	11	12.3	8
PVS7	NDR-9830102	3.6	2	2.4	2	7.0	5
PVS8	NDR-9730002	8.0	7	10.0	9	8.7	7
PVS9	NDR-9730015	5.6	5	6.4	5	5.0	2
PVS10	NDR-9730020	5.2	4	7.0	6	6.0	4
PVS11	Mashuri	10.6	10	13.6	13	7.0	4
PVS12	RAU-1308-10-11-3-1-4-3	8	10.2	10	12.7	9	9
PVS13	NDR-96012	10.8	11	7.2	7	9.3	7
PVS14	RAU-1411-10	7.0	6	10.0	9	9.0	7
PVS15	**NDR-9830103**	**1.6**	**1**	**1.4**	**1**	**5.3**	**3**
PVS16	RAU-1400-13-20	15.0	15	10.0	9	9.7	6
			w=.65**		w=.65**		w=.60**

**Significant at 0.5 and .10 per cent level.

Table 6. Summary Ranking of Preferred Lines by Male and Female Farmers and Plant Breeders, 1999

	Male farmers		Female farmers		Plant breeders	
	Field 1	Field 2	Field 1	Field 2	Field 1	Field 2
Basalatpur						
PVS1	3	2	2	3	2	4
PVS3	5	7	5	5	3	3
PVS7	7	3	7	5	5	5
PVS9	2	1	1	1	4	1
PVS10	1	2	3	4	1	3
Mungeshpur						
PVS1	3	3	2	3	1	1
PVS3	6	7	4	4	2	2
PVS7	1	2	1	2	5	5
PVS9	8	5	5	5	4	2
PVS10	4	4	6	6	6	4
PVS15	3	1	3	1	7	6

Table 7. Farmers' Assessment of New Rice Lines during the 1999 *Kharif* Season

Lines (Location)	Name	Positive traits	Negative traits
PVS1		Good yield	
		Medium plant height	
		Good straw (quantity and quality)	
		Has regeneration capacity (faster recovery after submergence)	
		Short, bold, heavy grains	
		Best for puffed rice, has good	
PVS-3	NDR-973004	Medium plant height	
		Submergence-tolerant	
		Good tillering capacity	
		Long panicles	
		Good eating quality	
		Good milling recovery	
		Remains soft after cooking	
PVS-7	9830102	Short duration (110 d) which makes rice available during the lean period	
		Good yield (4 t/ha)	
		Medium plant height	
		Good straw (quantity and quality)	
		Better for early rabi crops	
		Good taste	
PVS9	NDR9730015	Medium plant height	More broken grains after milling
		Suitable to land type	Becomes hard after cooking
		Submergence-tolerant	
		Good tillering capacity	
		Long, bold grain size	
		Good straw	
		Good for puffed rice	
PVS10	NDR9730020	High yield—more grains per panicle than PVS1 (NDR-40032)	
		Suitable to land type	
		Medium plant height	
		Resistant to lodging (hardy stem)	
		Resistant to pests and diseases	
		Longer panicles	
		Grains are long and cylindrical and finer than PVS9 (NDR9730013)	
		Higher milling recovery	
		Good taste	
		Remains soft after cooking	
		Good for special social occasions	
		Easy to harvest and thresh	

Listening to the voices of male and female farmers

Aside from asking men and women to rank traits and varieties through visual assessment, we conducted informal interviews with men and women farmers, separately. This enabled plant breeders to listen not only to men but also to women. Some of their perceptions of the rice varieties and lines tested are below.

Mrs. Yadav is 53 years old, illiterate, and a full-time farmer. Her husband is a full-time worker in the flour and oil mills. This makes her the *de facto* head of household. She supervises the farm and makes decisions regarding what crops and varieties to grow. Three years ago, she grew mostly local varieties because of a lack of irrigation facilities. We gave her seeds of NDR 97, a new variety, which she planted on 0.10 ha of land. Later she increased the area planted to this variety to 0.5 ha. She told us the positive traits she likes in this variety, such as suitability to her land type, good taste, shorter duration, good milling recovery, ease of threshing, and medium height, and negative traits such as less rice straw:

> *I tried many varieties since the last four to five years such as Saket4 and NDR80, but because they were damaged by drought and disease, I stopped growing them. I shifted back to a local variety [ARI] although it does not taste good, has poor milling recovery and coarse grains. But I like NDR97 because of its suitability to my land, good taste, and shorter duration. The only problem is that it produces less biomass [straw], which is not enough for my two bullocks and five buffaloes. We need more straw for the animals throughout the year. We also grow* curbi *[green fodder] and harvest them green during the* kharif *season. Due to the early duration of NDR97, we can cultivate our land for early* rabi *crops such as oilseed and vegetables before wheat. I also like the taste of NDR97 and I am satisfied with its milling recovery. It is also easy to thresh; it is neither very tall nor short.*

Mrs. Savitri Devi is 45 years old, illiterate, and a full-time farmer of the backward caste. She cultivates 1.1 ha of land in Mungeshpur. She has two types of land, upland and lowland. She grew NDR359, Sarju52, and *Jallahri* in 1998. We gave the new seeds of NDR359 to her in 1996. She prefers this variety because it has a good taste and short duration. She describes their use of NDR359:

> *I don't like the taste of Sarju52. It is coarse and does not remain soft after cooking. It also does not have many broken grains after milling. So we sold Sarju52 and used NDR359 for home consumption. One thing I noticed with the straw of NDR359 is that it is soft, so instead of storing it for a long time, we had to feed it immediately to our animals. If we keep the straw for two to three months, it will not be very easy to cut and the animals will refuse to eat it. Instead of leaving the rice stalks to dry in the field, which is our usual practice, we immediately thresh after harvesting. Its short duration also enables me to grow another crop during the* rabi *season.*

Mrs. T. B Singh, 50 years old, belongs to the upper caste. Due to labor shortages during the peak season and the lack of male labor (her husband is fully engaged in a nonfarm job), she has been forced to provide physical labor in most of the rice operations. She was able to finish five years in school. She is the decision maker in the household and is quite knowledgeable about farming. In 1997, she was one of the collaborators of the project. After testing 13 genotypes on her field, she obtained 5.2 tons per ha from PVS5 (NDRSB9730015), so she decided to continue to grow this variety and expand the area during the 1998 *kharif* season. She expected to get six tons per ha, but because of drought, there were many unfilled grains. She told us about the variety's positive traits aside from its high yield:

> *I prefer PVS5 because of its medium duration; medium bold, cylindrical grain; resistance to pests and diseases; and better milling recovery.*

In 1995, we gave her new seeds of BKP246.

I like this variety too because it is suitable for the lowland rainfed area, has good yields, and is not susceptible to diseases. I like the size and the shape of the grain—medium and bold. It also has the best milling recovery and commands a high price in the market. In 1998, I sold four quintals of paddy at Rs 400 per quintal, while the other varieties are Rs 50 less than BFK246. We use Sarju52 and Saket4 for home consumption. Saket4 has fine grains and matures early, a trait ideal for the uplands. Our agricultural workers prefer coarse grains, which last longer in the stomach than paddy with finer grains. I observed that the quantity of straw of BFP346 is less, but grain quality is more important to us.

Mr. Bansat Lal , 42 years old, an illiterate father from the backward caste, is a full-time farmer. His sons are fully engaged in nonfarm activities and his daughter-in-law supervises farm activities and takes part in decision making. In 1997, he was a collaborator in the plant varietal-selection program and obtained good yields. After threshing and milling, the female members of his household also agreed that the PVS5 (NDRSB9730015) and PVS6 (NDRSB9730020) should be grown the following year. Both Mr. Lal and his daughter-in-law have the same criteria for selection, such as better yield, good quality of straw, medium height, resistance to pests and diseases, longer and fine grains, no broken grains after milling, softness and expansion after cooking.

My daughter-in-law observed that PVS5 is easy to hull through hand pounding after parboiling. It is also good for puffed rice.

Mr. Lal shared the seeds of PVS5 with other farmers. In 1998, he cultivated PVS5 and PVS6 on his 3 *bigha* (0.3 ha) land area. He was able to obtain a yield of six quintals per *bigha* in one plot and four quintals in another plot. These yields were higher than those in nearby fields.

Conclusions

Socioeconomic surveys revealed that a major determinant of varietal choice is the conscious attempt of farmers to match varieties with the land type. Each field position in the topo-sequence corresponds to a risk of drought or submergence. In Mungeshpur (shallow and submergence-prone) farmers' criteria for selecting rice varieties are associated mainly with duration (short to medium), for growing *rabi* crops after rice in the upland fields, and with better yield. A second determining factor is the adaptation to different user needs: food, livestock fodder, thatching, and cash. A third determining factor is related to different postharvest operations like ease of threshing, good taste, high milling recovery (above 65%), good storage capacity, and premium market price. Gender-specific roles and responsibilities also determine varietal preferences. For example, women prefer medium or semi-tall varieties that are easier to thresh, as well as varieties that have a good quantity and quality of rice straw for livestock feed. Moreover, they prefer varieties for the specific rice products that they make. While it may be difficult to combine all their preferred traits into one unique variety because of genetic correlations, it is important that both men and women have a "basket of choices" of varieties suited to their needs and agroecosystems. Clearly, listening to farmers' perceptions and involving both men and women farmers in selecting rice varieties at the early stage of breeding can lead to faster adoption of varieties suited to their specific rice ecosystems and diverse needs.

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Opportunities and Constraints for Participatory Plant Breeding: Farmers' Seed-Management Strategies and Their Effect on Pearl Millet Populations in Rajasthan, India

Kirsten vom Brocke, Anja Christinck, and Eva Weltzien

Abstract

This paper presents information from a study on farmers' seed-management practices growing pearl millet in Rajasthan, India. It describes farmers' own crop-improvement activities in regard to yield, quality, and diversity of pearl millet, with emphasis on seed-management strategies, such as introgression of modern varieties, selection, storage, processing, exchange, and procurement. It also examines the farmers' definition of "variety" as compared to the definition used by professional plant breeders. For the study, farmers were divided into four groups, based on their seed-management practices. Data were collected on specific traits and correlated with grain yield under different climatic conditions. The potential and constraints of farmers' practices are discussed, with emphasis on areas where researchers could concentrate on specific weaknesses that farmers' own selection practices cannot effectively address.

Introduction

In many regions of the world farmers routinely produce seeds for their staple crops. This is particularly common in regions where agricultural production is affected by frequent and unpredictable droughts, as in most areas where pearl millet (*Pennisetum glaucum* [L.] R.Br.), a cross-pollinating crop, is grown. Under these harsh climatic conditions, farmers have developed landraces that tend to show good levels of tolerance to these environments. The farmers have also evolved strategies for maintaining seed during drought years in order to safeguard food production and animal fodder. Given the fact that formal plant-breeding programs have failed to develop superior varieties for marginal lands and low-input conditions, the main objective of the study presented here is to better understand farmers' own seed-management practices as a basis for planning and implementing participatory strategies that capitalize on farmers' local knowledge. This approach would allow researchers to then concentrate on specific weaknesses that farmers' own selection practices cannot effectively address.

To date, these local strategies, including the farmers' needs and preferences, along with details of their cropping systems, are not familiar to scientists involved in conventional breeding programs.

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The work presented here is part of the project "Enhancing quality, diversity and productivity of farmers' pearl millet genetic resources in Rajasthan, India," which is a collaborative activity of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India; its national partner institutions in Rajasthan, including the Central Arid Zone Research Institute (CAZRI), Rajasthan Agriculture University (RAU Mandor), and the National Bureau for Plant Genetic Resources (NBPGR); and the University of Hohenheim in Germany. We thank all scientists and staff members involved for their personal support to this study, particularly Dr. Thomas Presterl and Prof. Dr. H.H. Geiger (University of Hohenheim, Institute of Plant breeding, Seed Science and Population Genetics), Prof. Dr. V. Hoffmann (Agricultural Social Sciences, Department of Communication and Extension), Dr. P. Bramel-Cox (ICRISAT), and Dr. O.P. Yadav (CAZRI). The enthusiastic and most competent participation of farmers from the villages of Aagolai, Udaipur Khurd, Kichiyasar, and Nunwa in the workshops is equally acknowledged. We further thank the German Ministry for Economic Cooperation and Development (BMZ) for funding through the German Society for Technical Co-operation (GTZ).

The objectives of this project are listed below:

1. To describe farmers' own crop-improvement activities in regard to yield, quality, and diversity of pearl millet, with special emphasis on seed-management strategies, such as introgression of modern varieties, selection, storage, processing, exchange, and procurement
2. To quantify the effects of farmer activities on the genetic structure and performance of pearl millet populations

Short description of the study area

Rajasthan is situated in the northwest of India (figure 1). It is a semi-arid region with a mean annual rainfall that ranges from < 250 mm in the western part (*Thar Desert*) to > 650 mm in the southeast (figure 2). In this study, we refer only to the western part of the state, where farmers must make do with less than 350 mm of annual rainfall, with high variability from year to year. Experienced farmers often talk of a 10-year cycle in which two seasons have good rains, two have severe drought with crop failures, and the rest usually have fair to good seasons. Soils are mainly sandy, and sand dunes are common. Villages are typically scattered across wide areas. Pearl millet is grown three to four months during the monsoon season, mostly in mixtures with other crops, such as legumes and cucurbits. Animal husbandry is another important part of the farming system. Social conditions in the villages are governed by the caste system. Even today, the caste system still largely determines people's social status, occupation, income, and access to education and information.

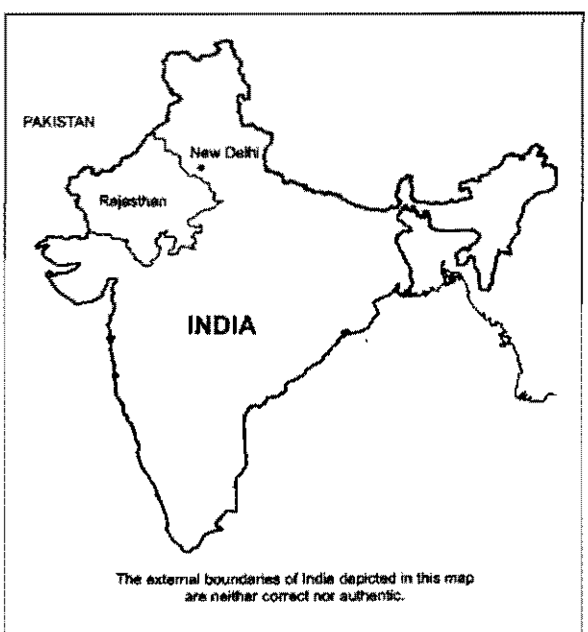

Figure 1. The state of Rajasthan in the northwest of India

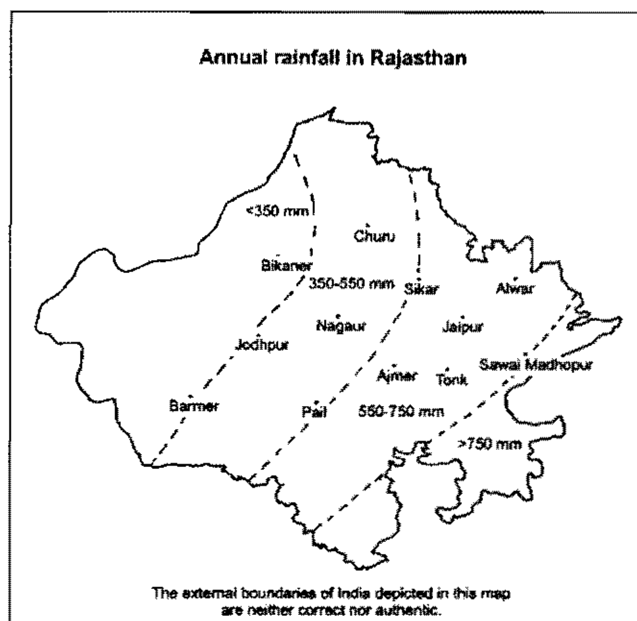

Figure 2. District capitals and zones of mean annual rainfall in the study area

Farmers' seed-management strategies

Farmer's concept of a "variety"

Farmers' seed management can only be evaluated if one fully understands the farmers' concept of a "variety." This term, as understood by plant breeders, does not seem to be fully appropriate for the farmers' pearl millet seed system in west Rajasthan. In order to learn how farmers perceive "varieties," informal interviews as well as classification and ranking exercises were carried out during workshops with farmers from the study villages. Care was taken to include both female and male farmers in the interviewing process. The results demonstrate that environmental adaptation was the main criterion for farmers' classification of pearl millet plants in western Rajasthan. Potential uses and quality aspects further contributed to the farmers' method of grouping different plant types (Christinck and vom Brocke 1998).

Traditional landraces that have adapted to the environment show a high basal and nodal tillering ability, indicating tolerance to drought and low requirements for soil fertility. If these characteristics are combined with thin stems, narrow leaves, and thin, compact panicles with small grains, farmers will conclude that such a plant will grow under low-input conditions (i.e., in their fields) and produce grain and straw of high nutritional quality. In contrast, the characteristics of modern varieties are low basal and nodal tillering ability, thick stems with broad leaves, and large panicles with relatively large grains that are mostly round in shape. From the farmers' experience, this plant type is not tolerant to drought stress, requires higher soil fertility, and has inferior food and fodder qualities. Farmers, however, are aware that pearl millet plants showing such characteristics can produce higher yields under favorable conditions (Christinck and vom Brocke 1998). Farmers are therefore concerned about the composition of their seed stocks, i.e., which plant types and, thus, which properties are present. Farmers expect plant types to change over time, in reaction to environmental conditions such as soil quality and rainfall, so that the seed stock generated in one year cannot be exactly reproduced the next season. They have a strong concept of continuous interactions between plant type and environment, as evidenced by their belief, or experience, that any pearl millet cultivar, including modern varieties, that is grown in their field for some years will eventually become like their local cultivars.

Contrary to the views of professional plant breeders, the farmers' concept of a "variety" is not that of a population with more or less uniform and stable plant characteristics based on its genetic background; the term "variety" is applied to a plant type that is evolving under or adapting to certain environmental conditions. This concept is reflected in the farmers' seed-management strategies.

What is seed management?

Seed management comprises all activities of a farming family that influence their seed stock, including introgression of modern cultivars (open-pollinated varieties or hybrids), seed selection, processing, storage, exchange, and procurement. In this paper, we refer mainly to seed selection and processing, and the ways in which farmers deal with modern varieties from the market.

Ways of selecting or processing seed

Farmers in Rajasthan generally employ two main selection methods. The first is winnowing or grading, which entails cleaning and separating seed grains. The rate of selection can vary greatly. It may be that only 10% of the threshed and stored grain will be rejected (mainly husks and broken and insect-infested grains), or more than 50% if the grains, for example, are small and not fully developed. Generally, the smaller grains are be used for food.

The second method, which is also very common, is the selection of panicles that show preferred traits. Farmers usually select for panicles on the threshing ground after the panicles have been separated from the straw, although some farmers prefer to select for panicles in the field before harvesting, taking the entire plant into consideration, e.g., number of tillers, height. Even by inspecting the panicle, farmers can envisage what the plant's other characteristics looked like (or would look like when regrown). Many farmers do not perform panicle selection every year, but only in the better seasons, which usually occur every two to four years. In harsher years, they are most likely to use the winnowing/grading method. A third, less common, form of selection is to use the harvest of a preferred field—a field considered to be more fertile than others—for sowing the following year.

Using "improved varieties" or hybrids from the market

If a farming family does use pearl millet seed from the market, in most cases it will be mixed into the family's own seed stock. In western Rajasthan, farmers without access to irrigation facilities generally do not grow improved varieties or hybrids in pure stands. Market seed is mostly certified or "truthfully labeled" seed. Further advanced generations of such seed can be optioned from the market or from other farmers. This grain is not labeled and its origin is often unknown. There are two ways in which farmers use seed from the market:

1. Occasional introgression of new seed from the market into the previous year's seed stock: the resulting crop consists of many different plant types (traditional landrace, market variety, and several generations of progeny). Mixing ratio and frequency can vary widely, ranging from 1:10 up to 50:50.
2. Regular introgression of new seed from the market into the previous year's seed stock, selecting for desired plant types among outcrosses: One or more new plant types will become dominant, and the variability of plant types is less than in the first example. The amount and frequency of mixing new seed, as well as selection intensity, can differ greatly from farmer to farmer and from year to year.

It is important to understand that most farmers do not use improved varieties to replace their own seed, as is often assumed. Rather, they use new seed to increase the variability of plant types in their fields, thereby creating new options for their strategies of selecting for preferred plant characteristics, including grain and straw yield, food and fodder quality, storability, drought tolerance, early maturity, tolerance to adverse weather conditions (heat, sandstorms, thunderstorms), and resistance to bird or locust damage.

Social aspects of seed management

The availability of seed grain at the onset of rains is very important for farmers in western Rajasthan. The success of a crop depends very much on sowing immediately after the first rains of the monsoon. For centuries, farmers have had to deal with crop failures due to severe drought conditions. Therefore, "taking care of the seed" is considered to be of great importance. Farmers who can successfully maintain their own seed, or be in a position to provide other villagers with seed in times of scarcity, are considered to be good farmers and are respected by all. There is a special caste in most villages for whom maintaining seed and sharing it with others is considered to be a traditional obligation. Nevertheless, other farmers can also build up a reputation for owning good seed, and "lending" or selling it to others. Seed management is, therefore, related to aspects of caste and status in village life. Furthermore, it is a gender-related activity. Selecting the seed, storing it, and processing it before sowing is traditionally done by women, whereas soil preparation and sowing is usually done by men. Men also often participate in harvesting, and depending on the family, they can be equally involved in selecting seed. Buying seed from the market and obtaining information about market varieties is done almost exclusively by men.

Diverse seed-management strategies co-exist in villages in western Rajasthan, reflecting the diversity of socioeconomic conditions: farmers who grow traditional landraces with or without selection; families who mix, sometimes or regularly, seed from the market into the landrace seed with or without selection; and families who sow the pure seed of market varieties. All these seed-management strategies can be found in one village. Even though pearl millet is a cross-pollinating crop, it seems to be possible for a village community to maintain a diversity of plant types. The reasons for a farming family using a certain strategy can only be partly explained by soil conditions and climatic factors. Other important factors seem to be the size of the landholding (market-oriented or subsistence-oriented), the number and species of animals and their fodder requirements, the access to cash income or loans to buy seed, the family tradition and knowledge, and access to information on new varieties, e.g., literacy and mobility. Most of these socioeconomic conditions are related to the caste system in Rajasthani villages.

Quantification of the effects of farmers' seed-management strategies

Material and methods

To quantify the effects of farmers' seed management, 69 grain stock samples were collected from 16 farmers located in four different villages in western and central Rajasthan during 1995–1997. Samples were characterized by the farmer, e.g., as separated seed grain and food grain, and were classified into four main seed-management strategies (table 1). These grain samples from farmers, along with 12 modern varieties known to be grown in these villages, were evaluated under varying drought-stress conditions at three research stations in western Rajasthan (Mandor, Jodhpur, Pali) between 1997 and 1998. Climatic conditions in 1997 were generally favorable, whereas in 1998 severe drought affected the plant growth, especially at Mandor. The field trials comprised 81 entries and were laid out in lattice designs with five replications. The different plant traits that are used by farmers and scientists to describe the performance of pearl millet were recorded in order to assess productivity and characteristics of entries. These plant traits included nodal tillering, leaf shape, stem diameter, panicle girth, number of productive tillers, grain weight, straw and grain yield, as well as diversity of plant types within one entry.

Table 1. Farmers' Seed-Management Strategies as Represented in Field Trials

LR	Maintains only local landrace seed without introgression of modern material Selection method mainly winnowing
IGR1	Occasionally introgresses modern varieties into landrace Selection method mainly winnowing
IGR2	Introgresses modern material more regularly than strategy IGR1 Selects regularly/frequently for panicles
MV	Modern varieties

Separate analysis of the five test environments revealed a significant phenotypic relationship between grain yield and plant characteristics (table 2). The number of panicles and basal tillers, plus nodal tillering and phenotypic diversity of plant types within one entry, were all positively associated with grain yield in the stress environments and negatively associated in the non-stress environments. Conversely, entries with large stems, large leaves and panicles, and bold grains showed negative correlation coefficients with grain yield under stress conditions and positive coefficients in the non-stress environments.

Table 2. Phenotypic Correlation of Observed Traits with Grain Yield

	Environments				
	Favorable		Mild terminal drought	Early drought	
Traits	MAN97	JOD97	PAL97	MAN98	JOD98
Grain weight	0.69**	0.75**	0.42**	0.08	–0.25*
Panicle girth	0.70**	0.83**	0.42**	–0.60**	–0.24*
Leaf width	0.38**	—	0.33**	–0.62**	–0.24*
Stem diameter	0.62**	0.69**	0.41**	–0.65**	–0.14
No. of panicles	–0.54**	–0.46**	–0.41	0.90**	0.48**
Tillers	–0.54**	–0.58**	0.01	0.67**	0.36**
Nodal tillering	–0.65**	—	–0.41**	0.56**	0.27*
Plant type diversity	–0.57**	—	–0.36**	0.32**	0.11

*$p < .05$.
**$p < .01$.

A genotype × environment (GE) analysis based on grain-yield data was carried out in order to gain an overall view of the effects of these strategies on the adaptation of farmers' seed stocks to different environments. For this purpose pattern analysis was used to classify environments and to assess relationships between the entries and between environments, as well as to analyze the interrelation between entries and environments. To generate the analysis, the statistical packet GEBEI was used (Watson et al. 1996). The details of this calculation will be published elsewhere.

Results and discussion

The phenotypic relationship described in table 2 shows the effectiveness of farmers' seed-management strategies. Entries with plant characteristics that farmers associated with adaptation to stress proved to be more productive under stress conditions than other entries. These findings were supported by the results of the pattern analysis. The analysis indicated that most of the entries classified as LR showed close interaction with the preflowering drought stress at Mandor and Jodhpur. Compared to the LR entries, entries classified as IGR1 tended to show a less specific interaction with the stress environments. In contrast to the management groups LR and IGR1, a change in the adaptation pattern seemed to be obvious in entries derived from IGR2. The positive interaction of the samples exclusively with the preflowering drought environments was mostly eliminated. Entries also tended to show relatively high productivity in more favorable environments. Samples grouped in IGR2 thus tended to perform fairly well in all the test environments. Entries labeled as modern varieties (MV), indicated almost no positive association with the preflowering drought environments. The exceptions were some modern varieties with pedigrees based on landrace material from western Rajasthan.

Farmers who practice IGR2, which includes introgression and selection for contrasting plant types, are generally successful with this method. In the one seed stock, the IGR2 method produced traits indicating adaptation to stress as well as potential for high yield under favorable conditions. In terms of potential grain yield, this method appears to be effective. Some of the farmers' grain stocks generated by this strategy even yielded better with increased rainfall compared to the "pure" landraces (LR). It was the farmers' aim to introgress modern varieties so as to produce seed stocks that "take advantage" of good rains and it appears they have met their objective.

Although "pure" landraces are not as productive under favorable conditions, they are more resilient under conditions of stress. For centuries they have been grown in heterogeneous environments. They therefore have the capacity to adjust to the erratic climatic conditions that occur in this region. Seed samples from farmers practicing introgression, in combination with regular panicle selection, seem to indicate that it is possible to improve a landrace population through newly introgressed variability. It also appears that if farmers use panicle selection to separate seed from food grain, they can improve their control over seed-stock performance.

Summary and conclusions

Potentials and constraints of farmers' own crop improvement

The present study has revealed opportunities, as well as constraints, for farmers' own crop improvement. Other studies have assumed that landraces are mainly a product of natural adaptation and that farmers often do not, or only "unconsciously," select landrace seed (Damania 1996). However, direct observation and interview data from this study have revealed that this view does not apply to the case of pearl millet in western Rajasthan. The results of this study confirm that different seed-management strategies are practiced in the one village. Some farmers maintain the local landrace with superior quality and yield stability, while others create variability through introgression of modern varieties. Furthermore, previous studies carried out in western Rajasthan also show that farmers use their own sophisticated strategies for seed management and crop improvement (Dhamotharan et al. 1997; Weltzien et al. 1998). Quantitative data from field trials proves that these farmer strategies lead to populations with diverse plant types. This diversity offers possibilities of recombination in the population and natural selection, and also increases the gains of farmers' selections.

Seed selection, especially intensive selection of plant type or panicle, enables farmers to exert control over the negative effects of introgression. Farmers select according to their various breeding goals, such as yield stability under stress conditions and higher productivity in regard to straw and grain yield in the target environment. These selection strategies are largely guided by their concept of a variety. Mainly farmers who practice introgression along with panicle or plant type selection are able to improve the productivity of their landraces without losing yield stability. However, other results show that traditional methods of seed selection practiced before the introduction of exotic material, such as winnowing/grading, can lead to a decrease in the expression of adaptive traits and characteristics in the typical landrace phenotype. This is due to seed winnowing and the use of the bolder grain for seed purposes. Smaller grains (representing adapted landrace types) are rejected, whereas bigger grains (representing less adapted modern material) remain in the seed stock.

It should also be taken into consideration that the farmers who benefit from the higher yield potential of the introgressed cultivars are mainly those who have relatively good land and resources. These farmers are traditionally those who distribute seed material to other, poorer, farmers in times of scarcity. As poor farmers usually have less fertile land and less manure, the properties of the original landrace pearl millet are ideal for them. If better-off farmers continue to use introgressed seed, which requires better land and continuous selection to assure yield stability, the availability of landrace seed may decrease for poor farmers with marginal lands unless measures are taken to maintain the original landrace plant type. Finally, farmers often show a lack of technical knowledge concerning the genetic material that is available on the market. For instance, most farmers are not aware of the differences between hybrid varieties and open-pollinated varieties, nor are they aware of the consequences of using hybrids in seed production.

Role of researchers

These constraints point to several possible ways in which researchers can help to improve farmers' seed stocks in western Rajasthan. Researchers could take on an advisory role and support farmers in their own crop-improvement strategies, for example, with technical knowledge or explanations of the effects of different management strategies. The plant breeder could recommend material that has the ability to combine with local material and has the potential to achieve genetic gains in farmers' preferred traits. Material should not merely be handed out to the farmer by the breeders. A material exchange between farmer and breeder should also be supported. Breeders could help to improve those traits that farmers have difficulty working with, e.g., specific resistance or seed-set improvement. Where farmer and breeder both provide material and resources, intellectual property rights should be respected.

Results from this study show that farmers in western Rajasthan are actively working on developing and improving their seed stocks, and that many opportunities exist for fruitful collaboration between farmers, plant breeders, and other scientists.

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Strength of Farmers' Knowledge and Participation in Crop Improvement and Managing Agrobiodiversity On-Farm

P. Chaudhary, S.P. Khatiwada, and K.D. Joshi

Abstract

This paper highlights the role of farmers in crop improvement and managing agrobiodiversity. The findings are mostly based on focus-group discussions and field observations. Documentation of farmers' knowledge and experiences in crop improvement and managing agrobiodiversity may serve as a reference for individual breeders or institutions involved in participatory crop improvement through different strategies like participatory plant breeding, participatory varietal selection, or participatory germplasm enhancement. The strength of participatory crop improvement is that there is multistage involvement of farmers, from parent selection through to cultivation and selection of planting materials, because farmers have a wide range of knowledge and experience, and they are the end-users as well. Since ancient times, farmers have been dependent upon the traditional seed-supply system, which still accounts for over 90% of the seed requirement in Nepal. A variety of mechanisms like varietal selection, seed selection, seed processing and storage, and the seed-flow system have contributed to crop development, creating agrobiodiversity on-farm. More recently, participatory germplasm enhancement has arisen as a new strategy to enhance the germplasm of local landraces, which will not only empower farmers in improving their landraces but also strengthen in situ conservation of such landraces on-farm. The current need is to incorporate farmers' relevant knowledge and use it in the overall crop-improvement process.

Key words: Participatory, crop improvement, agrobiodiversity, germplasm, on-farm, and knowledge

Background

In many developing countries, farmers play a pivotal role in the conservation of genetic resources, thus maintaining biodiversity, since they hold the bulk of these resources (Worede 1992). From time immemorial, farmers have experimented with naturally existing genetic variations in their own environments to produce present-day landraces (Sthapit and Joshi 1998). Farmers have grown, tested, utilized, developed, and finally, selected new varieties and crop combinations to suit particular ecosystems. The role of farmers in creating agrobiodiversity is also evident from their involvement in seed storage and seed exchange. Of course, the need and preferences of individual farm families have driven them in the selection of crop species. For this reason, they have acquired a profound knowledge about landraces and niche-specific placement.

Given the inherent advantages of traditional practices, on-farm landrace conservation and enhancement provides a valuable option for observing genetic diversity (Worede 1992). A large number of subsistence farmers still use traditional methods. Those using modern technology account for approximately 40% of global agriculture, while rest is under traditional agriculture, which provides between 15% and 20% of the world's food (Francis 1986; Sthapit and Joshi 1998). The most important factors that motivated farmers to diversify crop and livestock in the past were probably ensuring livelihood and meeting qualitative preferences and requirements (Roder 1995; Sperling and Berkowitz 1994; Sthapit and Joshi 1998). Roder (1995), has reiterated the factors motivating farmers in maintaining diversity as follows:

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- the need for high self-sufficiency due to communication problems
- reduction of risk factors
- labor considerations
- lack of availability of suitable improved varieties
- market fluctuations
- traditional food preferences
- special requirements for ceremonies and rituals

One of the commitments made in Leipzig in 1996 during the NGO conference on the access and control of agricultural biodiversity was to enable the formal sectors, through training, to recognize the value of farmers' and indigenous peoples' knowledge and practices in conserving and strengthening agricultural diversity. The following statements further stress that the documentation of farmers' knowledge and participation in crop improvement is essential.

- To be able to define precisely the objectives, limits and means for implementing in situ conservation, it is necessary to obtain a better understanding of the structure of polymorphism within farmers' varieties, ways it evolves with farmers' practices and the methods and mechanism for managing this source of diversity. (FAO 1989; Brush 1992; Louette and Smale 1996)
- Recognizing farmers' knowledge and the farmers' role in developing landraces and maintaining their genetic diversity through the partnership of farmers with formal science institutes is an important step in enhancing the maintenance of biological diversity, agricultural sustainability and food security at the farm, regional and global levels. (Teshome 1997)

This paper highlights the role of farmers in crop improvement and agrobiodiversity management. The different stages of crop development and different approaches applied to bring about current agrobiodiversity are explicated in the following chapters. The examples are mainly from one of the sites of the project "Strengthening the Scientific Basis of in situ Conservation of Agrobiodiversity On-Farm" being implemented in Nepal jointly by the Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity Research and Development (LI-BIRD), and the International Plant Genetic Resources Institute (IPGRI).

Farmers' role in crop improvement

Crops have traveled through different stages of natural evolution and systematic crop breeding. Breeding by different groups, such as routine seed selection by farmers and formal breeding in public and private institutions, has played an important role in bringing crops and varieties to their present status. Crop species have been adapted to different agroecological conditions while evolving from a wild to a cultivated form through more refined landraces because of farmers' selections. Farmers' landraces have been extensively used to develop improved varieties through breeders' efforts and again through diffusion through formal and informal institutions. Gene flow from wild relatives to farmers' landraces and from landraces to improved cultivars is a dynamic process and should be maintained if plant breeding is to meet the growing needs of the world's population (Vaughan and Stich 1991; Sthapit and Joshi 1998). This is why the conservation of plant genetic resources in situ has very recently been widely accepted by several formal and informal institutions worldwide. The inclusion of a landrace as one of the parents in participatory plant breeding and the involvement of farmers in several stages of its development is imperative if the needs of farmers are to be accurately met, leading to a successful conservation strategy. The figure below outlines the stages and the processes through which crops have traveled and the important role played by farmers to make the story successful.

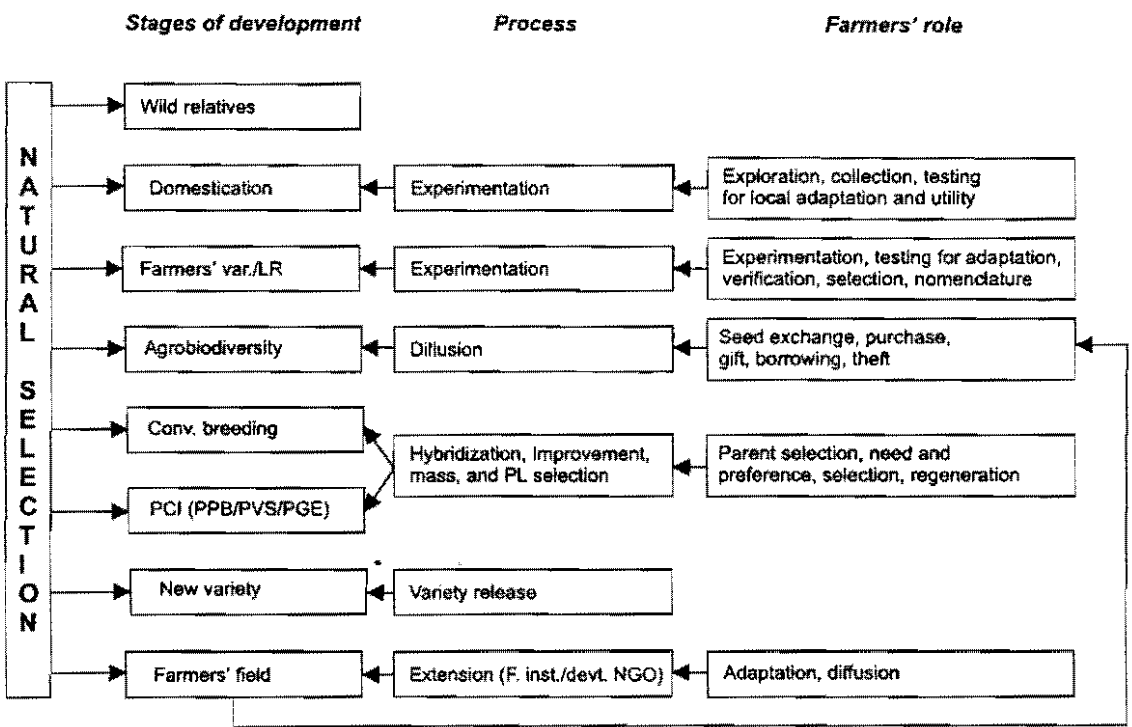

Figure 1. Farmers' roles in the crop-improvement process

Nomenclature of traditional varieties

Farmers have given names to their traditional varieties of different crop species based on their identifying characteristics, which can either be external appearance or internal quality. For some of the landraces, one can easily distinguish one from another on the basis of their names. Farmers' nomenclature has a scientific basis since words that constitute the name have an important meaning that reflects the characteristics of that variety. For instance, *lal tengan* is one landrace; it has been named for its red (*lal*) lemma and palea color and a long, stout tentacle/spur (a type of fish called a *tengar* has spur like this). A few examples of the names of farmers' varieties and their meanings are presented in table 1.

On-farm varietal diversification

Varietal replacement has been taking place with the introduction of modern varieties for several years, starting from the Green Revolution in Asia during the early 1970s. In many regions of the world, farmers have economic incentives to replace the varieties that have evolved within their own ecosystems with improved, introduced varieties (Louette and Smale 1996). Landraces seem so

Table 1. Name and Meaning of a Few Selected Landraces

S.No.	LR Name	Type	Name & meaning	Easy way to identify/distinguish
1	*Nakhi saro*	*Bhadaiya*	Nakhi=awn, Saro=bhadaiya type	Long awn; yellowish lemma and palea (L/P)
2	Bhadaiya basmati	"	Bhadaiya= early seasoned, Bas=aroma	Slightly rango-like color; fine grained
3	*Basmati*	*Aghani*	Bas=aroma	Like B. basmati; long panicle length; fine grain; aroma; awn on a few grains
4	*Lal tengar*	"	Lal=red, Tengar= type of fish with stout spur	Reddish L/P color; bold grain with long stout awn; grown in shallow water
5	*Amaghauj*	"	Ama=guava, Ghauj=cluster	Yellowish grain; two to four grains originating from a single point giving cluster-like look; long and strong stalk
6	*Dudhraj*	"	Dudh=milk	Whitish L/P color; milky-white grain
7	*Lalka faram*	"	Lal=red, Faram= research institution	Yellowish L/P color with minute reddish stripes
8	*Harinker*	"	Harin=spotted deer	L/P during milking and dough stage looks like spotted deer; small round grain,
9	*Parewa pankh*	"	Parewa= pigeon, Pankh=feather	The sterile lemma is long, covering the grain from both sides
10	*Kariya kamodh*	"	Kariya=black	Very fine grain; blackish in color; aromatic

fragile to maintain that farmers easily adopt improved varieties—they have a higher yield potentiality than farmers' traditional varieties. As a result, the number of farmers growing local landraces and the area covered by those landraces is declining. To counteract this trend, there has been a big contribution to varietal diversification through the varietal choices made by different institutions, and on-farm varietal diversity has further been enhanced by farmer-to-farmer dissemination of new rice varieties (Joshi et al. 1997).

Figure 2 gives examples of diversity created by different factors. For instance, rice varieties grown in *ucha khet* (upland) are different from those in *nicha khet* (low wetland) and *man/pokhari* (water-logged areas). Similarly, *basmati, sathi,* and *khera* fulfil cultural and religious requirements, while *sokan* and *sotwa* are valued for their medicinal qualities. *Bhathi* is grown for its unique characteristic of adapting in deep water, and *sathi, mutmur,* and *sokan* are grown in marginal uplands where no other landraces or modern varieties can be cultivated satisfactorily. In contrast, farmers generally confine their sources of planting materials to neighbors, relatives, and whatever is available in a new environment.

Conventional breeding

The farmers' role in conventional breeding generally starts after the variety has been released, particularly for adoption and diffusion if the released varieties are preferred by the farmers. Once a variety is released through the breeding system, it is made available to a few farmers for assessing acceptance and rejection. The farmers' role is still as a passive partner and as an end user. Farmers' responses about new technologies are collected through farmers' days, farmers' field observations, and demonstrations.

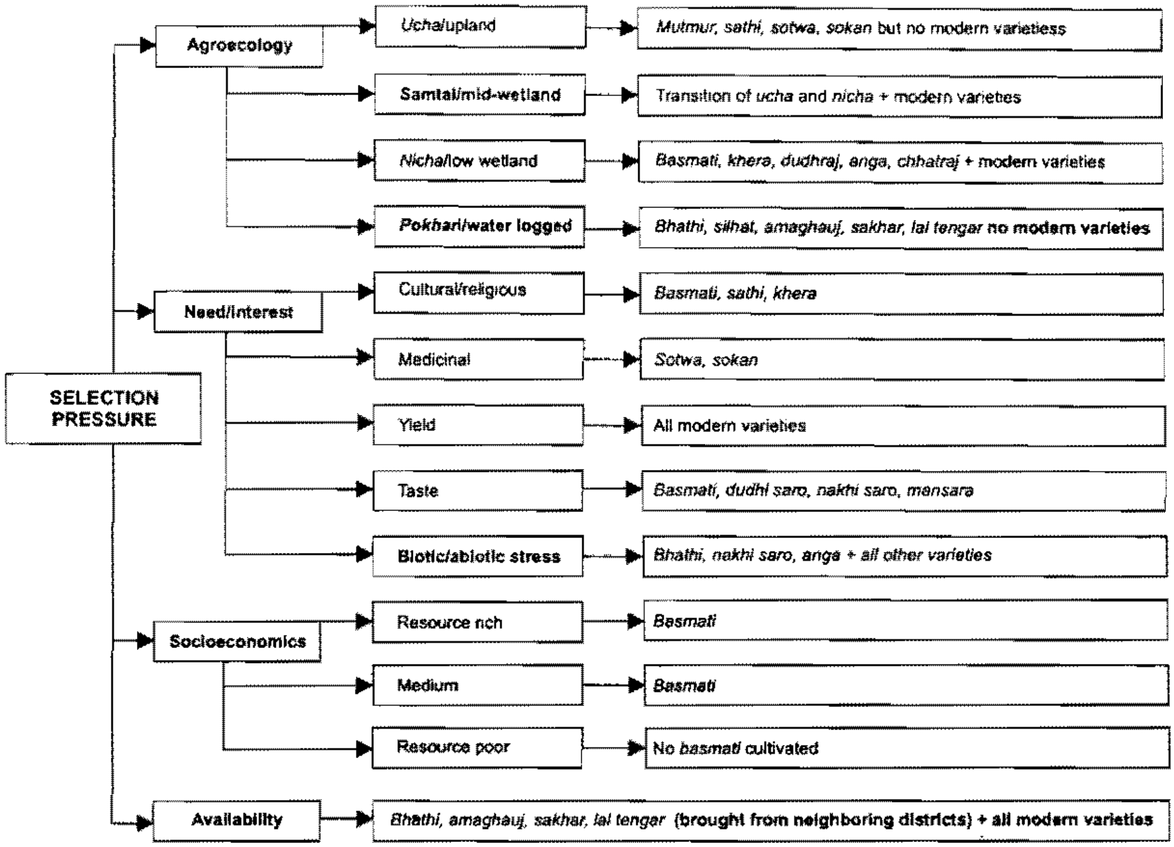

Figure 2. Agroecology and human-induced selection pressures on crop genetic resources

Participatory plant breeding

Participatory plant breeding (PPB) is widely used by different institutions, both government organizations and nongovernment organizations, and even by farmers. However, farmers' participation in PPB varies. The approach and methods of PPB are described in detail by IPGRI (1996: 57–65), Sthapit, Joshi, and Witcombe (1996), and Witcombe et al. (1996). However, the stages where farmers' involvement is most important are plant selection, germplasm enhancement, seed selection, and management (Joshi et al. 2000). Table 2 summarizes the range of farmers' participation in the PPB process.

Prospects for germplasm enhancement with farmers' empowerment

The germplasm of local landraces can be improved through pure-line or mass selection with the active participation of farmers and modest technical backstopping from formal institutions for most of the processes. This can be achieved through farmers' active participation, with minimum costs and little effort for breeders. At the same time, the genetic potential of local landraces can be conserved by encouraging in situ conservation.

Farmers at Begnas, Kaski and Kachorwa Bara have recently taken the initiative for participatory germplasm enhancement (PGE) through pure-line selection. In these areas, farmers' knowledge about seed selection and storage were first documented. On the basis of this information, the farm-

Table 2. Level of Participation in Different PPB Processes

Citation	Modes of participation	Level of participation by farmers
Witcombe (1996)	Consultative	Researcher consults farmers to assess needs, set breeding goals, and choose testing sites, but researcher retains key decision making
	Collaborative	Expert farmers grow early, variable generations and select best plants on their own fields
McGuire, Manicad, and Sperling (1999)	Farmer-led PPB	External agents support farmers' own system of crop development
	Formal-led PPB	Farmers join in formally initiated process of crop development

ers were next given an orientation on seed selection and germplasm improvement. Finally, an agreement was made to follow a pure-line selection process in which farmers' participation in the process was assured. This process was designed to help impart a selection of skills to farmers and improve their cop varieties through pure-line selection if they wished. They would also feel empowered through their own participation in the process. This process may be proven to be a holistic, less time-consuming, and more cost-effective approach to improve the quality of landraces, thus making them competitive with improved varieties and, eventually, invigorating in situ conservation on-farm.

The traditional seed-supply system

The role of farmers in crop improvement and managing agrobiodiversity can best be explained by the traditional seed-supply system (figure 3). Approximately, 60% of global agriculture is performed by subsistence farmers using traditional methods—providing between 15% to 20% of the world's food (Francis 1986; Sthapit and Joshi 1998). Diffusion in most parts of Nepal happens through the informal seed-supply system; the contribution of the formal seed sector is less than 5% in major staple crops (Baniya et al. 2000). The traditional seed-flow system includes variety selection and adoption, seed selection, seed exchange, processing, and storage (Shrestha 1998), and all of these processes are responsible for local crop improvement and creating agrobiodiversity. A review of case studies from Bangladesh (Mazhar 1997), Indonesia (Winarto 1997), Nepal (Joshi et al. 1997; Sthapit et al. 1998), and Ethiopia (Worede 1992) shows a wide range of examples in different countries where farmers—either independently or in collaboration with formal or informal institutions—have played an important role in crop improvement through seed production and dissemination (see also figure 1).

Variety selection and adaptation

From time immemorial, farmers have been observing and selecting their crops and crop varieties, saving and maintaining the seeds for next season, and experimenting with new seeds exchanged with neighbors and relatives (Shrestha 1998). It is noteworthy that farmers have tried to select the best available portion of the harvest for growing the subsequent year and also to meet the requirements of food and tradition. Farmers introduce new varieties in their localities to suit the different needs of soil fertility, moisture, family, and society, and to spread labor and reduce risk. Hardon (1995) and Joshi et al. (1997) reported that farmers possess the ability and knowledge to select crops and species that suit their environment and meet quality and other consumer requirements.

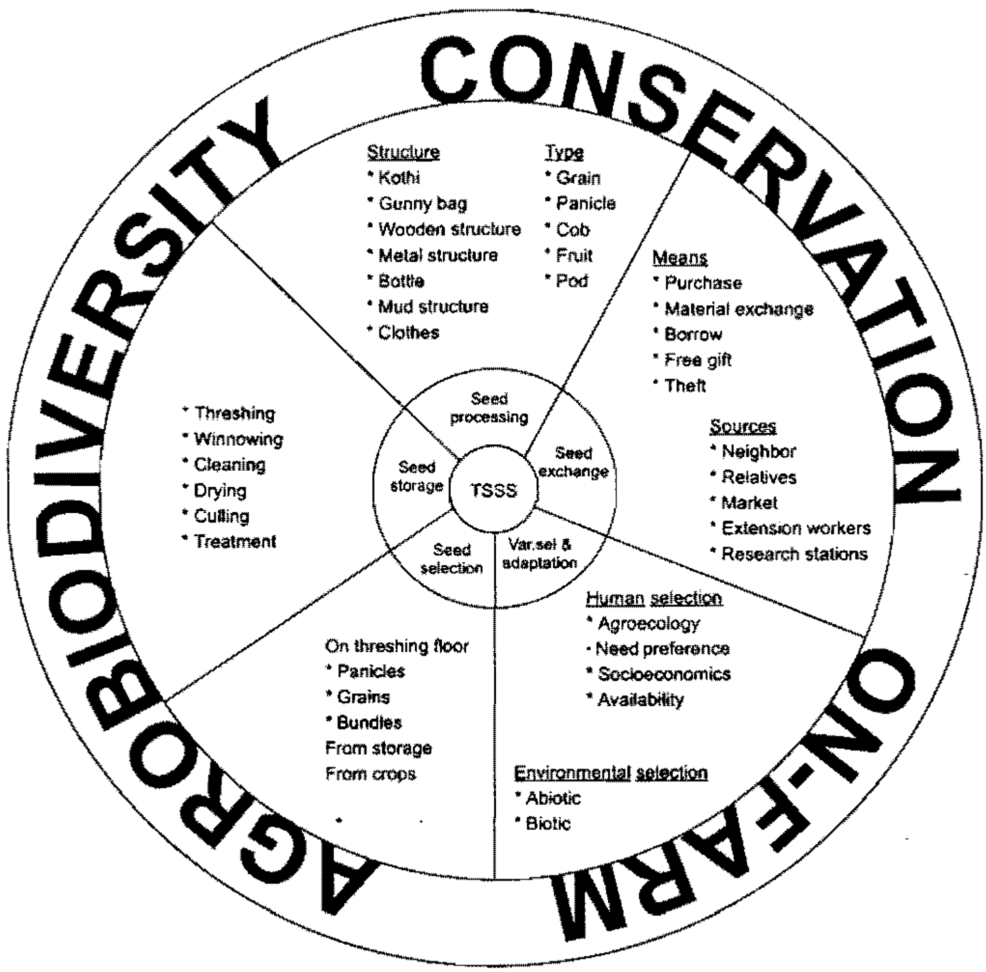

Figure 3. Farmers' role in the traditional seed-supply system

This process has created a diversity of crops and crop species, and thus, present-day landraces are no doubt the outcome of farmers' knowledge about and activities in crop improvement. Formal breeders in the name of "PPB" have lately consolidated the role of farmers in crop improvement through regular seed selection and exchange.

There is a wide range of information about the participatory methods practiced by scientists and breeders in several countries. Informal research and development (IRD), a type of participatory varietal selection (PVS) is reported to be 43% more cost effective compared to the formal system (Joshi et al. 1996 and Joshi et al. 1997).

Seed flow

The sources and directions of seed flow are vital to creating the diversity of both landraces and improved varieties. All the means through which seeds flow from one farmer to another contribute to diversity in totality. Seed flow includes purchasing, exchanging, giving as a free gift, borrowing, and stealing. Sources of new seeds might be markets, neighbors, relatives, agriculture extension, and research stations (see figure 1). In these ways, plant genetic materials drift from one place to another, creating new diversity in each community. This creates opportunities for farmers to meet different needs, which they could not do with a single variety (Joshi et al. 1997). In one of the studies in Begnas, Kaski, Baniya et al. (1999) reported that rich farmers generally initiate variety introduction. Most farmers (85%) change seed lots or cultivars regularly, and about 49% follow this practice every one or two years. Ex situ conservation in gene banks being unaffordable, the fate of crop diversity in many mountain areas is largely governed by the fate of the traditional seed-supply system that exists within local communities (Shrestha 1998).

Seed selection

For generations, farmers have been involved in seed selection, testing crop varieties to address single or multiple household needs such as food security, economic benefits, and religious and cultural requirements, as well as finding varieties that suit their land type depending upon the access or availability of planting materials (see figure 2).

The choices or preferences for varieties of a crop may, however, differ with differences in socioeconomic status. Religious and cultural considerations, level of education, and gender dimension are equally important in influencing the choices and preferences for different crops and varieties. Traditional methods of seed selection in one of the rural areas in terai region of the country are presented in box 1.

Box 1. Traditional Methods of Seed Selection at Kachorwa, Bara

Seed-selection practices	Rank
• At threshing floor, off -type panicles are removing, grains are removed by beating against hard surface to get seeds	I
• At the threshing floor, selected panicles are threshed by bullock and kept separately	II
• Panicles are selected at the threshing floor, keeping bundle of panicles and grains separated	III
• Seeds used directly from grain storage without prior selection	IV

Source: Chaudhary and Joshi (1999).

In traditional farming systems, varietal mixtures either emerge through the deliberate action of farmers, or seeds get mixed at several stages from seed sowing through harvesting, threshing, drying, and storage. Box 2 gives examples of the reasons for seed mixtures in rice, as mentioned by the farmers at Kachorwa, Bara.

Seed processing and storage

Farmers have developed different seed-processing and storage practices for different crops and crop species, which help the seeds stay viable. The practices that are followed by seed-storage companies and research stations today are the results of farmers' experiments in seed storage, transferred from generation to generation. Where seed processing is concerned, farmers keep the bare seeds of some crops, such as rice and wheat, or the cobs of maize or panicles or bunches or the fruit of some crop species, especially vegetables. For some crops, grains are cleaned and then dried well after threshing, while others require no such processing. Farmers store the seeds of some vegetable crops in the kitchen, where they are exposed to a continuous flow of smoke and heat. They dry the seeds of some other crops in the sun, some others (such as potatoes) in the shade. Some are kept in

Box 2. Traditional Methods of Seed Selection in the *Terai* Region of Nepal

Reasons for mixture in rice seeds

- *Jharan*: shattered seeds in the rice fields
- *Kheraha*: volunteer plants that emerge from jharan
- mixed in threshing floor because of a common floor used for a number of cultivars
- mixed because of using compost manure containing the seeds of other cultivars
- blown by air and getting mixed
- intermixed during planking
- mixed in seed bed because of flooding
- mixed by birds in the seed beds
- intermixed during transplanting
- careful seed selection process not performed in the mixed population by the farmer
- only a few farmers mix intentionally for monitory profit or to reduce the risk of failure

Source: Chaudhary and Joshi (1999).

airtight conditions, and some are spread on the floor. Baniya et al. (1999) reported on the different seed-storage practices followed by farmers in Begnas, Kaski, where there is a wide range of crop diversity even today. If farmers did not save seeds under proper storage condition, we would not have the diversity in both crops and crop species that we have today.

Limitations of participatory approaches

Participation

In the commercial world, there may be a lack of interest in participatory methods because resource-poor farmers might not appreciate immediate benefits from participation in research. They have a restricted time for contribution and limited resources to support research. On the other hand, resource-rich farmers, especially in a high production-potential system (HPPS) are likely to migrate to urban areas, thereby discontinuing active participation after a year or more. Urbanization and commercialization might have a negative impact on the participation since absentee landlords may have less time to think about all these participatory approaches, their being capable of supporting land for research purposes. Moreover, without compensation, long-term participation of farmers can not be assured, since the time for research activities can cause conflicts with farmers' field activities.

Knowledge

Confining farmers to traditional cultivation systems has made them focus on traditional selection practices; they are less aware of advances in agricultural science for seed selection and varietal selection based on agroecology. Searching and procuring seeds becomes cumbersome and time consuming for individual farmer. Traditional ways of procuring seeds without adequate information about new varieties might in some cases adversely affect the farmers' yield. Lacking adequate knowledge about seed selection, farmers keep mixtures in their selections to ensure adequate yields, but this also creates high diversity. Furthermore, in most of the participatory approaches to crop improvement, gathering postharvest information from rich people does not provide useful insights—they are not actually the end users, since they are likely sell a large portion of their produce in the market (Witcombe 1999).

Farmers' knowledge threatened

Several areas of knowledge are associated with landraces, and with the elimination of landraces, we not only lose genetic resources from our farming system or community but also the knowledge associated with them. With the ever-increasing dependence of farmers on modern technologies, accompanied by the use of chemical fertilizers and hazardous pesticides, farmers are being handicapped in several ways, including the area of indigenous knowledge. Farmers are, therefore, not only losing benefits from plant genetic resources, but more important, they are losing the right to save, exchange, and improve their seeds (Mazhar 1997).

Despite several efforts, it has been observed that no "steady state" is possible in populations of primitive cultivars because of technological changes in the farming systems that once produced them (Frankel 1970; Brush 1995). It is, therefore, certain that genetic erosion is pervasive and may accelerate if no proper action is taken on time to check it. It is also true that gradually the habitats of the landraces will be changed, the strength of the planting materials will be weakened, development and revolutionary options for various species may be shut off in the process, diversity will be skewed, and farmers' decision-making and indigenous knowledge systems will be diluted. The hardest hit by this will be small and marginal farmers, whose situations will be further worsened by concomitant increases in uniformity and expensive market seeds, fertilizers, insecticides, and pesticides, irrespective of their quality. As a result, food deficiency will become more widespread and the lives of people will be threatened. Thus, there is an urgent need to look for a solution that helps cope with food deficiency through the management of agrobiodiversity.

Coping strategies

The threat to farmers' knowledge, as well as to agrobiodiversity, can be addressed through the following strategies.

- Research should emphasize the process of responding to farmers' needs rather than designing fixed options in standardized trials. Research-managed on-station and on-farm trials need to be combined with trials designed and run by farmers. Researchers therefore need to expand their focus and learn about the complex adaptations made by farmers.
- Agricultural research needs to reflect farmers' own diverse conditions. It needs to be adapted to different settings (e.g., both dry-field and wetland agriculture), to different field conditions (e.g., a variety of soil types), and to different cropping patterns (e.g., multiple and intercropping patterns), rather than focusing on standardized, uniform trial plots, so that the processes of local adaptation and the technology developed are understood and can be supported.
- Farmers can be successfully empowered through training in the process of germplasm enhancement through pure-line and mass selection of their traditional varieties (Chaudhary and Joshi 1999), enhancing in situ conservation on-farm.
- The seed-supply system can be strengthened for self-reliance and cost effectiveness through the use of farmers' networks of information and seed exchange, involving grass-roots institutions (Joshi et al. 1997).

Conclusions

Farmers' knowledge (skills) and routine involvement in the crop-improvement process is crucial to the management of agrobiodiversity on-farm. Farmers are key players, bringing a wild species through generations, creating diversity to suit to their different agroecologies and traditions. However, farmers' knowledge is being eroded and plant genetic materials are being lost forever. Our current need is to document agrobiodiversity and the knowledge associated with it to use in crop improvement in the future. It is essential to have an adequate scientific explanation of farmers' knowledge in order to better and or improve this knowledge for efficient and sustainable agriculture. This can be achieved through different strategies such as diversity fairs, community biodiversity registers, poetry journeys (Rijal, et al. 2000), censuses, and field observations or transect walks. It requires the commitment of farmers and strong linkages with formal science institutes to enhance the maintenance of biological diversity, agricultural sustainability, and food security at the farm, regional, and global level.

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Need for Advocacy for Effective Participatory Crop Improvement and Plant Genetic Resource Enhancement: Case Studies on Rice-Breeding Processes from Khotang and Jajarkot Districts, Nepal

Yamuna Ghale

Abstract

This paper deals with advocacy for effective participatory crop improvement and plant genetic resource enhancement. First, the need for advocacy is highlighted; second, cases on the community-managed process of managing plant genetic resources is discussed. *Advocacy* is public action directed towards wider social change. It is about changing the policies, practices, attitudes, positions or programs of governing institutions within the public and private sectors that have a negative impact. In the age of globalization, multinational/transnational corporations (MNCs/TNCs) increasingly influence policies, but these organizations are not bound by rights-related laws and regulations. The trade-related intellectual property rights (TRIPs) agreement under the World Trade Organisation (WTO) is a major threat to crop and variety development and genetic resource enhancement. Advancements in genetic engineering promoted by profit-oriented MNCs/TNCs is gradually taking over the classical research-and-development process. If we are concerned about participatory crop improvement, we have to pinpoint the issue now. We need to enforce favorable policies and effective implementation for the conservation of our genetic resources and participatory development of crops and varieties. Therefore, to have influence at the policy level, we have to develop links between operational work and advocacy. In this context, advocacy can support communities demanding their rights in germplasm conservation. It is about having an input when government is formulating relevant policies, considering the voice of the powerless in developing plant- breeding program or plans, and bringing about the realization of favorable promises or policies for the benefit of farmers. The case studies show that farmers have selected and maintained their rice crops for generations with their own experience. The role of women farmer is vital to the process of seed selection, preservation, and maintenance. However, the cases indicate that men are still ignoring the role of women in the plant-breeding process. We argue that farmers are the owners of genetic resources, and they should have right to select, develop, conserve, and multiply them as they wish. Therefore, advocacy should be one of the major activities of all development organizations if they are to have any spillover effect for challenging sustained inequality and injustice to farmers.

Introduction

This paper basically deals with two issues: the first is the issue of advocacy and the need for advocacy in participatory crop improvement (PCI) and plant genetic resource enhancement (PGRE). It also analyzes the trend of global mechanisms to develop crops and or varieties without the participation of real stakeholders and the threat to developing countries. The second part highlights the major processes of seed production and saving rice in the mid-hills of Nepal. The cases elaborate these processes along with gender dimensions and the exclusion of farmers from breeding processes. Further to this, it highlights some of the advocacy and operational work of the development organization taking place in the Jajarkot area. The cases we highlight are from Khotang, in the eastern hills of Nepal for farmer-managed seed production, and Jajarkot, in the western hills of Nepal.

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The need for advocacy in PCI and PGRE

What is advocacy?

Advocacy is public action directed towards wider social change. It is about changing the policies, practices, attitudes, positions, or programs of governing institutions within the public and private sectors that have a negative impact. The co-director of the Advocacy Institute says, "To be meaningful, advocacy must be value based. It must be social, economic and political justice oriented." In most cases, government is still resisting the advocacy role being assumed by civil society.

Why advocacy?

Advocacy is not just another fad of development discourse; it is, rather, important to the sustainability of development work as well as policies. For the basic reason that for development organizations to have an effect, there needs to be a better understanding of the policies and practices of powerful development actors and how these can be changed in ways that benefit the large groups of poor farmers in their working areas. It is very important to recognize the importance of challenging deep-rooted and sustained inequality and injustice. In the age of globalization, policies are increasingly influenced by multinational and transnational corporations (MNCs/TNCs), which are not bound by rights-related laws and regulations. To have an influence at the policy level, linkages between operational work and advocacy should be developed, strengthening civil groups and alliances; lobbying decision makers directly; campaigning, promoting, and facilitating participation in research; building coalitions; and engaging the media.

Society is the common element that supports advocacy, with advocacy holding governing institutions to account on the behalf of citizens. There must be mechanisms to support nonrestrictive and robust debate on policy issues, procedures to resist harassment from authorities, and transparency in government. Civil organizations are increasingly expanding their activities beyond the provision of traditional services to include advocacy. Clear objectives, targets, methods or tactics, and allies are very basic elements of advocacy.

In the context of participatory plant breeding (PPB) and PGRE, advocacy can support communities in demanding their rights in germplasm conservation, in having an input when government is formulating policies, in making the voice of the powerless heard when plant-breeding programs/plans are developed, and in bringing the promises to the ground.

Advocacy in ActionAid Nepal

ActionAid Nepal's definition of advocacy is

> *a process, a deliberate, systematic and organised way of influencing public policy, public attitudes and policy practice in order to either change, maintain, implement or formulate new or alternative policies in favour of the poorest and most disadvantaged people.*

It is a set of coherent actions designed to introduce, influence, and change policies, practices, attitudes, and decisions for a just and equitable world. With this basic principle, ActionAid launched the International Food Rights Campaign to safeguard the right of poor people to food. The campaign aims to ensure that international agricultural trade benefits the poor and protects farmer's rights to seed and plant resources.

As biodiversity is owned by the community, there is an urgent need to include farmers in crop improvement and genetic resource enhancement. The issue of biodiversity conservation is rooted at the grass-roots level, which needs program linkage to be developed between operational work and advocacy. Therefore, ActionAid Nepal believes in strengthening the capacity of local organizations working at the grass roots to develop macro-micro linkages and, hence, to tackle the root causes of poverty, and it works to achieve this end.

Threat of the trade related intellectual property rights (TRIPs) agreement to the crop-improvement process and PGRE

The TRIPs agreement provides comprehensive rules and standards for the protection of intellectual property. Under this agreement, Article 27.3 (b) Patenting on Life Forms is a major threat for participatory plant breeding. It allows MNCs/TNCs to extend their control over the resources required to produce food in the South, as well as providing means to gain rights over many traditional plants growing in the South. This completely ignores rights of indigenous farmers to control and maintain the germplasm that fits in their lifestyles. There is a belief that TRIPs will have severe consequences for farmers in the South, that they will no longer be able to research, use, or exchange seeds and may lose ownership over traditional varieties of plants as well. Therefore, there is an urgent need to work on advocacy for participatory plant breeding, which preserves the rights of the indigenous farming community.

Where does the word *participation* fit in growing genetic engineering technology?

In the global trend of technology development, genetic engineering plays a crucial role in crop and or variety development. This kind of sophisticated technology is promoted by profit-oriented MNCs/TNCs and is limited to the laboratory. Therefore, the participation of farmers in this process is only a dream, and will remain so. If we are advocating participatory plant breeding, we must consider how we can play our role.

Case studies

The general Kiranti (Tibeto-Burman group) myth about the paddy crop invention in Khotang is that the ancestor, Khokchilipu, enjoyed a pot of rice cooked by his elder sisters, Nana Toma and Nana Khema, the cotton weavers, and he unfortunately trod on the fire-stick while dancing in the jolly mood and overturned the pot of rice. Another myth from Dhumi Rai is the story of an irritable king who had the habit of eating one *pathi* (approximately 4 kg) of rice, which had to be dehusked by nails. If this was not done properly, the cook was severely punished. These myths clearly show that the people of Khotang have grown a paddy crop since time immemorial.

In the case of Jajarkot, it is known that rice has been grown for about 110 years, and was brought from neighboring districts by the people of Jajarkot when they migrated. *Patle, mehel, kaumaro,* and *dotelo* are the main local varieties grown in the area.

Rice is grown as major crop in both Jajarkot and Khotang, especially in the less steep irrigated lowlands. It is strongly related to the eating habits of the local people.

Gender dimension

Seed choice. Seed is the basis for the next harvest. Farmers generally use seeds they have saved themselves. Family members discuss on selection of crop, seed, and land to grow it on, but the ultimate decision goes to the father or male head of the household. Women have a suggestive voice rather than an influencing one.

Nursery and plantation. For seed sowing, it is common practice in Jajarkot to soak the seeds in water for about four days and then to keep them in a bamboo basket before sowing in the nursery. In the process of preparing the nursery bed, men do the initial plowing but the rest of the job is mainly done by women.

Harvesting. Men and women are equally involve in harvesting, collecting, and carrying the paddy from field to threshing floor. Threshing is mainly the job of men with some assistance from women. After threshing, the job of mass cleaning is done by men but fine cleaning is done by women.

Seed selection. There are two main methods of seed selection.

In most cases, the paddy is harvested after it is fully ripe. Then the bunch of paddy will be threshed in the threshing floor once. The first harvest is then collected and kept for seed. The general reason is that the first harvest will have bold and healthy grains, which is good for seed. The farmers believe that "*jasto biuko ustai jiu*" (meaning, healthy seeds give healthy plants). Men perform this process, which requires more physical work. Then afterwards, the women collect the rest and finish the job.

The other method is where, after three or four years of harvest, the farmers choose the spikes in the field from healthy plants. The main reason is to get pure seeds. This method is used when the farmers realize the seed is not pure and the crops are not giving good harvests. This job is more or less done exclusively by women, who are very skillful and expert and have the patience for the tedious nature of the job. This clearly shows the relationship of power and skill with the division of labor.

The reason seed is selected by women is related to skill. There is a common saying that if the selected seed is not good enough, it means the women of that house are lazy and *allachhini* (meaning, women who have the greatest misfortune).

There is another method of seed conservation, which is very much tied up with the local culture. The farmers collect spikes that have ripened early and make a bunch, which is offered to the departed ancestors (*pitri*). This offering is not allowed for home consumption. When there is a famine and no seeds are available, the offerings can be used as seed to get the next harvest.

Postharvest storage. In most cases, all postharvest work is the exclusive job of women. They are responsible for cleaning and storing the harvest. During storage, the bold, ripe seeds are kept in local bins with *titepati* and cow urine.

Marketing

In the case of Khotang, the farmers generally keep whatever seed they need for the next season and use the seed accordingly. If there is any problem regarding the stored seed, they can exchange or barter seed with relatives or neighbors. The farmers sell paddy in the form of grain, not seed, in the market. Therefore, there is no influence from hybrid seed in the area.

In Jajarkot also, farmers are mostly dependent on internal sources of seed within the village. The Jajarkot Permaculture Program (JPP) has introduced some of rice varieties such as *machhapuchhre*

3, *chhomrong* and *badagaunle*. In addition, some of the new varieties such as the *radha* series and *mansuli*, have been introduced from district agriculture development. The JPP is working on advocacy in the promotion of indigenous seeds and technologies, and as a result, some of groups boycott the introduction of hybrid seed; they are more curious and alert about the value of local seeds and germplasm.

Cultural significance

In the Rai culture, rice must be offered to the departed ancestors. The local faith healers offer rice to chicks before sacrificing them as part of healing ceremonies. This shows the relationship between the culture and rice growing in the area.

In Jajarkot, the farmers celebrate *Harelo* on the third and fourth Sundays of Shrawan (August). During this festival, they spray cow urine by the twigs of *titepati* (*Artemisia vulgaris*) and worship the *Harelo* god with *bhojpatra* and pieces of red and white cloth.

Another interesting activity is a visit to a *Jhan* temple by pilgrims every five years during night of the full moon of *Paush* (Jan/Feb). There is a big trench below the ground where the pilgrims keep the rice grains they offered to the god. The grains replaced every five years to coincide with this celebration, so every five years there are new ones. When there is a famine and all the seeds stored in the house have been used for consumption, this store is opened and the stored grain is used for seed.

The first harvest is generally taken when there is *sait* (a good moment). The day of first consumption is considered a special day, when relatives gather and eat delicious foods. At the start of that occasion, the harvest is first offered to the god, and this offering is later used for seed if needed.

The role of intervening organizations

JPP has introduced a permaculture philosophy: making the earth live and grow on its own, with all bio-organisms surviving their full cycle. JPP has also encouraged farmers to use indigenous methods of farming and caring for nature. They have provided information on using green manure, on the use of skin-fermented water to control blast, and on patterns of crop rotation. JJP organized a farmers' level workshop on "Impact of Genetic Engineering on Indigenous Knowledge and Seeds" to raise awareness about the issues of biodiversity conservation. Now some of the women farmers' groups have dropped out of the commercial vegetable production group, which advocates the use of external inputs for agricultural production. The farmers have also boycotted the introduction of hybrid seeds in two of the village development committees. This means that farmers are able to make well-informed decisions if they have access to the right information. This will create a self-sustaining process among the farmers themselves, as well as helping to promote local biodiversity, in which they have the expertise of generations. Now Jana Sewa Samaj, a nongovernmental organization working in the Khotang district is trying to replicate the JPP model in the eastern hills of Nepal.

Conclusions

The case studies reveal that the indigenous community continues to manage plant breeding and that PGRE is most common in both case-study areas. Neither distinct formal-led nor farmer-led plant-breeding practices are common. Now such community-managed plant-breeding processes and genetic resource management are severely threatened by globalization, especially Article 27.3 (b) of the WTO TRIPs Agreement. ActionAid Nepal believes that the food security of poor farmers and farmers' rights in seeds and plant genetic resources should be protected from such threats. To minimize the negative impact of international policies that are unfavorable to poor farmers, ActionAid Nepal has implemented a food-rights campaign. Micro-macro linkages are extremely important in influencing the policies for which the food-rights campaign is working. JPP and Jana Sewa Samaj are examples of strengthening and mobilizing local organizations to work on community-based PGRE and PPB.

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Beyond Taro Leaf Blight: A Participatory Approach for Plant Breeding and Selection for Taro Improvement in Samoa

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Abstract

The 1993 outbreak of leaf blight in Samoa resulted in the devastation of the staple taro crop and farmer's incomes from local and overseas markets. The preferred cultivars were all susceptible to the disease, and attempts to solve the problem through fungicides and changed cultural practices have had little impact. Efforts to evaluate exotic cultivars and breed taro with disease resistance commenced in 1996. Recent initiatives to facilitate the breeding program in Samoa include a university breeders' club and the Taro Improvement Project (TIP), involving university and ministry research staff, students, extension staff, and farmers. Both initiatives have been motivated by an interest in greater participation of students and farmers in the breeding process and evaluation of introduced taro cultivars. This paper reviews and evaluates experiences in Samoa with participatory approaches to plant breeding using a breeders' club and a farmers' group (TIP), highlighting the benefits of both.

Background

Samoa is a small independent Pacific Island country with two main islands (Upolu and Savaii) and five other small islands (figure 1). It has a population of about 160,000 largely involved in agriculture. Most agricultural households grow a variety of crops, including taro, bananas, breadfruit, cocoa, and coconuts. Prior to 1993, taro (*Colocasia esculenta*) was the most important export of the country, with 96% of agricultural holdings cultivating the crop. It is estimated that the area under taro at that time was 14,600 ha, of which 76% was grown as a monocrop. A single cultivar, taro Niue, dominated the cropping area because of domestic and export demand. The appearance of taro leaf blight (TLB), caused by *Phytophthora colocasiae*, in 1993 demonstrated how vulnerable the intensive production of taro had become, and production virtually ceased overnight. Since then the Ministry of Agriculture, Fisheries, Forests and Meteorology (MAFFM) has explored various approaches to overcoming the problem, including plant breeding. More recently, research staff at the University of the South Pacific (USP) have also become involved in breeding taro for resistance to the disease. There are clear signs that farmers in Samoa are slowly returning to taro again.

Taro in Samoa

Taro, an edible aroid that originated in the Indo-Malayan region, is grown as a staple or subsistence crop throughout the humid tropics but is of greatest importance in the Pacific Islands, where it accounts for about 20% of the root crop area. The corms are baked, roasted, or boiled and the leaves are eaten as *palusami*. Taro spread eastwards into the Pacific, probably reaching the Polynesian islands 2,000 years ago. There is now evidence to suggest that most cultivars found throughout the Pacific were not brought by the first settlers from the Indo-Malayan region but were domesticated from wild sources existing in the Melanesian region (Lebot 1992). There are now thought to be

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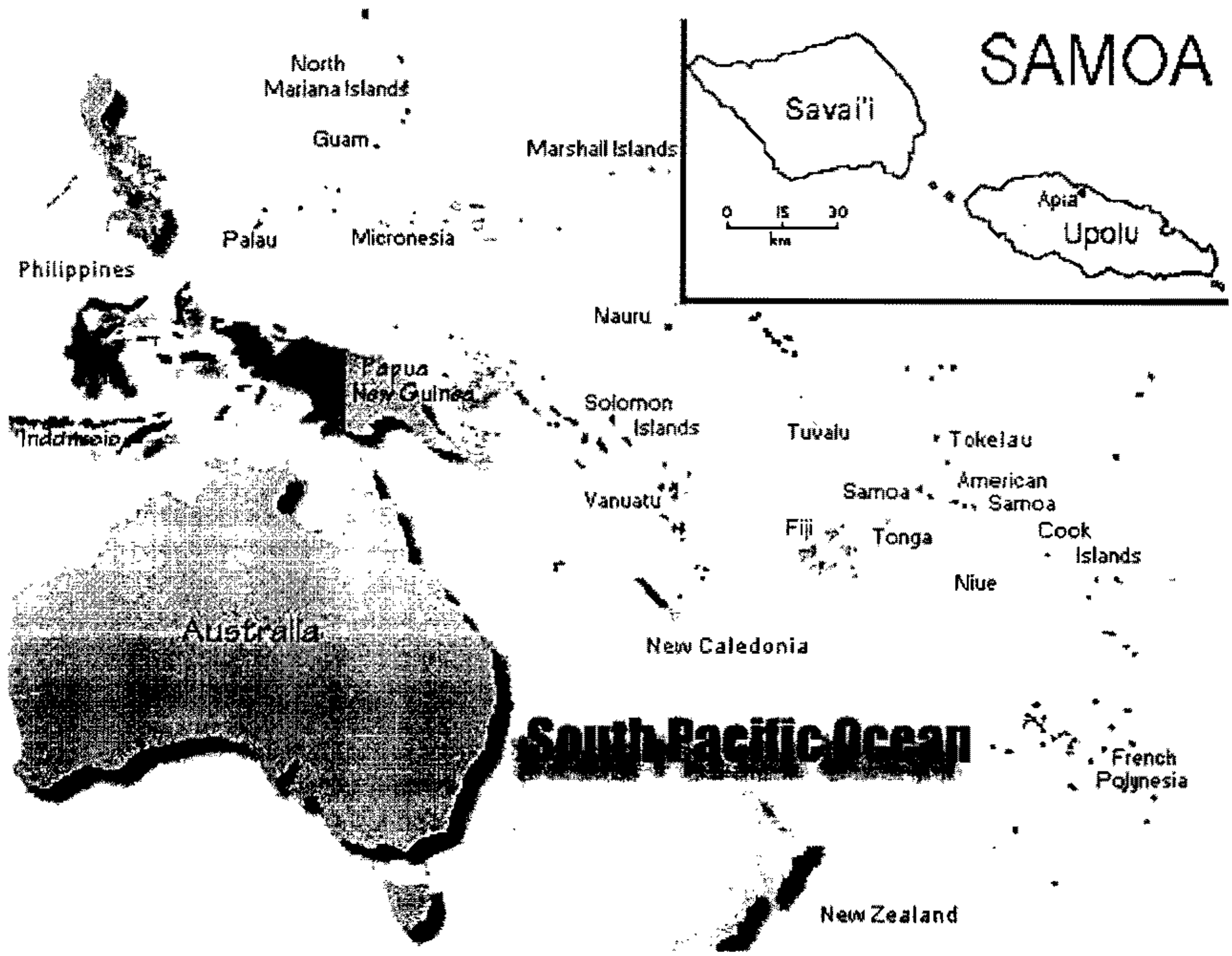

Figure 1. Samoa and its location in the South Pacific Ocean

approximately 2,000 taro cultivars in the Pacific region (Hunter, Pouono, and Semisi 1998). Prior to the arrival of TLB, farmers in the Pacific selected taro cultivars for a number of traits but not resistance to the disease. In the absence of this selection pressure, taro cultivars have reduced levels of resistance. At the turn of the century when the TLB pathogen began to spread into the region, it encountered a host plant that was genetically vulnerable.

Taro is the most important plant in Samoa, having special cultural, dietary, and economic importance. It is considered an essential component of an everyday meal. It is a plant with high prestige and great importance as a presentation on formal occasions. It is also favored for its considerable productivity in the fertile and high-rainfall environment of Samoa (Ward and Ashcroft 1998). In 1983, the returns from taro were three times higher than that from bananas and eight times higher than from coconuts (Asian Development Bank 1985).

Impact of taro leaf blight in Samoa

TLB was first observed on the island of Upolu at Aleipata and two days later from Saanapu and adjacent districts in July 1993. The disease spread rapidly throughout the country, severely affecting all local cultivars, but it was most devastating on taro Niue, the cultivar of choice for commercial production because of its quality and taste. Various factors contributed to the rapid spread of the disease in Samoa. The area planted to taro Niue at the time was extremely large and effectively ensured a monocrop situation. There was a continuous and abundant source of taro for the disease because of the practice of farmers to interplant on old plantations and stagger their cultivation. Combined with the widespread movement of infected planting material and ideal weather conditions, the disease quickly reached epidemic proportions.

In 1992, prior to the blight, the World Bank estimated taro exports from Samoa at US$10 million, with a similar value on the domestic market. This placed taro as the dominant export and domestic market commodity. By 1995, the export value of taro had fallen to US$60,750, or less than 1% of pre-blight figures. Initial efforts by MAFFM to contain the disease, including fungicide spraying, quarantine efforts, and a public-awareness program, failed dramatically. The disease spread rapidly, and by 1996 only 200 farmers were growing taro in Samoa.

Conventional taro breeding strategies in Samoa

In 1995, MAFFM, in conjunction with the Australian government-funded Western Samoa Farming Systems Project, initiated a program to evaluate exotic cultivars. Nine exotic cultivars were evaluated against taro Niue in preliminary trials in 1995 and 1996. The cultivars Pwetepwet, Pastora and Toantal (originating from the Federated States of Micronesia) and PSB-G2 (now known locally as taro Fili and originally obtained from the Philippine Seed Board) were assessed in on-station trials for resistance to TLB. These trials indicated that all four cultivars were more resistant than Niue, the locally preferred cultivar. MAFFM further evaluated these four cultivars in on-farm trials during 1996 and 1997. Farmers involved rated Fili as the best tasting and both Fili and Pwetepwet as the most resistant to leaf blight. MAFFM began recommending and distributing Fili to growers in late 1996.

The identification of taro Fili has allowed many farmers to return to taro production, and over the last few years, the area under taro has slowly increased. However, the release of this single cultivar has not been enough to meet the needs of all growers, and a few shortcomings have been reported, including the following:

- relative susceptibility to the disease, especially in wetter areas of the country
- low yields
- poor storability, which is a problem with growers starting to export to markets in American Samoa and the United States

In addition, MAFFM imported a range of exotic taro cultivars from Palau in 1995. Field trials at the University of Hawaii had shown that some of these cultivars had good levels of resistance to TLB. To date, no Palau cultivars have been released or recommended by MAFFM.

Efforts to breed taro with resistance to TLB in Samoa commenced in 1996. Crosses were made among introduced TLB-resistant cultivars and susceptible local cultivars. This cycle-1 population has been evaluated and 10 promising clones have been selected. These clones are being further evaluated in multilocational trials in Samoa.

Participatory approaches for taro breeding in Samoa

The apparent need for a more participatory approach to plant breeding in Samoa arose as a consequence of informal discussions with farmers, who often expressed dissatisfaction with the pace of release of resistant taro germplasm through the conventional taro-breeding program. Researchers at USP were also concerned with the rate at which resistant taro was released through conventional taro breeding and the rigorous testing over several years trying to identify a few clones or cultivars that might be of limited relevance to farmers. There is evidence from elsewhere that much of the germplasm officially released through conventional plant-breeding programs is of limited relevance to farmers, and much of the material that is rejected has been found to have subsequent acceptance among farmers (Maurya, Bottrall, and Farrington 1988). The conventional taro-breeding program was also doing little to increase the diversity of taro in the country.

A participatory approach to plant breeding, involving researchers, farmers, and extension staff, was considered as a means to

- learn more about what farmers want from improved taro cultivars and to involve them in the technology development process
- involve many farmers under diverse environments, providing them with a range of options so that they can select the best for their conditions, which would ensure that farmers gained quicker access to resistant taro
- increase the diversity of taro cultivars grown by farmers in Samoa. This was an important perception in minimizing a repeat of the disease outbreak. The danger of relying heavily on one or a few genotypes is only too apparent from events in Samoa in 1993
- strengthen the linkages between researchers, extension staff, and farmers
- make more effective use of limited time and resources of researchers and extension staff

Taro Improvement Project

The Taro Improvement Project (TIP), a large farmers' group, was initiated at USP in 1999. TIP aims to bring together taro growers and provide them with more options for improving production and managing taro leaf blight. It represents a partnership between USP research staff, MAFFM extension staff, and farmers. Currently, the project is working with 25 farmers on the island of Upolu to evaluate introduced taro cultivars from Palau, Micronesia, and the Philippines. Initiation of the TIP farmers' group was motivated by factors outlined above and the noticeable success of other similar farmers' groups implemented elsewhere to address problems aimed at farming systems improvement (Norman et al. 1988).

Farmers become members of TIP by either contacting staff at USP or notifying their district extension officer. When a farmer has been selected as a taro grower, he or she agrees to compare taro cultivars in a grower-participatory research program. Farmers have been selected from most districts on Upulo.

Cultivar selection. TIP supplies each participating farmer with planting material of several taro cultivars for a simple nonreplicated trial. Information is provided on trial layout, labeling, and simple data collection. The trials are maintained and managed by farmers. Farmers can record their own observations on the growth of taro cultivars using the simple data sheets provided. TIP research staff regularly visit participating farmers, help keep records on cultivar performance, and record yield data. To facilitate feedback and sharing of information on the evaluation of cultivars, the members of TIP hold regular monthly meetings at various locations. These meetings help growers to learn about other growers' experiences. Participants are also asked to bring corms of cultivars ready to harvest for taste-test evaluations. Growers also provide information on cultivars that have been prepared for home consumption.

Farmers have been evaluating cultivars from the Philippines, Federated States of Micronesia, and Palau. Recently, the TIP farmers who have been evaluating these cultivars, were asked to rank them on a scale from 1 to 4 for characteristics of vigorous growth, yield, TLB resistance, sucker production, and eating quality. These preliminary results are shown in table 1.

Table 1. Taro Cultivar Rankings by TIP Farmers

Culvivar	No. of growers	Vigor	Yield	TLB Resistance	Suckers	Eating Quality
Fili	12	3.1	2.4	2.0	3.4	4.0
Pastora	11	3.8	3.3	2.9	3.2	1.6
Pwetepwet	10	3.4	2.9	2.7	3.8	2.2
Toantal	10	3.3	2.3	1.7	2.7	3.5
Palau 3	8	3.3	3.0	2.6	3.1	2.9
Palau 4	9	3.1	2.1	2.6	3.9	3.1
Palau 7	8	3.5	3.0	2.8	2.8	2.4
Palau 10	12	3.9	3.8	3.5	3.2	3.2
Palau 20	11	3.7	3.5	2.6	2.9	3.6
Niue now	8	1.9	2.0	1.1	1.9	1.9
Niue before TLB	10	3.9	3.9	—	3.1	4.0
Alafua Sunrise	2	2.7	2.5	1.7	1.0	2.7

Note: 1 = Unacceptable; 2 = Okay, but not good; 3 = Good; 4 = Outstanding.

TIP meetings provide an excellent forum for conducting participatory rural appraisals (PRAs) to elicit information regarding problems facing taro growers, the important criteria of an ideal taro cultivar, and farmers' perceptions of the cultivars that they are evaluating. TIP meetings also allow research staff to address those issues that farmers would like more information about, such as disease management and the processes involved in breeding. TIP meetings also help to facilitate the organization of taro diversity fairs and farmers' field days in Samoa.

Clone selection. So far, farmers have been mostly involved with evaluation and selection of introduced cultivars. As the program develops, it is intended that farmers will become more involved in the breeding program and participate in the selection of clones. This process is already underway. In September 1999, a cycle-2 population of taro seedlings was transferred from USP to a farmer's field in the village of Safa'atoa. A farmers' field day organized at this location helped to explain the objectives of the breeding program currently underway in Samoa and how clones are selected from a seedling population. Farmers had the opportunity to observe firsthand the preliminary selections made by USP researchers. These preliminary selections totaled almost 200 clones. Duplicates (suckers) of these selections have been given to three farmers for evaluation on their own farms. The farmers as a group have also helped in narrowing the preliminary clones from 200 to the final 25 selections by participating in taste and quality tests during TIP monthly meetings. These 25 clones (table 2) are being multiplied for on-farm evaluation by TIP farmers later this year.

Table 2. Average Leaf Number, Months to Harvest, Yield, and Taste of the Top 25 Taro Clones Selected from a Cycle-2 Population in Samoa

Clone Number	Months to Harvest	Yield (kg)[1]	Average Leaf Number	Taste[2]
C2-30	5	1.0	6	3.5
C2-40	6	1.1	7	3.6
C2-47	6	0.7	5	3.5
C2-48A	6	0.8	5	3.6
C2-70	6	0.7	4	3.5
C2-77	6	0.7	5	3.7
C2-93A	5	0.9	5	3.6
C2-94	5	0.8	5	3.6
C2-97	6	0.7	6	3.7
C2-132	6	0.6	5	3.5
C2-144	6	1.1	5	3.8
C2-145	6	0.6	4	3.6
C2-147	6	0.6	5	3.6
C2-148	6	0.6	4	3.7
C2-152	5	0.8	5	3.8
C2-157	6	0.6	5	3.6
C2-160	5	0.6	5	3.8
C2-161	6	—	6	3.6
C2-194	6	1.1	7	3.9
C2-196	6	0.9	7	3.5
C2-227	5	0.6	7	3.6
C2-232	6	0.7	6	3.8
C2-234	6	0.9	6	3.7
C2-234A	6	0.8	5	3.8
C2-236A	6	0.7	7	3.5

1. Based on weight of single corm at harvest.
2. Evaluated as 1 = poor, 2 = OK, 3 = good, 4 = excellent.

University Taro-Breeders' Club

A university taro-breeding club was initiated at USP in 1999. The first university breeding club in the world was started in 1995 in Mexico. We believe that the club at USP is the first to be inaugurated outside of Latin America. The club represents an innovative approach to teaching and learning at USP. It is a cheap and easy approach to breeding. It ensures that there are many hands to do breeding work and has resulted in increased taro breeding activity. Robinson (1996, 1997) has proposed university breeding clubs as a "hands-on" approach for students to learn about breeding for horizontal resistance and a way of "scaling-up" farmer participation in plant breeding (see box 1). Robinson (1997) envisaged student-members of breeding clubs returning to their family farms with potential new cultivars for evaluation. After a few decades, there could be hundreds, or even thousands, of former club members testing new lines as they emerge from clubs. Additional breeding clubs would increase the output even more, providing the *widest extent and the highest possible quality of farmer participation in plant breeding.*

Box 1. Aspects of Breeding Clubs That Promote Student and Farmer Involvement and a "Scaling-Up" of Participatory Plant-Breeding Activity

- Clubs would provide a new "hands-on" approach to plant breeding in an effective group-learning context for students.
- Clubs could transfer plant-breeding skills to many amateur breeders working within a single agroecosystem involving a few thousand farmers.
- There would be a vast increase in breeding skills as graduates return to their villages and initiate local farmers' or amateur breeding clubs.
- Hundreds of plant breeding clubs worldwide could significantly improve crops by a huge increase in breeding activity.
- Clubs would re-establish links between researchers and farmers. High levels of farmer participation in plant breeding would result when farmers' children join university breeding clubs.

Source: Robinson (1997).

The overall aim of the USP taro breeding club is to produce high-yielding, good-quality taro cultivars that have high levels of horizontal resistance to TLB and other locally important taro pests, and that are adapted to a range of diverse environments. At the same time, the club allows students to learn about the breeding process in a practical way. The club is seen as an integral component of TIP, using selected farmers for evaluation of clones and multiplication of potential new cultivars. The club has a formal structure with elected officers, including a president, vice-president, treasurer, and secretary. A club constitution was drawn up and it is run along the lines of a student organization. Most members are students but some are professionals, such as lecturers, crop researchers, technicians, and university administrators, while a small percentage are farmers.

The club meets regularly at the University's Alafua Campus. This campus is the location for the club's breeding blocks and it is on-campus that most crossing takes place and where taro seedlings are raised. Screening and evaluation of seedling populations take place at locations with suitable disease pressure. To date, duplicate breeding blocks have been initiated on-campus. One block is for the use of researchers and the other for the use of students. The student breeding block is made available solely for the use of students, and they are encouraged to maintain their own subplot, make crosses within this, harvest seed, and raise seedlings for field evaluation. The committee decides on a program of topics and field visits to facilitate learning about plant breeding with assistance from university technical staff. The club is self-financed largely through the payment of member fees and fund-raising events.

Conclusions

Although TIP is a young organization, it is already showing that farmers can evaluate many different taro cultivars and select those they prefer. The membership of the program has expanded rapidly in its first year. The program has improved dialogue between researchers, extension staff, and farmers. Evaluation of cultivars is still underway and a considerable amount of quantitative and qualitative data have been compiled. This will be analyzed shortly. There are early indications that growers are selecting a range of cultivars. Taro *Fili* has been included as the preferred resistant cultivar to date. It is interesting to note that some growers are showing preferences for cultivars (*Toantal*, *Pwetepwet*, *Pastora*) that were evaluated by MAFFM at the same time as taro *Fili* but which were not recommended or widely promoted. Both *Pwetepwet* and *Pastora* were previously believed to be of poor quality, although they both have good levels of resistance to TLB and they are both high yielding. One farmer has observed that the quality improves if harvest is delayed for a few months. The same farmer has also reported that he likes *Pastora* despite its tendency to be *susu* (meaning wet, a quality not liked by Samoans). He removes the top (wet) half and uses the bottom part of this high-yielding cultivar.

There has been considerable confusion in Samoa about Palau cultivars. This has arisen as a result of unauthorized imports of batches of mixed cultivars from nearby American Samoa. There are 12 different cultivars from Palau in Samoa. Some are good quality and some are considered wet. TIP has been working to address this confusion, and gradually those cultivars of good quality are being identified. Early indications are that growers prefer Palau 20 and 10. Reports from American Samoa show that both Palau 20 and 10 are most preferred by growers there. Many of the growers have experimented with the harvest date of the Palau cultivars and report that this can significantly influence the corm quality. These findings are important. Some Palau cultivars are found to be wet if harvested early (five to six months), but this can be overcome, in some cases, by delaying harvest until seven to eight months. Research station evaluations of taro usually occur after six months.

As a result of the impact of TIP on Upulo, MAFFM have initiated a similar TIP program on the other main island of Savai'i. In May 2000, nine extension officers from Savaii spent time on Upulo visiting farmers involved with TIP and took part in the May monthly meeting to observe how the club operated. This should ensure that farmers on that island get quicker access to a range of resistant taros.

There are some aspects of the USP taro-breeders' club that make it different from other clubs like the one at the *Universidad Autonoma de Chapingo* in Mexico. The University of the South Pacific is a regional university, whereas the *Universidad* is a national university. USP draws a student body from over 12 individual countries dispersed in the Pacific Ocean. This poses one problem for a university breeders' club but it also has an advantage. Robinson (1997) highlights the positive interaction that may arise between a breeding club and farmer participation schemes. In the *Universidad* situation, students come from surrounding villages. Students can return to these villages with the progeny of the crosses they have made and carry out participatory selection with farmers on family farms. Certain selections may become potential cultivars but can also be fed back into the breeding club system to become future parents. Unfortunately, the majority of student members of the taro-breeding club come from countries other than Samoa and quarantine and unresolved ownership issues preclude taro germplasm leaving Samoa for evaluation on many family farms. The solution to this problem is to pool all crosses together and evaluate seedlings as one population through the TIP program. The advantage of having members from many different countries is the high potential for similar breeding clubs to be initiated elsewhere when students return to their home countries at the completion of studies. The club also plans a regular newsletter to maintain contact with members who have finished their studies.

The breeders' club has been successful as an innovative "hands-on" approach to teaching and learning, but club activities place considerable demands on student time. A three-year degree means that students have a packed timetable that allows little time for "extracurricular" activities. One possible solution to this problem is a cross-credit system to the conventional degree-level breeding courses that are taught at USP. This would allow students to obtain cross-credits for the breeding activities that they carry out as part of the breeders' club. Likewise, lecturers would also accrue teaching credits for their involvement in the breeders' club.

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Participatory Plant Breeding in Maize for the Chhotanagpur Plateau of Eastern India

Arun Kumar, D.K. Ganguli, S.C. Prasad, J.S. Gangwar, D.S. Virk, and J.R. Witcombe

Abstract

This paper describes a participatory maize breeding program that is a collaborative project between Birsa Agricultural University and the KRIBHCO Indo-British Rainfed Farming Project (East). At the beginning of the project, a base population was produced in the rainy season of 1997 by making nine crosses between three yellow-endospermed flint varieties (Suwan, Birsa Makka 1, and Chandan 3) and three white-endospermed flint varieties (GDRM 187, Shweta, and Rudarpur local). The parental varieties were selected either because farmers in the project area had accepted them or because they contributed complementary traits to the population. The population has been randomly mated for five cycles by hill-planting seed derived from the original nine crosses and detasseling 50% of the plants. After the initial random mating, each cycle was planted from pale yellow grains that should be heterozygous at the locus controlling endosperm color. Three composite varieties have been extracted from cycles three and four by random mating of early-maturing plants (75 to 80 days) with either yellow or white grains. Preliminary results show that these populations are superior to local checks for multiple traits. Intervarietal hybrids were also made from farmer-preferred varieties. Farmer-managed participatory research (FAMPAR) trials conducted in the rainy season of 1998 showed that farmers preferred the BM 1 x Suwan intervarietal hybrid to the local varieties. Further evaluations of hybrids in on-farm and station trials are being conducted.

Introduction

After rice, maize is the most important cereal crop in the rainy season for the largely tribal farmers of the Chhotanagpur plateau region of eastern India. However, maize is in decline and yields vary greatly from year to year. The Birsa Agricultural University (BAU), Ranchi has released several varieties, but tribal farmers have not adopted them because of their late maturity, which results in the common end-of-season droughts severely limiting yields. Therefore, a participatory maize breeding program was initiated in a collaborative project between Birsa Agricultural University, Ranchi, and the KIBHCO Indo-British Rainfed Farming Project (KRIBP) managed by KRIBHCO (Krishak Bharati Co-operative).

The major objective was to breed and test early-maturing and high-yielding open-pollinated varieties and intervarietal hybrids of maize in participation with farmers. An analysis of farmers' constraints showed that farm holdings are very small in the area and that shallow, infertile soils on sloping lands give poor yields. The crop is largely rainfed, and irrigation to mitigate the effects of drought is rarely available.

Participatory rural appraisals were used to solicit farmers' preferences in maize varieties. Farmers wanted the following:

- early maturity
- yellow-endospermed flint grains and high yield

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- long cobs with high placement on the stem
- prolificacy (two to three ears per plant)
- resistance to lodging, disease, and insect pests
- nonhybrid varieties because of the cost and difficulties of purchasing hybrid seed every year

Breeding strategies

To develop new varieties of maize, two strategies were adopted:

- breeding open-pollinated composite varieties
- breeding intervarietal hybrids

Composite breeding

To breed new open-pollinated composite varieties a base population was initiated in the main season of 1997 by making nine crosses between three yellow-endospermed flint varieties (BM 1, Suwan, and Chandan 3) and three white-endospermed flint varieties (GDRM 187 from Gujarat Agricultural University and KRIBP west, Gujarat [see Goyal, Joshi, and Witcombe, this volume]; Shweta, from Uttar Pradesh; and Rudarpur local, from Uttar Pradesh). The parental varieties were either farmer-preferred varieties or had complementary traits. The three yellow varieties are medium- to late-maturing and have a higher yield potential when water is not limiting than the three earlier-maturing white varieties. By 1999, the population had been randomly mated for five cycles by using a pseudo-random hill planting plan. In each cycle, 50% of the plants were detasseled, and pale yellow grains were harvested from the detasseled plants (Goyal, Joshi, and Witcombe, this volume). At the C_3 and C_4 cycles, two open-pollinated (C3/98-99 and C4/99) varieties were extracted from the base population.

The yellow-grained variety C3/98-99 was formed from deep yellow seed harvested from about 200 early-maturing, detasseled plants of the C_3 cycle of the base population in the post-rainy season of 1998–99. In the rainy season of 1999, the random-mating population was grown from these seeds. In the post-rainy season of 1999–00, farmers were invited to visit the research station at Ranchi to select desirable plants. Farmers graded them into three categories and the third preferences were rejected. In the rainy season of 2000, the selection will be repeated and the population will be tested in research station trials.

Similar procedures were followed for variety C4/99.

A white-endospermed population was also developed by bulking white grains from three sources: from selected plants of the C_4 cycle of the base population, from the C3/98-99 population grown in the rainy season of 1999, and from plants selected for making the C4/99 population. The first random mating will be carried out in the rainy season of 2000, and farmers will be involved in selection before and after flowering.

Intervarietal hybrid and composite breeding

Intervarietal hybrids offer a faster approach to creating new varieties for farmers than generating new composites, but they require more complex seed multiplication than open-pollinated varieties. However, the seed of intervarietal hybrids is cheaper and somewhat easier to produce than that of single-cross hybrids based on inbred lines. If intervarietal hybrids were greatly preferred, then KRIBP would attempt to produce seed within project villages.

In single-cross hybrids, advanced generations from farmer-saved seed are considerably lower yielding than the original F_1 generation. However, the advanced generations of intervarietal hybrids may still yield well. How much hybrid vigor is lost if farmers retain the seed of hybrids is being evaluated in the rainy season of 2000 by using advanced open-pollinated generations from the F_1 intervarietal hybrid.

Some farmers have preferred the open-pollinated varieties Suwan, BM 1, and Chandan 3 to their local varieties. These varieties, along with Megha, a drought-tolerant and early-maturing variety from Punjab, were used as parents to produce three intervarietal hybrids in the rainy season of 1997: BM 1 x Suwan, BM 1 x Chandan 3, and Megha x Suwan.

Evaluation

The new open-pollinated varieties developed have not yet been tested for yield on farmers' fields. However, intervarietal hybrids were tested in farmer-managed participatory-research (FAMPAR) trials in the rainy season of 1998 as well as in research-station trials in the pre-rainy season of 1998–99 and the rainy season of 1999.

Of the three hybrids tested, BM 1 x Suwan yielded the most in trials conducted in the pre-rainy season of 1998-99 (table 1). The advantage of the intervarietal-hybrid approach is clear: the hybrid yields more than either parent and is earlier than the later, highest-yielding parent (Suwan).

FAMPAR trials in the rainy season of 1998 showed the following:

Table 1. Performance of Three Intervarietal Hybrids of Maize on the BAU-KRIBP Research Farm, Ranchi, Bihar, during the Post-Rainy Season of 1997–98 (Summer 1998)

Hybrid	50% silking (d)	50% tasseling (d)	Maturity (d)	Plant height (cm)	Ear length (cm)	Yield/ plant (g)
Suwan x Megha	102	110	148	151	17	125
BM 1 x Suwan	99	108	147	136	17	145
BM 1 x Chandan 3	94	98	139	135	16	115
Suwan	104	111	159	146	16	105
BM 1	95	99	139	127	14	100
Megha	93	96	135	137	13	93
Chandan 3	96	101	144	129	17	125
GDRM 187	86	93	132	116	13	88

- Farmers preferred BM1 x Suwan and Chandan x Suwan because of their yellow flint grains, higher yield, medium maturity, and higher fodder yield.
- Hybrid Megha x Suwan was rejected because of a high proportion of poorly developed and diseased plants.

The two farmer-preferred hybrids were further tested in the rainy season of 1999 at the BAU-KRIBP farm (figure 1). Hybrid BM 1 x Suwan, the highest-yielding entry, yielded more than both parents and was earlier than the highest-yielding parent. Chandan 3 x Suwan was earlier than either parent, and although it yielded less than Suwan, the advantage in earliness of 19 days would mean that farmers would prefer it to Suwan. Both intervarietal hybrids had cob placement equivalent to the best parent, Suwan (high cob placement protects from jackal damage).

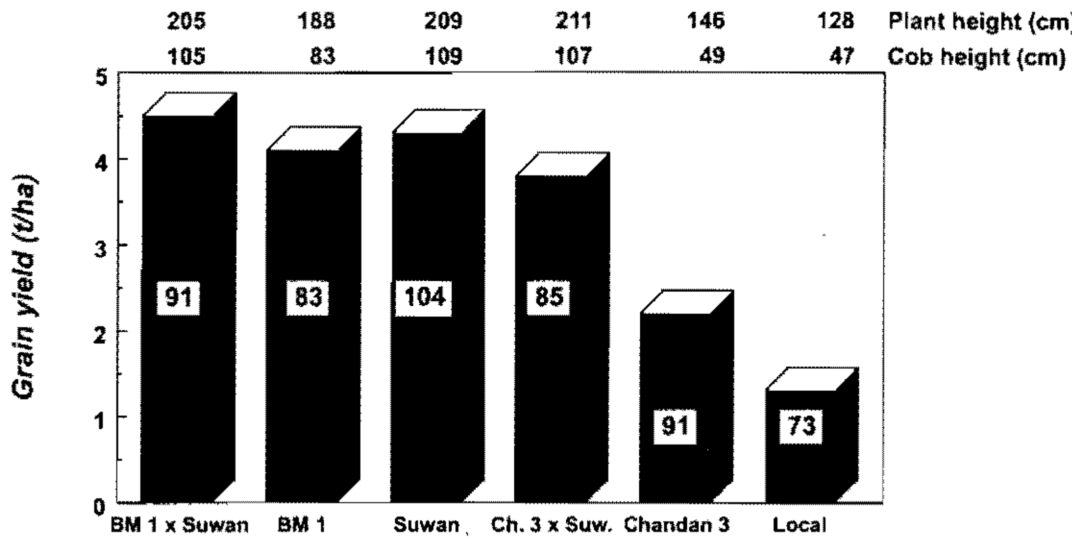

Figure 1. Performance of two intervarietal hybrids in the rainy season of 1999 at the BAU-KRIBP Research Farm, Ranchi, Bihar (Days to maturity are indicated on the bars.)

The intervarietal hybrids themselves are certainly promising. What now needs to be done is to look at the feasibility of their seed production—either with village-based organizations in the development project area or, on a more commercial level, with the public- or private-sector organizations. How important this will be will depend, in part, on how well the intervarietal hybrids compete with open-pollinated varieties derived from the composite.

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Participatory Plant Breeding in Rice in Eastern India

Ravi Kumar, D.N. Singh, S.C. Prasad, J.S. Gangwar, D.S. Virk, and J.R. Witcombe

Abstract

This paper describes a participatory plant-breeding (PPB) program for rice in eastern India, targeted at a range of ecosystems. Only a few crosses with large populations were used. Most resources were used on selection by farmers among F_4 progeny bulks grown on a research station, but farmers also selected within F_4 bulk populations on their fields. Farmers (both male and female) from villages served by the KRIBHCO Indo-British Rainfed Farming Project made selections among bulk progenies derived from a cross between Kalinga III and IR64 that were grown at Ranchi, Bihar, in the main (rainy) season of 1998. The three most selected progeny bulks were promoted to an All India Co-ordinated Rice Improvement Project varietal trial in the main season of 1999. One of these was Ashoka 200F, the result of selection within an F_4 bulk in a farmer's field. The performance of all three varieties in the initial varietal trial at Birsa Agricultural University (BAU), Ranchi, in the main season of 1999 was good. Ashoka 200F yielded 2.90 t ha^{-1} compared to 1.95 t ha^{-1} for Kalinga III. All three entries were as early and slender-grained as Kalinga III, and all were more resistant to lodging. In the main season of 2000, these varieties will be tested in a participatory varietal selection program in six project villages. The approach of using a low-cross-number, large-population breeding strategy with both consultative and collaborative participation has rapidly improved Kalinga III, the most widely adopted upland rice in India. Among other strategies, we have used modified-bulk population breeding to provide heterogeneous and homozygous bulks to farmers for selection.

Introduction

Bihar, a typical eastern Indian state, has 5.4 million ha planted to rice, with yields of, on average, only 1.2 t ha^{-1} of grain. More than half of the rice area is rainfed, including the drought-prone, upland ecosystem. In this ecosystem, most farmers grow traditional varieties and productivity is very low. Most farmers prefer to grow traditional varieties. Many of the varieties bred and released by the formal system, both nationally and at the state level, have not been adopted by farmers because they lack traits important to farmers (Virk and Bhasker Raj 1996). However, variety Kalinga III, which was promoted by the project in its target area covering nine districts of Bihar, West Bengal, and Orissa, has several advantages—excellent grain quality and extreme earliness, which allows it to escape end-of-season droughts. However, because it has weak straw, a major objective of the participatory plant-breeding (PPB) program was to breed varieties to replace Kalinga III that did not have this weakness.

Breeding strategies

The breeding strategy was to cross a popular, locally adapted cultivar (in this case, Kalinga III) with exotic, high-yielding cultivars from a centralized breeding program (Witcombe et al. 1996). Varieties IR64 and IR36 were chosen as the high-yielding cultivars since both are grown in large areas in eastern India. A strategy of a few crosses with large populations was used (Witcombe and Virk, in press).

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At the request of the Centre for Arid Zone Studies (CAZS), crosses were made at the International Rice Research Institute (IRRI), in the Philippines. Because only a few crosses were used, more resources could be devoted to each cross, so large population sizes and many progeny rows were employed in the breeding program. A large F_2 population was raised at Ranchi in the main season of 1997 and the F_3 was grown in the off-season at the Central Rice Research Institute (CRRI), Cuttack, in 1997–98. In the main season of 1998, the crop was grown at the collaborative research farm of Birsa Agricultural University (BAU) and the KRIBHCO Indo-British Rainfed Farming Project (KRIBP), Ranchi. Each year since then, two crops have been grown. We describe the breeding strategy for the Kalinga III x IR64 cross. Two participatory methods were used; they varied according to the main type of participation employed, i.e., consultative or collaborative (Joshi and Witcombe 1998).

Consultative breeding

In the consultative approach, breeders grew all of the trials on a research farm with moderate application of purchased inputs. Farmers from villages where the KRIBP project was operating were brought to the farm to make selections. Farmers visited the BAU-KRIBP research station farm on two occasions. There were two groups of farmers: one of 23 men and one of 12 women. Farmers observed 177 bulk-pedigree lines at the F_4 generation in 10 m^2 plots and 400 single-row plots of 2.5 m in length. Farmers selected plots for one of four ecosystems (uplands, medium uplands, medium lowlands, and lowlands) using labels of four colors. Farmers selected 68 plots; and breeders, 23. Of these, 20 were selected by both farmers and breeders.

The two most preferred entries—Ashoka 228 and Ashoka 238—were multiplied in the off-season 1998–99 at CRRI, Cuttack, and were submitted to formal trials at the F_6 generation in 1999 along with another variety derived from the same cross, Ashoka 200F (see below).

Collaborative breeding

In the collaborative-breeding program, farmers grew segregating generations in their own fields. Although we believe that the F_2 generation is usually too early a generation for farmers to make selection efficiently, given the availability of seed and as an experiment, two farmers were given F_2 seed in 1997. Neither farmer, one in West Bengal and one in Orissa, continued with the population. The F_3 generation was grown at BAU in the main season and further advanced in the off-season of 1997–1998. Ten kilograms of the F_4 bulk seed so obtained was given to four farmers in the main season of 1998. One farmer in Mehru village, Rajendra Singh, grew 2 kg of F_4 bulk seed and selected earlier-maturing plants of similar phenotype that had slender grains. This gave rise to Ashoka 200F. In Jhabrah village, West Bengal, Sakya Singh Mahto, grew 2 kg of the F_4 bulk in 1998 and its further generation in 1999. He selected for tall and dwarf types under medium land situations. Within the tall and dwarf bulks, he produced early and late bulks. These bulks will be tested in the main season of 2000 on the research station. The other two farmers did not pursue the populations further.

Performance of Ashoka entries

The three Ashoka entries were tested in the All India Co-ordinated Rice Improvement Trials, IVT E (DS), at BAU, Ranchi, in the main season of 1999 (figure 1). They were also tested in another trial at the BAU-KRIBP farm, Ranchi, under direct-seeded conditions. In both trials, all Ashoka entries yielded considerably more than Kalinga III (an average increase of over 50%). Two of them were as early to flower as Kalinga III. Farmer-selected Ashoka 200F was the best entry in the All India Co-ordinated trial at Ranchi and the second best for yield in the BAU-KRIBP trial.

A parallel program was followed for the Kalinga III x IR36 cross. The F_4 bulks of this cross have been named Sudha and are being evaluated in formal and farmer-field trials in the main season of 2000.

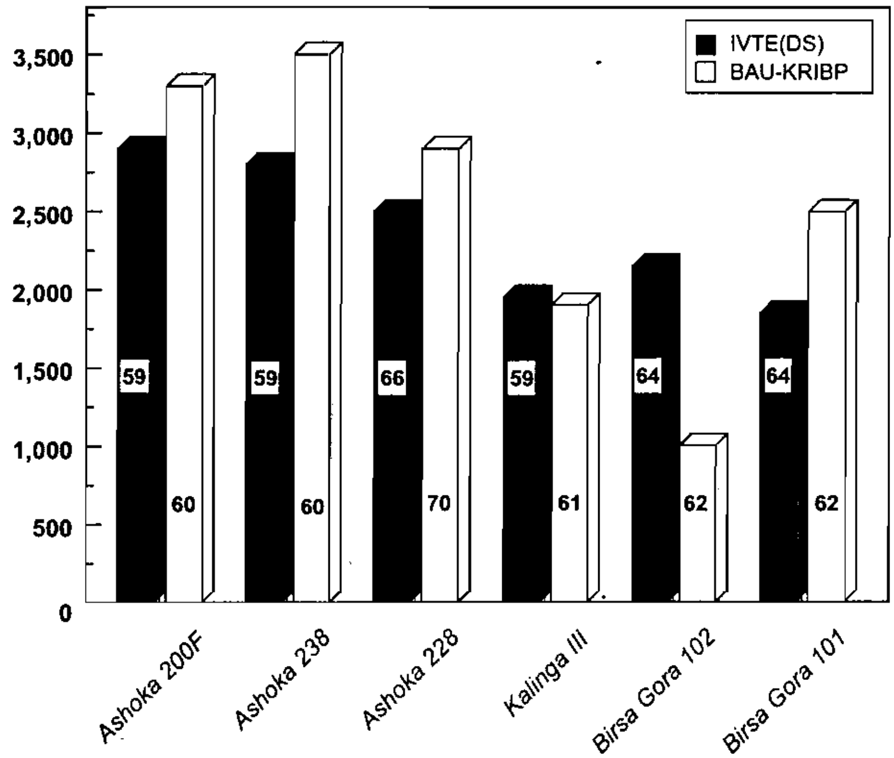

Figure 1. Grain yield (kg ha^{-1}) and time to flower (days) of three Ashoka entries derived from the cross Kalinga III x IR64 in comparison to check varieties in the All India Co-ordinated Rice Improvement Project trial (IVT E [DS]) at the Birsa Agricultural University, Ranchi, farm in *kharif* 1999, and in another trial conducted at BAU-KRIBP research farm (The numbers on the bars indicate days to flowering.)

Other participatory plant-breeding strategies

In addition to the two crosses of Kalinga III x IR64 and Kalinga III x IR36, other crosses have been made for participatory plant breeding (PPB). Modified bulk-population breeding is being used in the cross Kalinga III x Vandana, and the F_6 bulk populations will be grown in the main season of 2000.

Conclusions

Even though, so far, the products of only a single cross, Kalinga III x IR64, have been tested in formal trials, progress has been considerable. A yield increase of 50% over the variety targeted for replacement, Kalinga III, in only four years is an annual rate of gain far in excess of most conventional breeding programs. Moreover, the gain will reach farmers more quickly. The gains have been made without any loss in the quality of grain shape and, in two of three cases, without any increase in length of maturity. It is not possible to apportion these gains into the novel components of the breeding program, and it is over simplistic to say that the difference is due to participatory methods. This is only one component, since the breeding program also employed a strategy of low cross number, high population size, with selection in the target environment, or one very similar to it (Witcombe, Joshi, and Subedi, this volume).

The true success, or otherwise, of the breeding program awaits the results of collaborative participation (the testing of new varieties in farmers' fields in the main season of 2000), when traits other than yield and maturity will be evaluated. However, even if these entries prove to be unacceptable, the high population sizes used mean that there are many more entries from the same cross that can be tested. These entries, like Ashoka 200F, yield more than Kalinga III and have retained the desirable slender grains and early maturity of Kalinga III.

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Participatory Crop Improvement in Maize in Gujarat, India

S.N. Goyal, A. Joshi, and J.R. Witcombe

Abstract

This paper describes a participatory plant-breeding (PPB) program for maize in a rural development project financed by the United Kingdom's Department of International Development (DFID) and the Government of India and executed by the Krishak Bharati Cooperative (KRIBHCO). The program was targeted at low-resource farmers of the Panchmahals district of Gujarat. Farmers were given a range of maize varieties to try in a participatory varietal-selection program. However, none of these proved to be overwhelmingly popular with farmers, although maize variety Shweta from Uttar Pradesh was adopted by some farmers for more fertile fields. Hence, in 1993 a breeding program was begun by crossing yellow- and white-endospermed maize varieties, all of which had some acceptance or positive attributes identified in participatory trials. The breeding program targeted traits identified by farmers, and in some generations, selections were carried out by farmers in the populations grown on land rented by the project. Soil-fertility management was lower than that normally used on research-station land. The breeding program has produced several successful varieties. One of them, GDRM 187, has qualified for release and yielded 18% more than the local check in research station trials, while being seven days earlier to silk. In farmers' fields, where average yields were lower, the yield advantage was 28%. Farmers perceived GDRM 187 to have better grain quality than local landraces.

Introduction

The Gramin Vikas Trust (formerly the KRIBHCO Indo-British Rainfed Farming Project [KRIBP]) manages a participatory-development project in rainfed areas of western India. It is financed by the UK Department for International Development (DFID) and the Government of India. Initial surveys at the project planning stage showed that, in common with many marginal environments in India, the adoption of improved cultivars by the resource-poor farmers of the project area was extremely low. At the inception of the project, a program of participatory varietal selection (PVS) was planned. The methods of PVS employed (Joshi and Witcombe 1996) were designed to identify and overcome the constraints that caused farmers to continue to grow landraces. In the first three years of the project, PVS programs were conducted with several crops, including rice, maize, chickpea, black gram, and pigeonpea. The PVS program in maize identified varieties that were liked by farmers, but none of them were suitable for the most common agricultural environments of the project area. Given the shortcomings of the PVS program, a participatory plant-breeding (PPB) program was initiated early in the project. This paper describes some of this program.

Materials and methods

In the past, efforts to breed white-endosperm maize have been largely, or even entirely, dependent on the progeny of crosses between white-endosperm parents. However, since most maize-breeding programs have concentrated on yellow maize, the diversity and yielding ability of yellow maize parents is higher. It is, therefore, desirable that yellow-grained parents be used when breeding white-grained maize. Crossing white and yellow endosperm maize in the breeding of white maize is

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reasonably straightforward because grain color is a highly heritable trait, affected by xenia (i.e., the pollen genotype is apparent in the seed in the maize cob), which makes the trait even easier to select. Not only is access then gained to superior yellow maize as parents, but crosses between relatively unrelated yellow and white maize varieties create a very broad-based population.

Parents were chosen on the basis of adaptation to the project area in PVS trials (table 1), the results of which are summarized in Joshi and Witcombe (1998). In all cases, the varieties were within the maturity range of the maize grown by farmers in the project area.

Table 1. The Varieties Used as Parents of the Composite

White-endosperm varieties		Yellow-endosperm varieties	
Name	**Breeding institution**	**Name**	**Breeding institution**
Gujarat Makka 1	GAU[a]	Mahi Kanchan	RAU[b]
Shweta	G.B. Pantnagar[c]	Navin	G.B. Pantnagar
Chandan Safed 2	JNKVV[d]	Chandan Makka 3	JNKVV

Note: In all cases, the breeding institution was the State Agricultural University.
[a] Gujarat Agricultural University, Gujarat.
[b] Rajasthan Agricultural University, Rajasthan.
[c] G.B. Pantnagar University, Uttar Pradesh.
[d] Jawaharlal Nehru Krushi Vishva Vidhyalaya (JNKVV), Madhya Pradesh.

Selection was done in an appropriate environment: low-fertility fields under management typical of local farmers. The traits selected for were those identified by farmers. In some of the later generations, farmers were invited to carry out mass selection in the populations. Early in the breeding program, farmers were given the composite to evaluate in their fields, and as soon as varieties were produced from the composite, they were included in PVS trials.

Several white-endosperm and yellow-endosperm varieties were produced from the composite by selection for grain color after random mating was completed. Three white-endosperm varieties, GDRM 185, GDRM 186, and GDRM 187, were tested in formal trials and on farmers' fields in participatory trials.

GDRM 187 was bred as an extra-early variety of maize. Extra-early varieties, such as Chandan Safed 2, can play an important role in the farming system, particularly for growing in rows that alternate with other crops. Chandan Safed 2 had been appreciated by farmers in the participatory trials, particularly for intercropping with pigeonpea, as the maize could be harvested before it had a significant competitive effect upon the pigeonpea crop. Moreover, early varieties can escape end-of-season drought and produce a harvest at the time when grain is scarce, thereby fetching a high price. It was assumed that Chandan Safed 2 could be improved because it was a direct introduction from South America. GDRM 187 was bred from all six parents (table 1), but in the third generation of random mating, selection was made for plants that had Chandan Safed 2 as a maternal grandparent, and these lines were backcrossed to Chandan Safed 2.

Results

The white-grained maize varieties were tested by Gujarat Agricultural University (GAU) in the system of state trials that is used to identify varieties for release. The mean performance of these entries was superior for grain yield by 7%–29% (depending on the variety) in a multi-year, multi-locational trial to that of Gujarat Makka 1 (GM 1), a variety that out-yields the most widely grown local landrace by 10% for grain. They also silked two to six days earlier than GM 1.

In the rainy season (*kharif*) 1997, GDRM 185 and GDRM 187 were tested in farmer-managed participatory-research (FAMPAR) trials in Itawa and Bihar (Madhya Pradesh); Sarjumi, Bar, and Katarani Palli (Gujarat); and Khundini Rupa, Mathura Khali, and Kunda (Rajasthan). Focus-group discussions showed that both varieties were much preferred by farmers over the local varieties. Both were perceived to be earlier than the local varieties (GDRM 187 particularly so) and to be higher yielding. GDRM 187 was reported to have much better grain quality than the most widely grown local variety, and GDRM 185 was reported to have somewhat better grain. Both varieties were reported to have fewer plants that failed to produce cobs, more plants with two cobs, larger cobs, and, unlike the local varieties, cobs that were filled to the tip.

In *kharif* 1998 GDRM 187 was tested in three villages in Gujarat and one in Rajasthan (figure 1). Yield increases in farmers' fields were higher in percentage terms than those found in higher yielding research station trials. Overall, GDRM 187 was the variety most liked by farmers. Like GDRM 185 and GDRM 186, it yielded more than the local varieties, but it had the added advantage of being significantly earlier to mature. In addition, farmers commented that its cobs were tightly and completely enclosed by the husk, reducing insect attacks, and they also commented on the superior quality of its grain.

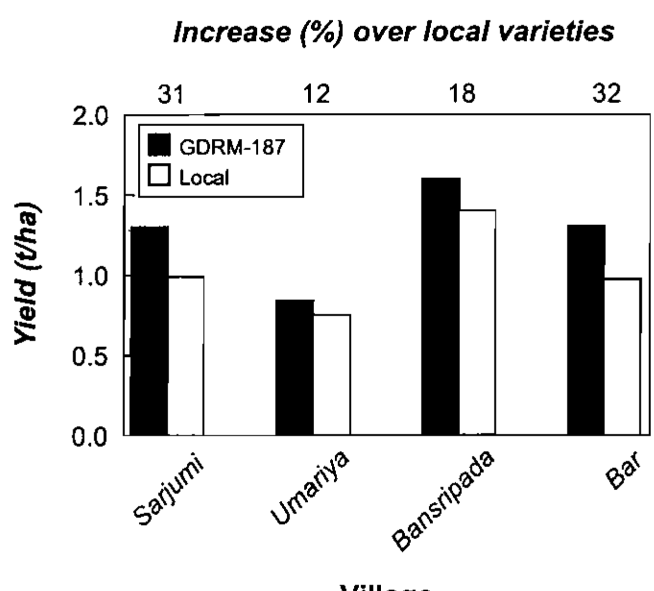

Figure 1. The performance of GDRM 187 in FAMPAR trials compared to the local varieties in four villages: Sarjumi, Gujarat (20 trials); Umariya, Gujarat (5 trials); Bansripada, Rajasthan (6 trials); and Bar, Gujarat (15 trials)
(The advantage of GDRM 187, averaged over 46 trials, was 28%.)

Discussion

PVS does not always work but it builds the foundation of a sound PPB program

The PVS in maize was not very successful. Perhaps this is not surprising since most of the varieties that were tested were not bred in the target environment. Gujarat Makka 1, the only cultivar that was bred in the area, was selected from the local landrace "Farm Sameri." Although this selection was successful in producing a statistically higher-yielding variety in trials, the difference was insufficient. On farmers' fields its 10% yield advantage was not noticed by farmers.

Even a PVS program that does not identify highly successful varieties is of use. In this case, it enabled target traits to be identified—for example, the preference for white grain and extreme earliness. Most important, it allowed the identification of parental genotypes.

Was this a participatory plant-breeding program?

Biggs (1989) classified participation into four types, two of which are collaborative and consultative participation. *Collaborative* participation by farmers mass selecting in the populations in their own fields was attempted, but failed. It was difficult for farmers to prevent cross-pollination of the composite with locally grown material by, for example, planting the crop in an isolated plot. Farmers were reluctant to mass select by uprooting undesirable plants because of the loss of yield this would entail. The alternative of detasseling undesirable plants and rejecting them at harvest time would be possible but difficult. However, the breeding program did involve *consultative* participation—farmers were involved in the identification of parental material and target traits, and in the evaluations of the breeding generations on the research farm. Of major importance was the *decentralization* of the breeding program. Although selection was not in farmers' fields, it was in the target geographical area. The composite was grown under lower input levels than normally found in a research station and closer to the levels used by farmers.

The breeding program also had innovative aspects that were not related directly to farmer participation. Wide crosses were made between yellow- and white-endosperm maize with reselection for white. Quite elaborate designs during the random mating of the composite were employed: hill planting and detasseling was done to increase the pollination between progeny of the original nine crosses and reduce sibbing within them. In the random-mating generations, grains with pale yellow were selected to advance the next generation. This color is the most probable phenotype of heterozygotes and selecting for it maximized the possibility of recombination around the locus controlling grain color.

It is not possible to know which component was most important in the success of the program—collaborative selection of parents by PVS, consultative PPB, decentralization to the target environment, or innovative breeding techniques. However, part of the breeding philosophy in PPB, argued by Witcombe et al. (1996), is the need to concentrate on only a few crosses or populations, which allowed the required resources for the novel techniques used in the breeding program.

Was PPB cost effective?

Conventional breeding had never produced a cultivar that was preferred by even a significant minority of the farmers in the project area. In about five years, PPB had produced at least one cultivar, GDRM 187, that was liked by most farmers for most of their fields. It yielded significantly more grain (about 15%–30% more) even though it was significantly earlier to flower (about one week earlier). This combination of higher yield and earlier flowering is extremely valuable for farmers and is normally a difficult combination to achieve in any maize-breeding program. GDRM 187 also had other advantages, including improved grain quality, that should increase its speed of adoption and its adoption ceiling. All this was achieved with modest resources, since only a single composite was created and only a few varieties were derived from it.

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Towards a Practical Participatory Plant-Breeding Strategy in Predominantly Self-Pollinated Crops

J.R. Witcombe, M. Subedi, and K.D. Joshi

Abstract

There is a limit to the capacity of any breeding program, and the more crosses that are made, the smaller the size of each cross. The theory of the optimum number of crosses in inbreeding crops is briefly reviewed. The theory is unsatisfactory in determining the optimum number of crosses, but models that take linkage into account show that very large populations are needed to recover specified genotypes. Hence, one possible strategy is to select a small number of crosses that are considered favorable and produce large populations from them. This strategy is ideally suited to the particular constraints and advantages of participatory plant breeding (PPB). When a breeding program is based on few crosses, the choice of parents is crucial and farmer participatory methods are highly effective in narrowing the choice. Modified bulk-population breeding methods are desirable strategies in the participatory plant breeding of self-pollinating crops when combined with a low-cross-number approach, and a participatory breeding program for rice in Nepal is described.

Introduction

In most, perhaps all, conventional breeding programs for inbred crops on research stations, breeders deal with many crosses each season. Even with fairly limited resources many hundreds, or even thousands, of F_4 or F_5 lines can be tested. Unless there is considerable researcher input into the layout of trials in farmers' fields, participatory plant breeding (PPB) has to employ many fewer crosses and entries than conventional or classical breeding. In farmer-designed, farmer- managed trials, each farmer usually grows only one entry (e.g., Joshi and Witcombe 1996) and the number of participating farmers thus limits the number of entries. However, a very large population of any entry can be grown, with little or no cost, or even with a benefit. In PPB, a farmer replaces his or her cultivar with a population for PPB on land that would normally have been devoted to the crop. The cost of this replacement is any decrease in value of the harvest caused by the replacement and the benefit is any increase in harvest value. In contrast, in classical breeding all the costs of any increase in the area of the cultivated crop are borne by the breeding program. We briefly review the theoretical evidence on the number of crosses that are required in a breeding program. We describe a rice breeding program in Nepal that is using a low-cross-number, high-population-size strategy.

Theory on the number of crosses in a breeding program

The optimum number of crosses required in an inbreeding crop was reviewed by Witcombe and Virk (forthcoming) and only a summary is presented here. To calculate the optimum number of crosses, crucial assumptions are required on the rate of the inevitable decline in the potential value of each cross as more and more crosses are made. If the decline is very significant (e.g., a few

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crosses can be identified as having a higher probability of giving desirable segregants than others), then only a few crosses are needed. If the decline cannot be predicted, then many are required. The lack of quantitative data to support assumptions on the rate of decline limits the role of theory in deciding the optimum number of crosses. However, to recover specified genotypes, large population sizes are needed that, given a limit to the overall size of any breeding program, will limit the number of crosses. Whether a high-cross-number or a low-cross-number approach should be used depends greatly on the judgment of the researcher as to whether the value of crosses can be predicted with any certainty. In a decentralized breeding program, the target environment and the required traits in a finished variety are known, and the knowledge of existing adapted germplasm is considerable. This allows such predictions to be made, so a low-cross-number strategy appears sensible. Many fewer crosses than are common in most breeding programs will be used, and for all of them there will be logical reasons as to why the cross should have a high probability of producing favorable segregants. There will be many fewer crosses than commonly suggested from theoretical calculations that invariably assume there is no prior information on the value of any cross, i.e., that all crosses are considered to have an equal chance of success (Yonezawa and Yamagata 1978; Wricke and Weber 1986; Huehn 1996).

In a large-cross-number strategy, population sizes are likely to be limited to a few hundred rather than several thousand. In a low-cross-number strategy, population sizes can be larger and increase the probability that desirable segregants that are an improvement over the best parent are recovered. All that is needed is that the two parents differ significantly for an important trait (a practical certainty) at some point in the genome. A segregant that has a genome substitution from the other parent at this point will be superior, providing the sum of the rest of the genome is equal to the best parent. The existence of a cross that cannot give rise to superior segregants is theoretically impossible, although the population size required to recover desirable segregants may be impracticably large. However, choosing complementary parents increases the likelihood that there will be a sufficiently high frequency of desirable segregants for them to be selected.

Towards a practical participatory breeding strategy

PPB is ideally suited to the strategy of rigorously selecting parents, using a small number of crosses and employing large populations. Participatory varietal selection (PVS) is the first step in selecting desirable parents. It allows local and introduced germplasm to be evaluated using participatory approaches; it identifies candidate varieties having suitable traits and determines their acceptability to farmers.

A PPB program in an inbreeding crop can start on the basis of one cross or very few crosses. Even with a low-cross-number strategy, the number of crosses covered will gradually increase over time if one, or a few, new crosses are made each year. This will help to maintain the farmers' interests by a supply of novel germplasm and allows a continuing incorporation of new genetic material from more centralized breeding programs.

Pedigree breeding generates a large number of lines (the selection units) that can only be accommodated with difficulty in a PPB program. The most effective methods keep the number of selection units to a minimum, thus allowing one, or an acceptably low number, of selection units per farmer. However, large population sizes can be used because the marginal costs to the program of increasing population size are very low (figure 1). Hence, bulk-population breeding is ideal for PPB, in either its pure form or modified by dividing the population into sub-populations according to

Figure 1. A very large population grown by a farmer, Chitwan, October 1998. The only possible cost to the farmer is that there might be a reduction in the yield of the F_4 bulk of Kalinga III x IR64 (right) compared to Masuli (left).

farmer-important traits. Bulk-population approaches have been used with success in classical breeding, e.g., Carver and Bruns (1993) report that 30% of wheat releases from a breeding program resulted from bulk population breeding that took less than 8% of the resources.

We are conducting a PPB program in rice, targeted at a range of environments in Nepal. These vary from the *Terai* (alluvial, low-altitude, flat land in the southern part of Nepal at about 150 m altitude) in both the main season (sown in June) and the *chaite* season (sown in February). The breeding program is also targeting a range of irrigated environments up to 1500 m altitude. Only a few crosses have been made during the course of this breeding program, which commenced in 1996 with two crosses made by the International Rice Research Institute (IRRI) at the request of the project and one cross made at the Center for Arid Zone Studies (CAZS), Bangor, by Dr. D.S. Virk.

All three crosses involved the upland rice variety Kalinga III as one of the parents. Kalinga III was identified in western India in a PVS program (Joshi and Witcombe, 1996). Farmers like it for its very short duration and, an unusual trait for an upland rice variety, its slender grains. Although it is an upland rice variety adapted to marginal conditions, it is widely adapted even though it was rejected from All-India Co-ordinated Crop Improvement Program multilocational trials. It was released for rainfed, drought-prone, cold-susceptible environments only in Orissa, on the basis of trials in that state, but is now widely grown in Bihar, West Bengal, Madhya Pradesh, Rajasthan, and Gujarat. In PVS trials, it performs extremely well as a *chaite* rice in the Nepal *Terai* under partially irrigated conditions and can be grown as a main-season rice in the low hills of Nepal up to 1000 m under rainfed conditions.

One of the crosses made at IRRI was Kalinga III x IR64. IR64 is a longer duration, high-yielding variety adapted to irrigated conditions. At one time it was the most widely grown rice genotype in the world and has occupied the majority of the rice-growing area in the Philippines and Indonesia. It has also been released in India for Tamil Nadu but is widely grown in other states as well, e.g., West Bengal and Haryana. It has wide adaptability, multiple pest and disease resistance, and slender, translucent grains.

It is clear that in this low-cross-number strategy, an enormous amount of information is available on the parents. Kalinga III has weak straw and a low yield potential. IR64 has complementary traits: a very high yield potential and it is highly resistant to lodging. It can also contribute pest and disease resistance to Kalinga III, even though this variety has few susceptibilities. In targeting high-yield-potential environments, Kalinga III can contribute earliness to IR64, and because of its extreme genetic divergence from IR64, it is reasonable to expect transgressive segregation for yield in these environments. For the *chaite* season and somewhat higher-altitude, high-yield environments, Kalinga III contributes cold tolerance.

In PPB, an essential part of the strategy of selecting appropriate parents is that one of them is locally adapted. Kalinga III has been adopted by farmers for partially irrigated conditions in the *chaite* season. However, it is a niche variety and other crosses have been made involving the most popular *chaite* rice, CH45, and the most popular main-season variety, Masuli.

In the early stages of creating the bulk populations, the breeding program for the cross Kalinga III x IR64 was entirely researcher managed on land rented from a farmer. Initially 290 F_3 lines of the cross were grown in the *chaite* season of 1998. The progeny rows were highly diverse and they were grouped into six bulks based on their height (tall or dwarf) and maturity classes (early <110 days seed to seed; medium 110-125 days; and late >125 days). The bulks were named as follows: ED = early dwarf; ET = early tall; MD = medium dwarf; MT = medium tall; LD = late dwarf and LT = late tall. Of these, the performance of the early dwarf proved to be unsatisfactory and it was dropped. The performance of the MT bulk was good but highly variable, so it was further divided into four: MT1 = earlier shorter; MT2 = earlier taller; MT3 = later shorter; and MT4 = later taller (figure 2).

After dropping the ED bulk and dividing the MT bulk into four, there were eight bulks. Three were then advanced without further division (the two dwarf bulks and the late bulk). However, in five of the bulks, further division was made among the F_5 seed into grain type, i.e., long, intermediate or short in length. In the F_6 generation, the resultant bulks were grown by researchers and evaluated by farmers (consultative participation). Combinations of maturity and grain types were selected and rejected. For example, in later-maturing bulks that more or less matched the maturity of CH45, only nonslender types were acceptable. For rice of this maturity, the harvest of which coincides with the rains, it is only economic to produce roasted, flattened rice, for which only less-slender-grained varieties are suitable. In contrast, in the earlier groups, all grain types were acceptable.

By the F_6 generation the bulks were recognizable by farmers, because most of the plants shared common traits, but the bulks still had significant genetic heterogeneity within them for farmers to be able to make selections. In the *chaite* season of 2000, farmers were given the bulks at the F_7 stage and the results of this farmers' selection will be evaluated.

As well as the modified bulk populations breeding approach, we are also trying variants of single-seed descent (SSD) such as equal-seed descent. In classical breeding programs, SSD is increasingly employed to rapidly and cost-effectively produce homozygous lines. It concentrates

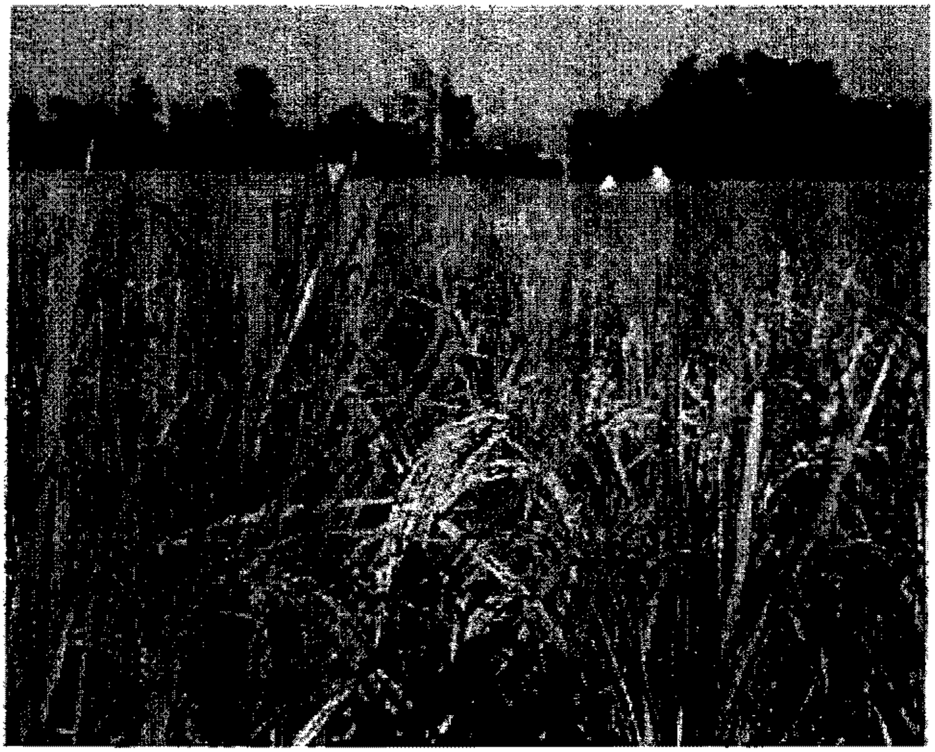

Figure 2. An example of rice sub-bulks at the F_5 stage in the cross Kalinga III x IR64, Chitwan, October 1999. Note the large population sizes (the people in the background are working in the same bulk as the one seen in the foreground) and the two bulks—earlier-maturing bulk MT2 (right) and a later-maturing bulk MT3 (left).

selection in advanced generations that are highly homozygous and where selection is more effective than in earlier, more heterozygous generations (e.g., Delzer, Busch, and Hareland [1995] and Van Oeveren [1992] in wheat; Fahim et al. [1998] in rice). We have modified SSD to retain even more variation by using equal- rather than single-seed descent in the earlier selfing generations. It also allows multiplication so that by the F_5 or F_6 generation, large quantities of seed of each bulk (or sub-bulk) can be supplied to many farmers. The probability of selecting desirable segregants is increased when the entire selection process is replicated across farmers.

Participatory techniques must complement and cannot replace classical breeding. Some low-heritability traits can only be selected under controlled environments, and modern techniques that facilitate wide crossing, such as embryo rescue, are confined to the laboratory. No single participatory plant breeding program can hope to screen more than an insignificant proportion of the germplasm available in collections of genetic resources or, for example, attempt to create populations with novel resistance traits. Classical breeding is a strategic approach that creates improved parents for the cost-effective, adaptive approach of participatory plant breeding.

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Participatory Crop Improvement for Intercropped Maize on *Bari* Land Terraces with Trees

T. P. Tiwari, Daljit S. Virk, and Fergus L. Sinclair

Abstract

Maize (*Zea mays* L.) is the most important crop in the middle hills of Nepal and is mostly grown in association with finger millet (*Eleusine coracana* Gaertn) and fodder trees. Seven maize varieties have been recommended for the hills but few farmers have adopted them. As a prerequisite to designing a participatory maize-improvement program for the middle hills that could reverse declining yields, local knowledge and practice were investigated and combined with micro-meteorological measurements at three sites, each with 20 participating farmers.

In a participatory maize-improvement program, both participatory varietal selection (PVS) and participatory plant breeding (PPB) were carried out side-by-side with varieties selected on the basis of criteria derived from farmers' knowledge. Four different varieties were tested (Manakamana-1, Arun-1, BA-93-2126#2, Population-22) with local varieties at each site. Participatory trials, where each farmer grew a new variety alongside local varieties, were combined with display trials of all the varieties at five locations. Questionnaires and focus-group discussions were used to assess farmers' evaluation of varieties. Population-22, despite its late maturity, was liked by farmers for disease tolerance, higher yield potential, white and large grains, and its stay-green characteristics. Statistical analysis of grain yield confirmed farmers' preference for Population-22, since this out-yielded the other new varieties ($p<.05$), which were similar in yield to local varieties. A seed-multiplication program of this preferred variety has been initiated by participating farmers. As part of the PPB program, the best four local varieties (Marga local, Muga local, Madi local, and Fakchamara local) were collected from various parts of the middle hills and crossed with adapted exotics (Manakamana-1, Arun-1, Population-22, and Pool-21). Five composites have been created by random mating so as to offer choices to farmers in the coming seasons, thus increasing the genetic diversity they are able to evaluate and utilize.

Introduction

Maize (*Zea mays* L.) is the most important crop grown in association with finger millet (*Eleusine coracana* Gaertn) and fodder trees in Nepal. About 80% of maize is grown in the hills, which constitutes 20% of the total cereal production of the country with productivity of slightly more than 1.5 t ha^{-1} (CBS 1997). There has been a decline of 20% in maize productivity in the hills since the mid-1970s (Palikhe 1996; Adhikari 1998; NMRP 1997). This is proof of the inefficiency of the traditional approach to maize improvement. The problem with the present approach is that it has assumed that biophysical and socioeconomic factors are commonly shared. The nature and importance of farmers' knowledge is poorly understood, and farmers' involvement in the research process has not been realized. The complex system of growing maize/millet with trees has been overlooked and farmers have not been recognized as research partners in the process of maize

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technology generation. Consequently, the impact of seven newly released maize varieties has been insignificant.

It is not surprising that most of the maize-growing areas in the middle hills of Nepal are covered by the traditional varieties. Either new varieties are not reaching a majority of farmers or those farmers with access to them are not continuing to use them (Khadka et al. 1993). Pham, Waddington, and Crossa (1989), in their review report on the impact of germplasm from the International Institute for Wheat and Maize Improvement (CIMMYT), mentioned that in most developing countries, maize farmers are, by and large, growing the old established landraces.

It was therefore realized that it is necessary to develop a more efficient and effective approach where researchers, maize breeders, and farmers can work together for a common goal. The need to bridge the gap between local and scientific knowledge is a necessary prerequisite to developing an effective maize-improvement strategy. A farmer-participatory approach would involve developing a community-based adaptive research capacity, achieved by working with groups of farmers, maximizing the use of rural resources, and utilizing farmers' knowledge in parallel. This approach can bring farmers' knowledge (farmers' perspectives) and scientific ideas (researchers' perspectives) together (Walker et al. 1997; Sinclair and Walker 1998; Wagner 1993; Joshi 1997). Besides the acquisition of local knowledge, a fuller understanding of the maize-growing environment and how farmers manage scarce resources are major prerequisites for investigation.

Farmer participatory maize improvement

During the early 1970s, when research on maize started, there were high expectations that the development of maize in Nepal would offer better varieties to farmers. However it has been realized that the adoption of new varieties by farmers was not as simple as the researchers and development workers had thought. The farmer-participatory approach began in response to the inefficient, traditional, top-down approach, where more focus was paid to a few researchers' traits of interest rather than to the needs of farmers managing complex and heterogeneous systems.

There are many good reasons to encourage farmers' participation in the process of agricultural research and development (Farrington and Martin 1988; Farrington 1998; Witcombe et al. 1996; Joshi and Witcombe 1996; Witcombe and Joshi 1996; Witcombe and Virk 1997; Sperling and Scheidegger 1995; Sthapit, Joshi, and Witcombe 1996; Subedi, Rana, and Joshi 1997). The complexity of the system is only understood by the farmers. The traditional approach is deficient both in understanding such systems and in using farmers' talents. The participatory approach will help empower local groups of farmers by enhancing production (through the acceptance of preferred varieties), genetic diversity, and "togetherness" (Sperling and Scheidegger 1995; Eyzaguirre and Iwanaga 1996; Chambers and Mascarenhas 1990).

As part of farmer-participatory maize improvement, both participatory varietal selection (PVS) and participatory plant breeding (PPB) were carried out side-by-side, although the latter is usually initiated when PVS fails to identify farmers' preferred genotypes (Witcombe et al. 1996; Joshi and Witcombe 1996). The two activities were carried out at the same time in order to create broad, genetic-based populations simultaneously with PVS activities so as to offer choices to the farmers as quickly as possible.

Materials and methods

Participatory varietal selection

Farmers' criteria for selecting maize genotypes were based on local knowledge. Suitable varieties were sought to meet the important traits that were identified as preferred by farmers, particularly those relating to grain size, color and type, plant height, suitability for agroecological niches, and compatibility with the system. Varieties were selected as suggested by Witcombe et al. (1996) from the releases for the same domain (Manakamana-1), for one other domain (Arun-1 for lower hills but for the middle hills a new introduction), and from pre-releases (Population-22 and BA-93-2126#2).

Sites were chosen where maize is the important crop for household income, in farming systems that were representative in terms of agroenvironmental and socioeconomic conditions, and where there were no political or social obstacles to effective researcher-farmer interactions. Marga, Patle and Fakchamara were selected for the farmer-managed, participatory-research (FAMPAR) trials.

A total of 60 packets (15 of each variety) containing 500 g of seed were distributed randomly to 20 farmers at each site to compare with their local varieties. Therefore, FAMPAR trials of one variety were replicated over five participating farmers at each site. Farmers were asked to grow the new varieties alongside their local variety in the same field and under the same management conditions. However, fields for the FAMPAR trials were to be selected mutually by farmers and researchers for their representativeness (not too sloping, not too marginal or too fertile, and with some degree of tree shade, if possible). Periodic farm visits and interactions with farmers were made so as to observe performance of varieties at different stages. Assessments of the pre-harvest traits of test varieties were made by joint visits between researchers and farmers to each participating farmer's fields. A wide range of issues, covering field management and performance of varieties in the complex and heterogeneous environment, were discussed. Farmers' observations of experimental varieties and their own local varieties were discussed at greater length and were recorded using household-level questionnaires (HLQs). Farmers were asked to harvest both new and local varieties separately and to measure grain yield using their local measurement units. They were also requested to store the harvests separately using existing practices and to assess/evaluate other postharvest characteristics, such as grit-to-flour ratio, grain type and color, cooking quality, taste, and market value. They were also asked to assess fodder quality.

Also as part of the PVS program, demonstration trials were conducted in five different sites (Marga, Patle, Fakchamara, Murtidhunga, and Parewadin). The same four FAMPAR varieties were given to one farmer at each site to grow together with his/her local variety for comparison; 500 g of seed of each variety was given to farmers to grow on their own farms.

Group visits were organized to see FAMPAR trials in the field grown by individual farmers in various growing conditions. The performance of the FAMPAR varieties was assessed jointly, and finally, farmers were brought to see varietal demonstrations to compare all varieties at one site. At the end of the session, focus-group discussions were organized and views were collected as per questionnaires developed for the discussions. Male and female farmers were grouped separately and discussions were initiated accordingly. Based on the performance of FAMPAR varieties, farmers were asked to rank the varieties.

Participatory plant breeding

The germplasm that farmers felt was best adapted to the eastern middle hills of Nepal was collected.[1] Before collection, the fields where these varieties were grown were visited and their performance was assessed. Individual growers and local farmers were consulted in order to identify the best-adapted local germplasm. The varieties Muga local, Madi local, Fakchamara local, and Marga local from local varieties and Manakamana-1, Population-22, and Arun-1 (white) and Pool-21 (yellow) from the improved varieties were used in the PPB program. A total of five composites were prepared with different crossing combinations of farmer-preferred varieties (table 1).

Sowing time was staggered according to the maturity class of the variety so as to synchronize flowering. A purposive randomization was followed to equalize the chances of random mating. Three seeds per hill were sown and later thinned to one. At the vegetative stage, individual plants were tagged to detassel later. Diseased and other abnormal plants were removed as soon as the tassel appeared. These composites were sown on-station with irrigation, because the previous year there had been a severe drought (the longest in 35 years). Seed priming was practiced for early establishment. Final selection was done by farmers from tagged and detasseled plants. Laboratory selection was done for flinted and white grains, rejecting yellow, dented, and diseased grains.

Farmers prefer white-grained maize varieties; however, some yellow-grained types possess desirable traits. A novel PPB program was followed to exploit yellow-grained types in composite breeding, where pale yellow grains are used for further cycles of random mating (Goyal, Joshi, and Witcombe, *this volume*). Pale yellow grains represent a cross between white- and yellow-grained varieties. All other grain types, being more likely to be parental types, are rejected.

Results and discussion

Unlike PPB, which requires a long phase of breeding before its products can be tested in FAMPAR trials, PVS provides a means for immediate identification of farmer-preferred varieties. The products of PPB are not yet ready for such an evaluation but the results of the PVS program are available and are presented in this paper.

Participatory varietal selection

Group interviews were conducted to compare all experimental varieties with local varieties at the end of the growing season. The objective and expected outcome of the project was reviewed once again as a reminder to the group members, since they are the ultimate users. Groups of farmers visited each other's fields to see all the FAMPAR varieties grown by different farmers, which may be under different management but were grown under similar growing conditions (with respect to altitude and system). Each trait they mentioned was recorded. Most of the traits were compared against local varieties; however, the overall ranking of the acceptability of the varieties was made among test entries, including local varieties. Farmers' perceptions of major pre- and postharvest traits are summarized in figures 1a and 1b. It was noted that most of the farmers could not make confident contributions regarding cooking quality and taste. Assessment of problems with pest in the stored grain is continuing because it has not yet been taken out of the *thangkro* (maize crib).

1. Descriptions based on farmers' knowledge about and experience with varieties were prepared but not included in this report.

Table 1. Farmer-Participatory Maize Breeding Plan

Parent selection: Well-adapted landraces with good phenotypic traits were selected by farmers.

Locally adapted new varieties identified from the search program as suggested by Witcombe et al. (1996).

A.White composite

	First year, Season-1 (March sowing, hill)	Season-2 (September, teral)	Second year	Third year	Fourth year
Composite 1 Population-22 Muga local F/mara local	Sowing time adjusted according to maturity class. Purposive randomization done to allow equal chance for random mating. 50% plants detasseled and selection concentrated only from those. Good maize growers invited during the field selection. Lab selection for healthy, white-flinted grains.	Broad-based composite First 3 composites grown together to prepare broad-based composite. Sown by purposive randomization to allow equal chance for random mating at Rampur during winter. Other techniques not changed.	Upgrading continued at station. Good maize growers invited for field selection. FAMPAR trials. Seed increase in farmers' fields.	Upgrading continued. FAMPAR trials. Co-coordinated multilocational trials (CVTs). Disease nurseries. Seed increase in farmers' fields.	Formal on-farm trials.
Composite 2 Manakamana-1 Marga local, F/mara local	ditto				
Composite 3 Arun-1, Madi local Marga local	ditto				
Composite 4* all above four locals	ditto	ditto	ditto	ditto	ditto
Composite 5 FAMPAR varieties	Best ears from the respective farmers' fields selected by farmers and collected from three different sites.	Seed of different varieties mixed and sown as composite. Good maize growers invited to select in field. 50% of plants detasseled for random mating.	Bulk sowing. Random mating as other composites. FAMPAR trials.	Upgrading continued. FAMPAR trials. Co-coordinated multilocational trials. Seed increase in farmers' fields.	ditto

Table 1. Farmer-Participatory Maize Breeding Plan (continued)

B. Composite breeding using yellow types

Pool-21 yellow (Female) Arun-1, Madi local Manakamana-1 Population-22	Female parent sown in alternate rows with other varieties. All female and undesirable and diseased plants from male rows detasseled. Good maize growers invited for field selection. Deep yellow and white seeds and other diseased grains discarded. Only pale yellow seeds (being hybrids) from yellow female parent continued.	Pale yellow seeds sown at Rampur. 50% plants detasseled. Field selection. Lab selection; only white seeds selected to continue. Other colors discarded.	White seed continued by random mating. Good maize growers invited for plant selection. FAMPAR trials.	Upgrading continued. FAMPAR trials. Co-coordinated multilocational trials. Seed increase in farmers' fields.	ditto

Note: Two years on-farm testing to satisfy variety release committee is to be conducted before proposing variety to be released.

* Adapted local germplasm from various parts of the middle hills should be continuously collected, evaluated, and combined in local composite so as to make broad genetic base which could be used for future crossing programs. Recurrent selection of these composites (randomly mated) should be continued

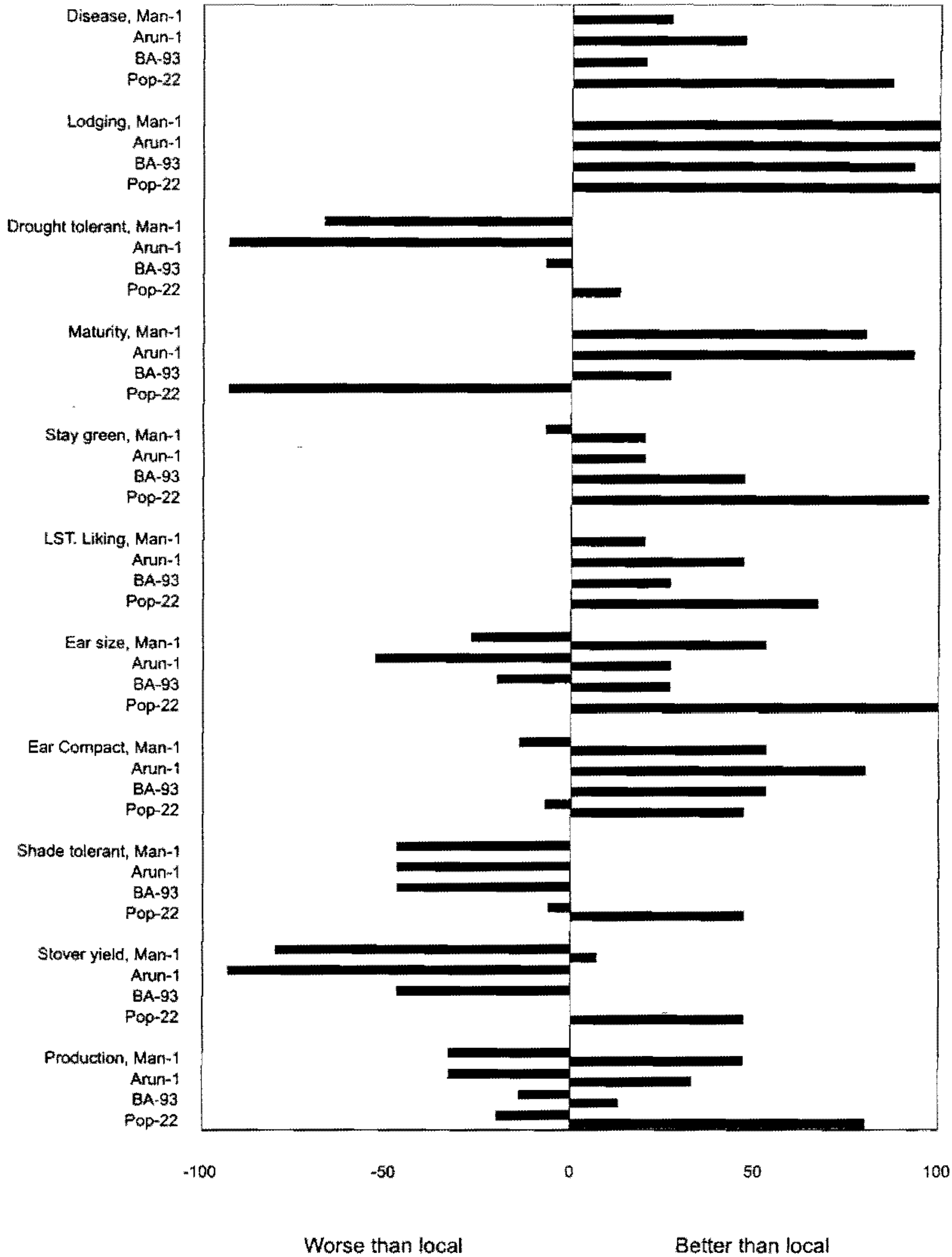
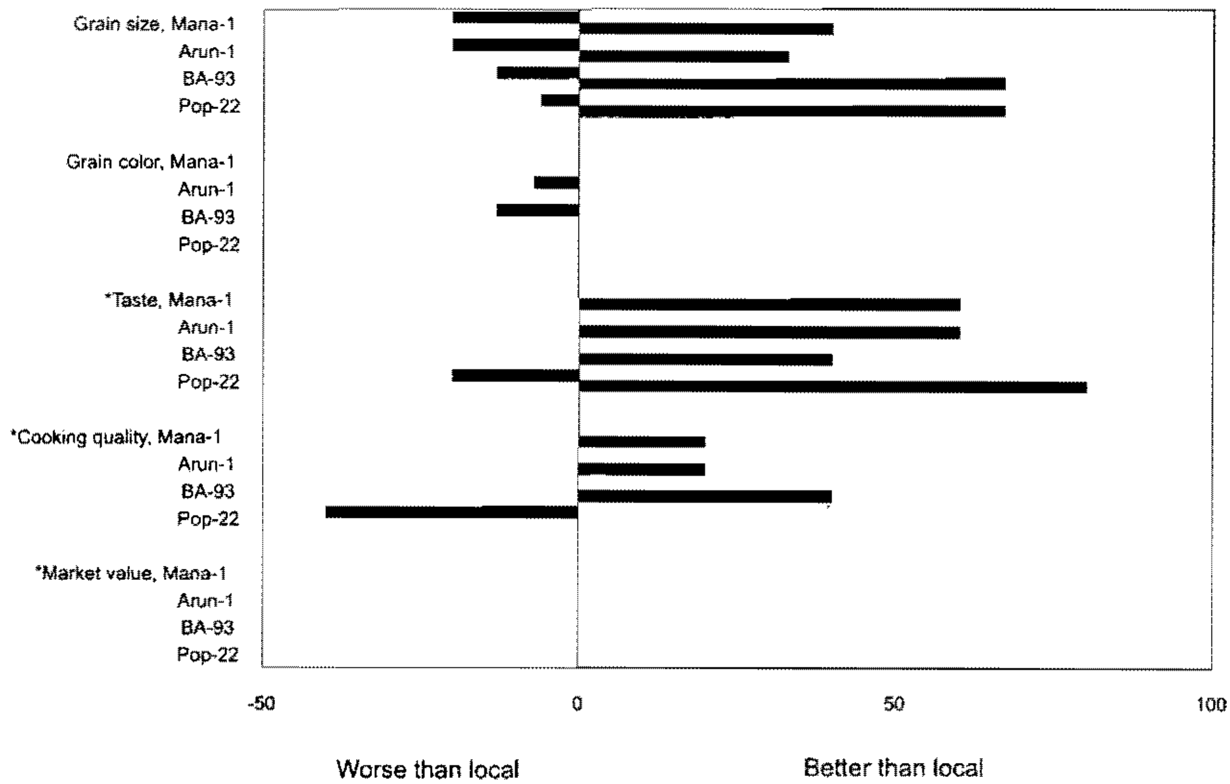


Figure 1a. Farmers' perceptions of pre-harvest traits of four new maize varieties (Farmers' perceptions as to whether the test varieties were better or worse than the local varieties are indicated by lines. The shorter the line, the more similar the variety is to the local varieties.)



*Results based on single site.

Figure 1b. Farmers' perceptions on postharvest traits of four new maize varieties (Farmers' perceptions as to whether the test varieties were better or worse than the local varieties are indicated by lines. The shorter the line, the more similar the variety is to the local varieties.)

Preharvest traits. Farmers observed that the germinative ability of the new varieties was better than that of the local varieties since better quality seed was given to them. During the group discussion, one of the participating farmers said that if the quality of seed of the new varieties was as poor as the usual inferior (insect attacked) quality of the the local varieties, then the germination percent of the local varieties would be higher under stressed situations (drought and soil capping). Additionally, the farmers said that when the maize was sown, there was sufficient moisture in the soil, and as a result, there were no germination problems this year.

Farmers also perceived that the new varieties had stronger stems and shorter plant height than the local varieties, resulting in reduced lodging. The test entries were better with respect to foliar diseases, particularly turcicum blight, but they had problems with ear rot. Within the new varieties, Population-22 was preferred. This was mainly because it had larger ears and lower rates of infection with turcicum blight. Farmers thought this was because it was less affected by tree shade. New varieties matured earlier than local varieties except for Population-22 (figure 1a). The new varieties had similar requirements for fertilizer and water as the local varieties; however, their drought tolerance was less. There were mixed responses from farmers on ear size, production estimates, shelling percent, and grain size. Despite the desirable thinner stems of the local varieties for livestock stover, farmers preferred the new varieties for this purpose because they had improved stay-green characteristics. Except for Population-22, the new varieties were not shade-tolerant.

Postharvest traits. Assessment of postharvest traits revealed that the local varieties were better with respect to grain color and type, taste, grit-to-flour ratio, stored-grain pest infestations, and cooking quality. The farmers who were able to comment on taste reported that Manakamana-1 was good but still inferior to the local varieties. The taste of Population-22 was inferior to local varieties and to Manakamana-1. However, these varieties all fetch good market prices compared with yellow types (figure 1b).

The overall ranking of the tested varieties from different sites with different groups of farmers revealed that despite its lateness, farmers liked Population-22 in field conditions (table 2). The traits farmers liked were higher yielding potential, taller plants with multiple ears, stay-green characteristics, freedom from foliar diseases, and tolerance to lodging. Because of the taller plant height, there was less shading of millet when the lower leaves are stripped by farmers to harvest fodder and reduce competition with the millet. However, at the Murtidhunga and Parewadin sites, farmers said it affects millet because of its larger leaves and late maturity.

Table 2. Overall Rank of Varieties from Different Sites with Different Groups of Farmers (1999)

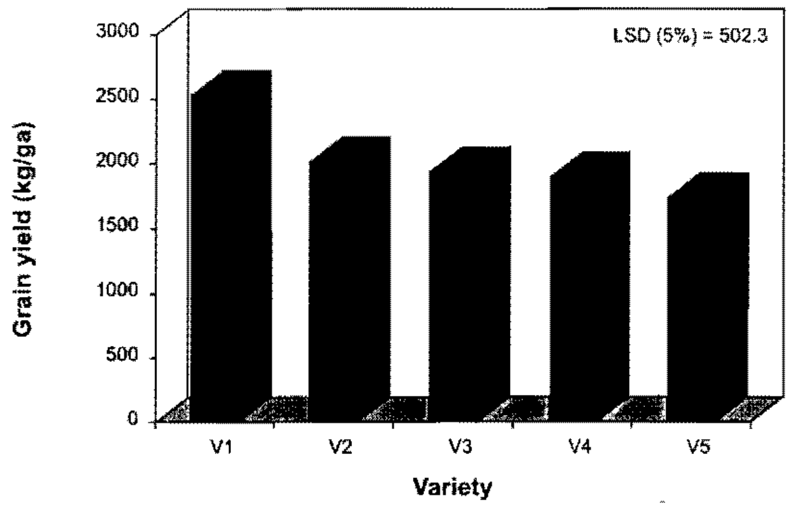
	Marga		Patle		Fakchamara		M/Dhumga	Tankhuwa
CVs\sites	Male	Female	Male	Female	Mixed	Mixed	Mixed	Mixed
Mana-1	2	5	3	2	5	4	3	3
Pop-22	1	1	1	1	1	1	1	1
BA-93	4	3	5	5	4	3	5	2
Arun-1	2	2	2	4	2	2	4	4
Locals	3	4	4	3	3	5	2	5

There was little distinction between the preferences of male and female farmers. It was rather surprising that the late variety Population-22 scored the highest (40), followed by Arun-1 (26). The score of Mana-1, local varieties, and BA-93 was similar (21). This was supported by the observed grain yield from FAMPAR trials, where Population-22 was found to be significantly superior ($p<.05$) to local varieties (figure 2). Other entries were on par with local varieties for grain yield.

As in the FAMPAR trials, Population-22 was found to be the highest yielder in the multilocational varietal display trials, although this result was not statistically significant ($p=.38$). The mean grain yield, irrespective of site, ranged from 2294 kg ha^{-1} to 2949 kg ha^{-1}. Arun-1 was the lowest yielder. Most of the farmers who grew Arun-1 commented that because of its early maturity, birds and rodents were attracted to it. A further problem was the theft of ears. Thus, there was no seed to keep for the following year or to assess for postharvest traits. However, because of its earliness and other desirable traits, farmers were willing to continue to use it. Some farmers also expressed the opinion that it provided early food and that demand for it would increase in the future when green ears were marketed locally for roasting.

Impact of FAMPAR varieties

The impact of any variety is assessed by looking at the area covered by that variety in a particular location and how confidently farmers have taken to that variety. Although it is too early to assess



Note: V1=Population-22; V2= Manakamana-1; V3=BA-93; V4=local varieties; V5=Arun-1.

Figure 2. Summary results of grain yield of FAMPAR varieties

impact, most of the participating farmers stated that they had saved seeds from some of the FAMPAR varieties that they grew last year, thus confirming the potential of PVS to increase biodiversity. The amount of seed saved for this year's sowing was 31 kg of Population-22, 29 kg of Manakamana-1, 24.5 kg of BA-93, and 13.5 kg of Arun-1 across all sites. Most farmers stated that one or two years' experimentation was not sufficient to fully understand the performance of a variety, so a few more years would be needed to have a more complete picture. According to the farmers, the seed demand from other farmers for FAMPAR varieties was limited except in a few cases (there was some demand for Population-22, Manakamana-1, and Arun-1) because of less exposure. A participatory seed-multiplication program for Manakamana-1 and Population-22 has been launched. Farmers were briefed about the selection of maize seeds in the field and the relative advantages of the field selection techniques.[2]

Conclusions

The basis for farmers' decisions to either accept or reject a variety is complex.

- Farmers' interest in growing new maize varieties without replacing existing local varieties confirmed that participatory crop improvement is a means of increasing genetic diversity.
- No ideal variety that satisfies all the criteria set by farmers has been developed so far by research. Varieties generated by following the top-down approach provide only a few traits that farmers required, but the participatory approach is more satisfactory because it offers more choices and gives the new varieties more exposure.

2. This refers to detasseling of 50% of phenotypically desirable maize plants from the terraces, which mostly lie in the central part of the field. Tassels from detasselled plants can be used as fodder. This operation is also expected to reduce the shading effect on the maize crop, reduce the degree of lodging, and stabilize yield through regeneration of heterosis. This operation also creates interest among farmers for testing the variety in the next season. This is a very simple and easy technique; however, care should be taken not to damage the flag leaf, which is important for photosynthesis.

- Farmers' interest in taking an active part in the selection process indicated that the success of this approach could be sustainable in the future.
- Farmers who had only one year's experience with a variety felt that this was not sufficient for precise feedback on a variety. This could have resulted in inconsistent opinions during the assessment of pre- and postharvest traits.
- Women farmers need to be encouraged to participate in the program because most of the field work in maize is carried out by women. It was noted that feedback received from women farmers was of better quality.
- The participatory approach provides a reciprocal educational experience between farmers and researchers because each recognizes the other's opinions and taken them into account.
- Despite its lateness, farmers liked Population-22 in field conditions (table 2). The traits farmers liked were higher yielding potential, taller plants with multiple ears, stay-green characteristics, freedom from foliar diseases, and tolerance to lodging.

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Participatory Varietal Selection in Finger Millet

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Abstract

Finger millet (*Eleusine coracana* [L.] Gaertn.) is an important small millet for rainfed areas in India. A dozen varieties have been released for cultivation but there is little adoption by farmers, particularly in the Chitradurga and Bellary districts of Karnataka state where the present study was conducted. Participatory rural appraisal (PRA) showed that all farmers wanted higher grain and fodder yields, while only 8% mentioned resistance to diseases. Varieties of 105 to 110 days duration with moderate to high tillering and compact-top, in-curved ears were more acceptable. The PRA also showed that there was a varietal monoculture of PR 202 from Andhra Pradesh state.

Six varieties were selected for testing with farmers. They were chosen from those released for Karnataka but not adopted, and from those that were promising in all India co-ordinated trials. Most of them performed well in two-year trials. Participatory varietal selection (PVS) trials were conducted with 150 farmers in seven villages. Pre- and postharvest focus-group discussions (FGDs) revealed that the two recently released varieties, GPU 26 and GPU 28, met several of the farmers' selection criteria. GPU 26 was found to be suitable for late sowing up to the middle of August if the onset of rain was delayed, but GPU 28 could be grown in the second week of July. Among the nonreleased varieties, the short-duration variety (85 days), VL 305, was identified to be suitable as a second crop for sowing in September after sesame or cowpea—an option not available to farmers with the released varieties or nonreleased cultivars.

Introduction

In India, finger millet occupies an area of around 2 million ha, and annual production is about 2.6 million tonnes. It is grown as a rainfed crop on marginal sloping lands, where moisture and plant nutrients are limited. The crop withstands a variety of biotic and abiotic stresses, and traditionally, it has been an indispensable component of the dryland farming system. It is a staple food in southern Karnataka and in Tamil Nadu, Andhra Pradesh, South Bihar, Maharastra, Orissa, and Uttar Pradesh.

In Karnataka, a dozen high-yielding varieties were bred and released for cultivation during the 1970s, '80s, and '90s. These varieties were developed through hybridization between exotic (African) and native Indian germplasm. Farmers, particularly in areas where rainfall is more evenly distributed, have accepted some of these varieties, but their adoption is uneven in the major finger-millet-growing belts of Karnataka. Adoption is higher in districts and areas where annual rainfall is more evenly distributed than where rainfall is scanty and erratic. For example, in Chitradurga and Bellary, farmers still grow old varieties because of their specific adaptation to the local environments. The reasons for nonacceptance of new varieties in these districts could be a lack of traits farmers consider important in the new varieties, or a lack of location-specific adaptation, or both.

This paper reports results on farmer participatory varietal selection in finger millet in Karnataka. The major objectives of the study were to find out what traits farmers prefer to have in a new

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variety, to provide a basket of choices of recommended and nonrecommended varieties (the nonrecommended selected from those in advanced stages of formal varietal testing) to farmers for testing and selection, and to identify farmer-preferred varieties for dissemination.

The study was carried out in three major finger-millet-growing subdistricts (*taluks*): Chitradurga, Holalkere, and Hosadurga of Chitradurga district, Karnataka, India. The mean annual rainfall in Holalkere is 602 mm, in Chitradurga 590 mm, and in Hosadurga 463 mm.

Participatory rural survey

A household baseline survey for varietal preferences was conducted, involving 150 finger-millet-growing farmers categorized into upper, medium, and lower socioeconomic classes. The survey was made in 1999 in seven villages: Katihalli, Jalikatte, and Erajjanahatti of Chitradurga *taluk*, surveyed in May; Maddheru and Kumminagatta of Holalkere *taluk*, surveyed in June; and S. Roppa and Bansihalli of Hosadurga *taluk*, surveyed in July.

What characteristics do farmers want in a new variety?

Disregarding those farmers who did not respond, all farmers preferred a variety with higher grain and fodder yields. Among other traits, 67% farmers preferred varieties with compact ears, 65% wanted plants of medium height of around 100 cm, and 38% considered early maturity an important trait. Farmers did not express a specific preference for characteristics such as ear size, number of tillers per plant, or quality of fodder or grain (table 1).

Table 1. Frequency of Farmers' Preferred Characteristics in Finger Millet

Trait	Preference (percent, based on 150 farmers)	
Higher yield	100	(11 not responding)
Higher fodder yield	100	(11 not responding)
Ear compactness	67 compact, 8 semi-compact, and 25 loose	
Ear size	69 medium, 31 large	
Plant height	65 semi-dwarf, 15 medium, and 19 tall	
Duration	38 early	(62 not responding)
Tillers per plant	16 high	(84 not responding)
Fodder quality	11 good	(89 not responded)
Grain color	11 red	(89 not responded)
Grain quality	1 good	(99 not responded)
Disease resistance	8 resistant	(92 not responded)

The farmers' ideal variety would be high-yielding, maturing in about 105 days, with a plant height of 100 cm, medium-sized compact ears, and moderate tillering ability (table 1). Farmers also required a suitable variety for late sowing (in the middle of August) as a second crop following sesame or cowpea in the rainy (*kharif*) season.

The baseline survey also showed that there was a varietal monoculture of PR 202, a selection from local cultivars from Andhra Pradesh. PR 202 is an old variety that was released for Andhra Pradesh in 1976 as a pure-line selection from a Mettachodi landrace of the Vishakapatnam area. Its plants are medium tall (110 to 120 cm) and ears are in-curved with six to eight fingers per ear. PR 202 has a good threshing ratio, and its orange-brown grains are medium bold (1000 grains weigh 2.8 g). However, PR 202 is highly susceptible to blast—a major disease of finger millet, and farmers wanted an alternative to this variety.

Selection of cultivars for farmer-managed participatory-research trials

Following the baseline survey, a search was undertaken to find varieties that would best match the farmers' selection criteria. Six varieties were chosen for testing by farmers in a participatory varietal selection program. Three of the selected varieties were released varieties, or identified for future release, i.e., GPU 28 and GPU 26 (released for Karnataka in 1998 and 1999, respectively), and VL 149 (nationally released in 1994). The other three varieties, VL 305, GPU 46, and 9002, were promising entries in advanced All-India co-ordinated finger-millet trials.

Conduct of the farmer-managed participatory-research trials

All the 150 farmers sampled in the baseline survey were involved in the conduct of farmer-managed participatory-research (FAMPAR) trials during the rainy season of 1999. There were two types of trials.

Single-variety trials

The 150 farmers were divided into six groups of 25 each across the seven selected villages; the number of participating farmers varied across villages. Each group was given one cultivar to grow side by side with their local variety in the same field under farmer-managed conditions, so there were 25 replicate-farmers for each variety. Each participating farmer was supplied with 1 kg of seed of the new variety (table 2).

Table 2. Details of the FAMPAR Trials Conducted in the Study Villages and Their Clusters, Chitradurga District, Karnataka, India

Taluk	Cluster	Village	No. of trials	Mean distance from district headquarters	No. of trials	No. of successful trials
Chitradurga		Katihally	30			
	1	Erajjanahatti	12	10	30	29
	2	Jalikatte	18	7	30	30
Holalkere	3	Maddheru	30	32	30	29
	4	Kumminagatta	30	38	30	29
Hosadurga	5	Bansihalli	18	50	30	29
		S.Roppa	12			

Single-replicate all-variety trials

Two farmers in each village were given seed of all six varieties for growing together with the local variety in the same field in a single-replicate trial. These trials served two purposes: to compare the performance of all varieties and to serve as foci for demonstration and focus-group discussions. A two-way analysis of variance with varieties as one factor and locations (villages) as the other provided significance of differences among location, varieties, and interaction of varieties with locations.

Farmers took a great interest in experimentation since only four FAMPAR trials out of 150 were unsuccessful. The variety GPU 28 yielded more than all other varieties in all clusters (table 3). Only variety GPU 46, in clusters 1 and 5, and variety GPU 26, in clusters 2 and 5, yielded on a par with GPU 28. All other varieties yielded less than GPU 28 in all five clusters.

Table 3. Mean Performance of Six FAMPAR Varieties over Five Village Clusters (Table 1), Rainy Season, 1999

	Grain yield (t ha^{-1})						Increase over local
Variety	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Mean	(%)
GPU 28	5.52 a	5.21 a	5.85 a	5.46 a	4.91 a	5.39	51
GPU 26	4.82 bc	4.76 ab	4.10 cd	4.82 b	4.66 abc	4.63	29
GPU 46	5.34 ab	4.34 bc	4.80 b	4.58 bcd	4.75 ab	4.76	33
VL 149	4.15 d	3.94 cde	3.87 cde	4.21 de	3.74 de	3.98	11
VL 305	4.29 cd	3.88 cde	3.41 e	4.25 cde	3.70 de	3.91	9
9002	4.72 cd	4.12 cd	4.12 c	4.68 bd	4.11 d	4.35	22
Local	3.44	3.41 e	3.41 e	3.57	4.05 de	3.58	—
LSD (t ha^{-1})	0.61	0.55	0.55	0.44	0.53	—	—

Note: Values followed by the same letter do not differ significantly from each other.

On average, GPU 28 yielded 5.39 t ha^{-1}—51% more than the local cultivar. All of the varieties showed some yield superiority to the local cultivar. GPU 46, the entry ranked second for grain yield, produced 33% more grain than the local variety, and GPU 26, the entry ranked third, yielded 29% more grain. Moreover, GPU 26 was significantly earlier to mature than either GPU 46 or the local variety, an important advantage as it allows the escape of terminal drought caused either by late sowing or early cessation of the rains.

Farmers' perceptions were recorded in pre- and postharvest focus-group discussions (FGDs). Nine traits were scored in the FGDs: grain yield, stover yield, grain size, grain density, grain color, ear type, cooking quality, days to flowering, and disease resistance. The cultivar GPU 28 closely matched farmers' criteria for a variety to grow under normal sowing in the second week of July. Early-maturing GPU 26 was the most preferred variety for late sowing. A nonrecommended variety, VL 305, was preferred by farmers for its 9% higher yield than the control and its extra-early maturity in 85 days, which allows it to fit in a double-cropping sequence. It can be sown in September after a crop of sesame or cowpea.

In the present study, farmers of Chitradurga district did not prefer the nationally recommended variety, VL 149. On the other hand, varieties GPU 26 and GPU 28, released by Karnataka state were accepted by farmers, although they still lacked the ear characteristics preferred by farmers. An important result of farmer-participatory varietal selection was the identification of variety VL 305 for growing in very specific niches as a second crop after sesame or cowpea. Farmers preferred this variety because of its earliness even though this results in lower productivity compared to later-maturing varieties.

Participatory varietal selection in finger millet has been successful in identifying varieties for specific agroecosystems, which are difficult to reproduce on research stations. Our results confirm those of various workers in other crops and agroecological systems: farmers prefer to adopt varieties from a basket of choices irrespective of their recommendation domains (Sthapit, Joshi, and Witcombe 1996; Joshi and Witcombe 1996, 1998; Virk, Bhasker Raj, and Witcombe 1996; Thiele et al. 1997). The participatory approach is more effective than conventional on-farm adaptive research (Gowda et al. 2000) because it provides farmers multiple choices from among varieties that are selected for farmer-preferred traits.

Conclusions

The PVS approach in finger millet was a useful tool for the following reasons:

- understanding farmers' criteria for selecting a variety
- analyzing reasons for nonadoption of a released variety
- identifying varieties for different sowing times and cropping systems from a basket of choices
- decreasing the gap between recommendation and adoption

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Participatory Varietal Selection, Food Security, and Varietal Diversity in a High-Potential Production System in Nepal

K.D. Joshi and J.R. Witcombe

Abstract

A survey of nearly 1500 households in the high-potential production system (HPPSs) of the Chitwan and Nawalparasi districts of Nepal showed great physical and socioeconomic diversity. Varietal diversity was low in all the crops studied and varied according to location in main-season rice. Masuli was the predominant main-season rice variety, occupying over 65% of the area in the surveyed villages. Seventeen modern varieties of main-season rice were introduced to farmers to test in collaborative trials. Farmers identified 10 of the new rice varieties as having useful traits, and seven were adopted to a significant extent within three seasons. The new varieties occupied about 13% of over 800 ha of main-season rice in eight study villages and increased on-farm varietal diversity by partly replacing predominant varieties. The accepted varieties offered, on average, an 18% yield advantage without any requirement to change agronomy or increase inputs. Other advantages of the new varieties were their early maturity, drought tolerance, disease and insect tolerance, and better adaptation to different ecological niches such as areas of shallow water. Despite the commonly assumed uniformity of high-potential production systems, the new varieties occupied specific niches in the farming system from irrigated land with varying duration of retained standing water, and from partially irrigated to rainfed lowland conditions. Farmers preferred specific varieties for different niches, which should help to increase and maintain biodiversity on the farm. Overall production is expected to increase as each niche becomes occupied increasingly by the best-adapted variety. Participatory approaches are simple, powerful methods for identifying superior varieties and deploying them in specific niches for increasing food production in high-potential production systems.

Introduction

Favorable agricultural environments, known as high-potential production systems (HPPS), produce most of the world's grain. In the developing world, HPPS are often intensively cultivated irrigated areas. The *terai* of Nepal (the alluvial, low-altitude flat land on the southern borders of Nepal at about 150 m altitude) has seasonal or perennial irrigation, high crop yields, and produces 57% of the total cereal production of the country (AMDD 1994/95). For Nepal to feed its ever-increasing population without increased reliance on imports, higher production is required in the *terai*.

A description of the study area

The study area is located in the south of Nepal at a latitude of 27° N. The climate is subtropical to tropical, with warm, humid summers (max. 40°C) and cool, dry winters (min. 8°C). About 90% of the annual total rainfall of about 2000 mm falls between June and September. The research was carried out in 18 villages comprising 3000 households. The villages were located in parts of two districts, Chitwan and Nawalparasi, and grouped into three clusters of six villages in East Chitwan,

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West Chitwan, and Nawalparasi. The villages were selected for the study using several criteria, such as having >80 households, good irrigation facilities, land suitable for double rice cropping, and good access to agricultural markets.

There are more than 53,000 ha of cultivated land in Chitwan and over 64,000 ha in Nawalparasi. Both districts have more than 72,000 ha of main-season rice. About 22% of the land is irrigated in Chitwan and about 36% in Nawalparasi. Farmers grow two or three crops per year. Main-season rice is the major crop in June to October and covers about 1600 ha in the study villages. Rice is followed by lentils or wheat in the winter, followed by maize and *chaite* rice in the spring. There is diversity in soil type, irrigation facilities, and production potential. Productivity is generally higher in East and West Chitwan than in Nawalparasi. There are also variations in the farming systems within clusters, e.g., some farmers in Chitwan grow maize and vegetables in the winter instead of wheat and lentils.

A survey of 1487 households in Chitwan and Nawalparasi conducted in 1997 showed high diversity in physical and socioeconomic conditions. In the study area, 23% of farmers were resource rich, 34% were classed as having average resources, and 43% were resource poor (Rana et al. 2000). There was wide variation in the size of land holdings, access to irrigation, and the use of production inputs, which has resulted in different cropping patterns: rice-vegetables-maize or rice-maize-vegetables and rice-wheat-maize in East Chitwan and mostly rice-wheat-rice, rice-fallow-rice, or rice-lentil-maize in West Chitwan and Nawalparasi. There is wide variation in the rice ecosystem, from perennially irrigated land with varying durations of retained standing water, to seasonally irrigated land, to rainfed lowland conditions.

The production potential is high. Yields of the most commonly grown main-season rice variety were measured in farmer-managed participatory research (FAMPAR) trials in 1997. The average yield of the predominant main-season rice cultivar, Masuli, was 4.2 t ha^{-1} (Joshi et al. 1999).

Participatory approaches

Two approaches—participatory varietal selection (PVS) and informal research and development (IRD)—were used to provide a choice of varieties to farmers in Nepal. In PVS, introduced varieties were tested in intensively evaluated FAMPAR trials using the methods described in Joshi and Witcombe (1996). IRD uses less intensive evaluation and has been proven to be effective for popularizing new varieties by the Lumle Agricultural Research Centre, Nepal (Joshi and Sthapit 1990). In each cluster of six villages, FAMPAR trials were conducted in three and IRD trials in three. In the IRD trials, the same ranges of varieties were used but there was no monitoring or participatory evaluation during the growing season. Instead, farmer's perceptions were evaluated after harvest by informal interviews with a sample of farmers. Data were collected on subsequent adoption and farmer-to-farmer seed dissemination. There were 536 FAMPAR and 546 IRD trials from 1997 to 1998.

Twelve new varieties of main-season rice were first offered to farmers to experiment with in the main season of 1997 and five more varieties were given out in 1998 (table 1). In each village, for each variety a 1-kg bag of seed was given to two farmers in each of three wealth categories (see below). Plot sizes varied because of differences in nursery raising practices. Planting methods, use of manure and fertilizers, and intercultural operations were unchanged. The farmers grew the new variety alongside their existing variety, usually Masuli, as a control. Care was taken to avoid any

Table 1. Rice Varieties Included in the Participatory Varietal Selection Program, 1997–1998 (The first 12 varieties were first offered in 1997, the last 4 in 1998.)

			Country and year of release	
Name of variety	**Entry name**	**Parentage**	**India**	**Nepal**
IR51672	IR51672	—	—	PR
Narendra 80	NDR 80	N22/IR36	1986	NR
Radha 11 (India:Rajshree)	TCA 80-4	Local selection in India	1989	1995
Rampur Masuli	AS781-1	Lalnakanda/IR30	—	1997
Pant Dhan 4	BG 90-2	IR262/Ramadja	1984	NR
Pant Dhan 10	IR9763	IR32/Mahshuri/IR28	1993	NR
PNR 381	—	Tainan 3 mutant/Basmati 370	1992	NR
PR 103	IR661	IR8/IR127-2-2	1976	NR
PR 106	IR665-79	IR8/Peta/Bella Patna	1978	NR
PR 111	—	IR54/PR106	1993	NR
Pusa basmati-1	Pusa 615	Pusa 150/Karnal local	1989	NR
Swarna	MTU7029	Vasista/Mahshuri	1982	NR
Pusa 33	—	Improved Sabarmati/Ratna	1983	NR
Pusa 44	Pusa 44-33	IARI 5901-2/IR 8	1993	NR
Pusa 834	—	IR 50/Pusa 33//IR 50/Pusa 33	1995	NR
Sarwati	—	—	—	NR

Note: NR = not released; PR = pre-release; (–) information not available.

chance of mixing the new variety with the existing farmer's variety from seed sowing through to post-harvest assessment. The area of the trial plots was measured by researchers, while farmers measured yield in local volumetric units, which were later converted to metric units. A paired *t*-test was used to test the significance of the difference for yield between the test entry and the existing rice variety.

To conduct the trials, each trial site was jointly identified and demarcated by the participating farmers and researchers. There were regular visits by researchers to the trial plots with the participating farmers to see the performance of the variety at different growth stages. A farm walk was organized in which researchers, participating farmers, and other interested farmers saw the standing crop in all or most of the plots when the crop was near to maturity. Immediately after each farm walk, a focus-group discussion was held, which included preparing a narrative summary of each rice variety, describing all its positive and negative traits, and preparing an overall preference ranking of all the varieties. A post-harvest evaluation of the rice varieties was done on the basis of farmers' perceptions two to three months after the harvest of the crop. This gave the farmers enough time to assess post-harvest traits. A structured questionnaire was used, which included questions on grain quality, market preference, and the farmers' intentions on whether to adopt or reject the variety. Questions were also asked on the distribution of the seed of the variety by farmers to monitor the adoption and spread of the new rice varieties through 1997 to 1999. In 1999, households that received seeds in 1997 and 1998 were visited first (purposive sampling) and then new adopters were interviewed based on the distribution list provided by each farmer.

The project mobilized existing farmers' groups in the project villages. These groups had been formed for different purposes, including agriculture, livestock/dairy, and water use. Distribution of the seed of the new varieties was done following discussions with the groups. Participatory well-being ranking was done to identify farmers from different resource categories. Through group consensus, an equal number of farmers from all three well-being categories were selected to participate in the trials. A brief overview of all the varieties included in the trials was given to farmers.

Varietal diversity in the project area before PCI

The baseline study showed that varietal diversity was low in *chaite* rice, wheat, and maize (Rana et al. 2000). In *chaite* rice, CH 45 covered over 97% of the *chaite* rice area in the project villages. In maize, varieties Arun 2 and Arun 4 occupied about 70% of the area, and Rampur Composite about 30%. In wheat, two varieties, UP 262 (50%) and RR 21 (20%), occupied most of the area.

For main-season rice, the greatest varietal diversity was in the East Chitwan cluster (ECC) of villages where 11 different rice varieties were grown by the farmers, of which Masuli and Ekhattar (a sister line of Sabitri) together occupied two-thirds of the rice area (figure 1).

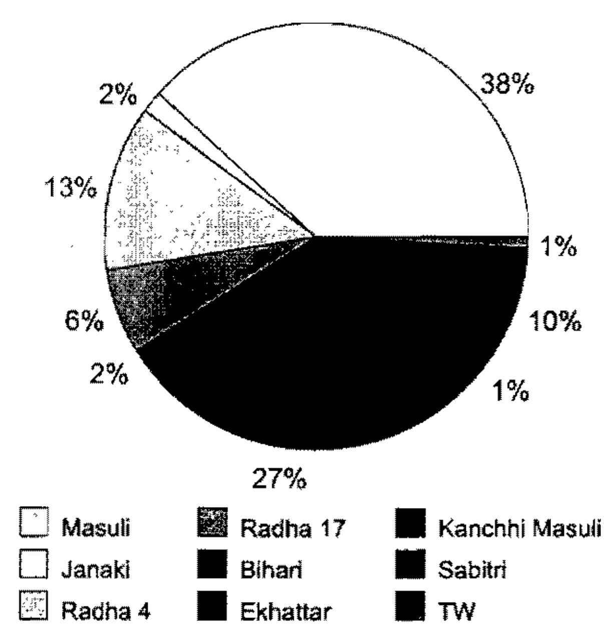

Figure 1. Area under main-season rice varieties in three study villages of East Chitwan cluster, 1997 (Himali and Chaite 6 occupied an insignificant area and are not shown.)

Six different rice varieties were grown by the farmers in the West Chitwan cluster (WCC) but Masuli alone covered 98% of the total rice area (figure 2). The narrow varietal diversity in this cluster could be attributed to a more uniform physical environment as the majority of the area is low lying and retains standing water during most of the rice-growing season. Another reason is that in WCC, in contrast to ECC, few vegetables are grown. Vegetable growing promotes diversity because farmers grow rice varieties of shorter duration than Masuli to allow timely sowing of the vegetable crops.

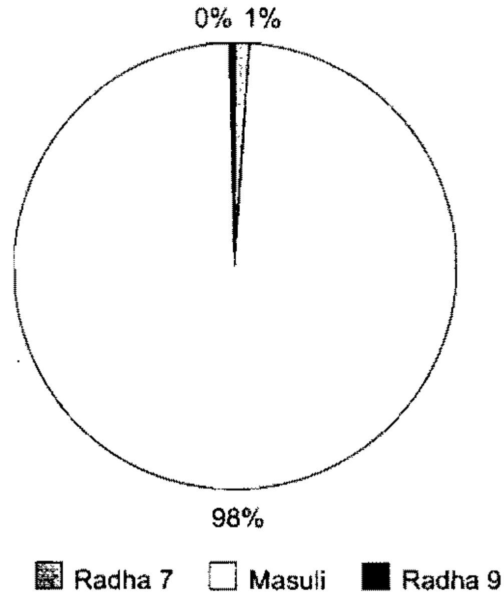

Figure 2. Area under main-season rice varieties in three villages of West Chitwan Cluster, 1997 (Sabitri, Kanchhi Masuli, and Radha 4 occupied an insignificant area and are not shown.)

The varietal diversity at the Nawalparasi cluster (NPC) is closer to WCC than to ECC. The main differences are that in Nawalparasi there is more Masuli and Sabitri and no Ekhattar at all (figure 3).

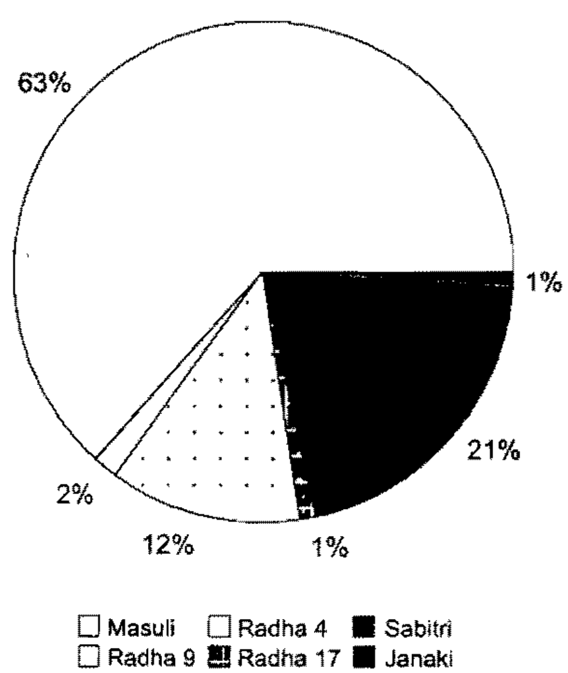

Figure 3. Area under main-season rice varieties in three villages of Nawalparasi cluster, 1997 (Kanchhi Masuli and Radha 7 occupied an insignificant area and are not shown.)

Varietal dynamics

The distribution of varieties over time is dynamic, as new varieties are adopted and old and obsolete varieties are dropped. How dynamic the system is can be quantified by measuring temporal diversity. A dynamic situation is found not only in high-potential systems with modern varieties, it also occurs in marginal areas and even for landraces (Joshi and Witcombe, this volume). As a result of the introduction of new varieties by PVS, most farmers indicated that the new varieties they were adopting would replace Masuli. Other varieties also likely to be replaced were Kanchhi Masuli, Radha 4 (also known as Chaurasi or Bammorcha) and Sabitri. Twenty varieties were listed as likely to be replaced, but 16 of them accounted for only 18% of the total varietal replacement indicated by farmers.

On-farm varietal diversity

The introduction of new modern varieties contributed to an increase in on-farm varietal diversity when diversity is measured simply as the number of varieties grown in each village (figure 4).

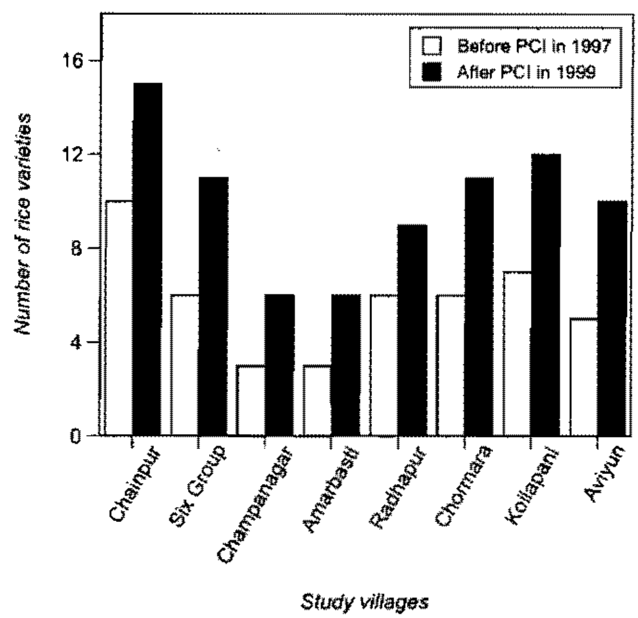

Figure 4. Varietal diversity in rice before and after a participatory crop improvement program across all nine FAMPAR villages, 1997 to 1999

Grain yield

Four varieties (Swarna, PNR 381, Pant 10, and PR103) had a statistically significant yield advantage over the farmers' existing varieties (table 2). From a few kilograms of seeds in 1997, these four varieties covered 22 ha by 1999 in the FAMPAR villages, which contributed 65 t of additional yield. A further 25 ha were occupied by four other new varieties: Rampur Masuli, Sarwati, IR51672, and Pusa 44. On average, these yielded 7% more than existing varieties ($p < .05$ in a pooled analysis). The added yield from these varieties was about 9 t. A similar or higher amount can

Table 2. Yields of New Main-Season Rice Varieties Compared to Existing Varieties in Participatory Varietal Trials in Eight FAMPAR Villages, Main Season, 1999

	Grain yield of rice varieties (t ha-1)		Difference relative to Masuli		
Variety name	New	Existing	Yield (%)	Maturity (days)	Area covered (%) by 1999
Swarna	4.40	3.35	31.0***	+5	5.2
PNR 381	4.04	3.45	17.0*	-30	2.1
Pant 10	4.37	3.95	13.5*	-25	0.7
PR 103	4.45	3.86	15.3**	-18	0.8
Other new varieties ‡	4.17	3.80	7.0*	—	3.0

* $p<.05$.
** $p<.01$.
*** $p<.001$.
‡ Mean of Rampur Masuli, IR51672, Sarwati and Pusa 44.

be expected for the IRD villages that were found to have higher farmer-to-farmer spread of new varieties than the FAMPAR ones. The monitoring of varietal adoption and spread done in 1999 confirmed that Swarna, Rampur Masuli, PNR 381, Pant 10, PR 103, and Sarwati covered significant areas, although other varieties, such as IR 51672, Radha 11, PR 106, and NDR 80, were also adopted to some extent.

Discussion

The existing varietal diversity in main-season rice was low in general and very low in the West Chitwan cluster. The differences between clusters reflected their physical and agronomic diversity. Because the dominant crop varieties grown by the farmers in the villages of the study area were 30 to 35 years old, farmers were not benefitting from several decades of progress in plant breeding, and because of narrow varietal diversity, these systems may be more vulnerable to pests and disease attacks, which contribute to instability in food production.

The participatory varietal selection program was successful in this high-potential production system. Farmers identified and adopted seven new rice varieties from the 16 given in PVS. Some of these, such as Swarna, PNR 381, PR103, and Pant 10, had a distinct yield advantage over the varieties farmers were currently growing. Others were preferred for their early maturity, lower water and nutrient requirements, or better grain quality. New varieties were adapted to specific niches. For example Swarna is suitable for fields where the water stands for nearly all of the growing season; Pant 10, PNR 381, and Sarwati are suited to conditions of partial irrigation and medium fertility; and PR 103 and PR 106 were adopted for more fertile, higher yielding environments. Radha 11 was found to be suitable for late planting conditions and for transplanting when the seedlings are more than one and one-half months old. This is an important trait for areas where rice transplanting is dependent on unpredictable monsoon rains.

Varietal diversity can be quantified but such quantification is scale sensitive. Diversity estimated over all the FAMPAR villages as one unit gives different results than if it's estimated on the basis of clusters. The varietal diversity in the WCC increased far more than in the other two clusters, which both had higher initial varietal diversity. From the viewpoint of diversity deployment to enhance food security, increasing diversity in the most vulnerable areas is not only important for the communities in those areas, but it also reduces the vulnerability of the system as a whole. The PVS approach in main-season rice has helped enhance varietal diversity on-farm in the same way that it has for other crops and areas (Malhi et al., this volume; Virk et al., this volume; Witcombe 1999a, 1999b; Joshi et al. 1997).

Participatory varietal selection was effective in increasing production in HPPSs by matching agroecological niches to the most appropriate varieties. Such increases in production are essential if the developing world is to feed its rapidly growing populations.

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A Holistic Approach to Participatory Crop Improvement in Wheat

D.S. Virk, D. Harris, B.S. Raghuwanshi, A.G.B. Raj, P.S. Sodhi, and J.R. Witcombe

Abstract

The term "participatory crop improvement" is used to cover all aspects of crop improvement where farmers are involved in a participatory role. In this paper, we describe the approach and results for participatory crop improvement in wheat, in Lunawada subdistrict, Gujarat, India. Nine villages were selected for study, and within each village, farmers were ranked into categories by wealth. An initial baseline survey on farming practices was conducted by semistructured interviews on a sample of farmers. Selected farmers from each wealth category kept weekly farm calendars of all operations in their wheat fields. Selected fields were termed "intensive data plots." They provided a basis for analyzing the farming system and profitability by wealth category, as well as for identifying constraints. The baseline surveys revealed that upper-category farmers benefitted most from the sale of wheat produce. The lower-category farmers consumed a large part of their produce. Intensive data plots showed that upper-category farmers accrued higher net gains from wheat cultivation than the lower-category farmers. Participatory varietal selection (PVS) offered new varieties to farmers for selection. PVS resulted in significant replacement of the old variety Lok 1, grown in about 90% of the area, by many varieties that increased yield levels and on-farm biodiversity. Resource-poor farmers benefitted as much as the better-off farmers from PVS activities. Participating farmers experimented on a simple, cheap agronomic intervention: seed priming. Most farmers intended to adopt it because of its multiple beneficial effects, including increased yields. This holistic approach to participatory methods was effective in analyzing poverty issues, identifying constraints and new opportunities, and monitoring impact.

Introduction

Farmers in high-potential production systems (HPPS) of the Indian subcontinent adopted modern Green-Revolution cultivars in the 1960s and 1970s. Indigenous cultivars were quickly replaced with CIMMYT wheat and IRRI rice varieties. Rates of adoption of modern varieties have since slowed. For example, in India the average age of cultivated varieties is between 10 to 27 years for most cultivated crops (Virk, Packwood, and Witcombe 1997). Slow turnover rates of cultivars mean that farmers are growing older, and therefore inferior, genetic material.

The extent of adoption of new varieties by farmers depends on multiple factors, including agronomic and socioeconomic constraints. We used a holistic approach to participatory crop improvement in wheat in the Lunawada subdistrict in Gujarat, India, to analyze constraints, provide new opportunities, and monitor the adoption of new cultivars chosen by farmers.

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Methods

Two levels of participation were used in the study:

- farmer-managed participatory research (FAMPAR) varietal trials in which farmers grow new varieties alongside their local variety under their management, with scientists and farmers evaluating many cultivar traits
- informal research and development (IRD) in which farmers evaluate new varieties with little intervention from scientists, and the evaluation is mainly from the examination of adoption trends

Baseline surveys

Baseline surveys were conducted in three villages—Kothamba, Ladvel, and Thanasavli—in 1997, at the beginning of the project to understand farmers' practices and to evaluate varietal biodiversity. A sample of 60 farmers was taken in each village, equally representing upper, medium, and lower wealth categories of farmers. Size of land holding was used as a proxy in categorizing farmers into wealth classes.

Another survey was conducted in 1999 after three crop seasons of testing new wheat varieties to assess their impact and changes in farmers' practices. The survey was conducted in six FAMPAR villages (Kothamba, Ladvel, Thanasavli, Vardhary, Chapatiya, and Dalvai Savli), three IRD villages (Panch Mahudia, Dokelav, and Panam Palla), one nonproject but project-influenced village (Dev-Jorapura), and three control villages (Golan Palla, Rajgadh, and Madhvas) that were solely reliant on government extensionl. In each village, 18 farmers were sampled, six from each wealth category.

Intensive data plots

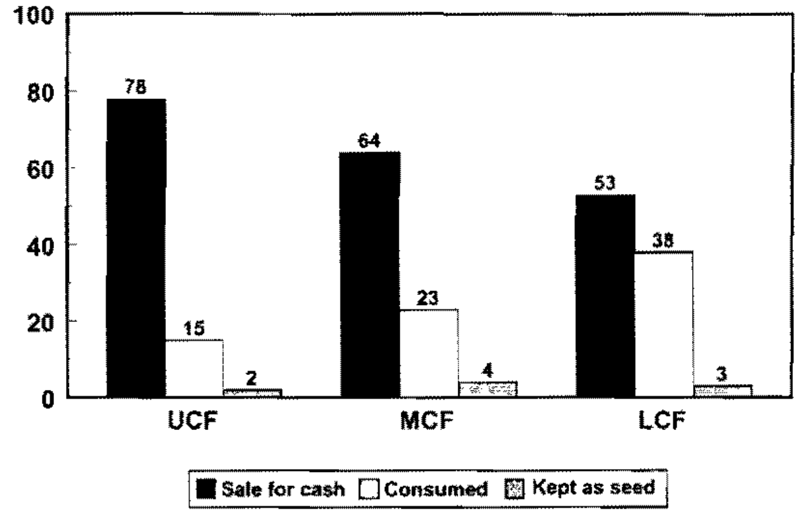
Intensive data plots (IDPs) were set up to collect information about all operations, inputs, and outputs on the farm. Selected farmers kept weekly farm calendars on one of their wheat fields. A project researcher vetted the farm calendar regularly. IDPs targeted the most popular variety, Lok 1. The study was conducted in six villages (Kothamba, Ladvel, Thanasavli, Dalvai Savli, Vakatapura-Chapatiya, and Vardhary) in 1996–97 and 1997–98. There were six farmers in each village, two in each wealth category, with a total of 72 plots in the two years.

The IDPs allowed an analysis of the farming system, profitability by wealth rank, and identification of important constraints.

Results and discussion

Baseline surveys

Utilization of wheat. Wheat utilization patterns vary with the wealth category of farmers. The upper-category farmers sell a larger portion of their wheat in the market, in comparison to the medium- and lower-category farmers. The medium- and lower-category farmers consume a higher proportion of the wheat that they produce (figure 1). They also keep a larger quantity of produce as seed for sowing the next year than do the upper-category farmers, who have the capacity to buy seed from the market at the time of sowing.



Note: UCF = Upper-category farmers; MCF = Medium-category farmers; LCF = Low-category farmers.

Figure 1. Utilisation of wheat in three villages (Kothamba, Ladvel and Thanasavli) of Lunawada sub-district, Gujarat, India. UCF = Upper category farmers; MCF = Medium category farmers; LCF = Low category farmers.

Trends in wheat productivity. In comparison to the previous three years, a majority of farmers perceived that wheat yields had increased. However, the perceived increase was more common with the upper- (73%) than the medium- (65%) and lower-category (58%) farmers in the three villages (Kothamba, Ladvel, and Thanasavli) of the Lunawada subdistrict. This recent increase in wheat yields reflects an improvement in agronomic practices rather than the replacement of old varieties with more recent ones (see below).

Intensive data plots

Cost of production and profits. Over all categories of farmers, the most expensive components of the total cost of wheat production were the cost of seed and sowing operations (24% of total cost), land preparation (23%), and fertilizer (23%). Harvesting and threshing together also accounted for a high proportion (21%) of the cost of production. The other minor components were irrigation (4%), farmyard manure (4%), and weeding (1%).

The net benefit from wheat cultivation is proportional to the status of farmers, the upper-category farmers benefitting the most, with a benefit-cost ratio of 101% in comparison to 77% for medium- and 38% for lower-category farmers.

Trends in scheduling of wheat sowing. Wheat sowing in Lunawada starts around the second week of November (figure 2) and progresses very slowly until the first week of December; most is sown in the second week of December. Wheat sown in December matures in mid-March. Because temperatures rise fast in February, adversely affecting grain formation, late-sown wheat produces lower yields. However, late sowing is prevalent in Lunawada because rice varieties grown by farmers mature too late to allow the fields to be prepared in time for early sowing of wheat. November is also a festival season in Gujarat, and wheat sowing only starts when the festivities are over.

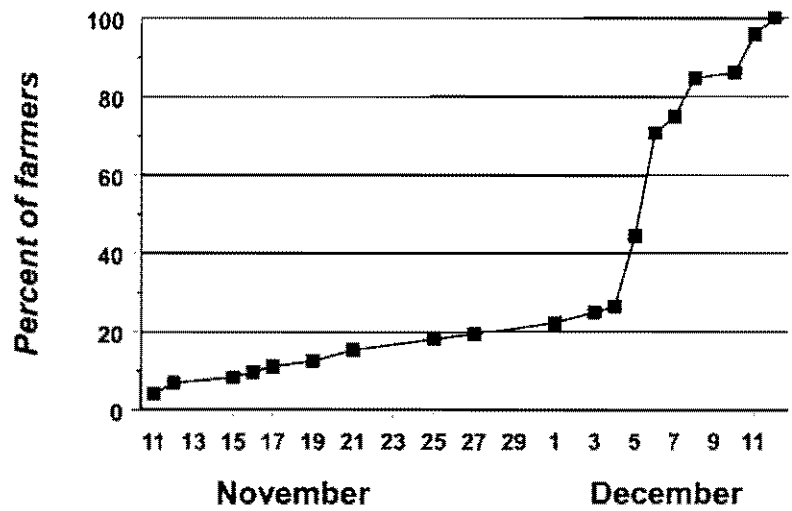


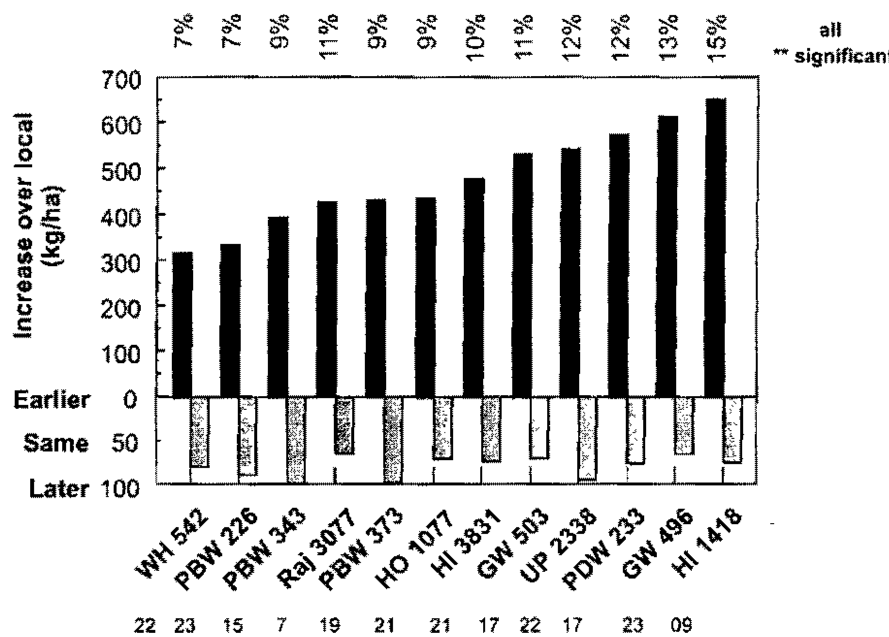
Figure 2. Cumulative time of wheat sowing in Lunawada subdistrict

New interventions

Participatory varietal selection (PVS). Participatory varietal selection (Joshi and Witcombe, 1996 and 1998) in wheat was carried out in six FAMPAR villages with farmers from all wealth categories. Because there were many new varieties, i.e., 13 varieties of wheat, a more complex system of FAMPAR trials was tried. Each farmer was given two varieties to test along with the local check, instead of the one variety provided in marginal areas (Virk et al. 1997). The results showed that the 12 introduced varieties of wheat yielded significantly more than the local check, Lok 1, by 7% to 17% (figure 3). (Variety Raj 3765 failed to yield significantly more because of the small sample size of three farmers, although it had 17% higher yield than the local variety.)In addition, farmers in three IRD villages conducted, on their own, trials as complex as those conducted in PVS villages.

PVS trials that included new test varieties were continued in later years. The most preferred variety tested in the second year was K 9107 from Kanpur in Uttar Pradesh. Varieties that were preferred and adopted by farmers over three years were PBW 343 (Punjab), PBW 206 (Punjab), K 9107 (Uttar Pradesh), UP 2338 (Uttar Pradesh), Raj 3077 (Rajasthan), and GW 496 (Gujarat). The demand for seed from the farmer-preferred varieties in the project and nonproject villages was tremendous. Relatives and friends of farmers in villages far from the project area, who had seen the trials or had had discussions with the project farmers, also asked for seed from the new varieties. Consequently, large quantities of seed, up to 1 tonne for a variety, were sold each year. However, there was lower seed demand in the project villages because farmers had farm-saved the seed of the new varieties. The quantity of seed sold, all at the full price of certified seed, was limited by supply and not by demand.

A second survey in 1999 revealed that farmers had adopted project-provided varieties in the project villages. An example of significant change in the varietal spectrum in three FAMPAR villages shows significant replacement of the most popular, but old, variety, Lok 1, which fell from occupying nearly 90% of the area in 1997 to less than 50% in 1999 after three seasons of PVS (figure 4). Patterns of adoption did not differ across wealth categories, with lower-category farmers benefitting as much as the upper category farmers. The following important facts emerge from the patterns of adoption of PVS varieties:



Note: All results are significant at $p < .01$.
Flowering characteristics are calculated as an average of the scores given by farmers, where 0 = earlier than Lok 1, 50 = same as Lok 1, and 100 = later than Lok 1.
GW 496 and GW 503 are the only varieties recommended in Gujarat.
The number of farmers that grew each cultivar is shown below the cultivar name.
The base for percent increase for the yield of the new variety varied because the yield of the check variety varied in each trial.

Figure 3. Results of participatory trials on 13 wheat varieties in Lunawada, Gujarat, 1996–97 (Raj 3765 not shown)

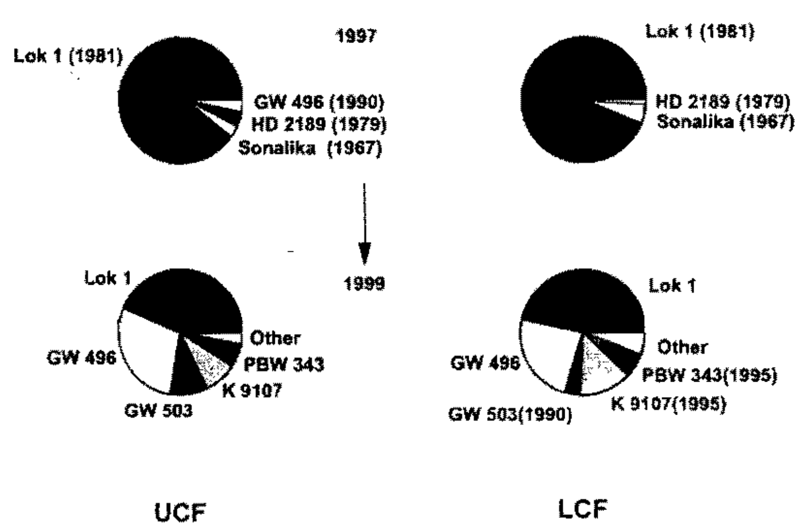


Figure 4. Comparison of percent area of varieties before PVS in 1997 and three seasons later in 1999 after introduction of new varieties in three villages: Kothamba, Ladvel, Thanasavli (Other varieties for UCF were 2% UP2338 [1995] and 1% Sonalika [1967]; and for LCF, 3% WH147 [1979], 2% Raj 3077 [1989] and 1% GW173 [1993].)

- Farmers adopt many cultivars and thus increase on-farm biodiversity. In three seasons, the number of varieties grown by the upper-category farmers increased from four to eight, and for the lower category, from three to nine. There was significant replacement of Lok 1 by more than one variety.
- The proportion of land planted to new varieties increased significantly, with both upper- and lower-category farmers (figure 5). Thus, lower-category farmers benefitted from the increased yields of new varieties as much as the better-off farmers.
- Out-of-state, nonrecommended varieties that meet farmers' selection criteria exist in the country. However, the recommendation domains determined by the formal system for these varieties are too narrow.
- PVS is a potent tool for popularizing recommended cultivars. Variety GW 496 had been released in Gujarat but its area increased substantially after the PVS program.

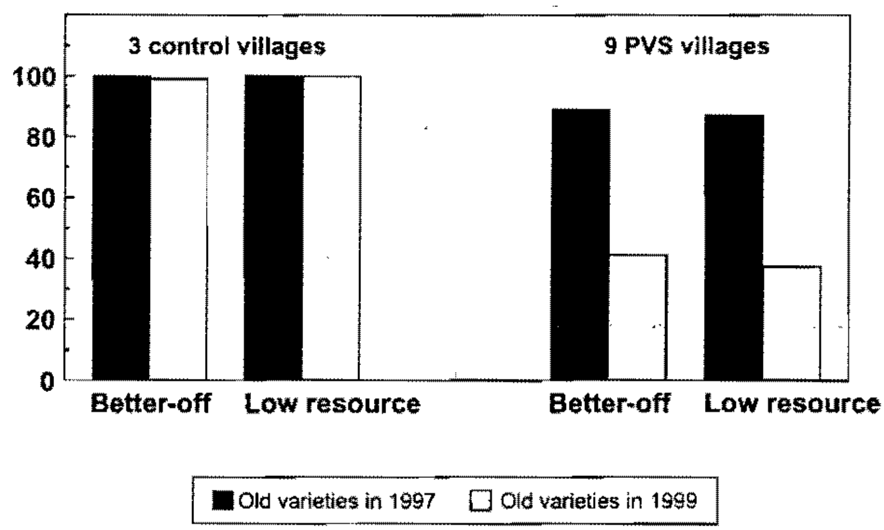


Figure 5. Change in proportion of old varieties (released before 1985) grown by farmers in three control villages and nine PVS villages (using FAMPAR and IRD approaches) (Note that farmers in the lower category benefitted as much from new varieties as those in the upper category.)

Participatory on-farm seed priming. Seed priming is a simple, cheap agronomic intervention to improve germination and ensure better emergence and proper plant stand, particularly in rainfed agriculture: seeds are soaked in water overnight followed by surface drying before sowing. We extended the approach to the HPPS area of Lunawada to compensate for the late sowing of wheat because seed priming has been reported to stimulate earlier maturity (Harris et al. 1999).

Participatory experiments on wheat seed priming in HPPS of Lunawada showed a number of useful effects (figure 6). Almost all participating farmers felt that seed priming induced earlier maturity and that they would use the practice again in the next year. Seed priming also increased yield significantly by about 5%, since the crop had more tillers per plant and larger spikes from more vigorously growing plants than the control.

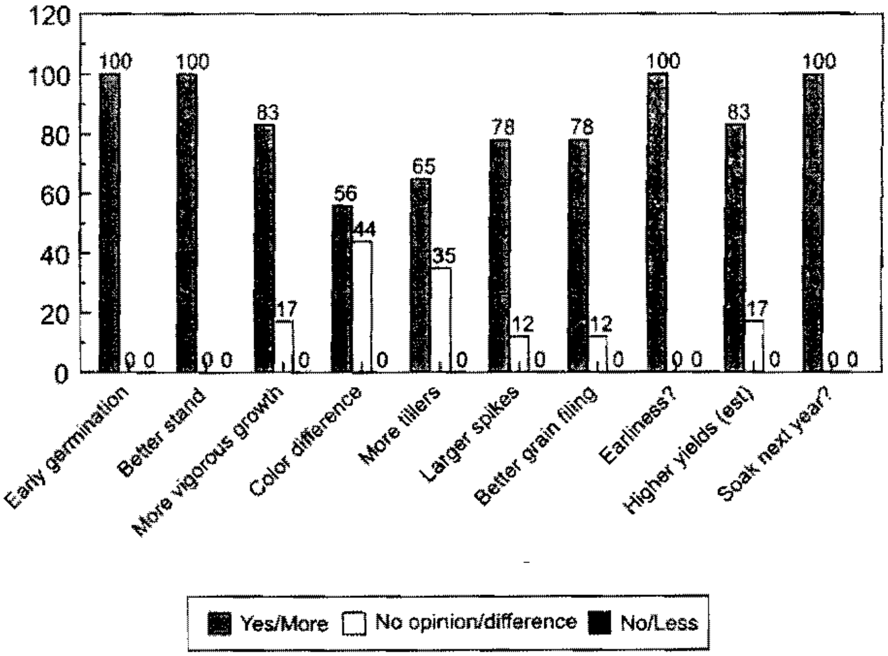


Figure 6. Opinions of 23 participating farmers in seed-priming trials of wheat in *rabi* 1997–1998 in Kothamba and Dalvai Savli villages in Lunawada

Conclusions

Participatory crop improvement should be based on a holistic approach to the farming system. Baseline surveys are needed to understand farmers' practices, and following participatory interventions, follow-up surveys are required to quantify changes in the farming system. This study has shown that participatory approaches to crop improvement can lead to improved livelihoods and can increase on-farm biodiversity.

The study also shows that farmer-participatory approaches are effective in HPPSs (Witcombe 1999), where farmers are benefitting only partially from modern varieties in the period following the Green Revolution. The single intervention of growing a new variety can result in large yield gains. The findings raise questions concerning breeding and extension policies for HPPS, as well as for assuring food security in developing countries.

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Participatory Varietal Selection in Rice in the Punjab

S.S. Malhi, J.R. Witcombe, D.S. Virk, and K.B. Singh

Abstract

Participatory varietal selection (PVS) was used to try to identify an alternative to the most popular rice variety, Pusa 44, in the Patiala district of the Punjab. Pusa 44 (released in 1993 in India but not recommended for the Punjab) is grown in over 50% of the rice area in Patiala. It is highly susceptible to bacterial leaf blight (BLB) but is preferred by farmers because of its high yield and resistance to lodging. Pusa 44 is late maturing and needs to be transplanted very early in the season—as early as the first week in May, when temperatures are very high. This greatly increases demand for irrigation water and accelerates the lowering of the water table, a serious problem in Patiala and the Punjab. It also causes an increase in humidity in the hot season, contributing to the build-up of insect populations on the rice, which is a continuous host after the harvest of sunflower. Because of the lack of a suitable alternative, no recommended variety has replaced Pusa 44 so far.

In the program described here, 12 Indian state-released varieties were provided to farmers to test. Among these 12 varieties, only two were recommended for the Punjab (PR 111 and PR 114). We tested out-of-state varieties since formal multilocational trials do not always determine the precise adaptation of a variety. Three varieties, IR64, IR36, and PR 114, were identified as better performing than Pusa 44, and of these, the best option was IR64. This variety yielded more than Pusa 44, even when transplanted three to four weeks later. This has several additional benefits: it can reduce the need for irrigation water by 20% to 30% and allow green manuring, to improve soil fertility, between the wheat and rice crops. IR64 is resistant to BLB and has better grain quality than Pusa 44. Further testing of IR64 for release in Punjab is being undertaken.

Introduction

Rice is the most important monsoon-season crop grown in the Punjab. The area under rice has increased progressively over the last 20 years, reaching 2.5 million hectares in 1998–99. The average yield of 3.5 t ha^{-1} in 1997–98 (the highest for any state in the country) decreased to 3.2 t ha^{-1} in 1998–99 due to the attack of *tungro* virus disease. Although there has been an increase in the area and total production in the state, there has not been any appreciable increase in productivity over the past decade.

The increasing area planted to rice is the result of a decrease in the area planted to cotton and other less profitable crops. The increasing area under rice presents a number of problems:

- increased water use
- problems of soil health arising from a continuous rice-wheat rotation
- environmental problems, such as the effects on human health of chemicals used to control pests and diseases
- seasonal use of labor
- increased mechanization, with reduced labor opportunities for the poor

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Two features of the large-scale cultivation of rice are relevant to the present study:

1. the widespread transplanting of rice early in the season, contrary to extension recommendations
2. trends in varietal adoption, such as the widespread cultivation of a single variety

We discuss these issues here and present evidence in support of an alternative approach to that of conventional extension: participatory varietal selection for new varieties.

Issues related to rice cultivation in the Punjab

Early transplanting

Time of transplanting is a major factor that substantially influences rice yield. A transplanting schedule has been recommended by the Punjab Agricultural University (PAU) to get the highest yield and prepare the fields in time for the following wheat crop. It is recommended that varieties Jaya, IR8, and all Punjab rice (PR series) varieties should be transplanted from 10–20 June, with the exception of the early-maturing variety PR103, which should be transplanted from 20–30 June. PAU has issued a general guideline stating that where the rice area is large, the transplanting period should extend equally around 20 June (PAU 1996).

Surveys conducted in the Punjab (Singh 1998, 1999) over four years (1996–1999) revealed that transplanting in the Punjab starts from 1 May (figure 1). By the end of May, about 22% of the rice crop is transplanted, and by the middle of June, about 65% of the crop is already in the field. This early planting is more conspicuous in the Patiala district, where about 50% of the rice is transplanted by the end of May and 89% by mid-June.

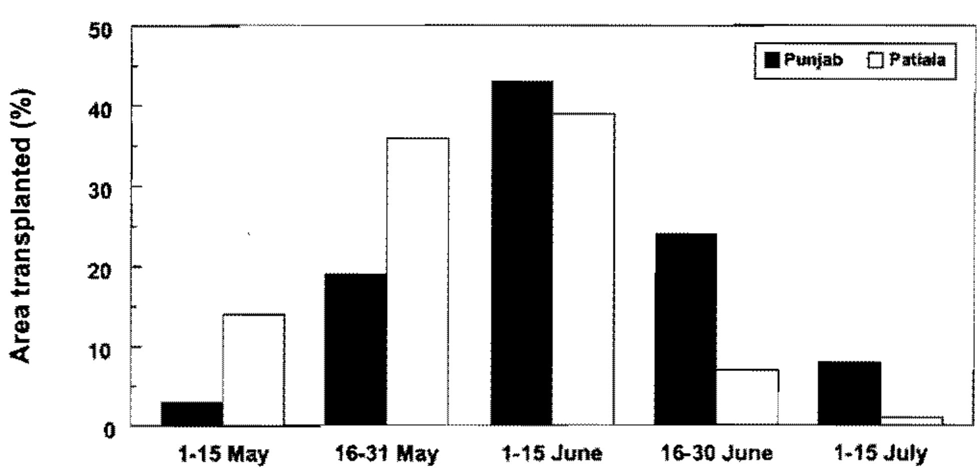

Figure 1. Rice area transplanted from 1 May to 15 July in Punjab and the project area of the Patiala district
(The averages are over four years (1996–1999), based, for Punjab, on a sample of 1076 farmers in 11 districts in 1996 and 1997, and 855 farmers in 1998 and 1999; in Patiala, based on a sample of 105 farmers in 1996 and 1997, and 100 farmers in 1998 and 1999.)

Why farmers practice early transplanting contrary to extension recommendations is an interesting question. Participatory rural appraisals (PRAs) done with farmers reveal some of the reasons farmers transplant late:

- the availability of tube-well irrigation and a cheap, flat rate for electricity
- the continued employment of labor after the wheat harvest
- the limited choice of early-maturing varieties, since high-yielding cultivars tend to have longer maturation periods and need earlier transplanting

Early transplanting of rice has led to multiple problems such as the following:

- a lowering of the water table from greater exploitation of ground-water resources (During May and June, the water requirements for crops are at their peak. The early transplanted crop requires 20% to 30% more water [PAU 1996].)
- the loss of nutrients from evaporation in the extremely hot months, resulting in increased use of chemicals and degradation of the environment
- an increase in diseases and insect pests
- less opportunity for green manuring

Specific varietal adoption patterns

Old varieties are cultivated on a large area. PAU has recommended a number of varieties of rice; however, farmers still prefer to grow old varieties. The varietal surveys conducted by PAU's senior extension specialist (farm management) showed that 36% of the area in the state during 1999 was occupied by varieties released 15 years ago, e.g., PR 106, IR8, Jaya, PR 103, and Govind (Singh 1999).

Weighted average age of varieties is high. The average age of varieties, weighted by the area grown to them in the Punjab, was 12 years in 1996, 11 years in 1997, and 10 years in 1998 and 1999. This average is very close to the 12 years reported by Witcombe et al. (1988) for the whole of India. More recently, farmers have replaced their varieties more rapidly, but the average age remains higher than what could be expected of an agriculturally advanced state. Varieties of wheat and barley grown in the UK in 1999 had an average age of only five years (analysis of data from the National Institute of Agricultural Botany by A.G. Bhasker Raj, *personal communication*).

Nonrecommended varieties occupy large areas. Despite many recommendations by PAU, there is significant adoption of nonrecommended varieties in the state. In fact, the area under non-PAU varieties increased in 1998 and 1999 (table 1).

In Patiala, the adoption of nonrecommended varieties was higher than in the Punjab as a whole (average of 53% over four years). Among nonrecommended varieties, Pusa 44 has the highest adoption. It occupied nearly 50% of the area in the Patiala district in 1996 to 1999. Pusa 44 is highly susceptible to bacterial leaf blight (BLB), and the large-scale cultivation of Pusa 44 has helped to build up the BLB pathogen, which causes losses in other varieties. However, farmers prefer Pusa 44 for its high yield and resistance to lodging.

Table 1. Area of Nonrecommended Varieties in the Punjab and Patiala District from 1996 to 1999

Year	Area of nonrecommended varieties (% of total rice area)		Area of Pusa 44 (% of total rice area)	
	Punjab	Patiala	Punjab	Patiala
1996	31	43	24	43
1997	33	47	28	47
1998	35	60	30	56
1999	38	60	28	54
Mean	34	53	28	50

Note: See figure 1 for information on sample sizes.

Methods and materials

Participatory approaches

Three participatory approaches were used in this study:

1. farmer-managed participatory-research (FAMPAR) varietal trials, in which farmers grow new varieties alongside their local variety under farmer management, with evaluation of many cultivar traits by both scientists and farmers
2. informal research and development (IRD), in which farmers evaluate new varieties with little intervention from scientists; evaluation is mainly from the examination of adoption trends
3. single-replicate design (mother trials), with all varieties grown together as demonstration plots to assess the relative performance of varieties (researcher-designed but farmer-managed trials)

Selection of farmers and villages

Eleven villages (Kalifewala, Chalaila, Kalwa, Barsat, Bhedpura, Gajjumajra, Kaidopur, Dhengera, Partapgarh, Kartarpur, and Jauramajra) were selected to represent agroclimatic situations in the Patiala district. Three villages (Gajjumajra, Bhedpura, and Barsat) represented salt-affected areas with soils having a pH between 9.0 and 9.5. Of these 11 villages, FAMPAR trials were conducted in six and IRD in the rest. All villages have either metaled or good earthen approach roads. All of the agricultural land is irrigated from canals or tube wells.

Farmers were selected to represent small, medium, and large landholdings. Willingness to experiment with new varieties was the key factor in selecting farmers. A total of 497 farmers were involved in participatory research in the *kharif* (monsoon season) of 1999.

Farmer-managed trials

Twelve varieties were tested in participatory trials: IR36, IR64, HKR 120, HKR 126, Pant Dhan 4, Pant Dhan 10, Gurjari, Kalinga III, Govind, Pusa 834, PR 111, and PR 114. Of these, varieties, PR 111 and PR 114 are recommended for the Punjab. All other varieties are out-of-state released varieties. Small bags (2–5 kg) of seed (varying according to the demand of farmers) were given to farmers with the understanding that they would grow the new variety alongside their local variety under the same management and that they would participate in the evaluation.

The plot area for FAMPAR trials varied from 40–5000 m^2. Most trials had an area of more than 1000 m^2 under any variety. Some farmers, particularly in IRD villages, pooled the seed to grow a larger area.

Researchers and farmers jointly evaluated the trials. Frequent farm walks, focus-group discussions, and household-level questionnaires were used for recording farmers' perceptions. Grain yield data were recorded jointly; researchers measured the plot size and farmers weighed the plot yield.

Demonstration plots of all varieties grown in the same field in a single-replicate trial were grown in all villages as mother trials.

Results and discussion

Of the 12 varieties tested with farmers, three (IR64, IR36, and PR 114) were preferred but IR64 was the most preferred. We shall restrict the description of trials to IR64 only. Variety IR64 was tested with 43 farmers (26 in FAMPAR villages and 17 in IRD villages) and compared to Pusa 44.

Farmer trials over several dates of sowing

The greatest power of participatory trials was experienced in this study when IR64 was tested over a span of time representing the whole of the transplanting period in the Punjab. This was not deliberately designed but was a result of the reasonably large sample size that represented the normal practices of farmers. This was not possible in earlier on-station trials that were invariably sown over a restricted, usually late, period. These on-station trials, done in 1985, 1986, and 1987, did not identify IR64 because it yielded less than the check varieties in trials that were transplanted in July.

Performance of IR64

IR64 had a significant yield superiority of 5% over Pusa 44 in 43 trials, giving an extra 300 kg of grain ha^{-1} over a base of 6550 kg (figure 2). IR64 showed the best performance (a 12% yield increase over Pusa 44) when transplanted from 21–24 June. The yield advantage decreased when IR64 was transplanted earlier or later in June, which fits very well with the extension recommendation to spread transplanting equally around 20 June.

An important feature of IR64 is that it matures 26 days earlier than Pusa 44. This trait, along with high yield, favors its adoption in various situations (figure 3).

Farmers' perceptions for traits other than grain yield (figure 4) identified IR64 to be superior to Pusa 44 for number of tillers per plant and resistance to BLB, stem borer, and leaf folder. IR64 is shorter so it is resistant to lodging, which allows it to be responsive to inputs.

Advantages of IR64 over Pusa 44

IR64 had the following advantages over Pusa 44:

- superior grain quality and higher yields
- earlier maturity, leading to a saving of irrigation water
- resistance to BLB and tolerance to white-backed plant hoppers
- resistance to lodging

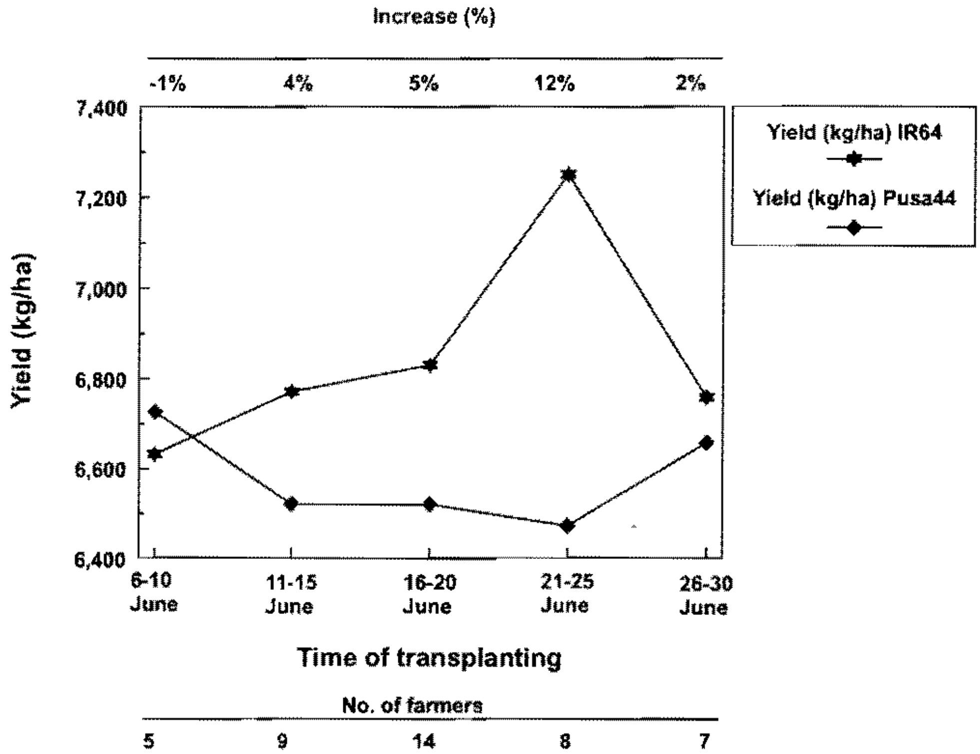

Figure 2. Yield (kg ha^{-1}) of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (The overall mean yield of 6860 kg ha^{-1} of IR64 was significantly higher [at the 1% level] than the 6550 kg ha^{-1} yield of Pusa 44 with a *t*-value of 4.1 over 43 sites.)

- allowing a green-manure crop or summer mung (*Vigna radiata* [L.] Wilczek) to be grown between the wheat harvest and rice transplanting

Adoption and further testing of IR64

All participating farmers saved IR64 seed in 1999 for growing in *kharif* 2000. There was considerable seed exchange from farmer-to-farmer. Seed demand in *kharif* 2000, from farmers who had seen the trials was considerable, but only five tones of seed could be procured and supplied to farmers. Some entrepreneurial farmers and farmers' groups in the state have already become active in producing and procuring IR64 seed.

As a consequence of the participatory trials in Patiala, PAU is retesting IR64 at a number of research stations under appropriate management. The Krishi Vigyan Kendra (KVK), Patiala, has undertaken large-scale testing on farmers' fields in Patiala and other districts of the Punjab in *kharif* 2000.

To exploit the advantage of IR64's early maturity, new agronomic practices and cropping patterns are being tested by the KVK Patiala in more than 40 trials with farmers. These are on growing summer mung and green manuring with sesbania in *kharif* 2000.

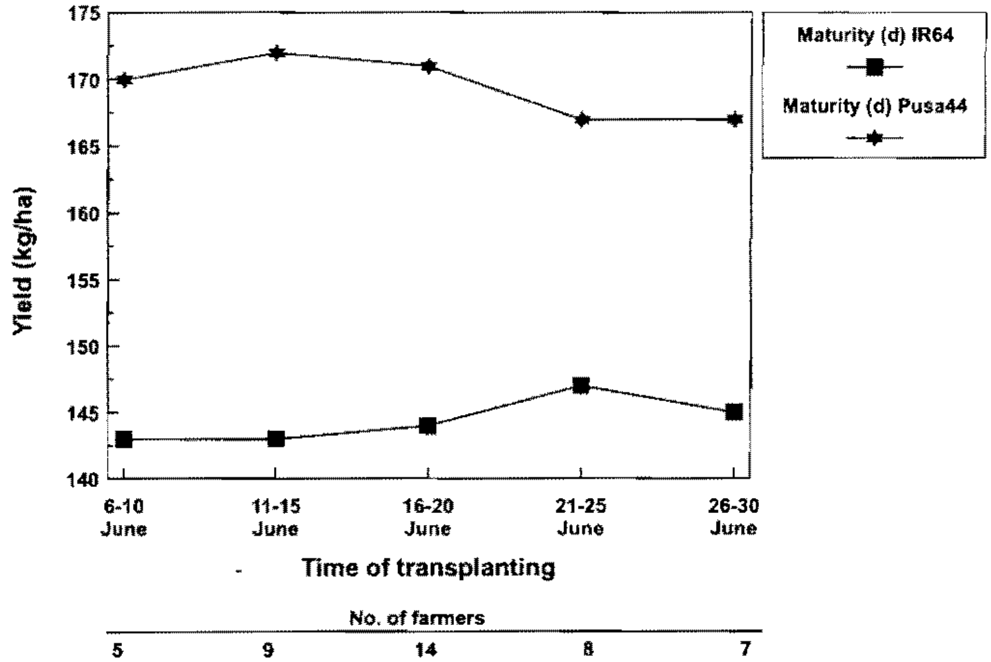

Figure 3. Days to maturity of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (Over 43 trials, IR64 matured significantly earlier [144 days] compared to Pusa 44 [170 days].)

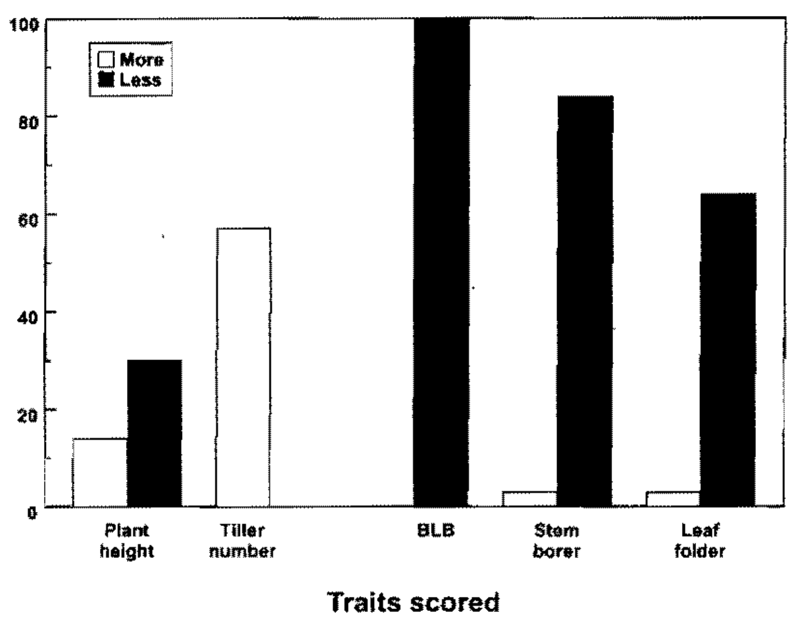

Figure 4. Farmers' perceptions (%) for IR64 in comparison to Pusa 44 for plant height, tiller number per plant, and resistance to bacterial leaf blight (BLB), stem borer, and leaf folder over 48 farmers (Like Pusa 44, IR64 was found to be 100% lodging resistant.)

Conclusions

The PVS approach has been shown to be a potent tool:

- to identify farmer-preferred varieties
- to identify the correct recommendation domain of a variety (IR64 was previously tested in formal trials but was rejected for the Punjab because formal testing did not represent the temporal variability that exists in high-potential production systems)
- to correctly determine the best time of transplanting of a variety
- to identify varieties that give farmers new agronomic options
- to promote the rapid adoption and dissemination of a variety

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Equity Issues in Varietal Dissemination through Farmers' Fairs (*Kisan Melas*) in Punjab, India

J. Singh, S.S. Malhi, J.R. Witcombe, and D.S. Virk

Abstract

In the Punjab state of India, grain production has rapidly increased. One factor in this increase has been the fast adoption of new varieties. Punjab Agricultural University (PAU) has played a major role in distributing certified seed of new varieties to the farmers of the state. Most of the seed is distributed by sales at farmers' fairs (*kisan melas*) held at PAU and its regional research stations. In this study, equity issues in the sale of wheat seed were examined in farmers' fairs held in September 1999.

In the PAU *kisan mela*, smallholder farmers were found to be considerably underrepresented and large farmers considerably overrepresented. The geographical distribution of the farmers who purchased seed was also studied. As might be expected, farmers tended to come to where the *kisan mela* was held from nearby administrative areas (termed *blocks*). This resulted in certain blocks being poorly represented.

PAU needs to address equity issues, both socioeconomically and geographically, by increasing the outlets for seed sales in remote districts and areas of the state, and by encouraging small farmers to attend the *kisan melas* and purchase seed.

Introduction

The Punjab State of India has witnessed a rapid increase in the production of food grains, particularly wheat. Wheat production was only 1.74 million tonnes in 1960–61, but it rapidly increased to 14.46 million tonnes in 1998–99 as a result of increases in both yield and the area under the crop. Wheat yields averaged only 1.2 t ha^{-1} in 1960–61, but this increased to reach 4.3 t ha^{-1} in 1998–99. This very large increase in productivity was due to several factors, including the breeding and popularization of high-yielding varieties (HYVs), increased irrigation and fertilizer use, and the mechanization of farm operations. The fast adoption of quality seed was a major—perhaps the most important—factor.

A survey of the wheat crop in the Indian Punjab (Singh 2000) showed that 79% of farmers kept seed from the previous crop, 12% purchased from private seed dealers, and 6% kept part of the seed and purchased part from seed traders. Only 3% of farmers practiced farmer-to-farmer seed purchase. About 4% of the purchased seed was bought from institutional sources such as the Punjab Agricultural University (PAU), the Punjab State Seeds Corporation, or the National Seeds Corporation. However, for new varieties, farmers tended, in the beginning at least, to purchase seed from PAU.

PAU produces and disseminates seed. Its primary responsibility for production is breeder and foundation seed. However, it also produces certified seed of recommended varieties and, for wider dissemination, recently released varieties. Most of this certified seed is distributed during farmers' fairs (*kisan melas*) that are held at the main campus at Ludhiana (PAU *mela*) and at four regional research stations (RRSs) situated at Rauni, Bathinda, Ballowal Saunkhari, and Gurdaspur. In this

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study, we examine the equity issues in PAU's wheat-seed distribution system at the time of the farmers' fairs.

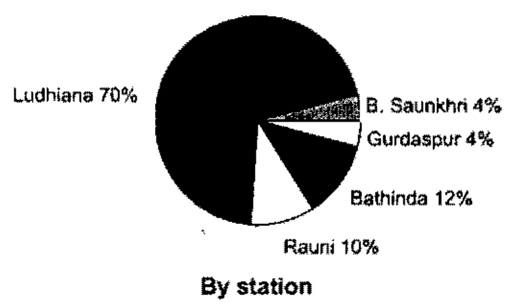
Methods

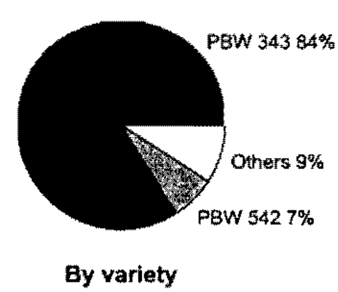
PAU holds farmers' fairs twice a year at the main campus and at four RRSs. At the fairs, certified or truthfully labeled seed is sold for the *kharif* (monsoon season) and *rabi* (winter season) crops. The seed is sold on a "first-come-first-served" basis—farmers queue for their turn to buy seed for cash. In September 1999, wheat seed sales at the five *kisan melas* were surveyed by distributing a simple questionnaire to the farmers in the queues. There was a random sample of 359 farmers who purchased wheat seed at the PAU campus *mela* and a random sample of 285 farmers at the RRS *melas*. Farmers were asked about their farm size, the location of their farm and the amount of seed they had purchased.

Results and discussion

Station-wise and variety-wise seed sales

Nearly 28 t of wheat seed was sold in all *kisan melas*. A major share of the seed was sold at Ludhiana (70%) because it is centrally placed and is the main campus of the university (figure 1). When farmers visit Ludhiana for seed purchases, they also have the opportunity to learn about other technologies. Also, this *mela* is widely advertised and is a more significant event than the regional *melas*. After the PAU campus, Rauni (10%) and Bathinda (12%) accounted for most of the remaining seed sales (figure 1).





Source: Director of Seeds, PAU and Ludhiana, personal communication.
Note: "Others" include varieties PDW 233 (1.8%), PBW 138 (2.1%), PBW 175 (0.3%), PBW 299 (0.4%), PBW 373 (2.5%), and PBW 396 (1.7%), all of which individually account for less than 5% of seed sales.

Figure 1. Wheat-seed sales of PAU at the main campus and regional research stations

Melas at Gurdaspur (4%) and Ballowal Saunkhari (4%) do not account for major sales of wheat seed. Gurdaspur is located on the northern corner of the state and is not well connected. Ballowal Saunkhari represents the mainly rainfed *kandi* belt of the state—a 10 km tract adjoining the hilly state of Himachal Pradesh, where irrigation facilities are very poor. Farmers in this area largely belong to the low-resource category.

Variety PBW 343 was in the greatest demand and accounted for 84% of the total seed sales (figure 1). The only other variety to account for an appreciable proportion of seed sales was WH 542 at 7%. The remaining five varieties accounted, in total, for only 9% of the sales.

Patterns of seed distribution in addressing equity issues

Overall seed distribution in the state in all *kisan melas*. A large proportion (45%) of the farmers in the Punjab have small landholdings of fewer than 5 acres. These farmers own only 12% of the cultivable land (table 1). In contrast, 29% of farmers who have more than 10 acres own 67% of the cultivable land (table 1).

Table 1. Patterns of Wheat-Seed Sales at Farmers' Fair at PAU, Ludhiana, September 1999

Farm size	Farmers attending the *mela*		Quantity of seed sold		Proportion of farmers in the state by	
(acres)	Number	%	Tonnes	%	Number (%)	Area (%)
< 5	20	6	0.9	5	45	12
5 to 10	49	14	2.0	11	26	21
10 to 20	125	35	6.1	35	23	40
> 20	165	46	8.7	50	6	27

When farmers attending all the *melas* were categorized by the size of landholding, it was found that smallholder farmers with fewer than five acres were extremely underrepresented (7% of purchasers versus 45% of the farmers as a whole). The 7% of the farmers from this category purchased 6% of the seed sold (figure 2). In contrast, farmers with large landholdings were hugely over-represented (46% of purchasers but only 6% of the farmers in the state). Less marked, but nonetheless quite large, underrepresentation occurred for farmers in the five- to 10-acre landholding category, and there was overrepresentation for farmers in the 10- to 20-acre category (figure 2). A similar, but less marked, bias was found for seed quantities purchased relative to the area of land held by each category of farmer (figure 2).

Seed sales as a percentage of total sales varied little from the data for farmers purchasing seed, i.e., once farmers decided to purchase seed, there was little difference in the quantity purchased, whatever the category of farmer.

The same analysis was done, disaggregated into the PAU *mela* (table 1) and the regional *melas* (table 2). Although, in both cases, there was underrepresentation of smallholder farmers and over-representation of larger landholding farmers, the situation was better in the regional *melas*. The biggest difference between the regional *melas* and the Ludhiana *mela* that there were fewer large landholding farmers purchasing seed (46% in the Ludhiana *mela* compared to 28% in the regional *melas*).

Spatial coverage

The geographical distribution of the farmers who purchased seed was also studied. The Punjab state is divided into 136 administrative units, called development blocks, that represent clusters of contiguous villages. As expected, farmers tended to come from nearby administrative areas or blocks

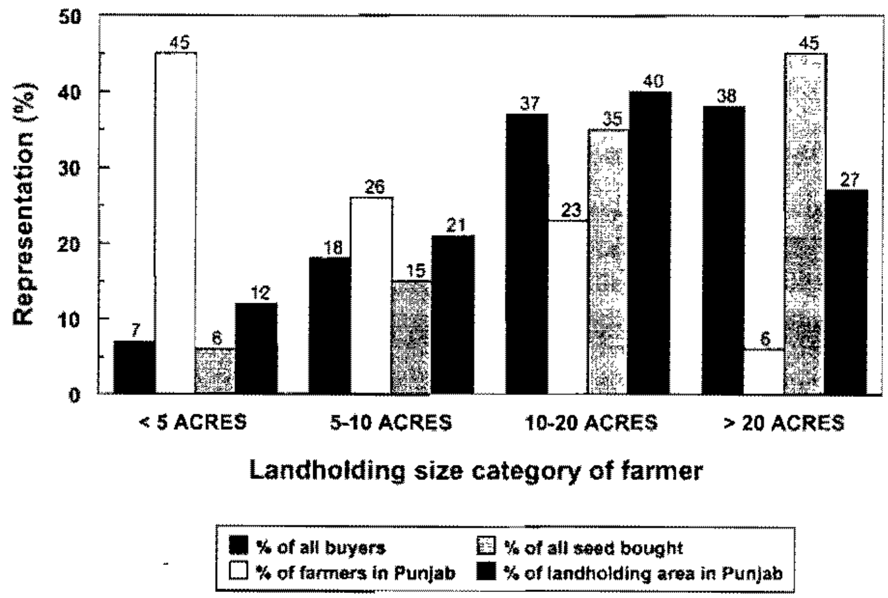


Figure 2. Wheat-seed sales by PAU at its main campus and four regional research stations, categorized by landholding size
(Sales by number of purchases and quantity of seed purchased are compared to the number of farmers and the area of land in the state by the landholding categories. The data presented are from a random sample of 644 farmers: 359 at the main campus and 285 at regional research stations.)

Table 2. Patterns of Wheat-Seed Sales at Farmers' Fair at Four PAU Regional Research Stations, September 1999

Farm size	Farmers attending the mela		Quantity of seed sold	
(acres)	Number	%	Tonnes	%
< 5	25	9	0.9	7
5 to 10	65	23	2.4	19
10 to 20	114	40	4.5	36
> 20	81	28	4.7	37

to where the *kisan mela* was held. Farmers who visited *kisan melas* at the main campus and RRSs belonged to 95 blocks out of 136 blocks in the Punjab.

In the PAU campus fair, the farmers sampled came from 65 development blocks of the Punjab state. Farmers also came from nine development blocks of the surrounding states of Haryana and Rajasthan. In the regional fairs, farmers came from 59 development blocks to buy seed. The geographical distribution at block level shows the following:

- Seed is only disseminated to 70% of the blocks in the Punjab despite the five kisan melas in the state. Forty-one blocks showed no representation among the farmers who were sampled.

- The majority of underrepresented blocks were in the Amritsar and Ferozepur districts where no fairs are presently held.

PAU developed its seed-dissemination system in the post-Green-Revolution period to improve the equity of seed distribution in the state. In this system, small kits of seed are sold to many farmers rather than larger quantities being sold to a few better-off farmers. When it was felt that farmers from remote areas were unable to travel to the main campus in Ludhiana, regional kisan melas were started in order to make seed available in the regions. However, the seed-dissemination system of PAU at present does not address these issues satisfactorily. It is not known if these equity issues have always been present or if they have worsened over time. It is possible that over years, small farmers and those in remote geographical areas have become less enthusiastic about traveling to kisan melas, and small farmers have become dependent on larger farmers for their seed supply. Another factor may be that farmers with smaller landholdings are less prepared to take the risk of trying new varieties immediately after their release and wait until they can judge their performance on the fields of better-off farmers in their village. Why small farmers have lower representation in melas and why they buy less seed are important issues that need to be addressed.

Large farmers, who generally employ labor for farm operations, can afford to be away from their farms. They have the means and the time to travel long distances to purchase seed to increase farm revenues. On the other hand, small farmers

- lack the resources to travel long distances
- lack time because of their involvement in farm and off-farm activities, particularly in September when they are busy attending to the maturing rice crop
- lack sufficient funds to purchase seed at the time when they have incurred heavy expenditures on the standing rice crop, and have yet to gain a return from it
- perhaps lack enthusiasm to try new varieties because their possible failure represents for them a greater risk to their livelihoods than it does for larger farmers

Although not ideal, the representation of small farmers is slightly better at the regional fairs because, on average, seed purchasers have traveled less far. Even there, they buy seed in smaller quantities than their representation. Small farmers require smaller quantities of seed because of their small landholdings, but this may also indicate that they lack money to buy more and that they have greater aversion to risk than large landholders.

Despite the sale of seed at regional stations, there are 41 blocks that were not served by the system in the sample. Most of these are in the border districts of Amritsar and Ferozepur where there are no RRSs. Ferozepur borders on Haryana and Rajasthan. Lack of availability of seed from sources in the Punjab probably leads to a higher adoption of varieties from adjoining states.

Conclusions

The PAU system needs to open more outlets for seed sales to address both equity issues. If new regional stations cannot be opened in the Amritsar and Ferozepur districts, *kisan melas* can be held in these districts in collaboration with the Department of Agriculture. More *kisan melas,* especially in poorly served blocks, may also help address the needs of small farmers in the state. Policies at the state level, involving Punjab State Seeds Corporation and the Department of Agriculture, that are more smallholder-farmer friendly need to be formulated and adopted. Extension workers could create greater awareness among small farmers of the benefits of replacing seed more frequently and adopting new varieties earlier. One way of doing this is to encourage farmer experimentation by recommending that farmers try new varieties on a small area to compare them to the existing variety (see Malhi et al., this volume).

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Participatory Varietal Selection in Rabi Sorghum in India

B.S. Rana, S.L. Kaul, Chari Appaji, Parbhakar, N.S. Kalyanshetty,
B.V.S. Reddy, J.R. Witcombe, and D.S. Virk

Abstract

Sorghum is the third most important cereal crop in India and, over both the rainy (*kharif*) and the post-rainy (*rabi*) seasons, totals a combined area of more than 11 million ha. *Rabi* sorghum is important for both food and fodder in the drought-prone areas of the states of Maharashtra (3.3 million ha), Karnataka (1.5 million ha), and Andhra Pradesh (0.45 million ha). Genetic enhancement and technology development have doubled the productivity of *kharif* sorghum. Progress in *rabi* sorghum has been slower because of several factors, such as more prevalent drought, shoot-fly infestations affecting the initial plant stand, low response of landraces to applied nutrients, and a limited choice of cultivars that have the traits required for adaptation to the *rabi* season. As a consequence, farmers continue to grow the cultivar M 35-1, developed in 1935, that was a selection from the Maldandi landrace. A participatory varietal selection program for *rabi* sorghum, to overcome the lack of cultivar choice, is described in this paper.

Introduction

Participatory varietal selection (PVS) provides an opportunity for farmers to select one or more varieties from a basket of recently developed genotypes from plant breeding programs. Witcombe et al. (1996) reported that if a suitable choice of cultivar exists, PVS is a more rapid and cost effective way of identifying farmer-preferred cultivars than conventional, transfer-of-technology, extension methods.

In India, Maurya, Bottrall, and Farrington (1988) tested advanced lines of rice with villagers in Uttar Pradesh and successfully identified superior material that was preferred by farmers. Also in India, Joshi and Witcombe (1996) identified farmer-acceptable cultivars of rice and chickpea from a range of released and nonreleased cultivars tested in farmer-managed participatory trials. Farmer-acceptable cultivars were found among released varieties but not among those recommended for the area.

Relevance of PVS in *rabi* sorghum

The participatory approach to varietal selection is considered valuable when formal breeding and seed-supply systems have been unable to fulfill the needs of users. This often occurs where the agroecological or socioeconomic environment differs significantly from those anticipated and tested for in the formal system of variety testing. In *rabi* sorghum, several factors mean that PVS could be a useful approach: low adoption of improved cultivars, variable growing conditions and multiple production constraints in farmers' fields that are difficult to simulate on the research station, and local preferences for grain quality.

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Activities

Six nongovernmental organizations (NGOs), six centers of the All-India Co-ordinated Sorghum Improvement Project (AICSIP) located in state agricultural universities, the National Research Centre for Sorghum (NRCS), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) collaborated in the research. The activities involved the identification of villages, NGO user groups and farmers in those villages, and the conducting of rapid rural appraisals (RRA) to identify which varieties farmers cultivated and how they cultivated them, as well as to assess constraints to productivity. Farmer-managed trials of 10 or more identified elite varieties, hybrids, and selected local control varieties were conducted by farmers on their fields. Joint monitoring by researchers and farmers was done at a minimum of three crop stages, and data were collected on the performance of the entries. before the *rabi* sowing, the NGOs selected the participating farmers by organizing group discussions that included both farmers and officials.

Materials

AICSIP has continuously developed new dual-purpose cultivars with *rabi*-adapted traits, such as resistance to drought, shoot-fly, and charcoal rot. It has involved direct selection from landraces, as well as hybridization and progeny selection. Genotypes in the trials included several that were developed and tested in initial and advanced varietal trials of AICSIP in recent years, and three selections from an ICRISAT population based on M 35-2. There were 11 genotypes in the *rabi* 1998 trials and 22 in the *rabi* 1999 trials. These included the following:

- five recently released cultivars: variety CSV 14R, GRS 1 (DVS 4), 9-13 (DVS 5), Sel.3, and a hybrid (CSH 15R)
- three elite genotypes from AICSIP advanced varietal trials: SPV 1155, SPV 1359, and SPV 1380
- six from AICSIP initial varietal trials: RSLG 262, SPV 1360, SPV 1375, SPV 1411, SPV 1428, and SPV 1429
- four genotypes tested earlier: SPV 655, SPV 1215, SPV 1217, and GSS 2
- three population bulks derived from M 35-1: BLK 1, BLK 2, and BLK 3
- the popularly grown cultivar, M 35-1

Five genotypes—CSV 14R, CSH 15R, SPV 1359, SPV 1375 and M 35-1—were uniformly tested by all six NGO groups, but others were tested selectively by from one to five NGO groups, depending on previous experience. Varieties for which farmers could maintain the seed themselves were preferred over hybrids.

Trial design

Each of the six NGOs selected three villages, each with six participating farmers. The number of varieties tested by each NGO ranged from 10 to 12. The NGOs, in consultation with farmers, had decided to give each farmer 2 kg seed of each entry for advanced varietal trials and 1 kg seed of each entry for initial varietal trials. However, involving more farmers by providing each of them with less seed was considered a more appropriate design. Each genotype was tested by three farmers to represent three replications. A trial consisted of growing the new cultivar alongside the local cultivar in a similar-sized plot without any plant protection and under farmer management. Observations on grain yield, dry fodder yield, grain appearance, and farmer-preferred traits (for male and female farmers) were recorded by skilled helpers. Farm walks, focus-group discussions, and house-level questionnaires were employed.

Results

Studies undertaken during *rabi* 1988 revealed that farmers' practices varied greatly. In most places, varieties were grown under rainfed conditions, but some farmers provided a single irrigation, and nitrogen applications varied from 0–100 kg urea per acre.

At Dhulia center, farmers planted deep behind the plough with no fertilizer and no pesticides. At Parbhani, farmers used four to five cart loads of farmyard manure and two 50-kg bags of 20:20:0 compound fertilizer per hectare. At Solapur center, the crop was planted in shallow soil, and 100 kg urea per acre was applied under irrigation, but other farmers did not apply fertilizer under rainfed conditions. At Bijapur, farmers applied 25 kg urea + 25 kg di-ammonium phosphate (DAP) per acre.

In 1998 in Maharashtra, SPV 1359 and SPV 1155 were often preferred by farmers over the local cultivar M35-1. At some locations, other varieties, such as SPV 1380 and the ICRISAT bulk derived from M35-1, were also preferred over M35-1. Local germplasm selections, such as RSLG 2623, were preferred at locations outside of their location of origin. This led us to test the local germplasm in all participating centers in 1999.

For 1999, although the genotypes were tested by all the NGO groups, only the data from Solapur are presented in detail (table 1). In six trials, SPV 1359 was found most productive with 3.7 t ha^{-1} grain yield, compared to 1.7 t ha^{-1} grain yield of the local cultivar. Thus, the grain yield of SPV 1359 in farmer-managed trials was more than double that of the local cultivar. There were more trials of SPV 1380 and CSH 15R; both gave almost double the grain and fodder yields of the local cultivar (table 1). M 35-1 was also tested against the locally grown landraces. In 16 such comparisons, its grain yield was 2.4 t ha^{-1} (compared to 1.5 t ha^{-1} for the local checks), an increase of 66%. The increases over locally grown cultivars are summarized in table 2.

Genotypes tested in the initial varietal trial also performed well (table 3). The cultivar SPV 655, earlier dropped from coordinated trials, gave the highest grain yield, 3.2 t ha^{-1} against only 1.3 t ha^{-1} of the farmer-grown local cultivar, an increase of 146%, and its fodder yield was double that of the local variety. The grain and fodder yield of SPV 1413 was also double that of the local variety grown by farmers. Two other genotypes, RSLG 262 and SPV 1411, gave more than 1.5 times the grain and fodder yields of the local varieties grown by farmers. These genotypes will be tested in 2000-2001 in more trials.

Farmers' perceptions of the improved genotypes

During 1998, farmers in general were satisfied with the grain yield of the new varieties, compared to their local cultivar, and demanded more seed from the new varieties. The popularly grown variety M 35-1 was not liked at certain places because of its side tillers. Women preferred bold and pearly seed, medium plant height (since this was convenient for harvesting the heads), higher flour

Table 1. Grain and Fodder Yields of Improved Genotypes in Farmers' Fields in Advanced Varietal Testing, *Rabi* Season, 1999, Solapur, India

		Grain yield (t ha-1)		Fodder yield (t ha-1)	
Entry	No. of trials	Improved	Local	Improved	Local
SPV 1359	6	3.7	1.7	4.5	3.0
SPV 1380	40	2.8	1.4	6.0	3.0
SPV 1155	2	2.4	1.8	5.2	4.1
M 35-1	16	2.4	1.5	5.4	2.9
CSH 15R	25	2.3	1.1	6.0	2.9

Table 2. Percent Increase of Improved Genotypes over Farmer-Grown Local Cultivar in Farmers' Fields in Advanced Varietal Testing, *Rabi* Season, 1999, Solapur, India

	Grain yield		Percentage of trials	Fodder yield	
Entry	(%) of local	Range	with >20% increase	(%) of local	Range
SPV 1359	116	7–195	67	32	(-)20–87
SPV 1380	96	4–194	88	113	20–244
M 35-1	66	(-)36–287	56	89	(-)14–382
CSH 15R	101	(-)7–228	88	105	(-)17–276

Table 3. Cultivar Performance in Farmers' Fields in Initial Varietal Testing, *Rabi* Season, 1999, Solapur, India

		Grain yield (t ha^{-1})		Increase over local	Fodder yield (t ha^{-1})		Increase over local
Entry	No. of trials	Improved	Local	(%)	Improved	Local	(%)
RSLG 262	3	2.5	1.5	69	5.6	3.8	47
SPV1462	5	1.6	1.4	14	6.3	5.3	20
BRJ 356	3	2.1	1.6	29	4.3	3.1	40
SPV 1413	5	2.5	1.2	109	6.0	2.8	117
SPV 655	15	3.2	1.3	146	6.6	3.2	109
SPV 1411	15	3.0	1.7	72	6.4	4.0	57
M 35-1 (B-3)	1	1.6	—	—	3.8	—	—

recovery (9:1), better cooking quality (good dough), soft and good tasting *chapatti*, and a longer storage life of the flour.

During *rabi* 1999 at Solapur, farmers reported on the high grain yield and good fodder quality of the improved cultivar SPV 1155 compared to M 35-1. Farmers said that SPV 1359 was excellent for its higher grain yield and bold grain but that it had no sweetness in the stem and thus its fodder was not preferred. In the case of SPV 1380, farmers' reactions were that it had excellent grain yield, bold grain, and loose panicles that helped stop birds sitting on them to eat the grain. However, they reported that it had poor-quality fodder because of a longer internodal length and leaf fall.

For the hybrid CSH 15R, farmers reported that it was good for high grain yield under irrigation, that it was earlier in maturity than the local cultivar, and that its fodder was moderately preferred. They were unhappy with the 60% to 70% grain filling that reduced its yield.

Conclusions

Participatory varietal selection appears to be an effective approach to supplement plant-breeding efforts in marginal areas, where progress with varietal adoption has been slow. It enables farmer-preferred varieties to be identified and tests the rigor of the varietal-testing program in multi-environment coordinated trials. In contrast to the general belief that M 35-1 is a popularly grown variety, access to NGOs and farmers revealed that various landraces are still grown in the Solapur area in addition to M 35-1. Improved varieties such as SPV 1359, SPV 1380, and SPV 1155 from the AICSIP advanced varietal trials, and SPV 655, a rejected genotype from the ACISIP trials, performed excellently. The first two have already been identified for release. Thus, the varietal testing at the research station is usually, but not always, satisfactory to determine adaptability under realistic farmer management. Further PVS success will depend on newly evolved varieties, based on the farmers' perceptions learned in these studies.

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The Impact of Participatory Plant Breeding (PPB) on Landrace Diversity: A Case Study for High-Altitude Rice in Nepal

K.D. Joshi, B.R. Sthapit, and J.R. Witcombe

Abstract

Participatory plant-breeding (PPB) methods were used to develop two acceptable, cold-tolerant rice varieties in Nepal: Machhapuchhre-3 (M-3) and Machhapuchhre-9 (M-9). Both were derived from the cross Fuji 102/Chhomrong Dhan. Following the introduction of these varieties from 1993 to 1998, the changes in the rice landraces and varieties that farmers grew were studied in 10 villages. In seven of the villages, for which data were analyzed for both 1996 and 1999, farmers grew 19 landraces and four modern varieties, of which three (M-3, M-9, and Lumle 2) were the products of PPB. These three varieties covered 11% of the total surveyed area in 1999. The introduction of the PPB varieties had the greatest impact on the more commonly grown landraces. During the years studied, because the new varieties had exotic germplasm in their parentage, there was an overall increase in varietal diversity. However, in the future, increasing adoption of M-3 and M-9 could result in significant reductions in varietal diversity.

Introduction

Participatory plant breeding (PPB) is increasingly being used for decentralized crop improvement (Weltzein et al. 2000; Eyzaguirre and Iwanaga 1996; Sthapit, Joshi, and Witcombe 1996; Witcombe et al. 1996). Important elements of PPB commonly include the use in the breeding program of a local landrace or locally adopted variety as a parent, the screening of segregating materials in the target environment, and the participation of farmers in goal setting, selection, and evaluation.

Farmers in the hills and mountains of Nepal continue to grow landraces because centralized plant breeding has had limited success in producing varieties that farmers wish to adopt. The use of decentralized, participatory methods could remove this constraint to the adoption of new varieties. However, the products of PPB, if highly preferred by farmers, could have a considerable impact on local agrobiodiversity. In recent years, there has been a growing awareness of the value and utility of agrobiodiversity, and local nongovernmental organizations (NGOs) and international organizations are concerned about the conservation and utilization of biodiversity. For example, during the third global meeting of the International Plant Genetic Resources Institute (IPGRI), in July 1999, Pokhara, Nepal, the in situ crop conservation project of Dr. Ramnath Rao of IPGRI presented one possible impact that PPB products could have on landrace diversity (figure 1).

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Most of this work was carried out with core funds from LI-BIRD. The initial monitoring of the adoption and varietal spread of PPB products was jointly funded by the UK Department for International Development (DFID), project R6636, for the benefit of developing countries and by the International Development Research Centre (IDRC). The views expressed are not necessarily those of DFID, LI-BIRD, or IDRC.

Machhapuchhre-3 and Machhapuchhre-9 are the products of the Agricultural Research Station, Lumle, Nepal Agricultural Research Council.

We acknowledge the contribution of all the farmers who collaborated in the initial PPB and in the spread of M-3 and M-9. The fieldwork by B. B. Paudel, community organizer of LI-BIRD is appreciated.

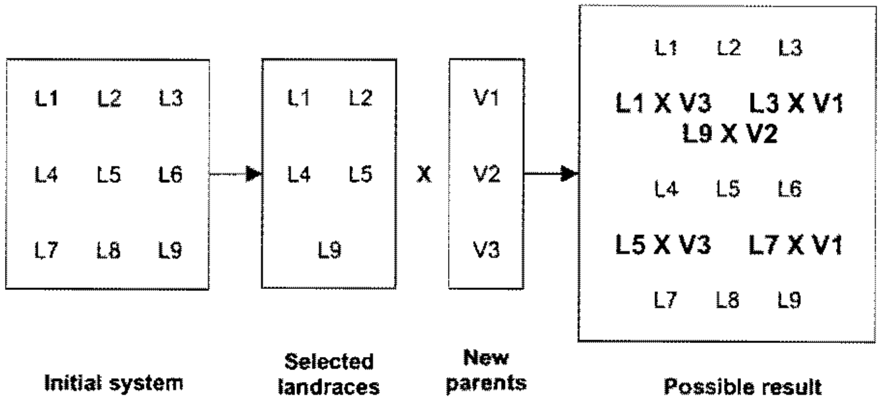


Figure 1. The impact of PPB products on local agrobiodiversity (In this scenario biodiversity is increased because it is assumed that none of the landrace are entirely replaced by new varieties produced by PPB.)

Materials and methods

Participatory plant breeding of high-altitude rice was initiated in 1993 by the Lumle Agricultural Research Centre (LARC) in the villages of Chhomrong and Ghandruk, both at an altitude of 2000 m, in the Kaski district of Nepal. Eighteen farmers collaborated in selecting between, and sometimes within, 10 F_5 bulk lines derived from three different crosses made by the Agricultural Botany Division of the Nepal Agricultural Research Council (Sthapit, Joshi, and Witcombe 1996). As a result of this program, in June 1996, the Variety Release and Registration Committee (VRRC) of Nepal made the first release of a variety produced with the extensive use of participatory methods: Machhapuchhre-3 (M-3) (Joshi et al., 1996). In a participatory varietal selection (PVS) program, farmers at Chhomrong also identified Machhapuchhre-9 (M-9), a sister line to M-3, as an acceptable variety. Starting in 1996, M-3 and M-9 were introduced into villages situated between 1200 m and 2300 m altitude by NGOs such as the Local Initiatives for Biodiversity Research and Development (LI-BIRD), CARE Nepal, the Annapurna Conservation Area Project (ACAP), and LARC.

The adoption and spread of M-3 and M-9 were monitored from 1996 to 1999. Five villages were surveyed in both 1996 and 1997, and 10 in both 1998 and 1999. Only the surveys in 1999 are reported here (table 1). Information was collected from the surveyed households using semi-structured interviews. Sampling was purposive (only from households known to have been given seed of M-3 or M-9). In 1998, farmers were asked about their adoption intentions to assess the possible impact of PPB products on the diversity of rice landraces. The 1999 survey, which covered about 18% of the households that had adopted and grown PPB products within the last three years (table 1), also collected information on the landraces farmers grew in 1996. For each household, the total area of *khet* land (irrigated and bounded terraces of land where rice is grown) was determined from the land-ownership certificates, and a total inventory of rice varieties, with the area that each variety occupied, was compiled.

The rice varieties and landraces were analyzed by the area in which they were grown and the number of households that grew them. Changes between 1996 and 1999 were assessed for area and household number for the more common landraces. The statistical significance of changes in area was determined by a two-tailed paired t test between the areas reported for 1996 and 1999.

Table 1. The Study Villages, 1999

Village	District	Altitude and aspect	Households: in the village	in 1999 survey	with data for 1996
Chhomrong –Ghandruk	Kaski	1800-2000, NE	55	12	12
Chane-Kimche, Landruk-Tolka	Kaski	1500-1900, SW	142	14	14
Marangche	Kaski	1400-1600, SE	34	30	30
Kande	Kaski	1400-1600, N	55	11	11
Khanigaun, Lwang	Kaski	1600-1900, SE	68	11	0
Patlikhet	Myagdi	1400-1700, SW	50	6	6
Bhakimle	Myagdi	1600-2300, N	181	16	16
Chipleti	Myagdi	1400-1800, S	78	11	11
Bangsing Deurali	Syangja	1300-1500, S	64	6	0
Bangephadke.	Syangja	1400-1600, S	28	10	0
Total		—	754	127	100

Results and discussion

Adoption of M-3 and M-9 in 1999

M-3 was introduced to all 10 study villages and was adopted in all of them, while M-9 was introduced to seven of the villages but was adopted in three (figure 2). The most important factors in determining adoption were the altitudes of the villages and the year in which they first received seed. Apart from the low-altitude village of Bangephadke, adoption of either M-3 or M-9 was at least 10% of the rice area in villages that had received seed before 1998.

Impact of M-3 and M-9 on varietal richness

Since the ancestors of the landraces were not known, no analysis of diversity could be done that required a knowledge of the relatedness of the cultivars with each other. However, richness can be assessed by the number of landraces and varieties grown (figure 3) for the seven villages for which there were data for both 1999 and 1996. The total number of rice cultivars decreased little in the study villages. This was despite the adoption of varieties produced by PPB that might have been expected to have replaced several of the landraces. The number of rice cultivars grown in 1999 increased in two of the study villages and decreased in two, while in three of the villages there was no change (figure 3).

The decrease in diversity in Chhomrong and Ghandruk is not surprising since the initial PPB program was conducted in these villages. In the early stages, as many as nine lines were grown in 1996 at Chhomrong alone, but by 1999, the undesirable lines had been dropped. Another case of decrease was in Chane and Kimche, where adopting households dropped the Tairige and Takmare landraces to grow M-3 even though M-3 covered less than 15% of the total rice area.

In all of the seven study villages, some of the rice area that was under landraces in 1996 was occupied in 1999 by M-3 and M-9. This increased genetic diversity, since M-3 and M-9 have exotic germplasm in their ancestry. M-3, M-9, and Lumle-2 all have a local landrace, Chhomrong Dhan, as a parent. Fuji 102, an exotic variety from Japan, is a parent of M-3 and M-9, and IR36, an

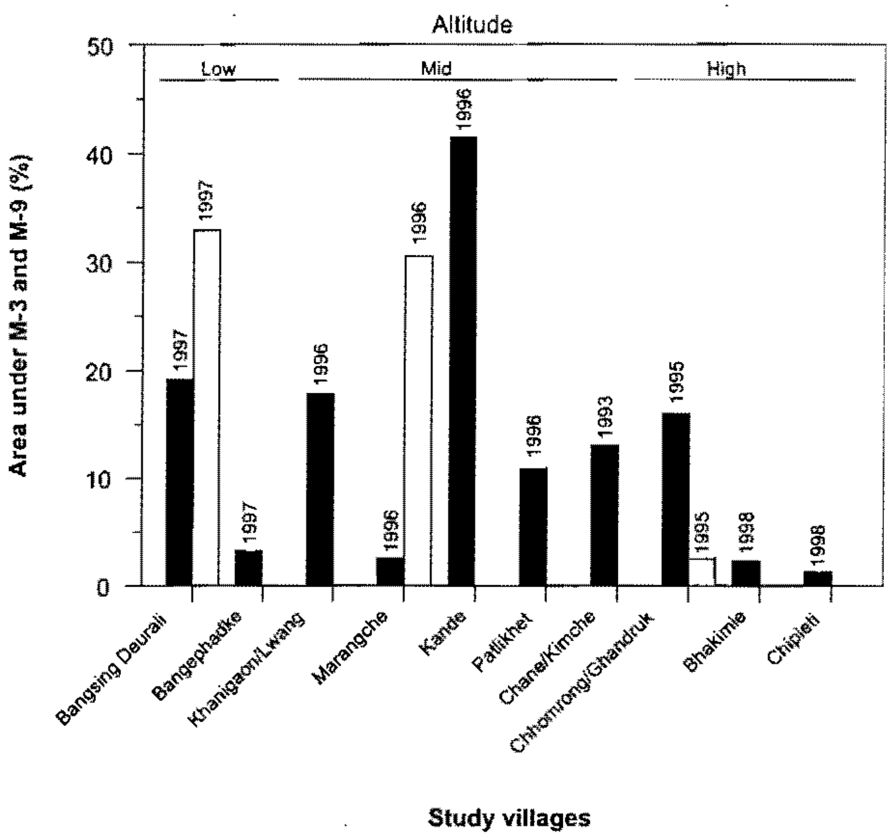


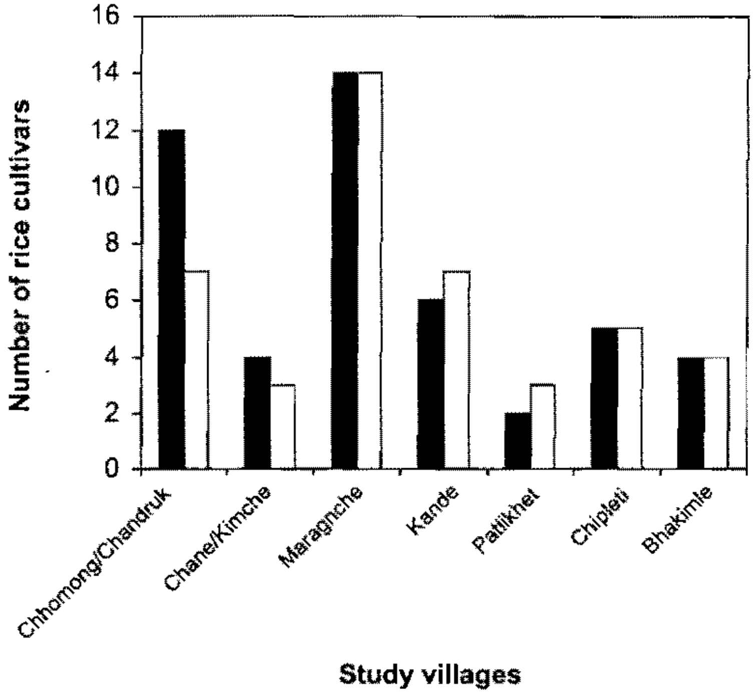
Figure 2. Adoption in 1999 of Machhapuchhre-3 (solid bars) and Machhapuchhre-9 (open bars) in 104 sampled households in the 10 study villages (The year of first introduction of M-3 or M-9 is indicated above the bars.)

International Rice Research Institute (IRRI) variety, is a parent of Lumle-2. Chhomrong Dhan was grown in only three of the seven villages, so in four of them, there was no cultivar that was genetically related to the PPB products.

Classification of landraces by their relative abundance

In 1999, farmers grew 19 landraces and five modern varieties in the seven study villages for which both 1996 and 1999 data were available. Of the five modern varieties, three were the products of PPB (M-3, M-9, and Lumle-2). The average area devoted to any landrace by the households in the study villages was quite small (<0.3 ha) (figure 4). Of the 19 landraces in these seven villages, 12 were reasonably common (figure 4). Of the seven less common, five were grown by only one of the sampled households and two had a combination of low household number and a small average area.

While studying the occurrence and diversity of local landraces in Kaski (a low to mid-hill site, 750 m to 1300 m) and Bara (100 m to 150 m), Joshi et al. (1999) found that only a few landraces were widely grown. The great majority of landraces or varieties were less common and had either a small area or few households growing them, or both. A similar result was found for *ghaiya* (upland rice) landraces (Joshi et al., forthcoming). This was also found for modern varieties in the Nepal *Terai* (Joshi and Witcombe, this volume).



Note: Open bars = 1996; solid bars = 1999.

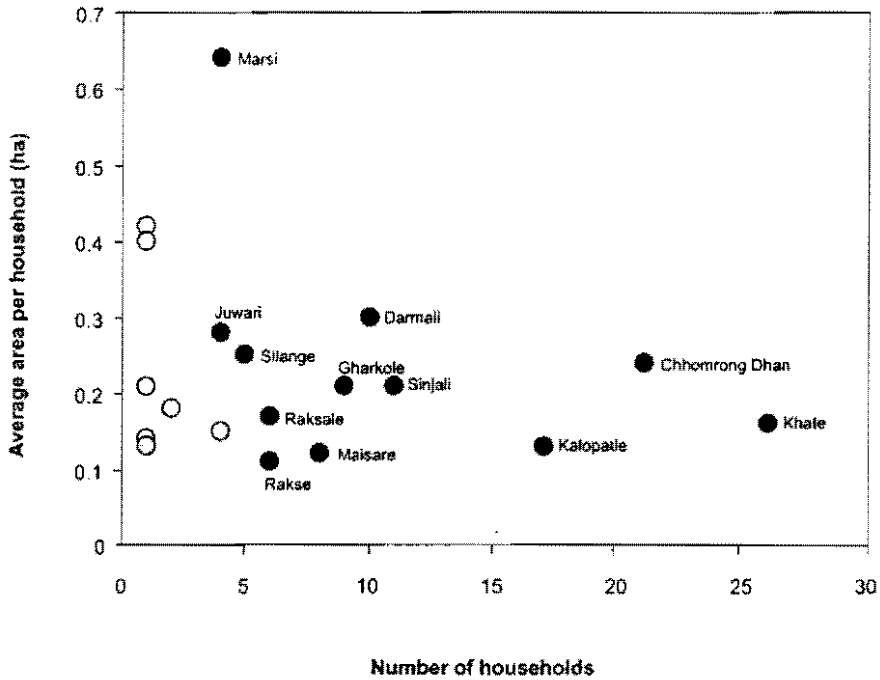
Impact of M-3 and M-9 on landrace diversity

Farmers' perceptions in 1998. In 1998, farmers' perceptions of the impact that PPB products would have on local landrace diversity were recorded. Most of the respondents reported that they would increase the area under M-3 or M-9. About 24% of the respondents reported that the adoption of M-3 or M-9 would either reduce the area under landrace Kathe or entirely replace it. A similar situation was perceived for landraces Kalopatle (8% of respondents), Maisara (6%), Raksali (3%) and Darmali (3%). A further 10% of the surveyed households also mentioned the possible partial replacement of 10 other landraces and one modern variety. No households reported that they would entirely replace the landrace Chhomrong Dhan or the modern variety Khumal-4, even though at least one household mentioned the complete replacement of at least one of the remaining 19 landraces.

Results of the 1999 survey

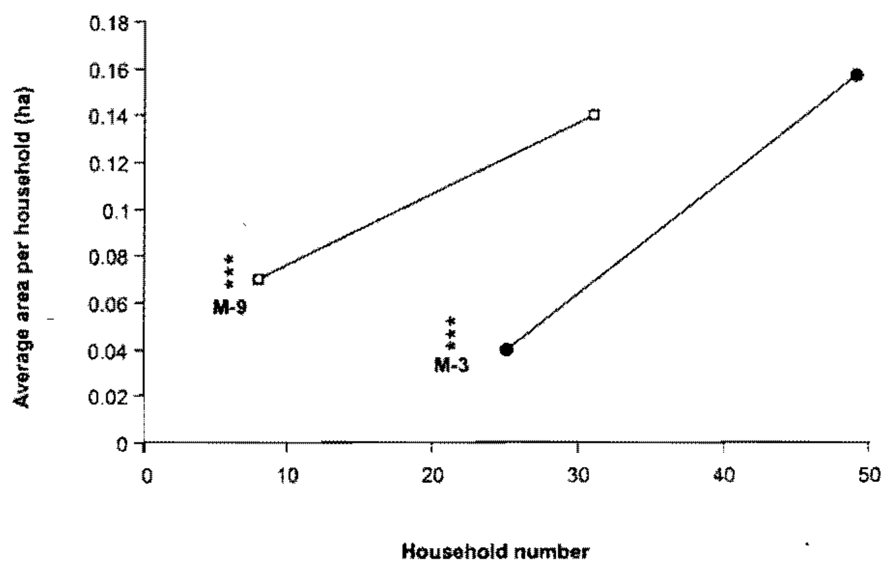
The 1999 survey confirmed most of the 1998 perceptions. The area and number of adopting households increased significantly for M-3 and M-9 (figure 5). The increasing adoption of M-3 and M-9 is likely to have far greater impact on landrace diversity in the future than what had already taken place by 1999.

In 1999, the area under 12 out of the 19 landraces had decreased, while for eight of them, the number of adopting households decreased. Area was more dynamic than the number of households probably because a decision to change the area under a landrace is more common than to entirely drop a landrace or adopt a new one.



Note: The more common landraces are marked with solid circles and labeled with names. Tthe less common landraces are marked with grey circles and are Phake Dhan, Gunta, Pahenle, Rakse, Maisare, Takmare, Galaiya, Tarkaya and Anga.

Figure 4. Landrace frequency by number of adopting households and average area grown by each household in 1999 in the seven villages for which 1996 and 1999 data were available (see table 1)

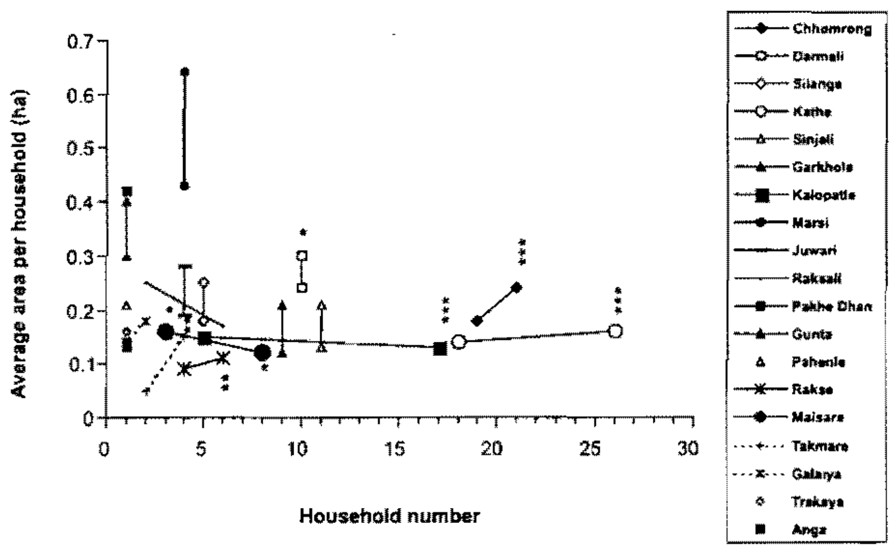


Note: Lines are labeled next to the 1996 origin of the line. Both cultivars have significant changes in area (*** = $p \leq .001$). The significance of changes in adopting households was not tested.

Figure 5 Change in area and household adopters from 1996 to 1999 for M-3 and M-9 in seven villages (see table 1)

As an example, the changes in adoption of rice cultivars from 1996–1999 were analyzed for the seven villages shown in figure 3. The decrease in area was statistically significant for eight of the 10 most common landraces, i.e., Chhomrong Dhan, Khate, Kalopatle, and Sinjali ($p < .001$), Raksali and Rakse ($p < .01$), and Darmali and Maisare ($p \leq .05$). In all cases, this decrease was largely accounted for by a compensating increase in M-3 and M-9. Of these six landraces, four of them had been mentioned by farmers for possible replacement in the 1998 survey.

Most significantly, three of the eight landraces where the number of adopting households declined were those that were grown by the most households. Hence, it was mainly the most common landraces that had fewer adopters in 1999 than in 1996, and the less common landraces were the most buffered against change. All of the five landraces with only a single household in 1996 were also grown by a single household in 1999 (figure 6).



Note: Cultivars with significant changes in area have been indicated by asterisks (*** = $p \leq .001$; ** = $p \leq .01$; * = $p \leq .05$). Nonsignificant changes are indicated with 'ns' close to the 1996 origin of the line. The significance of changes in adopting households was not tested.

Figure 6. Change in area and household adopters from 1996 to 1999 for high altitude rice landraces after the introduction of M-3 and M-9 in seven villages (see table 1)

Varietal change is a common and continuous process in most subsistence farming where farmers allocate different proportions of their land to a cultivar from one season to another. Landraces that most closely match the new varieties, but have a lower yield or other undesirable traits, are replaced first. The landraces with the greatest reduction in area and adopting households were Chhomrong Dhan, Kathe, and Kalopatle. The niches of these varieties closely match those of M-3 and M-9.

By 1999, six years after the commencement of the PPB program, the products of PPB occupied about 11% of the total rice area and about 14% of the surveyed households. There is a continuing trend of increasing adoption of M-3 and M-9 in both area and household number. In the past, in spite of concerted efforts by government extension agencies to promote modern rice varieties, their adoption was very poor. For example, only 10%–11% of farming households were growing improved rice cultivars in a survey of 1688 households in 11 districts of eastern and western Nepal nearly three decades after the intervention of improved varieties (Chemjong et al. 1995; LARC 1995). Targeting specific niches that were not addressed by conventional breeding programs is one of the objectives of PPB. The increasing acceptance of PPB products in the study villages provides evidence for its success.

To conserve landraces, maintaining diversity at the community level should be sufficient. Although there was an overall loss in landrace richness in the sample, it was not severe and M-3 and M-9 added to the diversity. Landraces found to be most at risk can be utilized in participatory plant breeding programs so that their useful genes are incorporated in more productive genotypes and hence conserved. In terms of utility and food security, diversity at the household level may be more important, and the addition of either or both M-3 and M-9 to the varietal portfolios of about 14% of the farmers would contribute to this diversity.

An important finding was that the adoption of landraces was highly dynamic, with losses and gains at the village level and common changes in areas. Ex situ conservation is simply a "snapshot" of a situation in the year in which the collection was made. PPB, in producing varieties that farmers like, contributes to the dynamism. It accelerates change by introducing genes and genotypes but may not fundamentally change the age-old process of varietal adoption. Indeed, as argued by Witcombe et al. (1996), PPB in its collaborative form in farmers' fields is a dynamic form of in situ genetic conservation.

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Role of Farmers in Setting Breeding Goals

M. Subedi, P.K. Shrestha, S. Sunwar, and A. Subedi

Abstract

Maize (*Zea mays* L.) is the most important crop in the hill farming system in Nepal. It plays an important role in the livelihood of the people living in the hills. The hilly area of the Palpa, Gulmi, and Arghakhanchi districts extending towards Pyuthan and further west has a unique geophysical environment, which is different from other maize-growing areas in Nepal. Farmers in this area not only have poor access to agricultural inputs, including improved genetic materials, but the improved varieties tested so far do not exactly match the unique growing conditions and the needs of farmers in the area. Therefore, the major proportion of maize in the Palpa, Gulmi, and Arghakhanchi districts is dominated by local varieties. Several factors are responsible for low productivity and for other associated problems of maize production in the area.

Initially researchers perceived low yields associated with inferior local varieties as the main constraint in maize production for the area. Based on past experience and success in upgrading the productivity of local landraces through the introduction of high-yielding varieties and subsequent seed selection, a breeding program was formulated in order to address the problem. The initial objective of the program was to increase farmers' access to new, improved genetic materials and provide them with training on mass selection. However, a different scenario emerged during the site-selection survey and the process of setting research goals. Farmers reported that maize production in the area was affected mainly by lodging problems. Farmers in the area have developed and maintained a variety called *Thulo pinyalo* that produces good yields and also meets their fodder requirements. However, the variety is prone to severe lodging, resulting in yield losses of 15% to 85%. Farmers therefore strongly suggested that rather than introducing new varieties, their local varieties be improved to address the problem. In this way, the breeding program changed from increasing grain yield to reducing lodging in the target environment. This paper discusses how farmers set their own breeding goals and the implications for methodological approaches to participatory plant breeding.

Introduction

Maize (*Zea mays* L.) is the second most important crop after rice in Nepal. It is grown largely on *bari* land (rainfed upland commonly associated with farm forestry) during summer and usually rotated with millet or beans. Maize is also grown as the sole crop at lower altitudes (below 1000 m) and at higher altitudes (above 1600 m). It is also grown in *khet* land (bunded land where at least one crop of puddled rice is cultivated) at altitudes below 1000 m during the spring season. Maize cultivation occupies nearly 0.8 million hectares (almost 30% of the total cultivated area), and 80% of this is under terraced hill farming, producing over 1.3 million tones/annum (MoA 1995).

The productivity of maize is quite low (about 1.7 tonnes/hectare), which is reflected by a high incidence of food-deficit households in the hills of Nepal. A number of factors appear to be involved in

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This work was carried out in collaboration with the CGIAR Program on Participatory Research and Gender Analysis (PRGA) for Technology Development and Institutional Innovation, convened by CIAT, Cali, Columbia. Farmers of the Gulmi, Palpa, and Arghakhanchi districts who participated in the process in one way or another and provided information are duly acknowledged. The contributions of Mr. D. Sharma, Dr. K.B. Koirala, Mr. C.B. Kunwar, and Mr. T. Rijal from NMRP, Mr. T. Shrestha from DADO Gulmi, and Mr. M. Chaudhary, Mr. B.B. Paudel, and Ms. N.K. Khatri from LI-BIRD in the site-selection process are highly appreciated. Sincere acknowledgement is also due to Dr. B.R. Sthapit and Mr. K.B. Kadayat for sharing the information, which was very helpful in planning and defining the processes.

the low productivity of maize in the middle hills of Nepal. These include rainfed farming with uncertain rainfall, poor access to chemical fertilizers and declining application of organic manure, and lack of varietal options and access to improved genetic materials suitable to local conditions. In areas where improved maize varieties have been introduced, farmers tend to grow the same seed for a number of years without replacing it or without practicing standard seed-selection procedures. As a result, these varieties generally deteriorate rapidly due to genetic contamination with poorer heterogeneous landraces and/or due to unconscious selection for negative traits, as farmers generally use either grain for seed or select harvested cob for the seed. Practice of selecting standing plants for the seed is rarely seen among the farmers.

From the point of view of varietal improvement, the problem of maize production in the hilly areas of Nepal is therefore threefold. First, farmers' access to new, improved germplasm is highly limited; second, the recommended varieties do not meet the multiple varietal needs of local farmers; and third, varietal deterioration occurs over time in the farmers' fields. To address these problems, Local Initiatives for Biodiversity Research and Development (LI-BIRD) is currently researching a farmer-led participatory plant-breeding (PPB) exercise in maize in the Gulmi district of the western hills of Nepal.

The maize-growing environment of Gulmi has a unique geophysical environment and represents the large hilly areas of the Palpa, Gulmi, and Arghakhanchi districts extending towards Pyuthan and further west. The maize is grown in outward sloped terraces of *bari* land under rainfed conditions, with minimal external inputs (seeds, fertilizers, and plant-protection measures). Farmers in the area have poor access to agricultural inputs, including improved genetic materials (Kadayat et al. 1998; Sthapit et al. 1997). Moreover, access to new sources of maize germplasm—that closely matches farmer-preferred traits—in the traditional seed-supply system is limited. A survey of preferred traits carried out in 16 villages in the Gulmi district revealed that grain and fodder yield, *aato* (grit) recovery, taste in various cuisines, grain color, resistance to lodging, and time of maturity are the most commonly cited preferred traits (Subedi and Shrestha, Unpublished; Kadayat et al. 1998). As a result, the major proportion of the maize area in the Palpa, Gulmi, and Arghakhanchi districts is planted to local varieties. The local varieties are the products of continuous seed selection carried out by farmers, consciously or unconsciously, over many generations and are well adapted to the local environments and meet farmers' multiple needs. However, these varieties have a number of undesirable traits that require urgent attention in order to ensure food security in the region.

Researchers' perceptions of the problem

LI-BIRD carried out a study to analyze the situation in the Gulmi and Arghakhanchi districts to develop a future strategy for agriculture. Maize was the most important crop; however, average productivity was reported to be low: below 1.5 t/ha in both districts (Kadayat et al. 1998; Sthapit et al. 1997). This may be partly due to a low supply of inputs in these districts, as the improved seed sold by AIC during 1996/97 was 1.22 mt in Gulmi and 0.91 mt in Arghakhanchi (Kadayat et al. 1998; Sthapit et al. 1997). Researchers concluded that the low maize yields were due to poor access to new, improved genetic materials and deterioration of farmers' maintained variety because of poor seed-management practices (figure 1). In such a situation, providing farmers with improved maize varieties and seed-selection skills appeared to be a practical and sustainable solution. As a result, helping farmers improve local maize varieties for yield-related traits became the goal of the program.

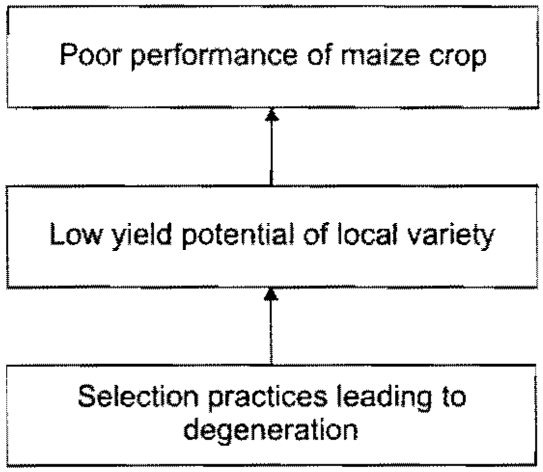

Figure 1. Researchers' perceptions of the causal relationships contributing to low productivity of maize in the mid-hill region of Gulmi and Arghakhanchi districts, Nepal

However, A different scenario emerged during the selection survey for the research site and in research-planning discussions with farmers at the research sites. Farmers felt that poor production performance was associated with the lodging of maize plants rather than yield traits, themselves, in most commonly grown local maize varieties.

Farmers' perceptions of the problem

An extensive reconnaissance survey was conducted in large areas of the Palpa, Gulmi, and Arghakhanchi districts during the process of selecting research sites for the project. A rapid survey of 28 villages was done, and farmers were consulted to verify the research problems in maize production and determine the suitability of these villages for implementation of the research program.

Potential sites were screened and narrowed down to six villages. Participatory rural appraisal (PRA) and field observations were done by a multidisciplinary team in these villages. Discussions were held in the farming communities during the site-selection process in order to collect information about the geophysical condition of the area, socioeconomic situation of the farming communities, and farmers' interest in the proposed program. Problems were discussed with farmers in greater length during the survey. Preferred-trait analysis was done during the PRA to verify the researchable problems. Major traits of interest and problems associated with the preferred traits were identified in the process.

Varietal traits of interest

Varietal performance for the trait of interest was discussed with farmers during the site-selection survey in order to understand farmers' needs and varietal strengths and weaknesses in relation to a particular trait. This exercise was important in order to develop a breeding program based on needs and problems. In this process, information on the desirable and undesirable characteristics of both local and recommended improved varieties was collected.

Farmers were found to grow a number of varieties (viz. *Thulo pinyalo, Thulo seto, Sano pinyalo, Sano seto, Amrikane, Kaude, Rato dhanthe, Thorgeli pinyalo*) to suit their growing environment and to meet their household needs. *Thulo pinyalo* is the most popular variety of the region and occupies as much as 80% of the maize area in some villages. Farmers liked most of its traits. This variety has good taste in all recipes, good grain and fodder yield, the biomass (both green and dried) is very much liked by the livestock, and it is easy to sell and barter because it has bold, flint grain with an attractive grain color. However, farmers had lodging problems with this variety, leading to as much as 85% production loss in the worst season (table 1). Lodging problems are equally high in other local varieties (viz. *Thulo seto* and *Amrikane*); however, the area under these varieties is very low. It was reported that the low production of *Thulo pinyalo* has more significant implications for the food security of the region than any other variety. So, the lodging in *Thulo pinyalo* was considered a major problem.

Resistance to lodging from thick stalks and strong, stout plants has been perceived by the farmers of the surveyed villages as the most desired characteristic in a recommended improved variety (table 2). The least desired characteristics were a relatively low grain and fodder yield compared to that of large local varieties, followed by inferior taste. Low fodder yields have been found to be associated with the low height of improved maize varieties, compared to local varieties. Farmers of Banjha reported that all the improved varieties under cultivation in the village were introduced nearly six years before, and now there is no difference between local and improved, due to heavy and recurrent cross-fertilization with local varieties.

Table 1. Desirable and Undesirable Traits of Local Varieties of Maize Grown in Surveyed Villages, 1999

	Surveyed villages					
Parameters	Digam, Gulmi	D/Devisthan, Gulmi	Simichaur, Gulmi	Chaun bari, Palpa	Banjha, Palpa	Kaule, Arghakhanchi
Desirable traits						
High yield potential	*	*	*	*		*
High fodder yield	*	*	*	*		*
High flour recovery		*				
Good taste	*	*	*	*		*
Undesirable traits						
Lodging	*	*	*	*	*	*
Head smut						*

Farmers of the surveyed villages reported that high-yield potential and resistant to lodging were the most preferred traits for maize, followed by good taste and high stover yield (table 3). Farmers perceived that grain yield is closely associated with the extent of lodging; they felt that these two parameters are highly interrelated and essentially synonymous. Farmers of Darbar-Devisthan reported that lodging problems are due to tall plant height, and therefore, they perceived relatively shorter plant height as one of the most preferred traits to be considered in the maize improvement program.

Revisiting farmers to discuss maize-production problems in the targeted area and to verify research hypotheses with farmers revealed that causal relationships in poor maize performance were not properly established. Earlier, a new research hypothesis surfaced, which explained that the poor

Table 2. Desirable and Undesirable Traits of Improved Varieties of Maize Grown in Surveyed Villages, 1999

	Surveyed villages					
Parameters	Digam, Gulmi	D/Devisthan, Gulmi	Simichaur, Gulmi	Chaun bari, Palpa	Banjha, Palpa	Kaule, Arghakhanchi
Desirable traits						
Nonlodging/thick stalks	*	*	*	*		
Early maturity	*					
Strong /stout plants			*			
Undesirable traits						
Lodging						*
Low yield	*	*	*	*		*
Low fodder yield	*	*	*	*		*
Inferior taste			*			*
More insect problems				*		

Table 3. Ranking of Preferred Traits of Maize in Surveyed Villages, 1999

	Surveyed villages					
Traits	Digam, Gulmi	D/Devisthan, Gulmi	Simichaur, Gulmi	Chaun bari, Palpa	Banjha, Palpa	Kaule, Arghakhanchi
Higher grain yield	1	2	2	1		1
Nonlodging	3	1	1	2		2
More stover yield	5	3	3	3		
Need for less soil fertility	6					
More grit recovery		5	5			
dctlparGood taste	2	4	4			3
White grain color				4		
Early maturity	4					
Short plant height		1				
Good husk cover				5		

performance of maize in the area is not due to yield traits but to lodging tendencies, and this, in turn, leads to poor production (figure 2).

Redefining breeding goals

In light of the new research hypothesis that emerged during the site-selection survey, a one-day village workshop was organized with the farmers at each research site selected for the implementation of the program. Farmers at the research sites opined that the local variety *Thulo pinyalo* has good yield and meets their requirements. They strongly suggested improving *Thulo pinyalo* for lodging resistance rather than just introducing new varieties. The underlying causes of lodging in *Thulo*

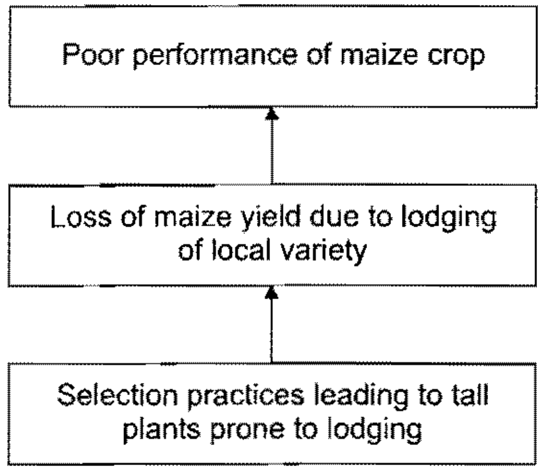

Figure 2. Farmers' perceptions of causal relationships for low productivity of maize in the mid-hill region of Gulmi and Arghakhanchi districts, Nepal

Pinyalo were explored with the farmers' group in order to understand and tackle the problem. Farmers perceived the following as the causes of the problem:

- The very tall plant stature of this variety is the main reason for lodging. Farmers reported it having as high as 27 leaves in one plant. In field observations, the plant height of *Thulo pinyalo* was found to be as high as 5.1 meters. Ear height has been found to be more than two meters under good growth conditions. The weight of the tassel and cob at such a height contributes to the extensive lodging of the thin-stalked *Thulo pinyalo*, even under mild wind pressure.
- *Thulo pinyalo* attains luxurious growth in fertile land, which is one of the reasons for lodging.
- Disease and insects attack the stem.
- The lodging is greater after prolonged rainfall followed by winds. According to farmers, they face substantial yield reductions even with mild winds, as very weak plants lodge under such conditions and fall on other, nonlodging plants. This phenomenon occurs in cycles and can affect large areas.
- The plants are more prone to lodging during the tasseling stage because of the increased weight at the top of the plant.
- Yield is inversely related to lodging. Yield losses due to lodging in this variety are as high as 85% in the worst season. *Thulo pinyalo* produces more grain than high-yielding varieties (HYVs) in a normal season and less if there is a lot of rain and wind.
- Lodging is greater in wet areas at lower elevations than in flat areas at the top of the hills.
- Lodging does not occur every year. However, there is no distinct pattern. High winds during tasseling contribute to severity of the problem.

Several possible options were discussed with the farmers to achieve the goal. The options that could be implemented within the project framework and which farmers considered possible to implement, considering their resources (time), knowledge, and skills, were chosen by the farmers' group. There were mainly three types of activities: a mass-selection program, a crossing program, and a participatory variety selection (PVS) program.

Refining the research process

The involvement of farmers in analysis of researchable problems helped change the researchers' perceptions of the problem (table 4) and redefine the goal of the maize-improvement program. The redefinition of the breeding goals of the maize-improvement program provided guidelines for refining the research process that had been proposed initially. A multiple approach (mass selection, crossing, screening of improved/pipeline varieties, and PVS) was taken to address the problems, some of which had not been considered before. Farmers liked the mass-selection technique because they perceived it as a simple method and as a possible option to improve specific traits, keeping the desirable traits of the variety intact. The crossing program was chosen in consideration of the slow genetic gain in the mass-selection method, particularly in farmers' fields. Considering the long gestation period of the variety-improvement program, which may delay the delivery of benefits to the farmers, the variety-selection program was planned. This would provide farmers with access to new, improved genetic materials to test in diverse farming situations.

A farmers' research committee was formed at each site in order to empower farmers and to ensure farmers' leadership in the project. It was decided that the committee would be equally responsible for the planning, implementation, and monitoring of project activities. The committee works as an interface between farmers and researchers. It is expected that involving farmers in the planning and

Table 4. Changes in Researchers' Perceptions after Involvement of Farmers in Problem Analysis

	Researchers' perceptions	
Parameters	**Before farmers' involvement**	**After farmers' involvement**
Varietal intervention	Low	Low and limited
Landraces	Low yielding and inferior	Despite good yield potential--low production due to lodging
Problem	Low yield	Lodging
Extent of problem	Not known	Yield loss: 15%–85% depending upon severity
Contributing factors of the problem	Not known	Tall plant and ear height Thin stalk Wind pressure
Ethno-perception	Not known	Local landraces are well fitted in different niches Widely grown *Thulo pinyalo* has all good traits but prone to lodging
Varietal requirement	HYV	Lodging-resistant variety
Objective	Increase access to genetic materials Provide mass-selection training to farmers	Improve *Thulo pinyalo* for lodging resistance Provide mass-selection training to farmers

implementation process will help in capacity building and increase the farmers' sense of ownership in the program.

Farmers are very supportive and cooperative in the project area. However, in some technical matters farmers' had different perceptions and attitudes, which changed along with the time. For example, farmers perceived that plants with short height could not produce good yields, that detasseling leads to total sterility in maize, etc. In the beginning, this made it difficult for researchers to facilitate some of the field activities, such as crossing, demonstrating short-statured varieties, etc. Later, the farmers found that their perceptions were not correct, and their faith in the researchers increased, leading to better understanding, cooperation, and collaboration. Some farmers who were not positive about the program in the beginning are the strongest members of the team now.

Conclusions

Involvement of farmers in the planning process resulted in the development of more specific breeding objectives, which were more focused on the farmers' perceived needs. It has helped to refine the context and process of the participatory plant-breeding program and has given farmers a leading role in the decision-making process.

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Sensory Evaluation of Upland Rice Varieties with Farmers: A Case Study

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Abstract

As part of a participatory plant-breeding project with methodological objectives to improve rainfed rice in eastern India, an evaluation of sensory characteristics was conducted with farmers in a village of Bihar. Twenty-four farmers (12 women and 12 men) evaluated 15 upland rice varieties as raw rice and parboiled rice for milled and cooked rice appearance, color, odor, texture, stickiness, taste, and overall acceptability. The rice samples were milled and cooked by the women farmers following their ordinary practices. One variety recorded good results with both raw and parboiled modes of preparation. The preferences of women and men farmers did not differ significantly. The rankings based on preferences were compared with the rankings of the varieties for various physico-chemical characteristics measured in the laboratory. Most correlations were not significant, indicating that, for the set of tested varieties, these parameters were poor predictors of farmers' preferences. The rankings based on preferences were compared with farmers' field rankings, and the correlation was positive for raw rice and negative for parboiled rice. Farmers' trade-off between field performance and grain quality is therefore important to assess for at least parboiled rice. The results of this first sensory evaluation experiment will be used to simplify the methodology and to improve varietal evaluation in the formal breeding process.

Introduction

In eastern India, rainfed rice represents a major component in the diet and income of millions of resource-poor people. In these harsh environments, the rate of adoption of modern rice varieties is low. Subsistence agriculture is still quite important, although market integration is slowly progressing (Pingali 1997). In these transition systems, grain quality and taste strongly influence the adoption of modern varieties. The main source of variation in grain quality is the variety, although environment and genotype-x-environment interactions also affect grain quality. Different grain types, and therefore different varieties, are needed for self-consumption, market sale, and various preparations or to pay wages in kind. For plain rice, precooking practices influence the varietal choices. Among the most common is parboiling, which is an age-old practice in some regions of eastern India, where rice is partly cooked before being air-dried and then sun-dried to improve its nutritional, cooking, and storage attributes. Preferences may vary across income levels, various social groups requiring various varieties.

Quality tests for breeding lines are routinely conducted by scientists in the laboratory. In the frame of a participatory plant-breeding project with methodological objectives started in 1997 under the collaborative program with the Indian Council of Agricultural Research (ICAR) and the International Rice Research Institute (IRRI) (Courtois et al. 1999), we developed a methodology to evaluate the grain quality of rice varieties in collaboration with farmers. To test the methodology, the

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sensory evaluation of a set of upland rice varieties was organized in a village of eastern India. The objectives of this study were (1) to document the process of rice preparation at the farm level for raw and parboiled rice, (2) to estimate the influence of the two modes of preparation on rice quality and identify the best varieties in each case, (3) to collect information about quality characteristics that determine varietal acceptability by female and male farmers, and (4) to relate the preferences with the physico-chemical properties of the varieties determined in laboratory.

Materials and methods

Fifteen modern upland rice varieties and a local check (Brown Gora, widely grown by upland farmers) were tested. The test was conducted in 1998 in the village of the Korahar district of Hazaribagh, Bihar, India. These varieties had been previously tested for their agronomic values in a participatory varietal trial conducted in the same village (Courtois et al., *submitted*).

Raw rice

For each variety, two kilos of sun-dried paddy of good quality were used. The paddy was dehulled and milled using a *dhenki*, a big wooden bar moving up and down around an axis. The *dhenki* was operated by two women, one of them moving the *dhenki* with her leg, the other shuffling the paddy grain after every stroke of the *dhenki*. All the varieties were dehulled and milled by the same two persons under the same conditions. The times necessary for completion of dehulling and milling, and the milling recovery (percentage of milled rice weight on rough rice weight) were recorded. The head rice recovery (unbroken grains) was not quantified but estimated visually (milled rice appearance).

Before cooking, one kilo of cleaned rice was washed with water. Aluminum vessels called *bhudeli* were used to cook each variety separately. All *bhudeli* were of the same capacity. The women suggested using 3 liters of water to cook 1 kg of raw rice. The *bhudeli* with water was kept on the fire up to the boiling point, when the washed rice was added. The cooking test was done by pressing the cooked rice between thumb and index finger. The same woman did the cooking test for all varieties. The cooking time of each variety was recorded. The excess water was drained and the cooked rice was displayed on a *pattal* (leaf mat) for sensory evaluation.

Parboiled rice

As decided by the women, 2.5 kg of paddy were soaked in 3 liters of water in a tin container for 18 hours. A common belief is that the soaking of paddy should be done in the evening rather than during daytime, with the excess water drained in the morning, to avoid the heat of the day. A temperature that is too high would induce the soaked paddy to ferment, leading to poor rice quality, high breakage, and bad odor (Bhattacharya 1985). The soaking of paddy in water started at 4:00 p.m. and the water was drained at 10:00 am the next day. After decanting the water, the soaked paddy was steamed on the fire. During the steaming process, the tin containing the soaked paddy was covered with a gunny bag to avoid loss of heat. When the husks of the paddy started cracking, the container was taken off the fire. The steamed paddy was spread in the shade on a mud floor for drying. The paddy was dried in the shade for 48 hours with intermittent mixing. It was then exposed to the sun for complete drying. An indigenous technique was used to test the proper drying of paddy. Twenty to 30 grains of paddy were dropped on a hard floor. The grains were crushed underfoot by rotating the heel. If this removed the grain husk, the rice was considered to be well dried and ready for dehulling. For dehulling and milling, 2 kg of cleaned paddy were used and the same process as for raw rice was followed.

More water is needed to cook parboiled rice than to cook raw rice. The women suggested adding 7 liters of water to cook 1 kg of parboiled rice. For the subsequent operations, the same process was followed as for raw rice.

Sensorial evaluation

A protocol for the practical organization of the sensory evaluation was designed following the recommendations of Amerine, Pangborn, and Roessler (1965) and Del Mundo (1991) and adapting them to the realities of an eastern Indian village.

Twenty-four farmers (12 women and 12 men) participated in the sensory evaluation. A hedonic scale was used. The farmers were asked to indicate whether they liked (score 1) or disliked (score 0) the varieties for milled grain appearance, cooked rice appearance, odor, color, texture (soft/hard), stickiness, taste, and overall acceptability. The samples were numbered and randomized to limit the "first-sample bias." The raw rice and parboiled rice were evaluated on different days to limit the testers' fatigue.

Physico-chemical characterization of the samples under laboratory conditions

The tests were performed at the technology laboratory of the Central Rice Research Institute, Cuttack, India, for raw rice and in N.D. University of Agriculture and Technology, Masodha, Faizabad, India, for parboiled rice. The parameters measured for raw rice were milling recovery, head rice recovery, grain length and width, alkali value, volume-expansion ratio, kernel-elongation ratio, and amylase content. For parboiled rice, hulling and milling recovery and grain shape were measured.

Statistical analysis

For rank comparison, Spearman's coefficient of correlation was used when only two rankings were compared. A Kendall coefficient of concordance was used, as described in Siegel (1956), when more than two rankers were involved. The mean comparisons were performed using a Student's t-test.

Results and discussion

Milling

No difference between the two modes of preparation was observed for milling time (table 1). Raw rice took significantly less time to cook as compared to parboiled rice. Milling recovery was significantly higher for parboiled rice in comparison to raw rice. There was no significant difference between farmers' practices and laboratory method for raw rice but recovery was higher with farmers' practices for parboiled rice. The lower coefficients of variation in the case of parboiled rice indicated a buffering effect of parboiling across varieties for recovery, which explains why parboiling is considered an excellent means to recover poor-quality samples.

Sensory evaluation

The method of rice preparation had a great impact on the ranking of the rice varieties for all traits, as shown by the nonsignificant and sometimes negative rank correlations between the two sets of

Table 1. Comparison of the Milling Properties and Cooking Time of Raw and Parboiled Upland Varieties Prepared by Farmers, Korahar, Bihar, India, 1998

Variety	Milling time (minutes)		Recovery farmers' practices (%)		Recovery laboratory (%)		Cooking time farmers' practices (minutes)	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
Brown Gora	19	30	70	71	58.5	75.0	11.0	23.0
RR139-1	16	17	63	77	62.3	80.0	8.5	33.5
RR151-3	18	19	69	72	67.3	75.0	10.0	17.0
RR151-4	22	19	57	74	67.5	80.0	8.0	20.5
RR166-645	15	23	65	74	59.5	76.3	11.0	23.0
RR203-16	15	17	63	73	56.0	76.3	11.0	22.0
RR2-6	27	18	70	72	60.5	76.3	13.0	33.0
RR265-1	20	15	70	72	76.5	77.5	8.5	22.0
RR347-166	20	17	66	74	73.5	7.38	15.5	23.0
RR348-5	30	17	71	72	66.3	78.8	9.0	23.0
RR348-7	13	16	69	74	51.0	77.8	13.0	32.0
RR352-1	16	24	66	72	64.0	76.3	14.0	27.0
RR354-1	20	23	59	75	69.8	77.5	16.0	29.0
RR50-5	18	20	67	71	67.8	80.0	13.0	34.0
RR51-1	19	18	66	72	58.8	75.0	10.0	26.0
Vandana	17	19	74	70	72.0	76.3	13.5	25.0
Mean	19.1	19.5	66.6	72.8	64.4	77.0	11.4	25.8
SD	4.4	3.8	4.5	1.8	6.9	1.9	2.5	5.1
t raw/parboiled	0.28ns		7.11**		4.29**		12.04**	

Note: ** = significant at the 1% level; ns = not significant.

scores (table 2). The preferred varieties in terms of acceptability were RR151-3, RR352-1, and RR354-1 for raw rice, and RR50-5, RR352-1, and RR354-1 for parboiled rice. For breeding purposes, it was interesting to identify varieties that could perform well under both preparations. RR352-1 and RR354-1 scored quite well in this respect.

The farmers were also asked to indicate the four varieties they liked the most (high score indicated high preference) and the four varieties they liked the least (this time high scores indicated high dislike). By this means, only one variety, RR354-1 recorded a good score for both raw and parboiled rice (table 3), being liked by 67% of the farmers as parboiled rice and 58% of the farmers as raw rice. RR151-3 and RR352-1 were appreciated by the farmers as raw rice but not as parboiled rice. Inversely, RR2-6, RR166-645, and RR265-1 were liked by the farmers as parboiled rice but not as raw rice.

For raw rice as well as parboiled rice, the rank correlations among characteristics scored by farmers were very strong and positive (table 4) except for stickiness, for which they were also positive but more seldom significant. This means that there is probably no need to ask the farmers to score all these traits. The acceptability or the choice of the three or four most preferred varieties should be enough to represent the group of traits. A simplification of the testing procedure an important in order to facilitate the integration of participatory approaches in the formal breeding system and to sustain farmers' participation.

Table 2. Sum of Scores Given by 24 Farmers for Cooking Quality Characteristics of Upland Rice Varieties, Korahar, Bihar, India, 1998

Variety	Milled rice appearance		Cooked rice appearance		Odor		Color		Texture (soft/hard)		Stickiness		Taste/ flavor		Accept.	
	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.
Brown Gora	1	11	5	13	2	11	2	7	2	10	8	12	10	13	4	9
RR139-1	4	10	18	19	13	18	17	21	13	17	11	20	15	20	12	16
RR151-3	17	1	20	9	18	10	20	9	18	8	16	10	17	9	18	6
RR151-4	17	16	16	19	12	23	17	19	13	15	10	22	18	18	16	19
RR166-645	4	11	11	18	11	17	6	8	12	10	9	13	11	16	9	18
RR203-16	8	6	13	14	9	16	14	15	5	12	8	15	13	15	13	11
RR2-6	8	13	9	21	8	23	12	23	6	17	8	19	9	20	8	20
RR265-1	19	18	13	18	10	16	13	21	12	18	9	19	13	16	9	18
RR347-166	21	6	20	17	17	17	21	17	14	14	12	16	14	13	12	12
RR348-5	1	22	19	20	13	17	16	20	15	16	15	15	17	14	15	16
RR348-7	1	13	7	16	6	16	4	19	5	14	11	13	8	14	6	13
RR352-1	22	10	20	21	20	20	18	20	17	17	16	21	21	20	17	22
RR354-1	12	23	15	24	14	23	19	23	16	20	7	22	18	22	17	24
RR50-5	21	16	14	24	15	21	15	22	10	22	11	19	14	22	14	21
RR51-1	9	7	11	14	12	12	16	10	7	13	13	15	13	11	11	13
Vandana	12	2	15	9	15	11	19	5	16	8	11	8	12	9	12	6
Rank correl. raw/parboiled	-0.12		0.10		0.12		0.20		0.06		-0.19		0.26		0.23	

Notes: Par. = Parboiled rice; Accept. = Acceptability; Varieties with high scores are the preferred ones.

Table 3. Preferences of Farmers for the Various Varieties in the Sensory Evaluation Conducted in Korahar, Bihar, India, 1998

Variety	Most liked*		Least liked*	
	Raw	Parboiled	Raw	Parboiled
Brown Gora	0	0	13	5
RR139-1	4	0	2	8
RR151-3	16	0	1	15
RR151-4	8	6	2	2
RR166-645	1	10	10	1
RR203-16	3	9	4	0
RR2-6	1	11	14	0
RR265-1	2	10	3	0
RR347-166	8	2	1	7
RR348-5	7	6	2	3
RR348-7	3	2	15	11
RR352-1	14	0	1	7
RR354-1	14	16	2	1
RR50-5	4	4	4	4
RR51-1	3	3	1	3
Vandana	0	0	1	13

*Farmers were asked to give the codes of the four varieties they liked most and the four varieties they liked lease. However, some of them gave only 1 or 2 scores.

Table 4. Correlations between Farmers' Ranks for Quality Traits of Raw and Parboiled Upland Rice Varieties (Women's and Men's Rankings Pooled Together), Korahar, Bihar, India, 1998

Trait		Milled rice app.	Cooked rice app.	Odor	Color	Texture	Stickiness	Taste
Milled rice app.	Raw							
	Parboiled							
Cooked rice app.	Raw	0.59*						
	Parboiled	0.55*						
Odor	Raw	0.72**	0.85**					
	Parboiled	0.68**	0.88**					
Color	Raw	0.60*	0.84**	0.88**				
	Parboiled	0.60*	0.87**	0.88**				
Texture	Raw	0.46	0.76**	0.80**	0.83**			
	Parboiled	0.50*	0.87**	0.87**	0.85**			
Stickiness	Raw	0.18	0.47	0.45	0.29	0.20		
	Parboiled	0.29	0.62*	0.66**	0.48	0.52*		
Taste	Raw	0.58*	0.87**	0.71**	0.72**	0.72**	0.28	
	Parboiled	0.53*	0.83**	0.72**	0.71**	0.74**	0.39	
Acceptability	Raw	0.67*	0.81**	0.82**	0.79**	0.75**	0.23	0.90**
	Parboiled	0.52	0.81**	0.87**	0.75**	0.77**	0.39	0.91

Opinions of women and men farmers were similar, with significant to highly significant correlations between their rankings for milled rice appearance, cooked rice appearance, texture, color, and taste (table 5). The only traits for which their agreement was weaker was stickiness and, to lower

Table 5. Correlations between Women and Men Farmers' Mean Ranks for Cooking Characteristics of Raw Rice, Korahar, Bihar, India, 1998

Trait	Spearman rank coefficient of correlation
Milled rice appearance	0.97**
Cooked rice appearance	0.57*
Odor	0.45
Color	0.75**
Texture	0.55*
Stickiness	0.22
Taste/flavor	0.54*
Acceptability	0.83**
Most liked	0.88**
Least liked	0.95**

Note: Sample size was 12 women and 12 men.
* = Significant at 5% level.
** = Significant at 1%.

extent, odor. In terms of overall acceptability, there was no difference in women and men farmers' opinions on the tested varieties nor in their final choices of the varieties they liked most and least.

Laboratory analysis versus sensory evaluation

The ranks given by farmers for the various quality traits were compared with the ranks of the same varieties for the main chemical properties of raw rice measured in the laboratory: alkali value, volume expansion, amylase content, and elongation ratio. Elongation ability was negatively correlated with stickiness $r = -0.55$, significant at the 5% level) but that was the only significant case. In the samples tested, amylase content did not seem to have any link to farmers preferences for texture $r = -0.14$) or stickiness $r = 0.04$).

It is unexpected to see so few relationships between consumer preferences and measurable chemical properties, since these are standard parameters used by all chemistry laboratories. However, for the varieties included in the evaluation, the variability for some traits was limited and therefore consumers had difficulty assessing differences.

Field performance versus grain quality

There was little relationship between farmers' field ranking and grain quality for parboiled rice, as shown by the very low coefficients of correlation for rank and a negative one for the ranking based on yield (table 6). The relationship was stronger and positive for raw rice. There was no particular reason why the rankings should be correlated, but a strong negative correlation would complicate the breeding work. These results confirm that participatory varietal selection should not stop after harvest. Since a compromise might be necessary, at least for parboiled rice, the trade-off between criteria for agronomic performance and cooking quality applied by farmers has to be assessed.

Table 6. Correlation Between Field Ranking and Yield, and Farmers Preferences based on Grain Quality, Korahar, Bihar, India, 1998

Variety	Farmers field ranking	Ranks based on observed yield	Most liked *		Acceptability ***	
	(1)	(2)	Raw	Parboiled	Raw	Parboiled
Brown Gora	15.0	10.5	15.5	14.0	16.0	14.0
RR139-1	12.0	16.0	7.5	14.0	9.0	8.5
RR151-3	4.0	2.0	1.0	14.0	1.0	15.5
RR151-4	2.0	10.5	4.5	6.5	4.0	5.0
RR166-645	6.0	8.0	13.5	3.5	12.5	6.5
RR203-16	10.0	12.0	10.0	5.0	7.0	13.0
RR2-6	8.0	13.5	13.5	2.0	14.0	4.0
RR265-1	13.0	13.5	12.0	3.5	12.5	6.5
RR347-166	3.0	3.0	4.5	10.5	9.0	12.0
RR348-5	11.0	6.5	6.0	6.5	5.0	8.5
RR348-7	16.0	15.0	10.0	10.5	15.0	10.5
RR352-1	7.0	5.0	2.5	14.0	2.5	2.0
RR354-1	5.0	9.0	2.5	1.0	2.5	1.0
RR50-5	9.0	6.5	7.5	8.0	6.0	3.0
RR51-1	14.0	4.0	10.5	9.0	11.0	10.5
Vandana	- 1.0	1.0	15.5	14.0	9.0	15.5
Rank correlation with (1)			0.35	0.03	0.57*	0.06
Rank correlation with (2)			.027	-.034	0.45	-0.28

* Ranked from 1 (most liked) to 16 (least liked); results of a participatory varietal trial conducted in Korahar in 1998 wet season.
** Ranked from 1 (highest yield) to 16 (lowest yield).
*** Ranked from (most acceptable) to 16 (least acceptable).

Conclusions and recommendations

Grain quality is an important selection criterion (Juliano and Villareal 1993). Sensory evaluation with farmers allows us to assess varietal preferences under conditions of food preparation very close to that of the final consumer. For the set of varieties tested, men and women seemed to share the same opinions. The physico-chemical analysis did not indicate much power to predict the results of farmers' rankings. The methodology was satisfactory although quite costly in terms of organization time. It is important to define which of the two modes of preparation (raw rice or parboiling) is most prevalent in the target area, since they lead to different varietal choices. A simplification of the ranking system by reducing the number of ranked traits is possible.

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Incorporation of Users' and Gender Perspectives in Farmer-Led Participatory Plant Breeding on Maize: Experiences from the Western Hills of Nepal

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Abstract

Maize production is the main source of livelihood for the farmers of the western hills of Nepal. However, farmers have very limited access to improved varieties of maize, suitable to their local requirements. They cultivate a number of maize varieties maintained locally through continuous selection for preferred traits. An initial survey of the two project sites in the Gulmi district of western Nepal suggests that farmers apply a number of criteria to the selection of a particular maize population to suite their production environment and to meet their family requirements for different uses of maize. However, the survey results show that the differences among farmers in the preference for and selection of a particular maize variety are not very strong. The report discusses the ways these differences have been analyzed and incorporated into the design of participatory plant breeding for the improvement of local maize varieties by the farmers.

Introduction

Maize is the first most important food crop in the hills of Nepal in terms of both area and its contribution to household food security. It occupies about 0.8 million hectares (about 35% of the total cultivated area); 78% of this is in terraced hill farming, which produces over 1.3 million tonnes per annum (CBS 1999). The productivity of maize, however, is quite low (1.7 tonnes/hectare) and, as a result, there is high incidence of food-deficit households in the hills of Nepal. One of the major contributing factors to this low yield is the poor performance of farmer-maintained maize varieties. Farmers' access to new seeds and varieties is extremely poor and, at the same time, a majority of farmers tend to keep their own seed without replacing it for years. It is estimated that nearly 90% of the total seed requirements for cereals and other food crops in the country is met by the traditional seed-supply system (Cromwell et al. 1993; Joshi 1995). Since maize is an open-pollinated crop, even new varieties rapidly get contaminated with the undesired traits of local varieties. On the other hand, most of the new varieties developed so far neither fit well with local environments nor meet farmers' diverse needs. Therefore, it is increasingly being realized that breeding must be carried out in the target environment with the full participation of farmers so that the users' perspective is well reflected in the new varieties developed.

The environments where maize is produced in the hills of Nepal are very diverse in terms of topography, soil types, and use of production resources. There are also differences between farmers and farming communities in terms of access to resources (i.e., wealth) and food culture, which is governed largely by ethnicity. These differences exist not only between wider agroecological zones but also between farming families in the same village. For these reasons, farmers require a large number of varietal options to fit into diverse production niches and to meet the varied consumption

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requirements of the farming families. Similarly, because of differences in gender roles and gender needs, there are also requirements for different maize varieties within the same household. Previous studies (Acharya and Bennet 1981; Bajracharya 1994; Shrestha 1998) suggest that women play important roles in agricultural activities and are responsible for major farming decisions. Because of these gender differences, different family members usually have different varietal needs and behave differently toward new crop varieties. The consideration of users' and gender perspectives in the process of variety development, therefore, is vital.

Local Initiatives for Biodiversity Research and Development (LI-BIRD), in collaboration with the Systemwide Program on Participatory Research and Gender Analysis (PRGA), is conducting research on a farmer-led participatory maize-breeding approach that incorporates users' and gender perspectives in developing farmers' preferred maize varieties. The two research sites, namely Darwar Devisthan and Simichaur, are located in the Gulmi district of the western hills of Nepal. This paper draws upon the work and experience of researchers in this collaborative project and discusses the findings regarding the analysis of this research and its subsequent incorporation into the research process.

Methods and sources of information

Various sources of information have been used in the report. These include focus-group discussions (FGDs) conducted during participatory rural appraisals, participatory gender analysis, and household baseline surveys undertaken at the Darwar Devisthan and Simichaur research sites at the inception of the project. Separate FGD sessions were held with different groups of farmers, categorized by gender, wealth, and ethnicity. There were two categories under gender—male and female; three categories under wealth—rich, average, and poor; and three categories under ethnicity—Brahmin/Chhetri/Jogi (BCJ), Gurung/Magar/Newar (GMN), and Kami/Damai/Sarki (KDS). The categorization of farming-household wealth was done by the farmers themselves, using their own perceptions and knowledge of wealth of these households. The ethnic categorization was done by researchers on the basis of sociocultural similarities.

The participatory gender analysis involved the analysis of gender roles and decision-making patterns in the production and utilization system for maize. A sample of 30 selected households was facilitated in doing their own gender analysis by using a pictorial set of a man, woman, and child, and maize grains, to indicate their roles. Similarly, a detailed household baseline survey was conducted to collect detailed and widely representative information, which also served as a major source of information for this report. It involved a questionnaire survey of 100 households (40 at Darwar Devisthan and 60 at Simichaur) selected using a stratified random sampling technique.

Analysis of users' and gender perspectives in maize farming

Users' perspectives in maize production and utilization

The perspective of users in maize production and utilization was analyzed using two socioeconomic variables: ethnicity and the wealth categories derived from participatory wealth ranking. The analysis of gender perspectives, on the other hand, utilized information from male- and female-headed sample households that were included in the household baseline survey. Of the total sample households surveyed, 19% were female headed. These are mostly *de facto* household heads, i.e., women have taken charge of managing the farm while men work off-farm away from home for several months, mostly in India.

Characteristics of heads of households

The characteristics of the heads of maize-growing households are presented in table 1. The family members who make major farming decisions are mature, with an average age of 50 years. Their literacy rate is much higher (81%) compared to the national literacy rate (39.6%). However, a majority of them (47%) are either barely literate or have a primary-level school education. The family member making the main farming decisions is younger and more illiterate in the average and poor wealth categories, in the KDS and GMN ethnic households, and in female-headed households.

Characteristics of maize-growing households

The characteristics of the maize-growing households are presented in table 1. The maize-farming families are relatively larger than nonfarming families, with an average of seven members per family. The family size is, however, relatively smaller in the average and poor wealth categories and in the KDS and GMN ethnic households than in other households. This implies that the family labor available to these households is less than in other households. Though farming is the major occupation for the households of the two research sites, family members of 72% of the farming households are engaged in off-farm activities to earn additional cash income for the family. The percentage distribution of these households across wealth categories and male- and female-headed households is similar. The percentage of households with family members engaged in off-farm activities, however, is slightly higher in the GMN and KDS households than in the BCJ households.

Maize is the main livelihood crop for the farmers of the research sites. The maize production in the area is subsistence-oriented and production is largely for self-consumption. The self-produced food, however, is not adequate to meet household food requirements. About 86% of the farming household experiences food deficits from less than one to 11 months of the year, and the average length of food self-sufficiency is only about seven months. The degree of food deficiency varies among the different household categories. The average time of food self-sufficiency is lower in average and poor households, in BCJ and KDS ethnic households, and in female-headed households. Only a small proportion of the households (10.4%) sell maize. The proportion of households selling maize is similar across households of different ethnic categories but is lower in the average and poor households and in male-headed households. A high proportion of the households (61%) purchase maize to offset their food-grain deficit. The differences in the proportion of households purchasing maize is highly significant ($p < .0001$) across wealth categories but not significant across ethnic categories and across male- and female-headed households. There is virtually no market influence on farmers' choice of maize varieties.

Access to farm resources

In general, farmers are smallholders with an average maize-growing *bari* land holding of 0.4 hectare, scattered over an average number of 2.3 parcels (table 1). (*Bari* represents rainfed upland where a maize-based cropping system is dominant.) The average holding size and the number of parcels of *bari* land decrease with the wealth of the farming household. The differences in *bari* land holdings are highly significant across wealth categories ($p < .0001$). Similarly, the variation in number of parcels of *bari* land per household is also significant ($p < .05$) across wealth categories. These differences in *bari* land holdings and the number of *bari* parcels per household are not statistically significant across either ethnic categories or male- and female-headed households.

Table 1. Characteristics of Maize Growing Households at Darwar Devisthan and Simichaur in Gulmi District, Nepal

Characteristics	All	Gender categories		Wealth categories			Ethnic categories		
		Male	Female	Rich	Medium	Poor	BCJ	GMN	KDS
Age of household head (years)	50.1±1.1	51.4±1.7	44.4±2.1	52.6±2.4	49.3±2.4	48.1±2.8	49.6±1.6	56.4±5.1	47.6±5.0
Education of household head (%)									
Illiterate	19.0	12.3	47.4	6.0	23.3	29.0	15.0	10.0	60.0
Just literate/primary education	47.0	48.1	42.1	57.1	43.3	40.0	45.0	80.0	30.0
Secondary education	21.0	24.7	5.3	14.3	23.3	26.0	24.0	10.0	10.0
University education	13.0	15.0	5.3	22.2	10.1	6.0	16.3	0.0	0.0
Food self-sufficiency (month)	7.2±0.3	7.3±0.4	6.8±0.6	8.9±0.5	7.6±0.5	5.3±0.4	7.5	9.3	3.3
Wealth class (% household)									
Rich	35.0	26.0	32.0	35.0	0.0	0.0	40.0	30.0	0.0
Medium	30.0	29.6	32.0	0.0	30.0	0.0	31.3	40.0	10.0
Poor	35.0	34.6	37.0	0.0	0.0	35.0	29.0	30.0	90.0
Family size (number)	6.7±0.4	7.2±0.4	4.9±0.5	7.8±0.5	6.1±0.5	6.2±0.7	6.9±0.4	5.4±0.9	6.7±1.0
Resource ownership									
Bari land (ha/household)	0.4±0.04	0.4±0.1	0.3±0	0.6±0.1	0.4±0	0.3±0	0.4±0.1	0.4±0.1	0.2±1
Parcel of bari land (Mean)	2.3±0.1	2.4±0.2	1.9±0.3	2.8±0.3	2.2±0.2	2.0±0.1	2.4±0.1	2.5±0.7	1.6+0.3
Buffalo (number)	2.6±0.1	2.7±0.2	2.05±0.2	3.2±0.2	2.6±0.2	1.2±0.1	2.7±0.2	2.2±0.3	1.6±0.2
Cattle (number)	2.4±0.2	2.4±0.3	1.5±0.5	2.7±0.4	2.1±0.4	2.2±0.4	2.5±0.3	1.8±0.4	2.0±0.0
Goats (number)	2.5±0.2	2.6±0.3	2.2±0.2	2.6±0.4	2.1±0.2	2.7±0.4	2.7±0.2	2.0±0.5	1.2±0.2
Poultry (number)	5.5±0.6	6.0±0.7	2.3±0.6	5.4±1.2	6.5±1.5	5.1±0.9	4.3±0.7	8.1±1.5	6.0±1.6
Livestock unit per household	2.8±0.2	3.0±0.2	1.9±0.2	3.8±0.4	2.7±0.2	1.8	3.0±0.2	2.4±0.4	1.4±0.2
Off-farm labour (%)	72.0	71.6	74.0	71.4	73.3	71.4	70.0	80.0	80.0
Sell maize (%)	10.4	9.1	16.0	20.0	3.4	6.3	12.0	-	11.1
Purchase maize (%)	61.0	60.3	64.3	31.0	74.0	84.0	60.3	44.4	100
Cultivation of improved variety (%)	13.0	8.3	39.0	13.3	12.0	13.3	16.2	0.0	0.0
Changing seeds for the last 5 years (%)	38.6	38.0	42.0	35.0	35.0	44.4	37.3	40.0	44.4
Participated in training (%)	8.2	8.8	6.0	15.2	7.0	3.0	10.4	0.0	0.0
Participated in educational tours (%)	6.0	7.4	0.0	9.0	7.0	3.0	7.5	0.0	0.0
Received information on improved technology for maize production (%)	15.1	16.0	12.0	23.0	21.0	3.0	19.0	0.0	0.0

Note: Ethnicity is represented as BCJ = Brahmin/Chhetri/Jogi; GMN = Gurung/Magar/Newar; KDS = Kami/Damai/Sarki.

Livestock forms an important and integral part of the farming system and, among other things, provides a major source of nutrients (i.e., manure) for plants. Buffalo, cattle, goats, and chickens are the main kinds of livestock in the area, with an average livestock unit of 2.8 per household. The average livestock unit is highest among households in the rich and BCJ categories and lowest in poor and KDS households. This difference is significant across wealth ($p < .0001$) and ethnic ($p < .01$) categories. Similarly, the female-headed households have lower livestock units per household than the male-headed households, but this difference is not statistically significant. The resource analysis thus indicates that BCJ households have the most resources, followed by GMN households, while KDS households have the fewest resources. Similarly, female-headed households have comparatively fewer resources than male-headed households.

Access to information and technology

The access farmers have to improved maize varieties suitable to local environments and their own needs is quite limited (table 1). Only 13% of the farmers reported growing improved varieties of maize; however, they know the value of changing their old seeds. About 39% of the households reported exchanging their seeds during last five years with other farmers. The users' and gender analysis showed that access to new maize seeds is similar across all wealth categories. However, GMN and KDS households have a complete lack of access to new maize seeds, and a lower proportion of male-headed households reported cultivating improved varieties than did female-headed households. The proportion of households changing seeds over the last five years, however, is greater in the poor wealth category, suggesting that farmers in this category change seed more frequently than do the others. Since these households are also highly food deficit, they may be consuming the seed and, therefore, borrowing seeds from other farmers. The proportion of households changing maize seeds is, however, similar across ethnic categories and between male and female-headed households.

Similarly, farmers' access to technical services and information on technology is also poor. Only about 3% of the maize-growing households reported participating in agriculture-related training, and only 6% participated in educational tours. Likewise, about 15% of the households reported receiving information on improved technology for maize production. This reveals that external technical support to farmers in their attempts to develop better maize varieties is quite limited. The proportion of households participating in agricultural training and tours is lower in the average and poor households than in rich households. A chi-square analysis shows significant differences ($p < .05$) in access to information on improved technology for maize production across wealth categories. Similarly, only BCJ households reported having participated in agricultural training and tours or receiving information on improved maize production. The proportion of female-headed households participating in agricultural training and tours and receiving information on improved maize production is lower than male-headed households.

Maize varieties and their uses

Farmers have been found to grow about eight different types of maize varieties, which they broadly categorize into two maize types: one is a large type (*Thulo makai*) with tall plants, big cobs, large grains and long maturity, while the other is a small type (*Sano makai*) with short plants, small cobs and grains, and short maturity. A majority of the farmers grow large-type maize, and it covers about 87.7% of the total maize area. Among the large varieties, *Thulo pyanlo* alone covers about 80% of the area planted to this type, which reflects that, although farmers grow a large number of varieties, a large portion of the maize-growing area is covered by a relatively small number of varieties.

A majority of the households grow one to two varieties of maize (46.5% to 45.5%, respectively) in a season (table 2). Only about 8% of the total maize-growing households grow more than three varieties per season. The varietal diversity maintained at household level, therefore, is low (figure 1). The ANOVA result shows that the difference in the number of maize varieties grown at household level is significant ($p < .05$) across wealth categories but not significant across ethnic categories and between male- and female-headed households. A higher proportion of poor households grows one variety of maize, compared to rich and average households. This is contrary to the currently held view that small farmers maintain significant amounts of crop genetic diversity (Jarvis et al. 1997) and agrees with the findings of other studies (Rana and Kadayat 1999). Similarly, though not significant, a very high proportion of KDS households (90%) grows only one variety of maize.

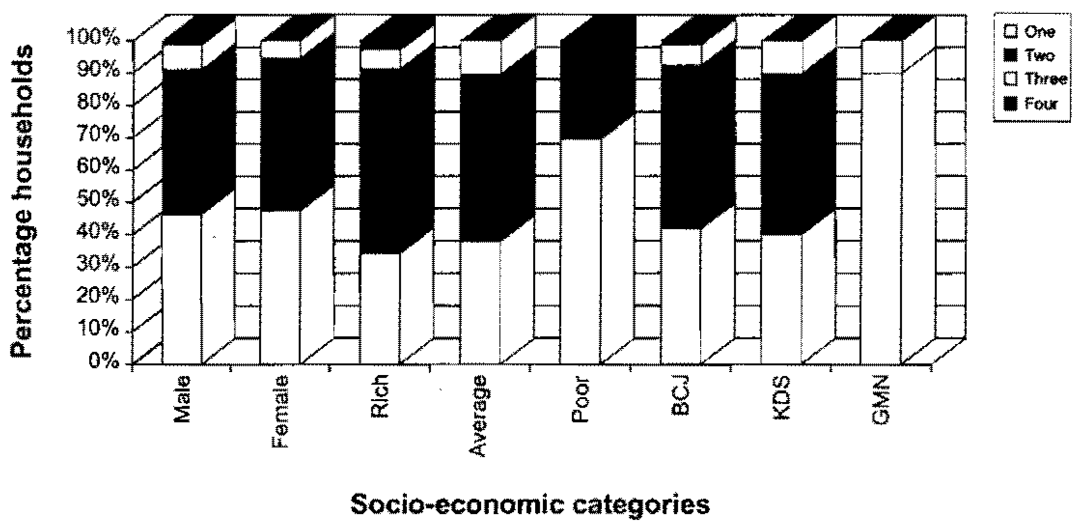

Figure 1. Number of maize varieties per household across gender, wealth and ethnic categories

Farmers who grow more than one variety mentioned various reasons for this (table2): to prepare different food items, to harvest at different times, to suit different land types, to use as animal feed, and to meet fodder requirements. However, a majority of the farmers (67.9%) grow to suit different types of land, and this is true across all wealth and ethnic categories and between male- and female-headed households. The ANOVA result suggests that the number of maize varieties grown at household level is not significantly related to the size of the *bari* land but is highly significantly related to the number of parcels of *bari* land the farmer is planting to maize ($p < .0001$). This indicates that with the increase in the number of parcels of *bari* land, the number of maize varieties grown at household level also increases. This also confirms the PRA finding that farmers in the area grow large-type maize on more fertile land while small-type maize is grown on less fertile soil. The number of *bari* parcels, therefore, appears to be the strongest determining factor in deciding the number of maize varieties to be grown per season. It is, however, true that farmers use multiple criteria to select maize varieties for their household production.

The gender differences in the use of some criteria to choose maize varieties are striking. A large proportion of female-headed households (more than three times the number of male-headed households) mentioned growing more than one variety to meet fodder requirements for their livestock. This is also confirmed by the PRA findings. During the focus-group discussions, women farmers

Table 2. **Maize Varieties and Their Uses as Reported by Farmers at Darwar Devisthan and Simichaur in Gulmi District, Nepal**

Characteristics	All	Gender categories		Wealth categories			Ethnic categories		
		Male	Female	Rich	Medium	Poor	BCJ	GMN	KDS
No. of varieties grown per year (% households)									
One variety	46.5	46.3	47.4	34.3	38.0	66.0	42.0	40.0	90.0
Two varieties	45.5	45.0	47.4	57.7	52.0	29.0	51.0	50.0	0.0
Three varieties	7.1	7.5	5.3	5.7	10.3	6.0	6.3	10.0	10.0
Four varieties	1.0	1.3	0.0	2.9	0.0	0.0	1.3	0.0	0.0
Reasons for more varieties (% households)									
Prepare different food items	41.5	41.9	40.0	43.5	27.8	41.7	32.6	100.0	—
Harvest at different time	34.0	37.2	20.0	34.8	33.3	33.3	28.3	83.3	—
Suit different types of land	67.9	67.4	70.0	69.6	55.6	50.0	69.6	50.0	—
For use as animal feed	32.0	30.2	40.0	17.4	22.2	75.0	26.1	66.7	—
Meet fodder requirements	20.8	14.0	50.0	21.7	11.1	33.3	21.7	—	—
Usage of maize (% households)									
Grit (*makai ko bhat*)	76.6	76.2	78.6	73.7	78.5	81.0	76.3	81.3	72.0
Bread (*roti*)	2.3	2.3	2.4	2.5	1.6	2.6	2.4	0.6	4.4
Poridge (*dhindo*)	0.9	0.85	1.1	1.5	0.23	0.2	1.0	0.0	0.0
Roasted	13.5	13.2	15.0	13	15.0	13.3	13.2	17	10
Others	6.7	7.4	3.0	9.4	5.0	3.1	7.0	0.9	13.3

Note: Ethnicity is represented as BCJ = Brahmin/Chhetri/Jogi; GMN = Gurung/Magar/Newar; KDS = Kami/Damai/Sarki.

strongly expressed their preference for tall varieties of maize like their local varieties because taller varieties produce more fodder than short varieties. Women appear to be more concerned with this issue because managing livestock fodder is largely their responsibility. Similarly, women farmers are very particular about the suitability of maize varieties for intercropping, especially with legumes (cowpeas and beans), because these help them meet the vegetable and pulse requirements of their families. The latter sometimes leads to conflicts with their male counterparts because intercropping with cowpeas and beans makes maize plants vulnerable to lodging and can cause big losses in the maize yield.

Maize is the staple food for farming households in the study area. Different preparations of maize are made for household consumption, of which steamed grit (*makai ko bhat*) is the most common preparation, reported by 77% of total production (table 2). Farmers, therefore, prefer maize varieties that have high grit recovery. They perceive that yellow (colored) maize has higher grit recovery and, therefore, prefer colored varieties over the white ones. The food preparation of maize is similar across households of different wealth, ethnic, and gender categories, and a majority of households use it in grit form. Users' and gender differences in the choice of variety, therefore, do not appear to be influenced by differences in the use of maize.

The analysis discussed above indicates that farmers' choices for maize varieties are not greatly influenced by their differences in wealth, ethnicity, and gender, i.e., different categories of farmers have preferences for similar types of maize varieties. Farmers across all wealth, ethnic, and gender categories grow only one or two maize varieties per household and, therefore, their varietal needs are not very diverse. However, farmers use multiple criteria in selecting the varieties they grow. They prefer to have as many traits of their preference as possible in one to two maize varieties. In this way, they are able to maintain and manage the variety of their preference for a long duration. Since maize is an open-pollinated crop, a large number of varieties is difficult to maintain and manage. This analysis is also confirmed by the findings of the PRA conducted at the project research sites. The participatory breeding program, therefore, should focus on developing fewer maize varieties with multiple traits that reflect farmers' preferences. Priority should be given to the maize varieties that have higher grit recovery, grow well under different land conditions, produce high biomass for use as fodder, and allow good intercropping with legumes.

Gender roles in maize production and utilization

The information on gender roles in maize production and utilization is based on a participatory gender analysis done with 30 maize-growing households selected for that purpose. The results show that there are distinct gender roles for men, women, and children in the production and utilization of maize in the hills of Nepal.

Women supersede men in their involvement in all three major functions of maize production and utilization: namely, (1) production, (2) household utilization and marketing, and (3) seed management (table 3). Their involvement is particularly high in the application of compost and farmyard manure to the maize field; seed processing, treatment, storage, and preparation for sowing in the next season; and intercropping of maize with beans, cowpeas, pumpkins, and other crops.

The results of the gender analysis show that women are also the prime decision makers in the family and their contribution to decision making in activities related to maize production and utilization is higher than that their male counterparts in the family (table 4). Their contribution to decisions is particularly high in the selection of crops for intercropping with maize, deciding on date and time of weeding and earthing-up in the maize fields, and in most of the activities related to utilization and

Table 3. Gender Roles in Maize Production and Utilization (Percentage Time Contribution)

Activities	Male	Female	Children
A. Maize production activities			
1. Seed preparation (shelling cobs, drying and storage)	24.8	61.1	14.1
2. Carry compost/FYM to the field	17.4	63.5	19.1
3. Land preparation	54.8	36.5	8.7
4. Seed sowing	11.7	42.8	45.5
5. Field supervision for seed germination	43.4	52.1	4.5
6. Weeding and earthing up maize crop (first)	34.1	49.4	16.5
7. Weeding and earthing up of maize crop (second)	41.0	54.5	4.5
8. Intercrop sowing of beans, cowpeas, pumpkin etc.	11.9	74.3	13.7
9. Relay transplanting of fingermillet in maize field	30.8	56.0	13.2
10. Field supervision of lodging of maize plants	41.3	52.1	6.6
11. Harvesting and transporting	35.9	50.3	13.8
12. Making bundles of maize stover and transporting	53.9	39.5	6.6
13. Processing (*khostyane/jhuto parne*) and storage of cobs	33.8	45.5	20.7
Total	**33.5**	**52.1**	**14.4**
B. Consumption and marketing activities			
1. Shelling cobs	24.2	57.1	18.7
2. Processing (cleaning and drying) grains for milling	15.3	76.6	8.1
3. Carrying grains to processing mills	27.2	52.0	20.7
4. Carrying grains to market for selling	49.7	50.3	—
5. Purchase	55.1	44.3	0.6
Total	**34.1**	**56.2**	**9.7**
C. seed management activities			
1. Selection of cobs for seed	37.3	57.1	5.6
2. Shelling grains from the selected cobs	31.1	52.4	16.5
3. Seed processing and treatment (cleaning, drying and treatment) and seed storage	21.7	74.4	3.9
4. Preparing storage pot/structure for seed storage	26.3	72.5	1.2
Total	**29.1**	**64.1**	**6.8**

marketing and seed management. The gender analysis thus suggests that women have important roles and a stake in the varietal-improvement programs designed to develop farmers' preferred varieties. Their participation in the whole process of variety development should be ensured and properly utilized.

Distribution of breeding knowledge

Participatory plant breeding seeks to use the knowledge and experiences farmers have accumulated over generations. It also creates an environment for mutual learning and sharing, which closes the knowledge gap and sets the stage for a working partnership between the farmers and researchers.

Table 4. Gender Differences in Decision Making in Maize Production and Utilization (Percentage Contribution in Decision Making)

Activities	Male	Female
A. Maize production activities		
1. Selection of maize variety for next season planting	49.2	50.8
2. Selection of land selection according to the variety	46.1	53.9
3. Date/time of sowing	51.5	48.5
4. Selection of crops for intercropping with maize	27.0	73.0
5. Date/time of weeding and earthing up of maize	36.2	63.8
6. Date/time of maize harvest	44.6	55.4
Total	**42.4**	**57.6**
B. Consumption and marketing activities		
1. When and how much grains to shell	30.6	69.4
2. Quantity of grits/flour to be milled at a time	23.2	76.8
3. When to carry maize grains to the mill (for milling)	27.6	72.4
4. Food items to be cooked daily	33.0	67.0
5. Whether to sale maize or not	44.8	55.2
6. Quantity of maize grains to sold	37.7	62.3
7. Whether to purchase maize or not	41.5	58.5
8. Quantity of maize grains to purchased	36.1	63.9
Total	**36.1**	**63.9**
C. Seed management activities		
1. Selection of maize varieties for next season	46.2	53.8
2. Quantity of seeds of different varieties for next season	39.9	60.1
3. Ways/methods of storing seed	35.3	64.7
4. Number of sun-drying of stored seeds and using other treatments	30.7	69.3
5. Whether to change old seeds or not	48.0	52.0
6. Type and quantity of seeds of new variety to be planted	48.8	51.2
7. Giving self-produced seeds to other farmers	36.1	63.9
Total	**36.3**	**63.7**

Facilitating and supporting farmers in their plant-breeding activities then becomes easy and smooth. Based on this understanding, farmers' breeding knowledge was assessed by surveying a sample of 113 households selected randomly. An analysis of the influence of gender, wealth, and ethnicity on the distribution of such knowledge was also done and is presented in table 5.

The majority of the households (more than 90%) separate seed and grain in advance, but the seed selection is almost entirely done from the cobs, and generally right after the harvest. Farmers virtually do not practice seed selection on standing crops. The majority of the households select big, good-looking cobs with big, bold grains for seed. Similarly, almost all farmers follow the practice of discarding grains on the tips of the cob when the cobs are shelled for seed. Only about a quarter of the farmers are knowledgeable about the role of seed replacement in maintaining varietal purity and vigor. Farmers' knowledge on the more technical side of breeding, such as identification of male

Table 5. Distribution of Breeding Knowledge by Gender, Wealth and Ethnicity (% Households)

Characteristics	All	Gender categories		Wealth categories			Ethnic categories		
		Male	Female	Rich	Average	Poor	BCJ	GMN	KDS
Separate seed and grain in advance	96.2	97.0	93.9	97.7	94.1	94.1	97.2	90.0	91.7
Stage of seed selection									
a. On standing crop	0.1	10.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
b. Immediately after harvest	100.0	96.0	97.0	44.0	32.0	3.8	10.8	8.0	12.0
c. From stored cobs	0.8	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
Basis of cob selection for seed									
a. Cobs with big and bold grains	67.2	63.6	67.6	30.0	32.0	26.0	72.0	7.0	7.0
b. Big and good looking cobs	83.6	75.7	79.4	32.0	31.0	32.0	5.0	8.0	9.0
c. Matured cobs	36.0	30.3	47.0	18.0	10.0	8.0	43.0	1.0	2.0
d. Healthy cobs without insect and disease damage	35.2	32.3	38.2	17.0	12.0	14.0	37.0	4.0	4.0
d. Cobs not damaged by birds and rodents	1.6	1.0	2.9	0.0	2.0	0.0	2.0	—	—
f. Uniform grain colour	0.0	4.0	2.9	1.0	0.0	0.0	3.0	—	2.0
Practice of discard grains on either tips of the cob while selecting seeds	97.7	98.0	97.0	95.3	97.1	100.0	98.1	100	91.7
Knowledge about the need for seed replacement to maintain varietal purity and vigour	24.2	24.0	25.0	27.9	23.5	13.5	28.0	0.0	8.3
Knowledge about male and female maize flower									
a. Male flower	6.0	8.0	0.0	8.7	3.0	0.0	7.2	0.0	0.0
b. Female flower	6.0	8.0	0.0	8.7	3.0	0.0	7.2	0.0	0.0
Knowledge about the use of tassel and silk									
a. Tassel	12.0	13.1	9.0	17.1	6.7	5.7	12.6	0.0	16.7
b. Silk	9.0	11.1	3.0	11.4	6.7	0.0	9.0	0.0	16.7
Knowledge about the reason of varietal mixture	10.5	13.1	3.0	14.3	6.7	2.8	10.0	•1.0	16.7

Note: Ethnicity is represented as BCJ = Brahmin/Chhetri/Jogi; GMN = Gurung/Magar/Newar; KDS = Kami/Damai/Sarki.

and female plants and their functions, was found to be very poor. Similarly, a majority of the farmers also do not know the actual mechanism that causes new maize varieties to rapidly deteriorate, compared to other cereal crops like rice and wheat. The survey thus revealed that there is good scope and a need for sharing scientific breeding knowledge prior to the inception of a participatory plant breeding program in order to enhance farmers' confidence and thereby increase their interest and participation.

Incorporation of the users' perspective in the research process

Considerations made in the research process

The project on farmer-led participatory plant breeding of maize has just completed one season of work. A number of considerations have been made, as suggested by the analysis of the users' and gender perspective of maize production and utilization. These are briefly discussed below.

Breeding objective and selection of breeding materials

The breeding objective has been redefined to improve the production performance of a widely grown maize variety, *Thulo pyanlo,* rather than creating a large diversity of maize varieties in order to improve the productivity of the niche environment. This variety has all the traits preferred by the farmers except one, i.e., lodging resistance. Reducing lodging in this variety is now the main objective of the breeding program. In addition, the selection of improved maize varieties to be used as one of the parents for crossing with *Thulo pyanlo* was done in a way that ensured that they met most of the farmers' preferences for different traits. These included relatively taller, stout plant varieties like Ganesh 1 and 2, Rampur composit, Rampur 1, Khumal yellow, and Pop 22. This would help to combine good traits from a large number of varieties into a few farmers' preferred maize varieties. At the same time, attention has also been given to meeting the specific needs of the niche environment through a participatory variety-selection program, which provides farmers with a choice from a large number of maize varieties.

Selection of research farmers

Farmers have formed their own research committee at both the research sites to ensure their participation in and influence on the research process. These research committees are well represented by different categories of farmers and 41% of its members are women. The Farmers' Research Committee, in consultation with the farmers at large, decide the breeding objectives and the research process. They also select research farmers to participate in the farmer-led maize breeding programs implemented at the research sites. Since farmers themselves select research farmers, it is envisaged that this will lead to the development of maize varieties preferred by a large number of farmers. Similarly, under participatory variety-selection program, care is taken to distribute the seed of new maize varieties to different categories of farmers.

Selection of trainees and contents

Based on the findings of the survey on the distribution of maize-breeding knowledge among farmers, field-based training was provided to the research farmers in order to supplement farmers' knowledge with practical scientific breeding knowledge. Attention was given to representation of different categories of farmers, including women. Forty-five percent of the total trainees were women. This consideration will also be made in future farmers' training programs.

Collection and analysis of users' and gender-differentiated data

The initial survey indicated that farmers use multiple criteria for the selection of a particular maize variety. Farmers may give different weights to these criteria to suite their individual needs and resources. With this in mind, the collection and analysis of users' and gender-differentiated data have been built into the research process to ensure that users' and gender perspectives are incorporated into the participatory breeding program. Data are collected in a form that allows users' and gender-differentiated data to be analyzed, which will facilitate the drawing of inferences about whether users' and gender differences make a significant difference in the process and product of participatory plant breeding in open-pollinated crops like maize.

Conclusion

The users' and gender analysis indicates that the differences among maize-growing households in regard to wealth, ethnicity, and gender do not have any significant influence on their choices for different maize varieties. Similarly, farmers across all wealth, ethnic, and gender categories grow only one to two maize varieties per household; therefore, their varietal needs are not very diverse. This is contradictory to what has been found in the case of self-pollinated crops. This appears to be largely because a large number of varieties is difficult to maintain and manage in open-pollinated crops like maize. Farmers, however, use multiple criteria in selecting the maize varieties they grow and prefer to have as many traits of their preference as possible in one to two varieties. It is, therefore, important for the participatory breeding program to focus on developing fewer maize varieties with the multiple traits that farmers prefer. Women farmers have strong preferences about the quantity and quality of the fodder by-products of maize and the suitability of new maize varieties for intercropping with legumes. The research process should allow farmers of different categories to use their criteria in developing and selecting new maize varieties. Farmers of all categories generally lack adequate practical breeding knowledge, and they are specifically poor in scientific reasoning, regardless of whatever breeding knowledge they have. Supplementing farmers' knowledge with practical scientific breeding knowledge is, therefore, necessary to empower farmers to sustain their breeding initiatives.

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Understanding Farmers' Selection Criteria for Rice Varieties: A Case in Madhya Pradesh, Eastern India

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Abstract

This paper presents information from a participatory breeding project initiated in 1997 at the International Rice Research Institute (IRRI) in collaboration with plant breeders and social scientists from six national agricultural research institutions located in eastern India. The Indira Gandhi Agricultural University (IGAU) in Raipur, Madhya Pradesh, is one of the collaborating centers. The information given here is based on a sample survey of 75 rice-farming households in three villages of the Raipur district, Madhya Pradesh. Surveys were conducted to characterize farmers' cropping/farming systems, rice varietal diversity, degree of market orientation, gender roles, as well as socioeconomic differences, and to relate these to farmers' rice varietal preferences. The focus is on methodologies for improving understanding of farmers' (including women farmer's) criteria for selecting specific rice varieties and how these criteria are considered in participatory breeding strategies for rainfed lowland conditions in Madhya Pradesh, eastern India.

Introduction

Rice is the principal crop grown during the wet season (June-October) and is the staple food in Madhya Pradesh, eastern India. In this region, rice is cultivated on 5.35 million hectares, with an annual production of 6.46 million tons. This state contributes 9% to the national production from 12.8% of the national acreage. Eastern Madhya Pradesh, known as Chhattisgarh is considered the rice bowl of the state. Of the total rice area, 80% is rainfed, and drought, which occurs every two years, is a major constraint in increasing rice productivity in the region. The rice yield in the region is low (about 2.3 tons per hectare) and is below the national average. Because of the frequent droughts, the majority of farmers are not willing to risk investing in farm inputs to increase productivity. Sustainability and yield stability are the most important considerations of farmers in the management of their farming systems. Rural poverty still persists in this region, and about one-third of the total poor in Madhya Pradesh depend on rice production as the basic source of livelihood. Therefore, improving rice production and productivity could directly lead to a substantial reduction in the rural poverty in the region (Janiah et al. 2000).

For the last four decades, a total of 512 modern rice varieties have been released in India. However, hardly 10 to 20 of the released varieties are in the seed-production channel. For example, the average age of cultivars for which there is a demand for breeder seed is 11 years. The average age of cultivars in certified seed production ranges from 12 to 17 years in the states of Gujarat, Madhya Pradesh, and Rajasthan (Virk, Packwood, and Witcombe 1996). Only a few modern varieties have been successfully adopted in the irrigated ecosystem.

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One of the main reasons for low adoption of released varieties in the rainfed environments is that farmers have inadequate exposure to new cultivars. If adoption rates are to be improved, farmers need to try a wide range of novel cultivars in their fields in participatory varietal-selection (PVS) programs. The cultivars should include prereleased cultivars, advanced lines, and already released cultivars from other regions or countries (Whitcombe et al. 1996). This would give farmers a 'basket of choices' of varied genetic material (Chambers 1989). Another reason for low adoption of modern varieties is that the breeding process does not meet farmers' diverse needs. Released rice varieties are not suited to the complex and heterogeneous rainfed agroecological environment or to the diverse uses and needs of different socioeconomic groups of farmers. In Uttar Pradesh, India, Maurya et al. (1988) tested advanced lines of rice in villages and successfully identified superior material that was preferred by farmers. Understanding farmers' preferences and needs is crucial for successful adoption and dissemination of improved rice cultivars.

In 1997, a farmer participatory breeding project was initiated at the International Rice Research Institute (IRRI) and conducted in eastern India (Courtois et al. 2000). This is a collaborative project among plant breeders and social scientists from IRRI and six national agricultural research institutions located in eastern India. The Indira Gandhi Agricultural University (IGAU) in Raipur, Madhya Pradesh, is one of the collaborating centers. The main objectives for pursuing farmer participation in plant breeding are as follows:

- to test the hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently
- to identify stages along the breeding process where farmers' participation has the most impact and to develop and test a methodology for effectively involving farmers in the breeding program
- to improve understanding of male and female criteria for selecting specific rice varieties
- to differentiate between the influence of farmer participation and decentralization of the breeding program
- to develop rice varieties suitable for heterogeneous rainfed environments and which meet farmers' preferences

This paper focuses on methodologies for improving our understanding of farmers' (including women farmers') criteria for selecting specific rice varieties and how these criteria were considered in participatory breeding strategies for rainfed lowland conditions in Madhya Pradesh, eastern India.

Methodology

This study is based on a sample survey of 75 rice-farming households in three villages of the Raipur district, Madhya Pradesh. Surveys were conducted to characterize farmers' cropping/farming systems, rice varietal diversity, degree of market orientation, gender roles, as well as socioeconomic differences, and to relate these to farmers' rice varietal preferences. Farmers were interviewed in regard to the positive and negative attributes of the traditional and improved varieties they grow and other seed-related information. A method of participatory weighted ranking was used to elicit male and female farmers' criteria for selecting rice varieties according to specific land elevations and information on how they trade off between traits. Basic information (name, age, sex, caste, size of landholding, elevation of rice plots, etc.) was collected from male and female heads of separate households who are actively involved in rice farming. Twenty cards that illustrate traits of rice cultivars were shown and explained to the farmers. Referring to a particular land elevation (*upland*, for example), each farmer was asked what traits he/she considered when selecting rice varieties for that elevation. The traits that the farmer did not consider important were discarded. With the remaining cards representing the chosen traits, the farmer was then asked how much weight he/she gave to each trait out of 16 ana (16 ana=100 paise, 100 paise = 1 Rs). For this process, a total of 16 pieces of stone were provided to the respondent to assign the weights according to his/her choice. An average weight was then computed by getting the sum of all the values assigned per trait, divided by the number of respondents, after which the proportion of each trait to all traits was calculated. This methodology in eliciting farmers' perceptions also provides room for trading off between traits (Sharma et al.1998; Paris et al. 1999)

Farmer participatory approaches for the identification or breeding of improved crop cultivars can be usefully categorized into participatory varietal selection (PVS) and participatory plant breeding (PPB). PVS is a more rapid and cost-effective way of identifying farmer-preferred cultivars, if a suitable choice of cultivars exists. A successful PVS program has four phases: (1) a means of identifying farmers' needs in a cultivar, (2) a search for suitable material to test with farmers, (3) experimentation on its acceptability in farmers' fields, and (4) wider dissemination of farmer-preferred cultivars (Whitcombe et al. 1996). In all of these phases, understanding farmers' local knowledge, perceptions, and criteria for varietal selection is important in improving rice varieties for rainfed ecosystems.

Two approaches were used to strengthen farmers' involvement in the project: (1) farmers were invited to the research station to view a broad range of genetic materials, and (2) farmers were asked to grow a set of diverse materials in their own fields using their own level of management and inputs. Two farmers in each village volunteered to evaluate 16 rice genotypes on their fields using their own labor and level of management. Two sets of medium-duration rice genotypes were planted in two farmers' fields in Tarpongi, which has comparatively lighter soils. One set each of late-duration varieties was planted in Saguni and Khairkut villages, which have heavy-textured soils. The set of rice genotypes include prereleased genotypes (F7-F8), advanced lines from the Shuttle Breeding Project, and a local check. During specific phenotypic stages of rice production, farmers and plant breeders, using a visual method, evaluated and ranked the same set of rice genotypes on the station and on farmers' fields. Kendall's coefficient of agreement was used to measure the agreement among farmers, among plant breeders, and between farmers and breeders. Farmers recorded the reasons for their ranking in their diaries. This was done for consecutive years from 1997 to 1999. In 2000, the number of rice genotypes was reduced to five choices (plant breeder, farmer, one common, and a local check). These genotypes will be evaluated before harvesting, both at the station and on farmers' fields by plant breeders and farmers.

Results and discussion

Characteristics of the research sites and the farm households

This research is being conducted in three villages in the Raipur district located on the Chhattisgarh plains of Madhya Pradesh. On the Chhatisgarh plains, rice is grown mostly in the lowlands in a drought-prone ecosystem. Drought is a major climatic constraint for rice crops in this region. The general climate of the region is dry sub-humid, where annual potential evapotranspirational losses are higher than the annual rainfall, which is about 1300 mm. Over 90% of the rainfall is received during the period from June to October. The monsoon sets in by 15 June and withdraws around 15 September. Winter conditions set in by mid-November, when the average minimum temperature reaches around 15°C. Hence, the rice crop should mature before this time. Sometimes winter conditions set in early—by the third week of October—and this results in increased sterility and, thereby, low productivity. Under such fragile conditions, the identification of suitable genotypes should be based both on climatic and edaphic characteristics (IRRI-IGAU 2000).

The research sites are located in three villages: Tarpongi, Saguni, and Khairkut in the Raipur district. Tarpongi is 29 km in the north of Raipur; Saguni and Kharkut are 5 km to the west of Tarpongi. These villages are located within 50 km of IGAU. There are 200 to 250 households in each village. More than 90% of the farming households in these villages belong to the other backward caste with small and marginal landholdings (owning less than a hectare), of which the majority are Hindus. Male heads of households have an average of four years in school, while the majority of the women have lower levels of education and did not go to school. All of the farmers interviewed owned their own land. In each village, 25 farmers were interviewed with regards to their farming and cropping systems, rice diversity, and their criteria for varietal selection. The survey was conducted in 1997 and 1998.

The areas for rice production in these representative villages are heterogeneous. Farmers in these villages classify their land according to the topography/slope, such as upland, midland, and lowland. The light soils in the uplands are classified by farmers as *bhata* (entisols), while the sandy loam in the midlands are referred to *matasi* (inceptisols). The heavy-textured soils in the lowlands are referred to as *kanhar* (vertisols). Most of the drought-prone areas have light-textured soils, whereas the more favorable areas have heavy-structured soils. Tarpongi has light-textured soils while the other two villages have heavy-structured soils. The length of the rice-growing season is primarily dependent on moisture availability, which is dependent on slope and soil type.

Rice is grown mainly in the rainy season (*kharif*) in a *biasi* system. Land preparation is done by bullocks and rice is dry-seeded at the beginning of the rainy season in June. When enough rain has accumulated in the field, 25- to 30-day-old seedlings are wet-plowed, laddered, and redistributed. This traditional practice, called *beushening* or *biasi,* is common in many rainfed areas of eastern India, particularly in Madhya Pradesh. Farmers continue this practice with the belief that it helps to control weeds and stimulate root growth (Fujisaka et al. 1993; Singh, Singh, and Singh 1994). Farmers grow purple-colored rice varieties as a strategy to identify and eradicate wild rice (which is prevalent in this region) at an early stage of crop growth.

Family members provide the major source of labor for rice cultivation. While male family members do most of the land preparation, rice broadcasting, and application of chemicals, females are predominantly responsible for weeding, applying farmyard manure, harvesting, threshing by hand, winnowing, and managing seeds for storage. Seed selection is done by both husband and wife. Other post-harvest activities, such sun drying, dehusking, and parboiling are exclusively done by women. Caring for livestock and, consequently, daily collection of green fodder for the livestock is done mostly by women (Sharma et al. 1997). Thus, women's criteria for rice varietal choices may be influenced by their roles and responsibilities in farming and their social and religious obligations, and may differ from those of men. The majority of the farmers obtain new seeds from their neighbors and from extension workers. Only 24% obtain new seeds from IGAU. This indicates a lack of awareness among farmers about the new technologies developed at the university. Weeds are prevalent in farmers' fields, and roguing the rice fields to protect the purity of seeds is not commonly practiced in these villages. Rice mixtures and weed seeds are commonly found in the seed stocked for the next season.

The cropping intensity in these villages is low because of the lack of supplementary irrigation water during the *rabi* season. The cropping systems in the villages are rice-fallow, rice-lathyrus, or rice-chickpea (table 1). The chickpea and lathyrus crops are grown as relay crops (locally called *utera* in rice).

Table 1. Characteristics of the Rice Land in the Research Sites in Raipur, Madhya Pradesh, Eastern India

Slope	Upland (ndulating)	Midland (gently undulating)	Lowland (leveled and gently undulating and terraced fields)	Lowland (leveled)	Lowland (low lying)
Soils	*Bhata* (entisols)	*Matasi* (inceptisols)	*Dorsa* (alfisols)	*Kanhar* (vertisols)	*Nala* (vertisols)
Texture	Gravely course loamy to sandy	Sandy loam	Silty clay	Clayey	Clayey
Depth (cm)	Very shallow (5–30)	Moderate (30–80)	Moderate to deep (80–150)	Deep (>150)	Deep (>150)
Internal drainage	Rapid	Moderate	Moderate to slow	Slow	Slow (surface flooding)
Mechanical composition (%)					
a. Sand	60–80	30–50	25–35	20–30	20–30
b. Silt	15–22	30–40	25–30	20–30	20–30
c. Clay	9–20	20–33	33–45	>45	>45
Cropping patterns	Rice-Fallow	Rice-Fallow	Rice-Lathyrus or Chickpea	Rice-Lathyrus; Dikes are planted with pigeon pea	Rice-Lathyrus
Duration of rice varieties suited to these land	Short (90–110 days)	Intermediate (110–130 days)	Long (130–145 days)	Long (> 145 days)	Long (> 145 days)

Adoption of rice varieties

A high diversity of rice varieties exists in these villages. The names of the varieties grown by farmers in these villages are shown in table 2. Of the total area grown to rice in the lowlands of Tarpongi, 73% is grown with traditional varieties, while the rest (27%) has modern varieties. Twenty years ago, there were about 20 traditional varieties; however, this number has declined. In contrast, in the uplands of Saguni and Kharkut, the adoption of modern varieties is slightly higher than thethe adoption of traditional ones. Traditional varieties such as Safri-17 and Chepti gurmatia are popular in the lowlands. The main reason for adoption of traditional varieties in the lowlands with heavy soils is because all the traditional varieties are tall and can sustain even late *biasi* operations.

According to the rainfall pattern and soil types of Chhattisgarh, farmers grow varieties according to the land elevation, hydrology, and soils. Rice varieties with a growth duration of less than 110 days are grown on the upper (undulating) portion of uplands with loamy to sandy soil *bhata* (entisols). Rice varieties with a growth duration of 110 to 130 days are allocated mainly to the midland (gently undulating) sandy loam *matasi* (inceptisols). Varieties with a growth duration of up to 140 days are best suited for light soils, such as those found in Tarpongi village. Late-maturing varieties (140 to 155 days) are ideal for low-lying, heavy-textured *dorasa* and *kanhar* soil types, such as those found

Table 2. Area (Hectares) Planted to Modern and Traditional Rice Varieties by Sample Farming Households, Elevation of Rice Land, and Village, Raipur, Madhya Pradesh

Varieties	**Tarpongi (n = 25)**		**Saguni (n=50)**		**Khairkut (n=50)**		
Modern	**Upland**	**Lowland**	**Upland**	**Lowland**	**Upland**	**Lowland**	**Duration (days)**
Swarna	0.8	7.82	27.64	9.86	38.66	5.0	Late (150)
Mahamaya		2.6	2.22	1.4	6.6	1.0	Medium (130)
Kranti	6.8	6.9	8.8	1.8	4.9		Medium (130)
262	7.5	2.1		0.1	0.8		Medium, (125)
H.M.T.					0.4		Medium (130)
Purnima	2.4	0.4					Late (145)
IR36						0.6	Early (120)
Culture		0.8	1.86	1.2			Medium (130)
Others				0.7			
Total MVs	17.5	20.62	40.52	15.06	51.36	6.6	
Traditional							
Safri-BD	2.9	**28.4**	7.7	4.04	**40.62**	5.2	Late (150)
Safri-17	1.2	**10.7**	12.3	3.64	0.44		Late (155)
Chepti gurmatia	**10.8**	7.0	3.2	3.8	0.64	5.0	Medium (130)
Ranikajar	1.8	1.4	6.3	1.84	5.68	0.4	Medium (130)
Bhata safri	4.44	7.8		0.4	2.12	1.6	Medium (130)
Anjan safri	0.5	0.1					Late (145)
Ganga safri	0.3						Late (145)
Nankershar	0.2						Late (135)
Dubraj		1.6					
Chepti				4.7			Medium (130)
Total Traditional	20.14	57.0	29.5	18.82	49.50	12.2	
Total of all varieties	37.64	77.62	70.02	33.88	100.86	18.8	
%MV	**46.49**	**26.57**	**57.87**	**44.45**	**50.92**	**35.11**	
%Traditional	**53.51**	**73.43**	**42.13**	**55.55**	**49.08**	**64.89**	

Note: Modem = semi-dwarf, high-yielding varieties. Traditional = tall in stature whether improved or not improved by selection. Upland = no bunds between plots.

in Saguni and Khairkut. Crops are grown chronologically with the lowland fields planted first and the upland fields planted last. Lowland fields are submergence-prone and need to be sown early so that seedlings are already established before the fields are flooded.

Farmers' perceptions of traditional and modern rice varieties

After identifying the modem and traditional varieties farmers grew, questions were asked about positive and negative attributes. These questions were open-ended and no attempt was made to impose *a priori* categories of answers. Table 3 shows the list of positive traits of popular traditional varieties such as Safri-17 (late duration) and Chepti gurmatia (medium duration). Although these traditional varieties have lower yields, farmers prefer them because of their combined positive

Table 3. Farmers' Assessment of Popular Traditional Varieties

Variety	Positive traits	Negative traits
Safri-17 (late maturing)	• stable yield every year • resistant to pests and diseases • drought tolerant • good for heavy-textured soil • good for *beushening* method of land preparation • tall (157 cm) and submergence tolerant • competes with weeds • requires less water and fertilizer • photosensitive • good taste and eating quality • good grain quality (slender, fine, shining) • commands high market price • high milling recovery • good quantity and quality of straw for making rope • matures near religious festival (*Diwali*)	• has lower yields (2–3 t/ha) than Swarna and Kranti • susceptible to lodging due to height (157–168 cm) • can't be used to distinguish wild rice (*karaga*) • too much straw and less grain
Chepti gurmatia (medium duration)	• good grain yield (3 t/ha) • competes with weeds • tolerant to drought • ideal for light soil or *Matasi dorsa* • medium duration and can be harvested early, allowing *rabi* crop • purple pigmentation helps in eradicating wild rice • has good taste and eating quality • commands a high price in the market • good for other rice products (e.g., *basi* and *pulao*) • preferred as wage by agricultural laborers due to its bold, coarse grains: can last longer in the stomach	• yields lesser than Swarna • susceptible to lodging because it is tall (137–142cm) • susceptible to bacterial blight and stemborer • has more straw than grain

qualities. *Chepti gurmatia*, for example, has purple pigmentation that helps farmers distinguish and eradicate wild rice (*karaga*).

Swarna and Mahamaya are two modern varieties that have the positive qualities present in the traditional varieties. Swarna is a high yielder, late maturing and semi-dwarf. Farmers perceive that these varieties can tolerate drought. Mahamaya, similar to Chepti gurmatia, also has the purple leaf sheath and purple auricle, which help to distinguish it from wild rice. It has potentially higher yields than the traditional varieties; however, the modern varieties are more susceptible to diseases (bacterial blight and gall midge). Mahamaya is also susceptible to lodging because of its short stature (table 4). Actually, Swarna was released in 1982 from Andhra Pradesh and was tested by the plant breeders. However, it was not recommended to farmers before 1992. The adoption of Swarna has been fast and it has replaced local varieties such as Safri and Dubraj and improved varieties such as Mashuri. However, since 1992, not a single variety with these positive combined characteristics could be released by the local breeders in IGAU.

Table 4. Farmers' Perceptions of Traits of Popular Modern Varieties

Variety	Positive traits	Negative traits
Swarna (late duration)	• high yield (4–5 t/ha), which is 1.5 tons higher than Safri • responsive to fertilizer • high number of medium-slender, fertile spikelets (150–200) • dark green color helps in distinguishing wild rice • can withstand drought • heavy tillering (8–10 tillers) • semi-dwarf (93 cm) and resistant to lodging • suitable to heavy-textured soils and retains moisture • requires low inputs • commands high price in the market • preferred for *basi* (leftover rice from dinner that is dipped in water and eaten the following day for breakfast or lunch) • good eating quality—remains soft after cooking for a long time compared to the other varieties • high milling recovery	• susceptible to diseases (bacterial blight, gall midge) • susceptible to brown plant hopper • poor weed competition due to its short stature, which requires early weeding • duration too long when *rabi* crops need to be grown • requires more water to mature • low yields of straw • less yield than Mahamaya • not photosensitive
Mahamaya (medium duration)	• higher yield potential • resistant to diseases (gall midge) and pests (brown plant hopper) • dark green color helps distinguish wild rice • purple leaf sheath and purple auricle help identify wild rice • early to medium duration—can harvest sooner and grow *rabi* crops • commands high market price • has bold, heavy grains • good quantity and quality of straw • more fertile spikelets • resistant to lodging—intermediate height • responsive to fertilizer • preferred by millers and traders for beaten rice (unbroken *poja*) and for puffed rice (*murmura*) because it expands easily • preferred by poor farmers and agricultural laborers because it remains soft after cooking and makes them feel full even when consumed in small quantity	• susceptible to stemborer • susceptible to sheath blight • not good eating quality • poor milling recovery—has more broken grains after milling

Mahamaya was only released in 1997. Both Swarna and Mahamaya were released for irrigated rice ecosystems, but because of their perceived ability to tolerate drought and their high market demand by traders, these two varieties have become very popular. Millers and traders prefer Mahamaya for making beaten rice and puffed rice. Poor farmers and agricultural laborers who are paid in terms of rice prefer Mahamaya because they feel that it satisfies their hunger. Mahamaya has bold, coarse grains that they believe last longer in the stomach. Farmers also prefer Swarna for *basi* (leftover rice from dinner, dipped in water with a little salt and eaten the following day for breakfast or lunch).

Male and female farmers' criteria in selecting rice varieties

Despite the active involvement of women in rice production, post-harvest, and seed-management activities, scientists, who are mostly men, often talk with male farmers only. Ignoring women's knowledge and preferences for rice varieties may be an obstacle to adoption of improved varieties, particularly in areas with gender-specific tasks and in farm activities where women have considerable influence. For example, a released variety such as Pant-4 is high yielding but is rejected by women farmers because it is difficult to thresh by hand. In contrast, traditional varieties that are low yielders are still grown because of their desirable taste and their eating and cooking qualities that make them well-suited for rice products that women prepare. Knowing men's and women's criteria in rice varietal selection and access to and control of new seeds, information, etc., will lead to more efficient dissemination of improved rice varieties for rainfed conditions and their subsequent adoption. Thus, in 1998, a team of scientists from the Directorate of Extension, IGAU, conducted focused research in the same villages. Our objective was to test and develop a methodology for eliciting male and female farmers' criteria and to determine whether there are gender differences in these criteria in rice varietal choice.

The majority of the women farmers are illiterate and are less exposed to household surveys; therefore, we used a simple participatory method of eliciting their perceptions regarding the useful traits they consider when selecting rice varieties. Men and women were separately involved in this activity. This method, which is like a game of cards (see methodology section), gave the farmers more time to think as well as to enjoy the process. Tables 5 to 7 show the important traits that male and female farmers consider when selecting rice varieties according to land elevation and size of landholding. The results show that grain yield was the most important criterion for both men and women farmers in selecting rice varieties for all land types and sizes of landholding. Both men and women gave more value to eating quality (taste) and duration/maturity for rice varieties grown on upland fields. However, women were more concerned with market price, drought tolerance, pest and insect resistance, and competitiveness to weeds. On the other hand, men gave more importance to grain size and shape than women did. For midland conditions, women gave higher values to eating quality and market price, while men gave more importance to duration and maturity. For lowlands, eating quality and market price were considerations for both men and women. Women consistently gave higher values to the multiple use of straw for varieties grown in all land types.

We also assessed whether there were differences in criteria between men and women from marginal and large farms. Table 6 shows that there is not much difference between the criteria across size of landholding. Both men and women with large farms gave the highest value to grain yield. Aside from grain yield, both men and women from the same economic category gave more importance to eating quality and market price. Duration/maturity was more important to male farmers from large farms than to women of the same category, similar to marginal farmers. Women from both large and small farms gave a higher value to the multiple use of straw than men did.

In summary, the most important traits that both men and women value in selecting rice varieties are grain yield, eating quality (taste), market price, duration/maturity, drought tolerance, and resistance to pests and diseases. Women placed higher weights on multiple uses of straw across all land types and for both large and small landholdings. Men did not consider this as important, obviously

Table 5. Men's and Women's Perceptions of Useful Traits of Rice Varieties by Land Elevation, Raipur, Madhya Pradesh

Traits	Uplands		Midlands		Lowlands	
	Men	Women	Men	Women	Men	Women
Grain yield	19	19	27	25	30	27
Eating quality (taste)	16	11	6	17	11	19
Market price	3	10	8	13	9	13
Duration/maturity	13	10	13	6	7	3
Drought tolerance	6	11	5	3	3	1
Pest/insect resistance	6	10	8	6	6	4
Multiple use of straw	0	8	5	11	6	11
Grain size and shape	16	0	2	2	4	3
Milling recovery	9	0	2	2	4	4
Lodging resistance	3	0	3	4	2	3
Fertilizer responsiveness	6	3	5	3	4	2
Weed competitiveness	7	7	3	1	2	2
Submergence tolerance	5	5	1	2	2	2
Good for rice products	0	0	2	2	1	0.5
Disease resistance	0	0	3	<0.5	3	0.5
Adaptation to soils	3	0.5	2	1	2	1
Adaptation to land level	0	0.5	2	1	0.5	1
Storage quality	0	2	1	<0.5	2	1
Fullness in stomach	0		1	<0.5	1	1
Cooking time	0	3	1	1	0.5	
	100	100	100	100	100	100

Note: Values have been rounded off. Values were computed by weighted-ranking method.

because women are more responsible than men in caring for the livestock. Rice straw is used as feed for the livestock and also mixed with cowdung to make a cake for household fuel. Thus, women consider both grain yield and rice biomass in selecting rice varieties according to their specific environments. A rice variety that has high grain yields but low quantity and quality of rice straw has a lower chance of adoption by women farmers. Men gave more importance to grain size and shape for varieties grown on the uplands. Men owning small farms considered adaptation of the variety to specific soil conditions as being extremely important (second to yield) but were the only group to rank this highly. This may be because poorer farmers cultivate more marginal land (explaining the need for adaptation of the variety to soil type). Women did not rank this characteristic highly, probably because of their role in production (men tend to choose the varieties and clear the land).

Logically, drought tolerance was more important for upland and midland areas than for lowland areas. Women weighted this more highly than men.

While the participatory ranking method was useful in assessing the trade-offs between traits valued by farmers, this method could be improved by including traits mentioned in the open-ended

Table 6. Perceptions of Useful Traits of Rice Varieties, by Size of Landholding and Gender, Raipur, Madhya Pradesh

Traits	Large farmers		Marginal farmers	
	Men	Women	Men	Women
Grain yield	36	34	19	21
Eating quality (taste)	13	12	9	18
Market price	8	12	6	13
Duration/maturity	10	3	7	8
Multiple use of straw	4	7	3	10
Drought tolerance	4	8	4	4
Pest/insect resistance	7	5	6	7
Grain size and shape	8	<0.5	5	2
Milling recovery	1	2	9	6
Lodging resistance	3	2	4	2
Fertilizer responsiveness	3	2	7	3
Weed competitiveness	1	2	2	1
Submergence tolerance	1	5	1	1
Good for rice products	1	<0.5	1	1
Disease resistance		1	2	<0.5
Adaptation to soils		1	12	<0.5
Adaptation to land level		1	1	<0.5
Storage quality		1	1	1
Fullness in stomach		0	1	<0.5
Cooking time		2	1	2
		100	100	100

questionnaires. The cards shown by the researcher limited the choice of desired traits—other traits based on specific cultural practices, such as a preference for purple-colored rice varieties or for varieties suited to the *beushening* method of land preparation, were not mentioned at all. Moreover, other social considerations, such as a preference for late and medium varieties to coincide with a religious festival such as *Diwali* were not captured. Farmers usually harvest rice only after the *Diwali* festival. During this festival, families give special rice as gifts to relatives.

Participatory varietal selection

Although scientists accept that farmers are careful managers and possess a wealth of knowledge about their production systems, this knowledge is not sufficiently used in the formal breeding process (Kshirsager et al. 1998) Several strategies were used to involve farmers in PVS. Farmers volunteered to grow 16 early- to medium-duration group varieties and late-duration varieties on their own fields for three consecutive years. The early/medium-duration group varieties were tested at Tarpongi village on two farmers' fields that have light soils. The late-duration varieties were tested on two farmers' fields at Saguni village under heavy soils. The new varieties had some of the preferred criteria mentioned by farmers obtained in the interview and participatory-ranking activities. Farmers and breeders ranked the rice lines on the station and on farmers' fields in the research sites.

Table 7. Comparison between Ranks Attributed by Farmers and Breeders at Different Growth Stages in the PVS Trials, Raipur Villages, Eastern India, and IGAU Station, 1997–99

Trial location	Year	Trial code[2]	Stage[1]	No var.	No F.	No B.	Agreement among farmers W	Agreement among breeders W	Correlation between farmers' & breeders' rankings r
Station	97	1	F	16	8	1	0.34**	–	–0.20
	97	1	M	16	8	1	0.51**	–	0.11
Tarpongi	97	1	F	16	5	–	0.51**	–	–
	97	1	M	16	4	2	0.55**	0.47	013
	97	2	F	16	5	–	0.50**	–	–
	97	2	M	16	7	2	0.34**	0.53	–0.03
Saguni	97	1	F	16	7	–	0.30**	–	–
	97	1	M	16	6	2	0.44**	0.30	–0.18
	97	2	F	16	5	–	0.79**	–	–
	97	2	M	16	5	2	0.54**	0.56	–0.06
Station	98	1(M)	F	16	8	2	0.32**	0.77	0.16
	98	1(M)	M	16	6	2	0.26	0.60	0.50*
	98	2 (L)	F	16	8	2	0.31**	0.54	–0.04
	98	2 (L)	M	16	6	2	0.67**	0.70	0.28
Tarpongi	98	1(M)	F	16	5	1	0.55**	–	0.46
	98	1(M)	M	16	4	1	0.30***	–	0.20
	98	1(M)	CROP FAILURE						
Saguni	98	2 (L)	F	16	4	1	0.56**	–	0.07
	98	2 (L)	M	16	4	1	0.59**	–	0.02
Khairkhutt	98	2 (L)	F	16	6	1	0.38**	–	0.51*
	98	2 (L)	M	16	4	1	0.44*	–	–0.01
Station	99	1 M)	M	16	7	3	0.49**	0.91**	0.33
Station	99	2 M)	M	16	7	3	0.65**	0.89**	0.62*
Tarpongi 1	99	1 M)	M	16	6	3	0.65**	0.94**	0.61*
Tarpongi 2	99	2 M)	M	16	5	3	0.62**	0.84**	0.46
Station	99	1 (L)	M	16	7	3	0.53**	0.81**	0.15
Station	99	2 (L)	M	16	7	3	0.34**	0.76**	0.11
Saguni 1	99	1 (L)	M	16	7	3	0.50**	0.93**	0.66**
Saguni 2	99	2 (L)	M	16	6	3	0.66**	0.91**	0.64**
Station	99	1	V	20	5	3	0.98**	0.94**	0.90**
Station	99	1	F	20	5	3	0.98**	0.98**	0.91**
Station	99	1	M	20	5	3	0.96**	0.97**	0.89**
Khairkhut	99	2	V	20	5	3	0.98**	0.95**	0.87**
Khairkhut	99	2	F	20	5	3	0.94**	0.99**	0.92**
Khairkhut	99	2	M	20	5	3	0.90**	0.97**	0.41**

Note: – = not tested. W = Kendall's coefficient of concordance. r = Spearman's coefficient of correlation. F = farmers. B = breeders.

1. Stage: V = vegetative stage, F = flowering, M = maturity.

2. Trial code: L = late, M = medium.

Farmers' rankings were compared with breeders' rankings during different stages of crop growth (vegetative, flowering, and maturity) as shown in table 7.

Correlation between breeders and farmers at all sites and in all the years was consistently low. Very few of the trials showed significant or highly significant agreement between farmers and breeders (trials that showed any significant agreement were mainly in 1999). In general, agreement was insignificant or even negative (although not strongly so). It was impossible to make an assessment of agreement between farmers and breeders in 1997 and 1998. However, in 1999, although there was high agreement in varietal ranking among farmers and among breeders, there was generally low agreement between farmers and breeders, which may indicate that farmers and breeders consider different criteria. Farmers' rankings are not correlated with yield, indicating that farmers consider other criteria in their rankings.

Assessment of late-duration varieties included in PVS in Saguni, Raipur

The breeders' top five favorite late-duration varieties in the 1999 trials included Swarna, BKP-232, R650-1817, R304-34, and R738-1-64-2-2 (all modern varieties). These varieties also ranked in the top five in yield. The farmers' top five favorite varieties included Swarna, Safri-17, R738-1-64-2-2, Mahsuri, and R650-1817. These were not always the highest yielding varieties—in fact, Mashuri gave one of the lowest yields and Safri-17 (a traditional variety) was somewhere in the middle. These varieties were likely selected for other reasons than yield. Varieties preferred by both groups (ranking on average in the top 5) included Swarna (first choice of both farmers and breeders, and also high yielding), R650-1817, and R738-1-64-2-2. These are all modern varieties, and are also the three varieties that had the highest yields in the trials (table 8).

Table 8. Assessment of Late-Maturing Varieties Included in PVS, Saguni, Raipur, Madhya Pradesh, Eastern India

Variety	Ranking
Swarna (check)	Favorite of both farmers and breeders Consistently ranked highly in the top 5 by both groups in the field sites and on-station
Safri-17 (check)	Always ranked in the top 5 by farmers, but not so well ranked by breeders
R738—64	**This is ranked in the top 5 by farmers and breeders in the farmers' fields, but less well ranked in on-station trials.**
R304-34	**Ranked first by breeders, but not liked by farmers, even though yield is quite good (5 t/ha)** **Ranked low by both groups in field sites** **Bold grains, not susceptible to disease, commands high market price**
Mahsuri	On-station, ranked within top 5 by farmers, on station and in one farm site, although yield is consistently low Ranked consistently low by breeders
IR54896	On-station, ranked highly by breeders Yield is good, but farmers don't like it (one of their least favorites) Ranked low by all in farm trials

Assessment of medium-duration varieties in Tarpongi, Raipur, Madhya Pradesh

In Tarpongi, the top ranking medium-duration varieties for breeders were R574-11, IR42342, Chepti gurmatia, BG380-2, R703-1-52-1, and OR1158-261. All of these were also the top six yielding varieties. All are modern varieties except for Chepti gurmatia. For farmers, the top ranking varieties included BG380-2, OR1158-261, R714-2-9-3-3, IR63429, and R574-11. These are all modern varieties, but not always top yielding. R714-2-9-3-3 gave medium yields, while IR63429 gave relatively low yields when compared with the other varieties. Farmers and breeders agreed only on R574-11, BG380-2, and OR1158-261 as their favorite varieties (table 9).

Table 9. Assessment of Medium-Duration Varieties Included in PVS, Raipur, Madhya Pradesh

Variety	Ranking
R714-2-9-3-3	Ranked highly by farmers on farmers' fields and in 2nd on-station replication, and is among the farmers' favorites Consistently marked low by breeders
R574-11	**Top ranked by farmers and by breeders in station trials. Also, highest yield On-farm, is still in top 1-2 for breeders but drops to 8-10th rank for farmers Yield on farm is less (4th and 6th rank)**
OR1158-26	Ranked about 5-6 (on average) in all sites except in one field, where it was #1 among farmers Yield ranges from 3-8 t/ha Among the top varieties for farmers and breeders
IR63429	**Ranked well by farmers in all sites but consistently ranked low by breeders Lower-yielding variety compared to others, but farmers seem to like it in any case Early, long grain, intermediate height**
IR42324	Consistently highly ranked by breeders, but given low rank by farmers in all sites except station replication #1 Consistently high yield, but even with highest yield on farm, farmers don't like it
Chepti gurmatia (local check)	Consistently ranked well by breeders, also one of the top 5 yielding varieties However, it ranks in the middle with farmers
BG380-2	**Ranked highly by breeders and farmers in field and on-station Generally has good yield**

During the *kharif* season 2000, the medium-duration varieties that were further evaluated on-station and on farmers' fields were IR4234 (breeders' choice), R574-11 (farmers' choice), BG380-2 (common choice), and Chepti gurmatia (best local choice). The late-duration varieties were BKP-232 (farmers' choice), R304-34 (breeder's choice), R650-1817 (common choice), and Swarna (local check).

The challenge facing plant breeders in IGAU and IRRI is to develop new cultivars that are better than Swarna and Mahamaya, while also meeting the other requirements and criteria that farmers have for their given rice environments. While it is impossible to combine all the requirements in one single variety, giving farmers (both men and women) an opportunity to test the performance of different rice genotypes on their own fields and to evaluate their cooking and eating qualities can lead to more efficient rice varietal improvement in the Chhattisgarh region in Madhya Pradesh.

Conclusions

This paper focused on methodologies for improving our understanding of the criteria used by farmers (both men and women) in selecting specific rice varieties and of how these criteria are considered in participatory breeding strategies in the rainfed lowland environments of the Chhatisgarh region in Madhya Pradesh, eastern India. Different methods for understanding farmers' criteria in selecting rice varieties were used. These methods were (1) a questionnaire with open-ended questions eliciting positive and negative attributes of the most popular modern and traditional varieties, (2) a participatory weighted-ranking method, disaggregating the perceptions of men and women by land types and size of landholdings, and (3) participatory varietal selection, where farmers evaluated several prereleased and local varieties on their fields as well as on-station. The results of the study highlight the importance farmers attach to characteristics other than grain yield: eating quality (taste), market price, duration/maturity, drought tolerance, and pest and insect resistance.

Both men and women have similar criteria in choosing rice varieties. However, straw quality for multiple uses is an important consideration for women farmers but not for men. Farmers, particularly women who do most of the weeding, prefer rice varieties that are inherently dark green or purple to distinguish them from wild rice and enable the farmer to eradicate the wild rice at an early stage of crop growth. Wild rice is a prevalent pest and a constraint to high rice productivity in the Chhattisgarh region. The attributes considered by men and women farmers, however, are not generally used as screening criteria in most formal breeding programs, where the emphasis is mainly on grain yield. Quality attributes should be emphasized more than they have been in the past in breeding programs for rainfed areas. Because of the proximity of the villages to the market, farmers prefer to grow varieties that not only meet their own consumption needs but also those of consumers, including millers and traders. Therefore, farmers maintain their rice diversity and grow both traditional and modern varieties that meet their varied interests and needs. Using approaches like farmer participatory breeding and varietal selection from many rice lines provides an opportunity to farmers to choose varieties suitable to their environment and needs as well as access to new seeds.

Breeding lines R574-11, BG308-2, and IR42342 performed well over the three years of the project in the medium-duration group and showed tolerance to drought. Breeding lines R304-34 and IET-14444 (R738-1-64) also proved promising. A large quantity of seeds have been multiplied by one of the farmers of Saguni village where blight is a problem.

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Seed Security in Badakshan, Afghanistan

Iqbal Kermali

Abstract

Badakshan is located in the extreme northeastern corner of Afghanistan and has not yet come under Taliban control. The province is virtually cut off from the rest of the country and is traditionally food deficient. The 20-year-old conflict in the region has further aggravated the situation, causing massive population displacement and almost complete destruction of civil institutions and infrastructure. The situation has become so serious that food aid has to be distributed in the period of grain deficit, starting from before the harvest. Simultaneously, efforts are being made to rehabilitate and improve the agricultural systems of these farming communities.

In all formal and informal surveys in the area over the last three years, the farmers have identified good seed of wheat cultivars and fertilizer as being their main priority. Currently the seed of high-yielding cultivars acquired from the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) are available, but such varieties do not always perform well under farmer's conditions. The potential of these varieties can not be realized without the use of fertilizers. Almost all the available animal dung is used to as fuel and little is available for use as manure. The small amounts of chemical fertilizer available are totally inadequate in quantity and exorbitant in price. In response to these needs, improved varieties of wheat, potatoes, and vegetables are being provided to over 100 villages in five isolated districts bordering Tajikistan. Three to eight farmers in each village are testing the new planting materials under their local conditions. These farmer-led, on-farm evaluations are also serving as demonstration plots for the remainder of the farmers in the village. The farmers will compare the performance of the varieties provided with their existing varieties. Cultivation of the better of the two will be encouraged through farmer-to-farmer exchanges and credit through village organizations for the inputs. This procedure will be repeated every growing season whenever new potential materials, including varieties, landraces, and different crop species are available. A secondary goal is to enhance on-farm genetic diversity among and within different crop species. These activities will be gradually transformed into participatory breeding, allowing the community to gain full control over the type and amount of varieties being produced and exchanged with their neighbors. Participation in the management and decision making for seed security by the farming community will contribute to reestablishing local food security and peace in the area.

Introduction

Focus Humanitarian Assistance (FOCUS) is an international group of agencies established in Europe, North America, and South Asia to complement the provision of emergency relief, principally in the developing world. It helps people in need reduce their dependency on humanitarian aid and facilitates their transition to sustainable, self-reliant, long-term development. FOCUS is affiliated with the Aga Khan Development Network, a group of institutions working to improve opportunities and living conditions for people of all faiths and origins in specific regions of the developing world. Underlying the establishment of FOCUS by the Ismaili Muslim community is a history of successful initiatives to assist people struck by natural and man-made disasters in South and Central Asia, and Africa.

Assisting farmers in disaster situations to restore agricultural systems was identified as a priority in the Global Plan of Action for the Conservation and Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture. The plan was adopted by over 150 countries at the International Technical Conference on Plant Genetic Resources (Leipzig, Germany, June 1996). The conference

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recognized that disasters, civil strife, and war pose challenges to agricultural systems. Often, adapted crop varieties are lost and cannot be recuperated locally. Food aid, combined with the importation of often poorly adapted seed varieties, can undermine food security and increase the costs of donor assistance. In such situations, the goal is to deliver seed of adapted varieties and landraces as needed to help reestablish indigenous agricultural systems in areas affected by disaster. In turn, this can play a major role in restoring local food security.

Afghanistan

Afghanistan is one of the poorest countries in the world. This millenium, the country passed the mark of 21 years of conflict, which has brought complete destruction and immense suffering to its people. After the fall of the Soviet-backed government in 1992, the prospects for peace have receded, with continuing civil war fragmenting the country into struggles between the various political and military groups in shifting alliances. Currently, more than 80% of the country is under the Taliban, while the remainder is under a united front. However, the Taliban movement is not yet recognized by the international community, except for Pakistan, Saudi Arabia, and the United Arab Emirates.

The nation's agricultural system has suffered from physical damage to irrigation structures, from mines, and from the disruption of normal markets and input-delivery mechanisms. Security concerns, high transport prices, and continual currency depreciation all combine to cause shortages of agricultural inputs such as seeds, fertilizers, chemicals, credit, and labor, resulting in increased food scarcity. The civil unrest has caused the country to move from near self-sufficiency in the mid-1970s to a dependency on imports in recent years.

Badakhshan

Badakshan, one of the most remote areas in Afghanistan, is located in the northeastern corner bordering Kunar, Lagham, Kapisa, and Thakar provinces. In addition, the province borders Pakistan in the southeast, China in the east, and Tajikistan in the north. It is one of the two major areas not under the control of the Taliban. The Panj River (Amu Darya) separates its long border with Tajikistan. The province is normally linked with the rest of country a by narrow, drivable road through the province of Takhar on the West. Currently, after Takhar the road intercepts the frontline with the Taliban. The province is thus virtually cut off from the rest of the country. On the eastern side, the road is linked with the Gorno-Badakshan province of Tajikistan through a narrow bridge over the Panj River at Ishkashem.

Badakshan lies in the Hindu Kush mountain range with the Wakhan rising up into the Pamir Mountains. The Hindu Kush mountain system is characterized by young, rugged ranges with sharp peaks and deep valleys. The eastern half of the province lies between 1,300 meters (Darwaz) to 3,000 meters (Wakhan). The western half is at a lower elevation, with Keshem, the lowest point, at 960 meters. Inside the province, most of the districts are isolated from each other for a greater part of the year by heavy snowfall in the winter, landslides in spring, and floods in the summer. Because of the rugged mountain terrain, much of the land area is uninhabitable. Connecting dirt roads are either very rough or do not exist. Donkeys, horses, and walking constitute the major means of transport. It is common for villagers to walk three to four days to the nearest market. There is virtually no effective government operating in the province at the current time. The villages and larger towns in the province have no electricity, no running water, no sanitation facilities, few medical facilities, and poor schools.

Badakshan province has historically been isolated and neglected. It has always been considered a poor province; even before the war, local agricultural production met only 50% of the needs. The few development initiatives ever started were abandoned after the communist takeover and the subsequent fight between the Taliban and the Northern Alliance. It is estimated that agricultural production is down by at least 40% as a result of the war (UNIDATA 1966).

Agriculture

The province has a highly diversified cropping system. Crop production, horticulture, and livestock are the main sources of income for most households. It is difficult to obtain reliable statistics on agricultural production. Figures on land holdings provided by farmers during interviews tend to be grossly underestimated for fear of government taxation and to qualify for humanitarian assistance. The majority of households own less than one hectare, and further fragmentation of land holdings occurs because of the traditional inheritance laws. Smaller farmers usually sharecrop the land owned by farmers with relatively larger holdings (more than two hectares). Many districts do not produce enough food, for example, surveys have shown that food deficits in Sheghnan, Ishkashem, and Wakhan range from two to six months.

Autumn and spring wheat is the main grain crop. Other crops include pulses (broad beans, vetches, field peas, grass peas) often grown as a companion crop with spring barley. Finger millet and chickpeas are also planted in spring. Small quantities of oil-seed crops such as sesame and flax are occasionally grown for oil, but the wild mustard that grows as a weed in the wheat fields is harvested by women and children for oil and cooking. Maize is grown at lower elevations (below 1600 m) from Darwaz through Shekay as a second crop after wheat. Cotton is also grown in small quantities in some villages from Darwaz downstream, where it is used for stuffing quilts and pillows, and the oil extracted from the seed is used for lamps.

Vegetables include spinach, onions, beans, occasionally tomatoes, carrots, squash, and a variety of herbs. Several kinds of potatoes of varying lengths of maturity are grown. These vegetables provide a supplementary diet during the hungry months of spring and early summer before the harvest. Fruit trees, particularly mulberries, are important. Other common trees include fruit trees such as walnut, apricot, plum, sour cherry, apple, and grape, and timber trees such as poplar, willow, and walnut. Several wild plants play an important role and include wild mustard, wild rhubarb, wild orchid tuber, black cumin, licorice, and mushrooms, in addition to the wild herbs of medicinal value. Opium poppy is not cultivated on a commercial basis, although small patches may be planted by addicts for their own use.

Livestock are a main source of the household economy in rural areas. The sale of livestock is the primary means for much of the population to earn income for purchase of other food and essential items, especially wheat, during the spring months when they run out of food stock. The province has huge common grazing areas that support herds of livestock belonging to the local people as well as to nomads.

Humanitarian assistance

The chronic food-deficit situation in the province results in a cycle of poverty leading to hunger, and hunger leading to even greater poverty, which is very difficult to reverse. Because of its remoteness, very few assistance agencies are able to work in the province.

In response to the food deficit in the region, FOCUS is implementing a relief program. The program has included the distribution of 10,000 tons of food aid to 250,000 people over the last years. Food rations were provided for every household in about half of the province. In some districts, food was provided in a food-for-work program. FOCUS is able to carry out its activities in Badakshan for several reasons: FOCUS is affiliated with the Aga Khan Development Network, which has been active in Tajikistan and Pakistan on the northern and southern borders of Badakshan. During the last three years, good working relationships have been established with local leaders and with international organizations. A participatory model for rehabilitation comprising situation assessment, health, food assistance, village organization, agriculture, physical infrastructure, education, and economic initiatives is being considered.

Agricultural interventions

Agricultural interventions by FOCUS have been initiated this year in the districts along the Panj River (Darwaz, Sheghnan, Ishkashem, Zebak, and Wakhan). Although Zebak is not strictly along the river basin, its farming systems resemble those of Ishkashem. These districts are among the most food-deficient areas in the province. FOCUS is able to access these areas across the river from Gorno-Badakshan in Tajikistan where the Aga Khan Development Network has a comprehensive development program, of which agriculture is an important component.

The populated areas of the Sheghnan, Ishkashem, Wakhan, and Zebak districts are at an altitude of 2200 to 3000 meters. Population densities are low. Although there is a comparatively large area of land per capita, low temperatures, short growing seasons, low rainfall, and poor soils combine to lower productivity. Darwaz, on the other hand, is at a lower altitude (minimum 1300 meters) and has a longer growing season with higher rainfall and temperatures.

Table 1. Characteristics of the Target Areas

	Ishkashem	Zebak	Wakhan	Sheghnan	Darwaz
Number of villages	30	14	16	17	54
Households (farms) per village	39	45	68	160	132
People per household	9.0	9.3	8.7	8.3	8.7
Land resources: ser* per household	21	11	25	12	6
Number of animals per household	15	10	12	14	6
Number of households surveyed	1200	635	1084	2555	2648

* A *ser* is a local measure of land area based on seeding rate, ranging from 20 to 35 *sers* of wheat seed per hectare.

Needs assessment

Only 2% of eastern Badakshan is suitable for agriculture, and its soil quality is often poor and deficient in nutrients. A large portion of the agriculture is based on irrigation from rivers and torrents. Extensive systems of irrigation channels have been developed by the communities over centuries, bringing water long distances along the mountainsides. There is also a considerable amount of farming that depends on moisture from rainfall and melting snow, which is less productive.

The general constraints on crop and livestock production in the area include the following:

- lack of access to good, pure seed for cereal crops
- lack and/or cost of inputs such as fertilizers and plant-protection materials
- diseases, pests, and weeds
- lack of irrigation water and the state of the water system
- remoteness of markets and lack of transport facilities
- lack of agricultural and livestock services
- taxes (generally as a part of their crop yield)
- displacement of technical staff and farmers and destruction of institutions

In all formal and informal agricultural surveys, the farmers' priorities have always been fertilizers and good seed of improved varieties. Most farmers are aware of the possibilities of increasing their production through these inputs, especially fertilizers. The soil is generally very shallow and lacks sufficient nutrients to support intensive crop production. With shortages of fuel, especially firewood, most of the available animal dung is used for cooking and for heating in winter. The population of trees remaining is barely sufficient for watershed purposes and needs to be replenished. Lack of sufficient fodder for feeding livestock during the winter also limits the amount of animal dung available for the household. Small amounts of fertilizers are sometimes available in the markets but are usually of poor quality and very costly. Most farmers lack resources at planting time and have to pay high interest to borrow money for purchasing small amounts of fertilizer against the expected harvest.

The attitude of farmers towards weeds is rather tolerant, as many are also seen as serving a useful purpose. At a certain level, weeds in the wheat are considered to improve the quality of the straw as fodder. The presence of some wild rye is said to improve the quality of bread. Wild mustard is harvested separately by the women and processed for lamp and cooking oil. Some families consume plants of edible species weeded in the fields, such as *Chenopodium* spp.

Wheat is a staple food in all the communities of eastern Badakshan and is grown on both irrigated and rain-fed land. Altitude and snow cover tends to dictate whether wheat is sown as a spring or an autumn crop. Wakhan, Ishkashem, Zebak, and southern Sheghnan grow mostly spring wheat, while northern Sheghnan and Darwaz grow winter wheat.

Overall, wheat yields per hectare vary from 0.5 to 2.0 tons under irrigation and from 0.3 to 0.7 tons in rain-fed areas. The yields vary enormously with location, altitude, soil quality, the availability of farmyard manure (chemical fertilizer in the area is a rarity), susceptibility to fungal diseases such as rust and smut, pests such as locusts, weeds, and the genetic origin and purity of the seed planted.

Little or no introduction of improved varieties had taken place in eastern Badakshan prior to 1979. AfghanAid has recently established demonstration plots of improved varieties from the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) as part of an integrated development program in Badakhshan, including the districts of Ishkashem and Zebak. Almost all farmers grow a number landraces that are of local origin and of very mixed appearance, often heavily infested with weeds, particularly wild wheat, wild oats and mustard. *Sorkhak*, an indigenous red-grained wheat, is generally planted in the autumn, while safidak, an amber/light-grained wheat, is planted in the spring. A few farmers have part of their fields under seed from other districts, including from Pakistan and Tajikistan. Some of this is of improved origin but by now very mixed with other varieties and weeds.

In Darwaz, different types of wheat are cultivated with different lengths of straw, some with awns and some awnless. Winter-wheat types clearly owe their origin to Russian varieties and to the facultative varieties introduced elsewhere in the province under various United Nation and aid programs. Local cultivars are almost exclusively sown on rain-fed land.

Participatory seed-security strategy

Seed security (farmers' access to adequate, good-quality seed of the desired type at the right time) is the first defense for food security (the access by all people at all times to enough food to maintain an active and healthy life). This is especially true for war-torn Afghanistan in general and for neglected Badakhshan in particular. As recognized at the World Food Summit held in Rome (FAO 1996), poverty and impoverishment precondition people to a state of vulnerability—vulnerable to life-cycle hunger, vulnerable to seasonal hunger, and vulnerable to the impact of disaster. This also describes the state of food security today in eastern Badakshan.

The loss of access to seeds and food are often interconnected. While seeds are crucial to agricultural recovery, human energy is equally important. Seed relief is being viewed as an integral part of the emergency package. There are several examples from other parts of the world that show that the action taken to restore seed security quickly after disaster is an effective way to help restore food security in an area. During the 1991/92 drought in Southern Africa, an emergency seed-production project, jointly coordinated by the Southern African Development Community (SADC) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), was highly successful compared to the projects in which seed was imported. Their success was due to the distribution of better-quality adapted varieties. The Seeds of Hope initiative helped rebuild domestic food security through the rehabilitation of seed security following the civil war in Rwanda in 1994. Adapted varieties and landraces were assembled and multiplied in neighboring countries and reintroduced into Rwanda.

The seed program aims to ensure availability of the right kind of seed in the right place. Adapted varieties are obtained from similar agroclimatic conditions in Tajikistan and delivered across the Panj River to several distribution points. Transportation within Afghanistan is mostly by volunteers, by donkeys made available by the communities for this purpose. This helps to keep the costs of introducing the varieties to a minimum. The amounts being distributed have been minimized to enable the local seed-production and -distribution systems to continue functioning smoothly.

Early in spring of this year, seeds of high-yielding varieties of wheat, maize, other cereals, potatoes, and vegetables appropriate to the agroecological conditions of the area were introduced through on-farm, farmer-managed observation sites in the target districts. All the villages in the Wakhan, Ishkashem, Zebak, Sheghnan, and Darwaz districts are participating. The farmers are selected through village committees, traditionally known as *shuras*. Attempts are being made to involve as many different farmers as possible by restricting the distribution of only one kind of crop commodity to each participating farmer.

Initially, for each kind of crop, varieties that are widely adapted and available in sufficient quantity are being introduced. This will be followed by varieties and landraces with superior traits such as higher yield, better adaptability, improved disease and pest resistance and stress tolerance, and more consumer acceptability. In future, different kinds of lentils, forages, fruit and timber trees, and herbs of medicinal value will also be introduced into the farming systems. It is expected that the introduction of useful germplasm will be repeated every growing season whenever new potential materials are available and the farmers—through their village committees—are in favor of it. Rather than replacing existing germplasm, the goal is to increase the range of germplasm available on-farm. This will contribute to enhancing on-farm genetic diversity among and within different crop species.

The emphasis is on farmer and community empowerment. Participating farmers and their neighbors will judge the usefulness of the materials being introduced and their subsequent multiplication and distribution. Farmer-to-farmer seed exchange forms the basis of the local seed system in the region. It is a part of the local culture that anyone with seed of improved varieties is obliged to share the seed produced at the first harvest with his extended family. Such acts of cooperation reinforce family ties with distant blood relatives. In some cases, extra amounts of seed will be distributed on credit if the demand for the varieties introduced cannot be met by the local seed systems. Credit systems in which farmers pay for the inputs at harvest are also being used for supplying fertilizers.

These activities will be gradually transformed into participatory breeding, allowing the community to gain full control over the type and amount of varieties being produced and exchanged with their neighbors. Participation in the management and decision making for seed security by the farming community will contribute to reestablishing local food security and peace in the area.

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Involving Farmers in the Development Process to Improve Adoption of Varieties Developed by National Maize-Breeding Programs

J.K. Ransom, K.B. Koirala, N. Rajbhandari, and K. Adhikari

Abstract

Developing maize varieties that will be readily adopted by subsistence farmers is challenging as there are numerous characteristics in addition to agronomic performance that are important to these farmers. Furthermore, these preferences vary from location to location. It may be logical to conclude that because of these location-specific requirements, maize breeding that targets subsistence farmers should be done at a localized level. National maize-improvement programs have an important role to play in developing improved maize genotypes for these farmers because they have access to a wide range of genetic materials that allows for the identification of genes for disease resistance and high yield that may not be available in local germplasm. Furthermore, they have the expertise required to incorporate these genes efficiently into genotypes that meet the farmers' other requirements. To increase the impact of genotypes developed by national maize-improvement programs, however, farmer input into their activities is essential. A balance between on-station breeding activities and interactions with farmers is needed in order for the process to be efficient. Therefore, the National Maize Research Program within Nepal's National Agricultural Council (NARC) has developed the following procedures for developing maize genotypes for subsistence farmers with their input. First, through on-farm surveys, the required grain (i.e., flint, dent, yellow, or white) and plant (i.e., tall, leafy, early, or late, etc.) types are determined. Second, exotic and locally developed genotypes are screened for the desired characteristics and general adaptation on-station using local varieties from the targeted environment as checks to ensure that maturity duration matches that already used by farmers. Promising materials are initially tested on-station for yield and disease resistance. Elite materials (approximately six to eight genotypes) are then tested in on-farm trials under farmers' conditions. Farmers who grow these materials observe their agronomic performance and provide input about which entries they prefer. Only those varieties that have proven to be high yielding and stable, and which have the characteristics preferred by farmers, will be released and made available on a more national scale. Maintenance of released genotypes and seed multiplication is a resource-intensive activity that must be limited to genotypes that are the most likely to have an impact. We believe that this varietal-development scheme will efficiently provide new and desirable options to small-scale subsistence maize farmers in Nepal.

Introduction

Maize is one of the three most important cereal crops in the world. Global annual maize production now exceeds 550 million tons. Of that, approximately 100 million tons are used directly for human food (CIMMYT 1999). Maize is growing in importance in Asia, primarily as a feed for animals. Nevertheless, there are significant areas of the region where maize is still the dominant cereal in the human diet. In Nepal, for example, of the 1.4 million tons produced annually, it is estimated that 86% is used directly as human food (CIMMYT 1999). The development of hybrids is one of the main reasons for the phenomenal advances in maize productivity throughout the world in the past few decades. In most developed countries, the area planted to hybrids approaches 100% of all land planted to corn. Growth in the use of hybrids has been impressive in areas of the developing world as well. For example, 60% and 46% of the area planted to maize is sown to hybrids in Thailand and

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Vietnam, respectively. Both within Asia and globally, there is a significant negative correlation between the percent utilization of maize for human food and the use of improved varieties (CIMMYT 1999). This can partially be explained by the fact that subsistence farmers have limited cash and are reluctant to pay the premium price associated with improved seeds, particularly hybrid seed, which must be purchased each year. Single-cross hybrid seed in Asia costs on average US $3.12 per kg, in comparison to US $0.69 per kg for open-pollinated varieties (OPVs) (Gerpacio 1999).

The development of OPVs for areas of the world where maize is grown as a subsistence crop makes good sense. Compared to hybrids, OPV seed is more readily produced, it can be made available to farmers at a lower cost, and it can be generated by farmers themselves. Nevertheless, in large areas of the world where maize is a subsistence food crop, a large percentage of the area is not planted to improved varieties (OPVs or hybrids) even though modern varieties with excellent adaptation are available from both the public and private sectors. The poor adoption of improved maize varieties can be attributed to many factors, primary among which may be the lack of viable seed enterprises. Other factors, such as the varieties' lacking the characteristics that are important to farmers, also constrain adoption. Farmers in Nepal for example, prefer their own varieties because they are earlier, have better husk cover and culinary characteristics than improved OPVs. In order to improve adoption of modern varieties, there is a need for greater farmer input into the development of genotypes that take these preferences into account. This paper discusses issues relative to developing and providing improved maize genotypes to farmers and describes a germplasm-improvement scheme adopted by the National Maize Research Program in Nepal to ensure that the products they develop are better targeted to the requirements of farmers.

Fixing favorable alleles—the numbers game

Maize is cross-pollinated under normal circumstances. Therefore, a crop or plot of a desired genotype must be carefully managed if the seed it produces is to be genetically pure. Furthermore, in relation to participatory approaches to plant breeding it means that seed of genotypes that are tested or demonstrated in farmers' fields in a typical small plot are likely to be contaminated or genetically altered through the inflow of foreign pollen. Saved seed will, therefore, not produce a phenotype identical to that observed the previous season. In a varietal-improvement program, be it through informal farmer selection or through a formally organized plant-breeding program, success is determined by the ability of the breeder to find desirable characteristics and fix them in the population so that they can be expressed in subsequent generations. For traits that do not exist or that have little expression in an otherwise desirable population, conventional breeding programs have a substantial competitive advantage over farmer-led approaches. In order to find favorable alleles for stress tolerance, for example, many thousands of lines and populations might need to be screened in order to identify a few genotypes with the desired characteristics. Similarly, for alleles that are found in a very low frequency in a population, breeding techniques that include selfing and extensive testing with recombination of best lines can be used to increase their expression relatively quickly.

Developing OPVs through conventional methods requires both time and land resources. As an example, the following steps are required to develop a superior experimental variety using full-sibs developed from an improved population (which itself may have been improved through many cycles of selection). First, 250 full-sib progenies are generated by hand-pollination. These are tested in up to six locations, including sites where a stress of interest is present. Next, eight to 10 superior families are selected and recombined using remnant seed. The progeny of these crosses are then allowed to intermate for one further cycle. The favorable alleles in these EVTs are now more or less fixed and these varieties are ready for testing.

In order to maintain these materials (produce breeder seed), at least 1500 plants need to be grown if they are hand-pollinated (bulked pollen). Foundation and certified seed can be produced from this breeder seed. Using these procedures, the greater the number of materials tested and the lower the experimental error of the experiments, the greater the likelihood that superior materials can be identified. Seed production requires isolation, and minimum standards of isolation are set for different classes of seed. As mentioned, this process is expensive and requires substantial areas of uniform land to ensure adequate testing. Nevertheless, it is very effective in identifying and fixing favorable alleles for the traits of interest. It is very effective in identifying resistance or tolerance to stresses that are prevalent in the testing environments and in developing materials with high yield potential. High yield potential and stress tolerance in OPVs, however, does not mean that they will be acceptable to farmers or will be adopted by them.

Adding farmer participation to the conventional breeding program

The rates of adoption of improved genotypes developed through the conventional methods described above have not been high in many areas of the world. Including traits that farmers prefer in OPVs may help improve rates of adoption in some of these regions. We propose that (1) input in the beginning of the development process, (2) coupled with more intensive on-farm testing of the materials that are developed, are two ways to improve the rates of adoption of newly developed genotypes that farmers desire. Moreover, we believe that identifying and fixing farmer-desired traits is most effectively carried out through conventional, tried-and-tested breeding methods, like those briefly referred to above.

Input at the beginning of the development process

Before a breeding program begins, the target environment and the basic requirements of the farmers in that particular environment must be clearly understood. In Nepal, the National Maize Research Program is currently developing materials that target the mid-hills, the high hills, the *terai*, and areas in both the *terai* and valley bottoms that require early-maturing varieties. Generally speaking, the biotic stresses differ significantly between the various agroecologies—enough that material developed for one ecology will not do well in another, and vice versa. Some extremely important farmer characteristics that must be ascertained at the beginning stages are length of growing period and grain type. This input can be obtained through farmer interviews (rapid rural appraisals [RRAs] and more formal surveys) and by soliciting farmers' reactions to on-going trials either on-farm or on-station. In Nepal, using an RRA approach, we found that farmers in different areas of the country preferred different characteristics (table 1). Furthermore, by having farmers view trials, they provided valuable feedback on the length of maturity they desired.

Farmer feedback during testing

After the on-station work of identifying and the fixing favorable alleles has been concluded, the experimental varieties need to be tested widely. Multilocational testing, usually on-station where experimental error can be controlled, allows researchers to identify high-yielding genotypes that are stable and adapted across environments (including having resistance to the prevalent diseases).

Table 1. Grain Characteristics Desired by Farmers in Maize Varieties in Various Regions of Nepal, Based on Results of Rapid Rural Appraisals Conducted by the National Maize Research Program, October 1999

Region	Grain type	Reason for preference
Eastern	White flint	Good storage, high grit yield
Central	Yellow flint	Good storage, taste, grit yield
Far western	White dent	High flour yield—used in *rotis*
Terai	Yellow dent or flint	Used for animal feed

Farmer input into the selection of experimental varieties can be obtained by allowing them to visit trials being conducted on-station. Generally, however, on-station yield trials contain a relatively large number of entries. Furthermore, a single visit to the research station would not allow farmers to select entries for grain type, unless farmers visited trials at the time of harvest. In the Hill Maize Research Project, the top four to six entries of the coordinated varietal trial are tested further on-farm, in what is termed a farmer field trial (FFT). These trials are conducted as widely as resources allow, and in addition to yield, feedback from farmers on varieties that they prefer is obtained and used in determining which varieties are released. This process allows farmers to evaluate fewer materials, and since plots are larger, a good evaluation of seed characteristics can be obtained.

A novel approach to allow farmers' input at an earlier stage of testing is being used by Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) in southern Africa (CIMMYT 2000:12–14). It is called the mother-daughter testing scheme. Within a given agroecology, a complete set of experimental varieties is tested on an experiment station, on a substation, or on-farm (with researcher management). The complete set can contain as many entries as desired by the breeder. These are grown in a lattice design with replications. The complete set is referred to as the "mother." In farms in the area represented by the mother trials, four to six entries that represent a block within a rep of the lattice are grown. These smaller on-farm trials are referred to as "daughters" and these daughter trials may be managed by nongovernmental organizations (NGOs), extension programs, community-based organizations, or farmers themselves.

Yield and farmer preferences are obtained from each of these on-farm trials. The results from all of these daughter trials can be combined and statistically analyzed as components of the complete trial. Although each farmer only sees a subset of the complete mother trial on his or her own farm, with sufficient replication, this approach should allow researchers to obtain yield data that can be analyzed statistically, as well as information from the farmers as to which materials are preferred. The approach allows for more effective farmer input at an earlier stage of testing. With the assistance of extension officers and NGOs, nearly 300 on-farm daughter trials were conducted in 1999/2000 in Zimbabwe.

A note on seed production and maintenance

Developing improved varieties is only part of the process of getting them into production in farmers' fields. Distinct from the cases of rice and wheat, seed production in maize is more complicated. Plots must be isolated to eliminate genetic contamination from foreign pollen. Furthermore, the number of plants grown must be sufficiently large to ensure that the genetic variability of the population is well represented and inbreeding effects are reduced. Seed enterprises rely on a good source of foundation seed, which is usually produced from breeder seed maintained by the organization that develops the genotype. A lack of resources universally limits the number of varieties that can be maintained by public institutions. Due to the lack of involvement of the public and private sectors in seed production (certified seed) within Nepal, the Hill Maize Research Project supports seed production at the community level. This should allow quality seed of improved varieties to be available to farmers at a reasonable cost, even in relatively inaccessible areas.

Furthermore, farmers who use improved seed and retain their own seed for subsequent plantings must be trained in how to select seed if they are to continue to benefit from the "fixed favorable alleles" in the improved varieties. This training should emphasize that seed should be from plants in the field and not cobs in the store, that it should be selected from the center of their larger fields so as to avoid contamination from pollen from adjacent fields, and that it should be dried well and stored in such a way that it is protected from insect pests and will maintain a high level of germination.

Conclusion—the strategy of the Hill Maize Project

Based on the need to have greater input from farmers in the variety-development process and the efficiencies in finding and fixing favorable alleles inherent in station-based breeding programs, the following breeding strategy has been adopted by the Hill Maize Project for the development of OPVs for the hill areas of Nepal.

1. Based on information from RRAs and other survey instruments and feedback obtained from farmers from on-farm and on-station trials, breeding activities will focus on incorporating traits desired by farmers (i.e., grain texture and color, maturity length, plant stature, etc.) into new varieties.
2. Exotic and locally generated germplasm will be evaluated to determine source populations with which to work.
3. Tried-and-tested breeding procedures will be used to identify desirable traits and fix them into experimental varieties.
4. Promising genotypes will be identified through multilocational on-station testing.
5. Elite material will be evaluated in farmers' fields for both agronomic performance and farmers' preferences in either FFTs or mother-daughter trials.
6. Only varieties that are desired by farmers will be released.
7. Community-based seed production will be used as one mechanism for making seeds available to farmers at a reasonable price.
8. Farmers will be trained in techniques that can be used to ensure the maintenance of genetically pure seed.

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Participatory Plant Breeding and Property Rights

Project of SWP PRGA

Abstract

Participatory plant-breeding (PPB) efforts have proliferated within the last 10 years; however, other key aspects have yet to be explored. As in many other fields, the property rights and ethical issues of participatory plant breeding are lagging far behind technical advances. The urgency to define property-rights issues for PPB arises at an opportune time. This paper introduces incipient work (including development of a state-of-the-art paper) on property rights (i.e., legal issues, best-practice options to guide field programs, and ethical concerns in PPB work) and participatory plant breeding. Steps for development of the state-of-the-art paper and the types and issues to be covered are listed.

Introduction

Participatory plant-breeding (PPB) efforts have proliferated within the last 10 years, with some 65 examples identified worldwide (McGuire, Manicad, and Sperling 1999; Weltzien/Smith, Meltzner, and Sperling 2000). A range of international agricultural research centers (IARCs), national agricultural research systems (NARS), nongovernmental organizations (NGOs), and universities are experimenting with varied approaches (about 50 institutions belong to the plant-breeding group of the Systemwide Program on Participatory Research and Gender Analysis [SWP PRGA] alone), with the research paradigm increasingly being framed as a mainstream or strategic activity. Yet while work is mushrooming on certain aspects of PPB—for example, development of farmer-friendly breeding schema, analysis of possible cost efficiency, and testing of models to promote varietal diversity (SWP PRGA 1996)—other key aspects have yet to be explored. As in many other fields, the property rights and ethical issues of participatory plant breeding are lagging far behind technical advances. This is serious for an approach that pivots around the tenets of "trust" and "collaboration" among different groups—most often among poor farming communities and formal-system researchers.

Joint collaboration should mean joint benefit sharing. At this point, there are no ready-made arrangements or "best practices" to suggest for the processes and materials that emerge from PPB collaborations. Most of the PPB work to date has simply skirted the issues of property rights with two very diverse strategies: materials jointly developed by formal breeding and farming communities have been fed into the formal system for variety release and seed multiplication (completely ignoring farmers' input), or the PPB-developed materials have been "released," "let go" into farming communities—with no official launch of any kind. This has had a positive impact among farmers with mostly self-pollinated crops where issues of seed increase and quality are relatively easy for farmers to manage at their own level.

The urgency to define property-rights issues for PPB arises at an opportune time. The debate over farmers' rights seems stalled in many quarters on political, legal, and practical levels. Further, The legislation on plant breeders' rights makes varied assumptions about how much formal breeders control the process (to the exclusion of farmers)—assumptions that have rarely been placed under closer scrutiny. Exploration of property rights, and related issues within the field of participatory

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plant breeding, offers the possibility of giving a second mirror to these other realms. PPB has the advantage of being able to follow farmers' practical, and often varying, contributions in very specific ecological and historical contexts. Similarly, within PPB work, the contribution of plant breeders is given well-defined geographical and historical specificity. PPB has many variations, ranging from superficial consultation on farmer preferences to farmers actually being involved in choosing parents and crossing material. Scrutiny of the *variations* of PPB—and the reflections on property rights associated with these *different* farmer-breeder relationships—might indeed prove useful for grounding some of the discussions about farmers' rights and plant breeders' rights.

This short note announces SWP PRGA's incipient work (including development of a state-of-the-art paper) on property rights and participatory plant breeding. We use the term *property rights* as shorthand for considering three separate but related aspects: legal issues, best-practice options to guide field programs, and ethical concerns in PPB work.

Overview of procedures

The "think paper" is being based on intensive discussion of actual and developing practice in PPB. The paper's development is a four-step process:

1. identification of 8–10 type-case scenarios for PPB
2. analysis of legal, best-practice, and ethical issues for each scenario by a team of specialists: lawyer, breeder, and social scientist
3. feedback of initial recommendations/insights to the SWP PRGA and a wide range of groups involved in plant genetic resources (PGR) and intellectual property rights (IPR)
4. synthesis/publication/distribution

Identification of type cases for PPB

We recognize that there are substantial variations in PPB (as there are, in reality, even in many farmers' breeding situations). We are in the process of identifying the 8–10 classic types by analyzing programs along such variables as

- Goals of PPB—skill building/empowerment; varietal improvement/release
- Roles of partners (farmers/researchers)—everything from simple consultation on preferences to actual collaboration in choosing crosses and crossing (analysis of stages of involvement)
- Type of germplasm used—local/exotic; stable/variable
- Sites in which material is stabilized—farmer controlled, researcher controlled, mixed
- Type of product derived—homogeneous/variable
- Means by which product is distributed—informal or formal seed channels

The Plant Breeding Group of the SWP PRGA, now encompassing 170 members from a broad PGR spectrum, is helping to identify these classic PPB types through email discussion.

Analysis of legal, best-practice, ethical concerns

A team of three, an IPR lawyer specialized in cultivated plants, a plant breeder, and an applied social scientist will analyze the cases—legally, ethically, and operationally—in terms of such issues as

- broad obligations of each party (legal, ethical, best practice)

- germplasm ownership issues (i.e., recognition of contribution to the creative process)
- distribution rights (i.e., recognition of rights to move seed)

The team will synthesize knowledge on existing practice (including constraints and opportunities) and suggest draft recommendations or options for better practice (e.g., what is being tried where).

Feedback on initial recommendations for widespread comment

The draft document will be widely distributed among PPB, breeding, and PGR advocacy groups. It aims to stimulate lively discussion—and present a more grounded view of what different types of farmer and breeder collaboration might entail.

Synthesis

The final paper will be published as a SWP PRGA working document. Decisions on wider distribution should be made after an independent panel evaluates the final product.

Outputs

The primary output would be a think paper on options for considering property rights (in the broad sense) in participatory plant breeding. It would be geared to those who variously reflect on (1) legal issues, (2) best-practice options, and (3) ethical issues as paramount.

While not binding, the paper would be written in such a way as to achieve the following:

- guide ongoing practice within SWP PRGA
- guide practice among PPB projects in general
- inform and ground debates surrounding farmers' rights and plant-breeders' rights

Duration

Twelve to 18 months (project to be completed end 2000, early 2001).

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Identification of type cases for PPB

We recognize that there are substantial variations in PPB (as there are, in reality, even in many farmer breeding situations). We aim to identify the 8-10 classic types by analyzing programs according to such variables as

1. **Clarification of expectations**
   Was there any (oral or written) agreement? yes/no : rough/detailed
   [On which of the following variables has agreement been achieved?]

2. **Goals of PPB**
   Possible goals include:
   - Production increase, quality improvement
   - Variety conservation, enhancement
   - Farmer skill building, empowerment

3. **Quality of participation of farmers/researchers**
   Three elements relevant for qualifying the quality of participation of farmers/researchers:
   i. Degree of participation
      - Consultative (scientist-led)
      - Collaborative (joint)
      - Collegial (farmer-led or community-led)
   ii. Functions performed by participants
      - Technical expertise
      - Organizational skills
      - Information giving
      - Teaching/skill building
      - Field labor
      - Provide inputs (land, seeds, funds)
   iii. Stage of involvement in breeding process:
      - Defining overall goals
      - Defining breeding targets
      - Generating variability
      - Selecting early segregating populations
      - Variety testing
      - Variety evaluation
      - Seed multiplication/distribution

4. **Profiles of participants (in relation to 3)**
   Individual/group
   Male/female

5. **Type of germplasm used**
   i. Status of the germplasm under the current mainstream legal frameworks
      (this covers and goes beyond what was formerly the category of local/exotic in the first communiqué):
      - Who owns the material?
      - Is any material used subject to intellectual property rights?

- Does use of the material require prior informed consent of any country/community (access legislation)?
- What are the implications of the legal status of the germplasm for the use and distribution of any results, such as plant varieties?

ii. Local views on ownership and associated responsibilities on germplasm

iii. Stable/variable

6. **Breeding/Propagation processes used**
   Are the processes subject to exclusive rights?
7. **Sites used for the PPB program**
   Researcher sites
   Individual farmer plots
   Community plots
8. **Type of end-product**
   Homogeneous/less or not homogenous
9. **Means by which product is distributed**
   Informal or formal seed channels

Type cases for PPB analysis

Below we have outlined a range of cases in which there has been PPB collaboration. They include both farmer-led and formal-led collaborations. The cases in general represent the most common of the current applications of PPB. However, several have been constructed to anticipate future trends in PPB.

Case 1

- Formal breeders decide to increase the production of a crop in a given farming area.
- There is no prior agreement with the local population, which is mixed ethnically and has no strong views on germplasm rights one way or the other.
- Formal breeders screen exotic stabilized materials received from an IARC and make decisions at all stages.
- Formal breeders decide what to put into on-farm trials.
- Individual farmers, mostly male, run the on-farm trials.
- Farmer preferences are taken into account for the formal release of varieties.
- The released varieties are forwarded to the state seed-distribution chain.

Case 2

- Formal researchers are given the government mandate to improve crop production in marginal areas and specifically seek out farmer breeding priorities there.
- There is no prior consultation or subsequent formal agreement with the communities involved.

- Researchers realize that the existing available NARS germplasm has little promising material. They initiate a crossing program using some local germplasm and some germplasm supplied by a neighboring NARS.
- On-station, breeders do several cycles of screening. Interested farmers from the local target communities, some women, some men, are brought on-station for evaluation of materials, including feedback on specific desired traits.
- On the basis of farmer and breeder assessments, segregating material is put with farming communities in researcher-designed but community-managed plots.
- The material stabilizes on-farm.
- Farmers and breeders pick the most promising finished materials.
- Varieties are put through formal release and multiplication processes.

Case 3

- Farmer communities make a decision to build on and improve the quality of their existing local germplasm. While they want higher yields, they are concerned about keeping their local varietal diversity. They highly value free exchange of materials among themselves. In fact, giving a seed gift is a true sign of friendship.
- An "outside" scientist is called in to help devise a strategy for "strengthening" local germplasm (making it more productive). Community leaders insist that the final product will be for the local community with the right of the locals to decide on any further distribution. A local NGO has given funds to enable this program.
- The contracted scientist initiates a crossing program to improve "weaknesses" in local materials and collaborates with members designated by the Community Council—composed of male elders.
- The Community represented by the Community elders approves the stabilized end products, which have been tested at farmers' homes.
- The scientist is paid and thanked and the community decides its own path.

Case 4

- This case is a variation on case 3, where a technology that is a private company's patent is involved.
- A large women's cooperative thinks it can make money off of potatoes if they get rid of the tubers' blemishes. Supported by an NGO aiming for female empowerment, they call in a NARS researcher for consultation. He indeed confirms a virus problem and agrees that he and his institute can help the women's group.
- He proposes to breed potatoes resistant to the blemish-causing virus. For this purpose, a patented resistance gene will be introduced into the potatoes. A private company holds the patent granted for the gene.
- NARS personnel alert the cooperative that the end product has to be officially cleared under the newly adopted biosafety framework.

- Subsequently, the women's group gets their product. It is simultaneously put through an official release process.

Case 5

- In the course of doing a survey, formal researchers discover an innovative farmer breeder who has developed an "interesting population" from local materials. They ask the farmer if they can have a sample but no formal agreement is made. Scientists plant this population on-station, stabilize it, and come up with a highly productive mix.
- The product is sufficiently homogenized so as to be put out through a formal release process.

Case 6

- Scientists are concerned about the decreased use of a certain minor crop, which is important for local nutritional needs. As this particular crop is not among the NARS priority mandates, they aim to develop a program that strengthens farmers' own skills to maintain the crop and ensure planting material quality.
- Scientists invite key farmers from the region—locally recognized as experts—to pursue specialized training on plant improvement.
- Communities involved have themselves prioritized the need for technical support to ensure the crop's maintenance but no formal collaborative agreement has been signed.
- Fifty local experts are trained, both men and women, and formal scientists remain on hand to give occasional advice.
- The training proves effective for conserving and even improving the quality of the local crop.

Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of Jordan

S. Ceccarelli, O. Kafawin, S., H. Saoub, S. Grando, H. Halila, M. Ababneh, Y. Shakatreh, and E. Bailey

Abstract

Breeding philosophies and methodologies developed for favorable conditions and high-input agriculture have been ineffective in generating improved cultivars for marginal conditions and low-input agriculture. The project is implementing a novel breeding approach for barley improvement in the low-potential, marginal- rainfall environment of Jordan, based on early selection and testing under farmer's conditions and with farmers' participation.

The expected outputs include identification of farmers' (men's and women's) selection criteria, introduction of participatory approaches into national breeding programs, dissemination of information generated by the project, increased adoption of new varieties in low-input agriculture, and higher and more stable barley yields. The new breeding program, targeted at marginal conditions and low-input agriculture, will move selection and testing work outside experiment stations and put breeding into the hands of farmers. We expect that even in a relatively small geographical area, farmers will tend to exploit specific adaptation. Specific adaptation benefits biodiversity through selection and spreading of a number of different cultivars, instead of the few, often closely related, cultivars characteristic of conventional breeding for wide adaptation.

Project objectives

Through the development of a participatory approach to breeding barley for stress conditions, the project will identify improved barley varieties that fulfill the needs of poor farmers in the most difficult environments of Jordan and, by involving farmers in selection and testing, enhance the rate of adoption of these varieties.

Background and justification

Introduction

Plant breeding has been beneficial to farmers who enjoy favorable environments or those who can profitably modify their environment to suit new cultivars. It has not been so beneficial to those farmers (the poorest) who could not afford to modify their environment through the application of additional inputs (Byerlee and Husain 1993). Farmers in favorable environments using high levels of inputs are now concerned with the possibility of adverse environmental effects and the loss of genetic diversity. Poor farmers in marginal environments continue to suffer from chronically low

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This paper reports on an IDRC- funded project developed by ICARDA in collaboration with the University of Jordan (UJ), the National Center for Agricultural Research and Technology Transfer (NCARTT), the Jordan University of Science and Technology (JUST) and the Jordanian Hashemite Fund for Human Development (JOHUD).

yields, crop failures, and in the worst situations, malnutrition and famine. Because of its past successes, conventional plant breeding has tried to solve the problems of poor farmers living in unfavorable environments by simply extending the same methodologies and philosophies applied earlier to favorable, high-potential environments.

The essential concepts of the conventional breeding approach can be summarized as follows:

- Selection is conducted under the well-managed conditions of experiment stations.
- Cultivars, especially in self-pollinating species, should be pure lines and should be widely adapted over large geographical areas.
- Locally adapted landraces should be replaced because they are low yielding and disease susceptible.
- Dissemination of seed of improved cultivars should take place through formal mechanisms and institutions, such as variety-release committees, seed-certification schemes, and governmental seed-production organizations.
- The end users of new varieties need not be involved in selection and testing; they are only involved at the end of the consolidated routine (breeding, researcher-managed trials, verification trials) to verify which of a limited selection of finished cultivars are acceptable.

In situations where the objectives are to improve yield and yield stability for poor farmers in difficult environments, plant-breeding programs rarely question the efficiency and the effectiveness of the conventional approach. The implicit assumption is that what has worked well in favorable conditions must also be appropriate to unfavorable conditions, and very little attention has been given to developing new breeding strategies for low-input agriculture in less-favorable environments. There is mounting evidence that this assumption is not valid and that, in fact, the problems of marginal environments and their farming systems must be addressed in new and innovative ways.

Breeding for marginal environments

In those few cases where the application of conventional breeding strategies to marginal environments has been assessed, the following has been found:

- Selection in well-managed experiment stations tends to produce cultivars that are superior to local landraces only under improved management and not under the low-input conditions characteristic of the farming systems (Galt 1989; Simmonds 1991; Ceccarelli 1994). The result is that many new varieties are released, but few, if any, are actually grown by farmers in difficult environments.
- Poor farmers in difficult environments tend to maintain genetic diversity in the form of different crops, different cultivars within the same crop, and/or heterogeneous cultivars in order to maximize adaptation over time (stability), rather than adaptation over space (Binswanger and Barah 1980). Adaptation over time can be improved by breeding for specific adaptation, i.e., by adapting cultivars to their environment (in a broad sense) rather than modifying the environment to fit new cultivars (Ceccarelli 1996). Since diversity and heterogeneity serve to disperse or buffer the risk of total crop failure due to environmental variation, farmers may resist the idea of abandoning traditional cultivars.

- When an appropriate cultivar is selected, adoption is much faster through non-market methods of seed distribution (Grisley 1993).
- When farmers are involved in the selection process, their selection criteria may be very different from those of the breeder (Hardon and de Boef 1993; Sperling, Loevinsohn, and Ntabomura 1993). Typical examples are crops used for animal feed, such as barley, where breeders often use grain yield as the sole selection criterion, while farmers are usually equally concerned with forage yield and the palatability of both grain and straw (Saade et al. 1993).

Because the concepts of conventional plant breeding are rarely questioned, the blame for the nonadoption of new cultivars is variously attributed to the ignorance of farmers, the inefficiency of extension services, and the lack of availability of seed of improved cultivars. Thus, an impressive amount of human and financial resources continue to be invested in a model that has not been, and most likely will not be, successful in unfavorable agroclimatic conditions.

We base our approach on the following four assumptions:

1. Farmers have accumulated experience and know their specific environment better than breeders.
2. Farmers operate according to specific needs and objectives, which may not conform to breeders' research objectives.
3. Farmers will determine the success of a new variety, not breeders.
4. It is possible to integrate the scientific knowledge of breeders (in areas such as genetics, breeding, physiology, agronomy), as well as their broader experience across environments and their ability to create and manipulate genetic variability, with the knowledge and experience of farmers.

The concepts of the project are not new. Farmers have been participating to a greater or lesser extent in the pigeon-pea and pearl-millet programs of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in the breeding program carried out by the Centro Internacional de Agricultura Tropical (CIAT) in Rwanda, and in a number of projects implemented by ICARDA and national agricultural research systems (NARS) in Syria, Tunisia, Morocco, Eritrea, and Yemen (Ceccarelli et al. 2000, 2001). These projects, however, were only experiments in participatory plant breeding, since they did not incorporate the cyclical nature of plant breeding. The project presented here represents a step forward because it will transfer to farmers' fields various steps of a formal breeding program. Although we will document farmers' selection criteria, and whether selection criteria differ between men and women, through descriptive indigenous-knowledge studies, emphasis will be given to (1) measuring and quantifying the effect of using farmers' selection criteria on the performance and adoption of improved barley and (2) developing an approach that can be readily utilized by other NARS in developing countries.

The project area

The geographical scope of this research is the dry areas of Jordan where drought stress is the major biotic stress and where barley is often the only possible crop for resource-poor farmers. This area encompasses a range of agroecological conditions, all of which may be considered as low-potential environments for cereal production. Arable land is predominantly cultivated with barley landraces.

In Jordan, the popularity of barley among farmers, despite the failure to improve yields, lies in its use as feed for small ruminants (sheep and goats); meat, milk, and milk products represent the principal source of income for rural households in marginal areas. Barley grain and straw constitute the most important source of feed for the small ruminants throughout much of the year when grazing is in short supply. In the driest areas, a grain yield is obtained only one year in 10. And yet barley is sown every year, essentially as a forage crop whose value depends on biomass yield rather than grain yield (figure 1, table 1).

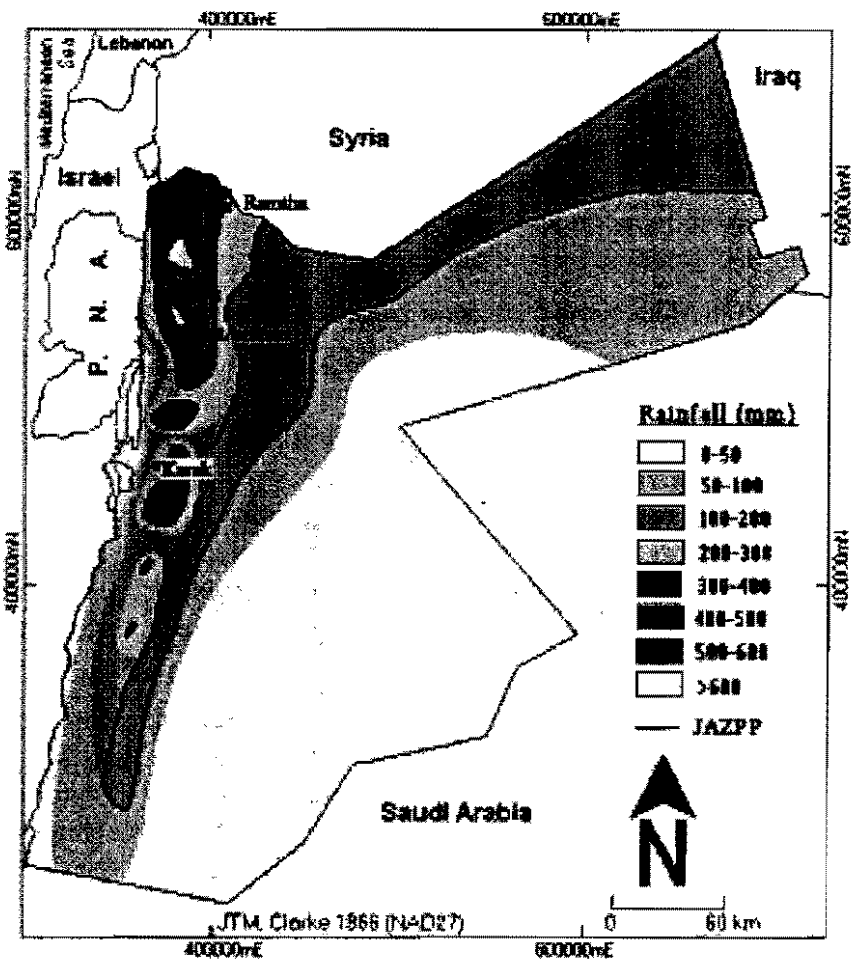

Figure 1. The rainfall zones of Jordan

Barley is mainly cultivated in the dryland areas that cover part of east Jordan. These areas are characterized by low rainfall, irregularly distributed, with most of the rain falling during the winter. Temperatures vary widely, with frequent frost in early spring and in late spring, resulting in head sterility, low yields (table 2) and often in crop failure. The unpredictable environmental conditions, along with poor soils and crop management, have made it difficult to introduce new cultivars and obtain yield increases.

Table 1. Planted Ares, Production, and Productivity of Barley in Jordan (1990–1997)

Year	Area thousand dunum	Production thousand ton	Productivity (kg/dunum)
90	34.44	36.4	1060
91	25.58	26.8	1190
92	83.63	103.2	1230
93	69.19	44.2	640
94	62.56	34.3	550
95	83.83	57.7	690
96	52.22	44.9	860
97	50.29	42.8	850
Average	57.34	48.8	883

Table 2. Mean Grain Yield, Biological Yield, Straw Yield, Plant Height, Harvest Index, Days to Heading, Days to Maturity, and Grain Filling Period at Four Locations in Jordan

	Locations				
Traits	Rabba	Khanasri	Ghweer	Ramtha	Mean
Grain yield (g/plot)	289.58	95.90	154.02	129.48	167.3
Biological yield (g/plot)	994.90	423.0	807.1	639.2	716.0
Straw yield (g/plot)	705.32	327.1	653.08	509.72	548.7
Plant height (cm)	59.50	33.1	47.9	56.6	49.3
Harvest index (%)	29.30	22.5	19.3	21.1	23.1
Days to heading (days)	118.50	110.8	85.6	128.7	110.9
Days to maturity (days)	152.0	137.8	113.2	155.9	139.7
Filling period (days)	31.50	24.0	26.5	24.2	26.5

Note: Data are the means of 84 barley lines during the 1996/1997 growing season.

Project objectives and expected outputs

The long-term goal of the project is the improvement of the welfare of small, resource-poor farmers by increasing and stabilizing barley and livestock production.

The immediate objectives of the project are

- to develop a participatory approach to breeding barley for stress conditions
- to improve barley varieties that fulfill the needs of poor farmers in the marginal rainfed environments of Jordan
- to enhance the rate of adoption of new varieties through farmers' participation in selection and testing

- to identify differences in selection criteria used by different types of farmers (according to gender, enterprise mix, and other farm characteristics)

At the end of the project we expect the following outputs:

- documented and validated information on farmers' objectives, knowledge, and field conditions
- the performance and quality, under both farmers' and station conditions, of barley lines selected by farmers in their fields, compared with the performance and quality of lines selected on the experiment station using breeders' selection criteria
- documentation of the selection criteria used by different types of farmers and/or different members of farm households
- a number of lines selected and developed through this participatory breeding program multiplied by farmers and tested by neighboring farmers
- the importance of the interactions between selection criteria and selection environment assessed
- incorporation of participatory approaches by the two national breeding programs

Methodology

Orientation and targeting

At each of the locations included in the project area, cooperating farmers ("host farmers"), who will host breeding plots and make individual selections, will be recruited from the pool of participants in previous on-farm research and cooperative research programs in ongoing research-and-development projects. A rapid-appraisal exercise will be conducted within the agricultural community associated with each of the selected agroecological locations, and a group of local "expert farmers" will be identified and recruited on the basis of reputation, key farming contacts, past performance, gender representation, producer and consumer categories, and self-selection. The expert farmer groups, together with the host farmers, will participate as key informants in the indigenous-knowledge study and will perform group selections from their respective host farmers' germplasm collections.

Indigenous knowledge

This component has several crucial outputs for developing the participatory-breeding approach. First, there will be an enquiry into farmers' objectives, reasons for producing barley, and different end-uses of the crop. This will include their perceptions of the difficulties they experience in reaching these objectives. Household economic security and risk considerations will also be considered in the context of production objectives and genotype evaluation.

The indigenous-knowledge study will provide the information needed for the analysis of concepts such as how farmers, both men and women, value various characteristics of the barley crop and how much they understand adaptation for specific environments and uses. The methodology for data collection and analysis will rely primarily on formal ethnographic techniques used in sociocultural anthropology, including participant observation, structured interviews, and taxonomic and componential analysis of labeled traits. As much as possible, barley characteristics recognized by farmers will be classified hierarchically to enable selection procedures to be applied one after the other according to priorities reported by farmers. Indigenous methods for recognizing desirable characteristics within populations of barley cultivars will be documented, and activities of farmers applying these methods will be recorded in detail.

An important aspect of this component is the identification of women's selection criteria, particularly, but not only, at those locations where barley is used for human consumption.

Specific outputs for this component include the following:

- evaluation of the innovative capacity of farmers and insight into their potential for direct participation in formal breeding programs
- lists of desirable characteristics, prioritized and cross-referenced to environment and utilization
- indigenous knowledge and perceptions of environment-genotype interactions in barley landraces
- the theory, objectives, and implementation of the participatory-breeding program will be discussed thoroughly with the host farmers and expert farmer groups in order to obtain their input into the design of the breeding scheme, including selection procedures, such as the proper time for selection, how often selection is done, etc.

From centralized nonparticipatory to decentralized participatory barley breeding

This component represents the major empirical thrust of the project and will quantify the effects of the selection environment (experiment station vs. farmer's field), of who does the selection (breeder vs. farmer), and whether these effects interact or vary from year to year.

The traits that farmers select for, and the criteria they use in their selection, will be recorded by the breeders and social scientists, and compared with objective measures of traits used by barley breeders, including the yield and quality of grain and straw.

A common set of lines and populations (including the farmers' cultivars) will be grown on a typically well-managed experiment station field and on one farmer's field at each of six locations in Jordan under farmers' management practices (fertilizer use, rotations, date and method of sowing, land preparation, etc.). The locations will be as follows:

Al-Mohay	60 km southeast of Karak and about 130 km south of Amman, with an annual rainfall of about 130–150 mm
Al-Muaqure	55 km east of Amman, in the arid areas, with an annual rainfall of 150 mm
Ramtha	160 km north of Amman, with an annual rainfall of 250 mm
Khanasri	135 km north of Amman, with an annual rainfall of 200 mm
Rabba	140 km south of Amman, with an annual rainfall of 340 mm
Ghwer	160 km south of Amman, with an annual rainfall of 280 mm

By including locations with less than 200 mm average annual rainfall, there will be opportunities to investigate the performance of breeding material in environments where barley is a forage crop rather than a grain crop. In addition, small grain-producing areas occur within the < 200 mm zone. These are seasonally flooded *wadi* floors (*marrabs*), where high grain yields are normal within a generally arid environment. Because of their importance locally, and the uniqueness of the agroecosystem, these locations are included in the project.

In the project area, the majority of farmers still grow barley landraces that are heterogeneous populations composed of a large number of individual genotypes. Although the population buffering of such heterogeneous populations—and, hence, their role in reducing the risk of crop failures—is well documented, we do not know whether farmers perceive this type of diversity as important and if this is the reason for the popularity of landraces. To gain information on this specific point, the genetic material will include high-yielding fixed or nearly fixed lines, segregation populations, and farmers' cultivars. The use of both pure lines and heterogeneous populations will provide a means for testing the attitude of farmers towards heterogeneity, as opposed to the conventional breeders' propensity for homogeneity.

The farmers' cultivars, which are likely to be different at each location, will be collected from each farmer during the harvest of the previous year, and all farmers' cultivars will be grown at each site. Selection will be conducted on the experiment station by breeders, and in each host farmer's field, selection will be conducted by both the breeders and the host farmers, their spouses, and/or other household members. Whenever possible, neighboring farmers will also participate in the selection process.

The collaborating farm householders will make selections from their fields. Following a group selection procedure similar to that used by ICRISAT in Rajasthan (ICRISAT 1996:98–100), the expert farmer groups will be asked to select material from that grown by their host farmers, material that they think would be useful for them and other farmers in their area. The selection will be conducted in such a way as to reveal the criteria being used by the farmers and others when they make their choices. There will be detailed discussions regarding the cultivars selected and the criteria used in selection. Farmers' observations, expected performance, and crop-management practices will be recorded.

At the end of the first year, in addition to the breeders' selections from the experiment stations, for each participating farmer, the following groups of selected lines will be available:

1. lines selected by the breeder
2. lines selected by the farmer
3. lines selected by other household members
4. lines selected by the farmer's neighbors

In the second year, each host farmer will grow all the lines selected in his/her field in the first year, regardless of who made the selection, i.e., groups 1 to 4 above, as well as the lines selected by the breeder in the experiment station. The selections will be grown as one population of lines without obvious distinctions between the groups to avoid any possible bias in the second cycle of selection. All the lines selected in the first year will also be grown on the experiment station in the second year to provide enough seed for the third year. Data on grain and straw yield will be collected at each host farmer's field and at the experiment station. Response to selection will be evaluated using the farmer's cultivar as reference. In the second and third year, selection will be done, as in the first year—on the lines resulting from the first and second cycle of selection. Thus, during the second and third cycle (year) of selection, the farmers and the breeders will be exposed to the material selected by each other. By the third year, the project will have involved a total of 36 households in the target area and will have simulated three cycles of selection of the same type of cyclical processes that take place in conventional breeding programs (figure 2).

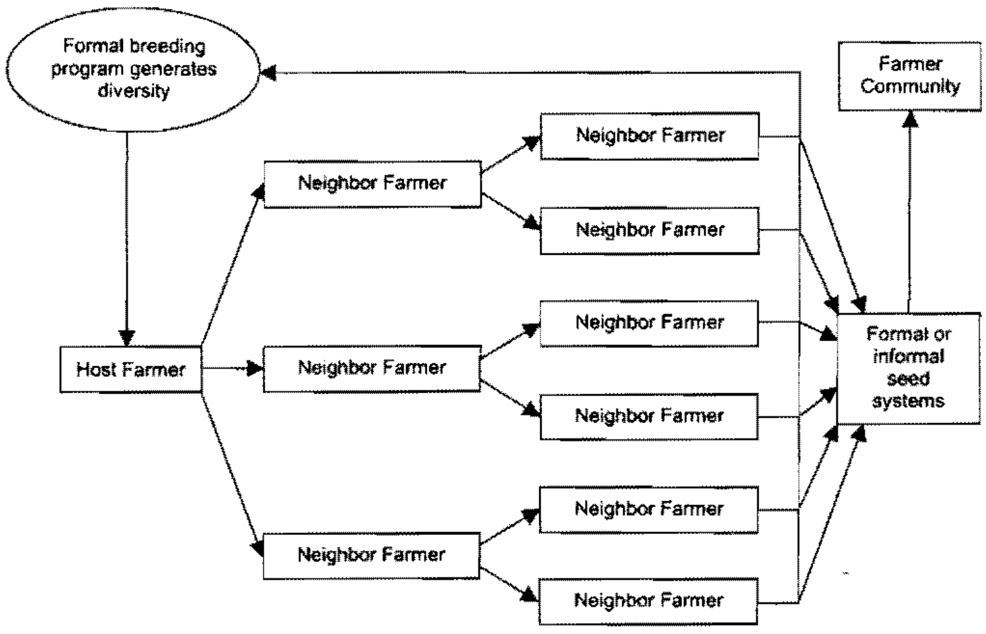

Figure 2. Scheme of the decentralized participatory barley-breeding program for one location (The number of farmers is arbitrary. The same scheme is repeated in six locations.)

During the selection process, the criteria of both farmers and breeders will be monitored and compared. Of particular interest will be the frequency with which the farmers, in the second and third year, select from the material they selected themselves in the first year and from among the material selected in the first year by the breeders. This will give not only an indication of the consistency of farmers' selection criteria, but also an indication of the possible effects of fluctuations in environment over years on genotype performance and farmers' perceptions of these effects.

This component is designed to quantify the following effects:

- the effect of the selection environment (experiment station vs. farmer's field) by comparing, both on the experiment station and on the farmer's field, the superiority over the farmer's cultivar of the lines selected by the breeder on-station with the superiority of those selected by the breeder in the farmer's field
- the effect of selection criteria (breeder vs. farmer) by comparing, in the farmer's field, the superiority over the farmer's cultivar of the lines selected by the breeder with the superiority of those selected by the farmer (this comparison will be extended to cover selections done by others, i.e., farm household members and/or neighbors.)

At the end of the first three years, it is expected that the number of selected lines will be small enough to stimulate the interest of the participating farmers, and possibly of some neighboring farmers, to grow one or more of them as commercial crops. The experimental material will be assembled and distributed by the barley breeders to ensure a uniform seed source.

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Present Status of Participatory Plant-Breeding Research on Wheat at the National Wheat Research Program of Nepal

M.R. Bhatta, G.O. Ferrara, B. Gurung, T.P. Pokhrel, N.R. Gautam, P. Gurung, and R.B. Neupane

Abstract

Participatory varietal selection work in the form of coordinated farmers' field trials involving farmers, extension agents, and researchers has been a regular component of the wheat-improvement program of Nepal since the 1970s. In this system, varietal testing is carried out in farmers' fields, but the participation of farmers in actual breeding work has varied greatly. Recently, more farmer-collaborative plant-breeding work has been initiated in the Bankatti village of the Rupandehi district. A pre-breeding participatory assessment involving 20 male and female farmers was conducted to determine the preference criteria that farmers employ in selecting for wheat varieties. There was some degree of variation in preference criteria listed by women and men farmers. Male and female farmers were allowed to select/evaluate 12 wheat varieties grown in farmers' fields at near maturity, based on preference criteria set out during the pre-breeding exercise.

This paper summarizes the results of the pre-breeding survey conducted at Bankatti village and the varietal evaluation done by male and female farmers. Comparisons are made between farmers' preferences and the traits set out by the National Wheat Research Program in developing wheat varieties for different domains.

Introduction

Wheat is the third most important cereal crop in Nepal, after rice and maize. Until the mid-1960s, wheat was considered a minor cereal and its cultivation was limited only to the far western hill region. Coordinated research and extension efforts in wheat during the last 30 years have significantly contributed towards an increase in the area planted to wheat and in production and productivity. At present, the wheat crop covers more than 640,000 hectares with a total production of 1,086,000 metric tonnes. The national average productivity of wheat is 1700 kg/ha (CBS 1999). Wheat occupies 22% of the country's total cultivated area and 20.2% of the total planted to cereals. It contributes 16.2% of the total cereal production in the country.

Although there has been a tremendous increase in area and production, national wheat productivity is still low, which is attributed to many factors. Some of these are a poor rate of seed replacement, slow varietal replacement, use of poor-quality seed by farmers, suboptimal fertilizer use, insufficient irrigation facilities, and a low farm-gate price. More than 90% of the wheat seed moves from farmer to farmer. The present seed-replacement rate is 4% to 5%, and a newly released variety takes five to 10 years to cover a large area, depending on the acceptance of the variety. Ninety percent of the country's wheat area is covered by modern wheat varieties; however, many farmers still grow old, disease-susceptible, low-yielding varieties, resulting poor yield.

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The national wheat research program was established in 1972 at the Botany Division in Kathmandu Valley. In 1975, the headquarters moved down to Bhairahawa, western *terai*, with the following national mandate:

1. develop, implement, coordinate, and monitor multilocational and multidisciplinary adaptive crop-improvement research for developing superior varieties resistant/tolerant to biotic and abiotic stresses for different agroclimatic conditions
2. collect, evaluate, identify, maintain, and use suitable donors for different biotic and abiotic stresses
3. develop appropriate crop-production technologies for optimal use of resources in a sustainable manner
4. produce a nucleus and breeder seeds of popular varieties in required quantities
5. establish national and international linkages for strengthening wheat-improvement research in the country

The National Wheat Research Program's wheat-breeding objectives are to develop wheat varieties with the following major traits:

1. high yield potential
2. resistance to multiple diseases
3. widely adaptive
4. medium in height
5. with bold, white grains
6. early in maturity
7. tolerant to late heat stress
8. tolerant to drought
9. tolerant to lodging
10. with high protein content (above 10%)
11. tolerant to sterility

Wheat-production zones

In Nepal there are two major wheat-production zones. One lies in *terai*, and *terai*-like areas in river basins and lower valleys up to 500 meters and the other is in the mid- and high hills, above 500 meters. The former zone represents 60% of the total wheat area and contributes 63% of the total wheat production in the country. This zone is further subdivided into three production environments: (1) rainfed, which represents 28% of the *terai* wheat area, (2) irrigated, which represents 72% of the *terai* wheat area, and (3) Late-sown, which represents 25%–30% of the wheat in the *terai*. Rice-wheat is the dominant cropping pattern in this zone. The mid-hills represent about 40% of the total wheat area and production, and the high hills, about 37%. In these areas, wheat is grown after rice-wheat in irrigated *khet* land and after maize and millet in rainfed *bari* land.

The wheat-research program has released 27 improved wheat varieties since 1960, and if we look critically at their adoption rate, five out of 27 have very high adoption, 10 have high, six have low, and five out of the 27 have a very low adoption rate (table 1).

Present yield gap

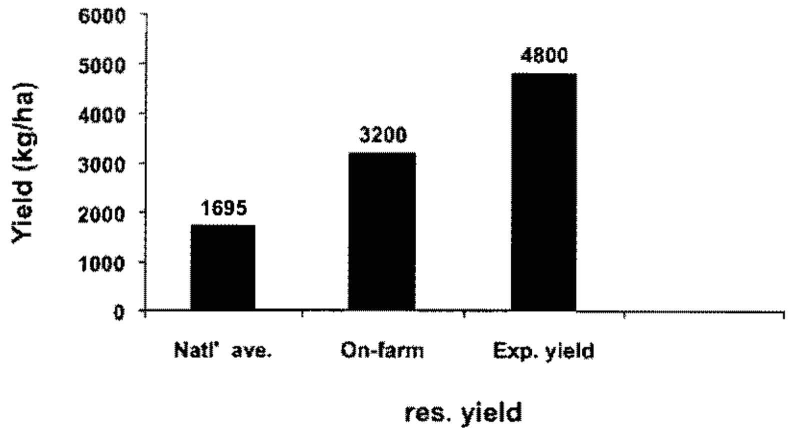
Figure 1 clearly indicates the research-generated technologies practiced on experiment stations, revealing a 4.8 t/ha grain yield, compared to 3.2 t/ha obtained in farmers' field trials. However, the

Table 1. Improved Bread Wheat Varieties Released Since 1960 and Their Adoption in Nepal

Variety	Pedigree	Year released	Area of adaptation	Adoption
Lerma-52	Mentana/Kenya 324	1960	Hills	High
LR-64	Y50/N10B//L52/3/2*LR	1967	Hills	Very low
Pitic-62	YT54/N10B 126.16	1967	Hills	Very low
Kalyansona	Pj"S"/Gabo 55	1968	Terai	Low
RR-21	II54-388/AN/3/YT54/N10B//LR64	1971	Hills and *terai*	Very high
NL-30	HD832-5-5-OY/BB	1975	Western *terai*	Low
HD 1982	E5557/HD845	1975	Western *terai*	Low
UP 262	S 308/BAJIO 66	1978	Terai	Very high
Lumbini	E4871/PJ62	1981	Terai	Very low
Triveni	HD1963/HD1931	1982	*Terai*	Low
Vinayak	LC 55	1983	*Terai*	High
Siddhartha	HD2092/HD1962// E4870 /3/K65	1983	*Terai*	High
Vaskar	TZPP/PL//7C	1983	Mid-west *terai*	Very low
Nepal 297	HD2137/HD2186// HD 2160	1985	Terai	Very high
Nepal 251	WH147/HD2160// WH147	1988	*Terai*	High
Annapurna 1	KVZ/BUHO//KAL/BB	1988	Hills	High
Annapurna 2	NPO/TOB//8156/3/ KAL/BB	1988	Hills	Very low
BL 1022	PVN/BUC	1991	Western *terai*	High
Annapurna 3	KVZ/BUHO//KAL/BB	1991	Hills	High
Bhrikuti	CMT/COC75/3/PLO// FURY/ANA75	1994	Terai	Very high
BL 1135	QTZ/TAN	1994	*Terai*	High
Annapurna 4	KVZ/3/CC/INIA//CNO/ ELGAU/SN64	1994	Hills	High
Achyut	CPAN168/HD2204	1997	Terai	High
Rohini	PRL/TONI//CHIL	1997	*Terai*	Very high
Pasang	PGO/SERI	1997	Hills	Low
Kanti	LIRA/FUFAN17//VEE#5	1997	Hills	Low
BL 1473	Nepal 297 /NL 352	1999	Terai	?

national average is 1.7 t/ha, clearly indicating that a threefold yield increase—compared to experiment-station yields—and a twofold increase—compared to farmers' field trials—is possible.

To achieve this, new technological advances are to be made in the area of crop improvement through participatory plant breeding and participatory varietal selection. This will facilitate the rapid adoption of newly released varieties, along with a faster seed-replacement rate. And ultimately, farmers will get varieties with their preferred traits. This will further help in the identification and release of location-specific wheat varieties for different agroecological niches.



Source: Mudwari, Bhatta, and Pkharel (1998).

Figure 1. Present yield gap in experimental plots and on-farm research plots compared with national average yields

Participatory crop improvement

The National Wheat Research Program has been involved in participatory crop-improvement activities since the 1970s, in the form of coordinated farmers' field trials (CFFTs), farmers' acceptance tests (FATs), frontline on-farm research, district seed self-sufficiency programs, supplying experimental germplasm to different nongovernmental organizations (NGOs), and participating in joint monitoring trips to evaluate wheat genotypes with farmers.

Figure 2 illustrates the present and past wheat varietal development process of the wheat variety release system. Farmers' informal participation starts from the initial evaluation trial onwards, where farmer-visitor groups are allowed to evaluate wheat genotypes planted at different research stations. Coordinated farmers' field trials are carried out in the farmers' fields in multilocational test sites. The genotypes in on-farm trials are evaluated jointly by farmers and researchers. As in farmers' acceptance tests, small seed kits of pre-released and released varieties are distributed to a number of farm families throughout the country, along with a questionnaire to be returned by them. The questionnaire used in evaluating coordinated farmers' field trials and the farmers' acceptance test are given in annex 1. Frontline, on-farm research is a triangular activity where farmers, extension personnel, and research scientists are involved right from site selection to variety evaluation. In frontline research, a complete technology package is introduced, along with an improved variety, in a large area where many farmers are allowed to join in. In the district seed self-sufficiency program, the multiplication of seed from recently released varieties is carried out jointly by farmers groups, extension personnel, and research scientists. The seed produced is procured and marketed by the farmers groups themselves. A part of this wheat-research program is continuously supplying genetic materials to several NGOs and actively participating in variety-evaluation work.

Thus, with the involvement of farmers and various developmental agencies, the participatory crop-improvement program could help in (1) the identification and release of farmers' preferred varieties, (2) the release of location-specific varieties for diverse agroclimatic niches, (3) faster

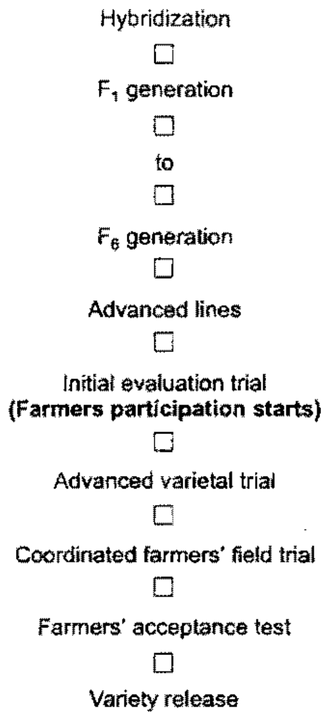


Figure 2. Variety release system followed by National Wheat Research Program

adoption of newly released varieties, (4) higher seed replacement and varietal replacement within short periods of time, and (5) the incorporation of a gender perspective on farmers' preferences in formal plant-breeding research.

Materials and methods

A participatory assessment to determine the preference criteria that farmers employ in selecting wheat genotypes was carried out at Bankatti village in the Rupandehi district. Twenty male and female farmers were invited, divided into two groups by gender, and asked to list the traits that they preferred in selecting wheat genotypes. After listing their preference criteria, individual members were allowed to rank the preference criteria. Based on their preference criteria, 12 wheat varieties with two replications were planted in farmers' fields in Bankatti village. These differed in maturity, height, tillering, grain size, disease response, grain yield, and other traits. At physiological maturity, women and men farmers were allowed to select wheat genotypes based on the preference traits listed and ranked previously. A format-containing list of 12 wheat genotypes and preference traits listed by the two groups was distributed to both the groups, and they were asked to rank the genotypes from one to 12. After harvesting the crop, farmers were asked to rank the grain size and color for their preference. Grain-yield samples from the harvest were weighed, adjusted to 12% moisture, and analyzed statistically.

Results and discussions

The preference criteria set by the two groups is presented in table 2. The women's group listed 12 traits, while men listed only nine traits. There were eight traits that were common to both groups. If we compare the criteria set by the two gender groups for selecting wheat genotypes and those set by the National Wheat Research Program, we can see many similarities, except in some traits related to quality, drought, and sterility. This is because Bankatti is an irrigated and sterility-free area and farmers have never experienced drought and sterility. Table 3 reveals the preference criteria set by the two gender groups after ranking in order. It clearly shows the differential ranking of traits by gender. Men gave top priority to tolerance to late heat stress, followed by large, white grains and tolerance to shattering, while women ranked resistance to diseases first, followed by high tillering and high yield.

Table 2. Preference Criteria Set by Women and Men Farmer Groups Separately for Selecting Wheat Genotypes (Pre-Breeding Survey)

Women	Men
1. Shattering tolerant	Shattering tolerant
2. Lodging tolerant	Lodging tolerant
3. Good chapati (soft)	Good chapati (softness)
4. High yielding	High yielding
5. Disease resistant	Disease resistant
6. Medium height	Medium height
7. Early maturity	Early maturity
8. Bold and white grain	Bold and white grain
9. High tillering	Late heat stress tolerant
10. Resistant to pests	
11. Large spike	
12. Short awns	

Table 3. Preference Criteria for Women and Men Listed by Ranking in Order of Priority

Women	Men
1. Resistance to diseases	Late heat stress tolerance
2. Early in maturity and pest resistant	White large grains
3. High yielding	Shattering tolerance
4. High tillering	Disease resistance
5. Medium height	Lodging tolerance
6. White bold grains	Early in maturity
7. Lodging tolerance	High yielding
8. Large spikes	Medium height
9. Good taste for chapati-making (softness)	Good taste for chapati-making (softness)
10. Resistance to shattering	
11. Short awns	

Tables 4 and 5 show the preference ranking of wheat genotypes by women and men farmers, respectively. Both the groups selected BL 1473—a recently released variety—as the number one choice, followed by Nepal 297. The differential ranking appeared when selecting the third genotype, where women group ranked NL 731 as third and the men group selected Bhrikuti (table 6). Table 7 represents the genotypes evaluated, along with their main characteristics. It can be seen that the farmers' number one choice is not grain yield but other important traits like bold grain, earliness, and disease resistance.

Table 4. Preference Ranking of Wheat Genotypes by Women Farmers at Physiological Maturity

Traits	Wheat genotypes											
	NL 297	NL 750	NL 731	Bhrikuti	NL 753	BL 1473	NL 872	NL 781	BL 1724	NL 783	BL 1692	BL 1810
Disease resistance	2	5	7	5	5	1	12	4	3	10	9	3
Early maturity	2	11	4	5	7	1	8	12	4	7	4	6
High yielding	5	8	4	6	8	4	6	10	3	2	10	5
High tillering	7	4	6	4	7	6	5	1	2	2	8	5
Medium height	4	3	2	3	5	2	12	3	4	5	5	2
White and bold grains	1	7	2	5	4	1	5	11	9	5	7	6
Lodging tolerance	3	4	4	3	4	1	2	2	4	5	2	6
Large spike	8	9	3	4	4	4	4	10	4	2	8	6
Good chapati												
Shattering tolerance	1	8	5	6	7	6	6	6	6	5	9	8
Short awns	4	3	4	4	5	5	2	1	3	5	6	4
Total	37	62	41	45	56	31	62	60	42	48	68	47
Ranking order	II	X	III	V	VIII	I	X	IX	IV	VII	XI	VI
Overall ranking	IV		V			I			II	III		

Table 5. Preference Ranking of Wheat Genotypes by Men Farmers at Physiological Maturity

Traits	Wheat genotypes											
	NL 297	NL 750	NL 731	Bhrikuti	NL 753	BL 1473	NL 872	NL 781	BL 1724	NL 783	BL 1692	BL 1810
Heat-stress tolerance	3	10	5	2	7	1	9	12	11	8	4	6
White and bold grain	2	11	3	6	4	1	7	10	7	6	3	4
Shattering tolerance	3	12	4	6	4	7	5	11	6	6	8	10
Disease resistance	7	5	4	5	6	2	12	1	2	7	11	8
Lodging tolerance	1	1	1	1	1	1	1	1	1	1	1	1
Early maturity	3	10	4	7	7	2	9	12	6	8	2	5
High yielding	4	12	2	4	10	5	9	7	2	11	6	7
Medium plant height	1	1	1	1	1	1	2	1	1	1	1	1
Good chapati												
Total	24	62	24	32	40	20	54	55	36	48	36	42
Ranking order	II	X	II	III	V	I	VIII	IX	IV	VII	IV	VI
Overall ranking	IV		III			I			V			II

Table 6. Differential Ranking of Wheat Genotypes by Gender Group

Women	Men
1. BL 1473	BL 1473
2. Nepal 297	NL 731 and Nepal 297
3. NL 731	Bhrikuti
4. BL 1724	BL 172 4 and BL 1692
5. Bhrikuti	NL 753

Table 7. Wheat Genotypes Evaluated in On-Farm Site Bankatti along with Main Characteristics

						Diseases	
Genotype	DH	DM	PHT	TGW	Grain yield kg ha^{-1}	HLB	LR
BL 1692	75	123	85	44	4000	84	0
BL 1724	80	123	93	41	4000	73	0
BL 1810	79	125	91	41	3575	83	0
NL 750	85	126	91	41	3950	73	0
NL 731	82	123	96	44	4400	84	0
NL 753	79	123	93	44	3750	84	0
NL 781	85	127	89	42	3700	73	0
NL 783	82	125	95	41	3875	83	0
NL 872	84	126	89	44	3900	86	60S
Nepal 297	77	123	89	47	3250	85	20S
Bhrikuti	80	124	89	41	3750	83	0
BL 1473	77	123	99	45	3500	73	0
Mean					3804		
F test					NS		
CV %					13.24		
LSD					—		

Conclusions

The results of this exercise revealed the following:

1. Farmers have vast knowledge and skills regarding varietal preferences and evaluation techniques (i.e., they can truly identify suitable genotypes and can look very critically at their farming system).
2. Women farmers seem to have an inherent ability to look at the required traits faster than male farmers do.

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Annex. Existing format for evaluating genotypes in on-farm varietal trials

A. Coordinated farmers' field trials

Questions to the farmers:

1. Which variety do you like the best?
2. Reasons for liking the variety

   a)
   b)
   c)
   d)

3. Which variety do you plant next year? ________
4. Researcher's comment about the varieties tested.

B. Farmers' acceptance test

Answer the following questions or tick mark in the correct places

1. Wheat variety planted _____
2. Date of planting _____
3. Wheat planted on (a) Khet ____ (b) Bari ____
4. Fertilizers used (kgs) (a) Urea ____ (b) DAP ____ (c) Potash ____ (d) FYM ____
5. Number of irrigation applied _____
6. Area planted _____
7. Date of wheat harvest _____
8. Grain yield (kgs) _____
9. Did you like this variety _____ Did not like _____
10. Reasons of like and dislike _____
11. Did have saved the seeds of this variety? Yes _____ No _____
12. Area are you going to plant this variety next year? Yes _____ No _____
13. If yes, how much area? _____
14. How did you like this program _____
15. Comments and suggestions of agriculture technicians about this variety _____

Conserving Agricultural Biodiversity

Sundaram Verma

Abstract
Research on chilis and agroforestry that received the 'Using Diversity Award' from the International Development Research Centre (IDRC), Canada, is briefly presented.

Introduction

The Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) has extended administrative support to the International Development Research Centre (IDRC), Canada, for monitoring the Using Diversity Awards—a small grant of approximately Rs 3 lacs each, given to individuals and institutions for conservation of agricultural biodiversity in South Asia.

This research award has provided support to my research ideas and enabled me to continue with experiments, successfully proving that locally developed varieties can be superior to the commercially released high-yielding varieties.

Under the Using Diversity Award Program, the different chili varieties were exhibited at the Golden Jubilee celebrations of the Agricultural University, Jobner, Rajasthan, India. The Governor of Rajasthan, along with a large number of scientists, farmers, teachers, and students of schools and colleges (a total of 10,000 people) were among the audience at the exhibit.

Table 1. Salient Features of My Results

S. No.	Name of crop	Number of varieties	Unique characteristics as compared to varieties developed by agricultural scientists
1.	Garlic	12	Higher productivity in 1 variety
2.	Onion	10	6 varieties with higher productivity
3.	Cluster bean	22	3 varieties with higher productivity
4.	Sesame	5	1 variety highly productive and resistant to red rot disease
5.	Green gram	5	1 variety performing better if sown out of season
6.	Cabbage/ Cauliflower	8	1 variety suitable for sowing Ageti, Madhyam, and Pichhchoti
7.	Fenugreek	16	2 varieties highly productive and 3 varieties resistant to *chachia* disease
8.	Check pea/ Bengal gram	20	4 varieties resistant to root rot disease
9.	Millet	36	2 varieties drought resistant, 1 variety highly productive
10.	Coriander	31	11 varieties highly productive
11.	Cumin	101	2 varieties resistant to *jhulsa* disease
12.	Chili	48	2 varieties high yielding, 1 variety with higher color value as compared to Rallis hybrid seed company
Total		314	

Sundaram Verma is a farmer in Rajasthan, India.

My experiments in dry farming and agroforestry

This is another area of my experimentation and innovation. I had learned the basic techniques of dry farming in the young farmers' learning course at the Indian Agricultural Research Institute (IARI) in 1982. The water needed for irrigation was very scarce. The only persisting problem was to stop evaporation and water loss by capillary action. This could be done by breaking capillary movement and controlling weed growth by plowing or digging into the soil up to 20 cm in depth. This should be done twice—10 days after the first monsoon and just after the last monsoon.

Table 2. Comparative Analysis of the Two Varieties of Chili

Features	Danta variety (Sundaram Verma's)	RS1 variety (Rajasthan Select)
Sowing time	Late sowing (April)	Sowing usually in February-March
Pest attack	Less	More
Pest and disease resistance	More	Less
Cold resistance	More	Less
Flowering	All at the same time (in flushes) But 5–6 times	Not at the same time 10–12 times
Time between pickings	More	Less
Production	200–225 quintals/hectare	150–170 quintals/hectare
Color value	Three times more than usual	Average
Dry weight	More	Less
Market value	Two times more than usual	

Note: Danta selection is compared to the existing two varieties of chili, namely RS1.

Table 3. My Experiment in Dry-Land Forestry

Description	General procedure	Sundaram's method
Sowing season for tree seedlings	Before monsoon	After monsoon
Preparatory procedures	Pits are dug	Pits not required
Irrigation	Each plant requires 15 liters of water at least 4 times	A single plant requires only one liter once and no extra watering
Cost	Proves to be more expensive	Proves to be less expensive
Type of trees	Most of the times only thorny shrubs survive	Any kind of tree can be planted (fuel wood, fodder, or other wood-yielding varieties)
Survival rate of planted saplings	50% to 65%	80% to 90%

Experience, Research, and Facts Related to Local Species of Paddy

Chapel Div Bhagat Mali
Assisted by
Pashupati Chaudhari and Parmananda Chaudhari
Bara

Abstract
This paper presents a discussion of the qualities of local species of paddy rice, along with the advantages of growing it—marketability, flavor, use in religious ceremonies—from a farmer's perspective. It also compares production technologies for local paddy and improved varieties, with information on traditional techniques for seed management.

Use and importance of the local species

I am Kapil Dev Bhagat Mali, an ordinary farmer owning about one and a half *bigha* of land in Bara and supporting a family of five members. I have been cultivating the same local species of paddy in the traditional method as had been practiced by my ancestors in the past. I have both types of land—*bhadaiya* and *aghahani* land. (In *bhadaiya* land there is a winter crop and in *aghahani* there is the summer crop.) In both types of rice fields, I cultivate local species of paddy. The advantage of the local varieties is their power to resist diseases and pests, and less labor is needed in weeding. This paddy gives good turnover despite less fertilizer and less water. Besides better production, in our religious and social rituals, only the local paddy is accepted and we cannot make use of the improved variety. In such sacred rituals, all types of *aghahani* species and in *bhadaiya*, the *sathhi* species are of great importance in the local community. The paddy species locally called *Sokan* and *Sotawa*, are even given to patients suffering from high fever, as the rice texture is soft and readily digested. In fact, some of the local types of paddy are no less in production than the improved varieties. Another advantage of the local paddy is that even in less fertile soil, it gives an excellent harvest. Some species of the local paddy have good production in deep-water fields and some other local species are equally good in rather dry fields too. However, in both these types of land—wet and dry—the improved species of paddy cannot be cultivated.

Special qualities of some of the local species of paddy

I have seen many local species of paddy and have also personally experienced their cultivation. Each of the local species has its own specific characteristics and qualities. I am giving a brief description of the specific qualities of the local species of paddy:

- Among the *aghahani*, the *Basmati* has a special fragrance, hence it is called *Basmati*. It is very tasty and very costly.
- In Aanga there is *tunda*; so these local types are not easily attacked by diseases and pests.
- The *Dudharaj* variety is thick textured, and it is white in color; hence, it is called *Dudharaj* (king of milk). This species grows equally well in all types of land, wet, deep, or dry land.
- The species called *Bhathi* is grown in deep water. It can grow equally well in fields that have water as deep as a man's height.
- *Budhi dayan* is another species of paddy that can be cultivated in high or low places. It is good for making beaten rice (*chiura*) and the rice is also excellent.
- *Anandi* is rather sticky in texture and is very good for rice dishes.
- The *Karma* species can be cultivated in both types of land, in high and low areas. The rice in yellow in color and has a very good taste.

- *Kamodh* is fragrant and delicious and grows equally well with less fertilizer.
- *Lajhi* is fairly good, grows well in less fertilized fields, is good for daily consumption, and the production is high—about two and a half *maund* of rice per each *katha* of land, almost equal to the improved variety.
- *Mansara* and *Mansari* have good straw and are very good for daily use.
- *Bachi basmati* (*Chanchur*) is fragrant, good for eating and makes good beaten rice (*chiura*)

Production technology and production status of the local and the improved varieties of paddy

- The local variety, in comparison to the *Bikashe*, is much less in production, but in order to get a good return on the production of the *Bikashe* species, there must be proper provision of fertilizers, good irrigation facilities, and as they are easily attacked by pests, it is necessary to make the field pest free with pesticides. Having provided all these facilities in cultivation, then there is only the possibility of getting 3 to 4 *maunds* of paddy per *katha* of land. But the local species, depending on the monsoon rain, with less manure and fertilizers and without the use of pesticides, can produce paddy in the same ratio as the *Bikashe* variety.
- In the case of paddy saplings to be replanted in the field, the timing is very important for the *Bikashe*, but for the local species, there is no such limitation, as the saplings can be either 15 to 20 days old or 35 to 40 days old.
- The straw (*paral*) of *Bikashe* paddy from one *katha* of land is equivalent to the straw from local species covering an area of 10 *kathas*.
- If the family members are few in number, it is not wise to cultivate *Bikashe* species because it requires great labor, as in sprinkling pesticides, spreading fertilizers, weeding, etc.
- Those farmers who cultivate *Bikashe* paddy make use of *tyanki* but I have never used any such thing.
- I experimented by cultivating two species of paddy in one field: in half the field, the *Bikashe* species called *Masula*, and in the other half, local varieties called *Dudhraj* and *Chhataraj*. In both, I used equal measures of irrigation and fertilizers, and I didn't find much difference in paddy production. I used 2 kg of urea fertilizer in each *katha* of land.
- Though I have the facility of irrigation in my field, I will not discontinue cultivating the local paddy because, with good irrigation, the rate of production of local species will also be equally high.

Cost differences between local and *Bikashe* (improved) paddy

The cost of the *Bikashe* paddy called *Mansuli* is Rs. 100 more per quintal than the local species of paddy. But rice varieties like *Basmati* and *Kamodh* are one and a half times more than *Mansuli*. During festivals like the *Tihar* (*Dewali*), the cost of local species of paddy like *Sathi* and *Khera* is higher than at other times. Besides the production of rice straw (*paral*) being more, if the sale of rice and straw can be made together, there is greater profit in the cultivation of the local breed of paddy.

Role of farmers in improving paddy harvest

In improving the paddy harvest, farmers have very important roles to play. If it had not been for the farmers who carefully kept the seeds of different species of paddy, it wouldn't have been possible for the scientists to bring about the improved variety of seeds now. In fact, they would not be able to see the present species of paddy that we have now carefully conserved among us. Besides, if we had not brought seeds from our relatives, neighbors, and other people, all the different species found now would not be available. It is because we have continued to cultivate with the old, traditional methods, selected the seeds, dried them, and stored them locally that these local species are still found now. Therefore, the extensive practical knowledge that we have of the local species of paddy, now, is also not with the research scientists.

Non-formal seed-management techniques

We are continuing to apply the same old technology in seed selection. When we keep the seeds for planting, we either select the seeds after we bring the paddy into the huge circular space (*khalihan*), or after the paddy has been de-husked, or from the storage room itself we select the seeds for the next planting. Since the different species of paddy are repeatedly threshed in the same spot (*khalihan*), there is the possibility that every year there is some degree of mixing up of seeds. Then there is again the possibility of mixing up seeds in storage, or by planting seedlings together in the same nursery. Sometimes the flow of water carries away the seeds and mixes up the seedlings, or they are mixed up in the process of keeping *henga*, or due to birds and animals. So there are many chances of mixing the different breeds and species of the paddy. Some farmers deliberately mix the different species of paddy in order to secure a good profit in the market. For this reason, these farmers mix together varieties of the same type of color and size so that nobody can see the discrepancy and find out the farmers' profit-oriented motives. For example, it is found that farmers mix *Mansara* in *Basmati*. *Mansara* looks rather like *Basmati* but is thicker in texture.

After the paddy has been separated from the stalks by threshing, it are kept in the *khalihan* (the huge circular floor for threshing the paddy) for a day or two to dry, and after that , it is weighed and stored in *bhakari* (huge cane baskets painted with a paste of mud and cow dung). If this storage is full, then the paddy is kept in sacks, and the next year, the seeds are taken from this stored container for paddy plantation. If it is necessary to bring seeds from neighbors, then the seeds are exchanged at the ratio of one sack of paddy seed to one and a half of de-husked rice. If the seeds are brought directly from the *khalihan*, then the exchange rate is the same in ratio. Likewise, sometimes the seeds are borrowed from relatives, sometimes bought from the market or at times exchanged or even bought from other farmers.

Training and tours

I have taken two training courses, about one or two days in potato cultivation. In terms of tours, this year I have visited the Paddy/Rice Harvest Research Center in Hardinath, organized by NAARC, LI-BIRD, and IPGRI, where I got to see the excellent species of paddy cultivation as well as our local varieties of paddy, which were grown there for study and observation. So now, I feel the necessity for us to be given training and skills in proper methods of keeping seedlings to maximize production from our local paddy species as well as technology in irrigating and fertilizing.

Conclusions

I am a small-scale farmer, cultivating a small plot of land and sustaining my small family, trusting the maxim that "contentment is bliss," and I have continued with the traditional technology of local paddy cultivation practiced by my ancestors since the remote past. I know that the local variety of seeds have many good qualities which are not available in the improved/*Bikashe* seeds. The local varieties have less chance of being attacked by diseases or pests, they are able to withstand climatic conditions, and give good production with less fertilizer and less care than the improved varieties. Besides these, the local varieties are delicious for eating, are acceptable in religious rituals, and have medicinal properties. Some varieties also have a higher market value than the improved variety of rice. It is not only difficult and labor consuming to cultivate the improved variety of seeds, but in terms of rice production, there is not much difference if the method of cultivating both types of rice is carried the same way.

I believe that farmers who are committed to developing improved varieties of paddy seeds must give equal importance to protect and promote the local varieties of seeds because these seeds are the basis for future improved varieties of species that can give better production at harvest. So if the government itself took the initiative to give the required training and make arrangements for educational tours, then the farmers could contribute better in farming and cultivation. We farmers are much behind in farming skills. We do not have the knowledge of the latest technology in farming. So we follow the same old technology that our ancestors have followed from past times. About selecting and keeping the seeds, storing them, we have the same traditional techniques. When we don't have seeds of our own, then we borrow from our relatives and friends as we don't trust the seeds that we buy out in the market. Neither have there been any effective measures taken by the government to ensure good storage systems for seeds to have better production.

Suggestions and recommendations

I request our farming community brothers and sisters to continue to cultivate our local paddy. Though less in quantity, the local species have less of a chance of pest and disease infestation, require less fertilizer, and grow equally well. Even in insufficiently irrigated fields, the production is good, and these local varieties are acceptable in our sacred and social rituals. As cooked rice also, it is delicious and it is good for our health. In poor soil also, it gives good production. If we let the local varieties and species disappear, then there is less chance for developing improved seeds for the future use.

Today the need is for an initiative that must be started from the government level to protect the local paddy seeds, which are fast disappearing and unaccounted for: to conserve, to protect, and to highlight them through local development clubs, district-level agriculture development offices, the Agriculture Ministry, departments, etc. The scientists must not only work towards making the rice grains from long to short or bringing greater production, but they must also make provisions for the availability of proper irrigation systems. In a similar manner, the government must also make provision to supply fertilizer in time, good seeds and the means to control and destroy the diseases and pests that attack the improved varieties.

Problems of Maize Cultivation and the Role and Approach of Local Farmers in Solving this Problem

Sri Hari Prasad Aryal
Secretary
Maize Cultivation Research Committee
Darbar, Gulmi

Abstract

Maize is the main crop in this village in the Gulmi district of Nepal. Farmers from this village discuss their experiences participating in maize-improvement research with the Local Initiatives for Biodiversity Research and Development (LI-BIRD). The farmers preferred their traditional variety for its flavor and fodder, but it tended to fall. This paper describes how they worked with LI-BIRD on maintaining the characteristics they preferred in their traditional maize variety, while working to overcome the problem of its weak stems.

The majority of the people in the Durbar Devisthan VDC in the district of Gulmi, which falls under the Western Development Region, are dependent upon agriculture. In this area, the prominent crop is maize. Other species of maize are also planted, but in this hilly region, the most common species is the large-sized yellow-colored variety. This type of maize is remarkable for greater production and the higher amount of fodder for animals, and the corn is delicious to eat. So the main crop here is maize, but farmers are facing a great problem as the maize plants have the tendency to fall. Other problems are related to the lack of irrigation facilities, the problem of pests and diseases, and also the scarcity of better technology to improve our crops.

We are making our own efforts to solve the problem of maize plants falling down easily. What we do is when the plant is about 20–30 days old, we dig and weed out the grass around the saplings. Then when the plant is about 45–55 days, then there is a special type of digging done just to loosen the roots, and we cut one side of the root, loosen it, and lay the plants on the soil. This stops the growth of the height of the maize plants for some days and the root is strengthened. Some farmers also plant maize in straight line.

Sometimes, after weeding out the grass around the maize saplings, the soil is pressed around it. In this way the farmers make great efforts to prevent the maize plants from falling down easily. Initially, when the Local Initiatives for Biodiversity Research and Development (LI-BIRD) came visiting our village, we were most happy. All of us villagers gathered together. At that time they were in the process of choosing the appropriate place to carry out their research. We requested them to carry out the program in our village only, so that we too could participate in the program.

After that, it was settled that the program would be conducted in our village. Under this program, they told us their plan—that they would give us new improved species of maize seeds, and we could choose those species that would be most suitable under our soil and climatic conditions. About this, we were not in agreement as we knew that the species of maize that we locally grew, the big yellow variety called *Piyalo,* was good for us. We were not willing to change from the local variety because this species gave a good harvest, the quantity of corn-flour after grinding was more, it was delicious either dry roasted or grilled over the fire, and the maize plants also provided excellent fodder for our animals. The LI-BIRD teachers had asked us whether we would grow a species of maize that was very similar to the *Piyalo* variety in taste, production, and as fodder, but the maize plants would be shorter in height.

We suggested that we didn't want any of the new variety but we would be happy to be taught the techniques to prevent the *Piyalo* maize plants from falling down easily. Then we asked if there could be improvements in this variety. So as we wanted, LI-BIRD is helping us to improve the big variety of *Piyalo*. We have started a cross-pollinating program in which we have crossed the big variety of *Piyalo* with improved varieties. Another program is mass selection. In this, the main work is to improve the big-grained *Piyalo* itself, by separating and selecting seeds from tall, weak maize stalks, identifying and marking poor seeds by removing the straws from such ears. We have done other programs too, and our farmer brothers have experimented by growing other improved varieties. Some of the species have also been appreciated by our folk. Likewise, we have also considered the 36 varieties of maize species brought by CIMMYT, and from among them we have selected some species for cultivation.

In this way, LI-BIRD has helped us to solve our problem and to bring improvement to the cultivation of maize. We have been given training in how to do cross-fertilization and mass selection. We farmers are also committed to improving the species of big *Piyalo* and we are very optimistic about this improvement. It is true that we have learned about crossing the maize species and plucking out the straws from weak and tall maize stalks in order to select good seeds, but still, we feel that if we are trained in other methods of improving our crop production, we would be capable and successful farmers. Therefore, through mutual efforts, understanding, and cooperation among our farming community and NGOs, we would surely be able to bring out improved maize species like the yellow *Piyalo* variety according to the suitability of our soil and weather conditions.

There Is the Possibility of *Simichaur* Becoming *Makai Chaur*: My Experiences in Crossing Maize Species

Mrs. Lal Kumari Basnet
Daha
Simichaur, Gulmi

Abstract
A maize farmer describes her experiences learning and using new technologies for improving her maize crop.

From the earliest times, Simichaur was known for cultivation of maize. Every year we suffered losses through the falling down of maize plants. Now we have an office that helps with maize cultivation, so we are happy. The species we grow is the big yellow variety, but the main problem with this species is, the plants fall down. But we are still continuing with this species, only because it is delicious to eat, either roasted dry or as corn meal; it gives more corn flour, grows more, and gives much fodder for our domestic animals.

In order to protect the plants from falling, we have a procedure by which we weed out the grasses and cut the roots on one side. In this way, the growth is controlled and the plant is strengthened. But then the falling process continues. Then we slash out the leaves. This makes the leaves less dense and there is plenty of space for the movement of winds. Even then the plants fall. So whatever means we have taken until now to protect our plants from falling, we still have no solution and this problem continues to be among us.

The teachers came. All of us—the village farmers—gathered. They asked us what species of maize we cultivated. We replied the species we grew were the big yellow variety *Khumaltar* and the small yellow variety. We told them that we liked the big yellow variety but these plants always fall. We asked them if there was the possibility of making this big yellow variety not fall. The teachers said that they had not come to make the maize plants not fall but they came to visit the villages in order to introduce new species of maize that we could grow in Simalchaur. If the local people didn't want to change the species of maize they have been cultivating and if they wanted to find the means to prevent the plants from falling, they could all work together to find the solution to their problems. Then we exchanged ideas as to how to prevent the plants from falling, and we farmers became participants in the discussion. We discussed the ways and means of solving the problem and then we reached our unanimous decision to create a new species by making the yellow variety of maize smaller in height.

In my field, we crossed between Ganesh-1 males and big yellow variety females. We planted three lines of male seeds and six lines of female seeds. Likewise, we advised some five other farmers to cross-fertilize the big yellow variety of maize with other species. While cross-fertilizing, we planted the male and female seeds separately, with a difference of five days. But all the time we were worried that the seeds might not grow. The seeds grew, but maybe due to the growth of the grass or something else., the saplings became yellow and they didn't grow well. Then I was very much frightened. I was worried that if we didn't have a good maize harvest, how are we going to survive? Then I visited the fields of those farmers who were asked to cross-fertilize maize seeds like me. At that time my husband came home. He was also surprised at what I had in the fields and asked what we were going to eat if we didn't have a good maize harvest. I assured him that there was not much to worry about as we had in our village the experts working in maize cultivation, so we would be happy if we could find out the means to stop the plants falling and prevent the yearly losses. So even if we didn't have a good maize harvest this year, there was still hope for a better return in the next year.

In the hope that the teachers would come and instruct us, we had not prepared the field for cross-fertilizing. But they came late. Here the seeds we had planted could not grow properly due to weeds. Then I took the risk, whatever the consequences, and we began to dig and to loosen the soil around the maize saplings. Then we put in a little urea and the maize plants showed good results. Then we put one teaspoon of urea into each plant and the result was excellent.

Then the teachers came and gave us training. In that training, I have to know that even maize has male and female flowers. I understood that even maize has a cross-fertilization process. When we cross the maize plants, we have to take out the straws from the ears of corn, and we were asked to take out the straws from the female maize plants. I was amazed that taking out the straws from the maize could result in the better growth of maize kernels. Even my father used to say if we remove the straws from the maize, there wouldn't be good corncobs.

Then it was time to take out the straws from the maize. I was still uncertain about the outcome of this but I reassured myself that since we were being told by people who are experts in maize cultivation, I shouldn't doubt. All the maize didn't grow the straws at the same time, so every day I went and pulled out the straws. After this work was completed, then it became my habit to go into the field at least two times to see the result. I was all the time worried about whether the maize cultivated in one *ropani* of land would yield as much crop as we expected.

Every day I saw corn cobs growing on the maize plants. Then I wanted to find out if the cobs had kernels inside. I was not without worries. Then one day I pulled out the corn cob, took out the outside layers and looked inside. There were beautiful kernels and now I was at peace.

Now I was confident and happy that we could bring out a new species of maize.

Now that we have learned the technology to cross species, we want to learn how and when the new species will come to be, how to grow many species, and if the maize is not well filled with kernels, what is to be done? If the seeds are of mixed variety, what is to be done? What measures can be taken to ensure the quality of one particular variety only? If we can get answers to such queries in our minds, I am sure our village called *Simichaur* would be changed to *Makaichaur.*

How Did the Farmers of Chhomrong Improve the Local Paddy Species?

Participant Representatives:
Mr. Om Bahadur Gurung
Mr. Najarman Gurung
Mrs. Min Kumari Gurung
Mrs. Nauli Gurung
Ghandruk VDC., Ward no.9, Chhomrong

Abstract
Farmers from the village of Chhomrong in Nepal describe their experiences with experimental varieties of paddy rice, growing experimental varieties and selecting for specific qualities, in an initiative that started in 1993.

Introduction

Chhomrong is a small village situated at the foot of the Machhapuchhare and Annapurna Range of mountains. It lies at the height of 1800–2000 meters above sea level, on the Pokhara-Baglung Highway, six to eight hours' trek to the north from Nayapul. This village has a majority of Gurung residents.

It is believed that in the year 1962/1963 *pakhe* red rice paddy species was introduced. This species was originally brought and cultivated as a specimen by a man who lived in Lumle VDC and had worked in Shillong, India. Gradually, this paddy was found to be planted in other villages too, and in this way it gained entry into Chhomrung village. Here people began to cultivate this variety of paddy too. To improve upon this species, the Lumle Agriculture Center took the initiative and this variety was recommended as the Chhomrong local.

From the year 1993, this village was selected for research under the Lumle Agriculture Center for the Participatory Plant Breeding Program. The main objective of this program was to improve the species of the local red paddy. It is rather hard textured and took long time in husking, and as there was no alternative species that could tolerate the cold of the local place, so research was begun to improve upon the local variety so that it could withstand the cold and make the grain white in color.

In the initial stage of the program, 250 species of paddy variety brought from the national and international paddy research program were planted in the nursery on an experimental basis. These different species were carefully selected and kept under the joint care of the technicians of the Lumle Agriculture Center and the Chhomrong VDC participant farmers.

The selection was as follows:

- *Chhomrong* Local ripened in its usual time period.
- The straws were the same as that of *Chhomrong.*
- Good grains of rice.
- Capable of tolerating diseases and pests.
- Capable of tolerating the cold.

These species were carefully selected and those that gave white grains of rice were particularly taken care of. Along with the experimental nursery planting, the participant farmers had also planted lines of paddy species for the experiment. The species used for the experiment were as follows:

1. Machhapuchhre - 2
2. Machhapuchhre - 3
3. Machhapuchhre - 4
4. Himchuli - 1
5. Himchuli - 2
6. Nilgiri - 1

After planting the selected species, the technicians, the scientists, and the participant farmers visited the fields and carefully selected the species on the spot. The process of selecting the species started from the year 1993 to 1995. Then those that was selected were carefully studied by using different methods.

- paddy abundant/not abundant
- giving good rice grains/not giving rice grains
- rice breaking into pieces/not breaking
- rice swelling/not swelling
- good rice straws/not good rice straws
- delicious rice/not delicious
- not quickly digested/quickly digested
- time taken to thrash paddy

The process of keeping and selecting these qualities in the species was initiated as a joint venture of the Lumle Agricultural Research Center and participant farmers. It was formally handed over to the Chhomrong Agriculture Development Committee. Then this Chhomrong Agriculture Development Committee requested the LI-BIRD Organization for assistance to give continuity to the research program.

Accordingly, the agreement was reached between LI-BIRD and the Chhomrong Agriculture Research Committee to carry ahead the joint participatory program.

In 1997 another improved species of paddy called Machhapuchhare-9 was being experimentally cultivated and developed.

We request that LI-BIRD will continue to assist us in giving continuity to our paddy research program.

Local Species: Methods of Cultivation, Some Successes and Some Problems

Ram Ashraya Saha Kalewar
Bara

Abstract
Farmer's description of paddy species, methods of cultivation, and use.

Introduction

My house is in the district of Bara at Karchowa VDC. For the last few years, I have taken land on lease, and I am cultivating the local species of plants. These species are quite rare species, which I am certain can't be available in any part of the Bara district. Why I am interested in cultivating these species is that the condition of this land that I have taken on lease is most suitable. In other words, the type of land that I have leased is such that it is always water logged, where neither any of the improved variety of seeds grow nor any of the usual local varieties. The positive quality of this land is that during the monsoon, the water collects. It is so deep that sometimes men can be drowned. I brought the seeds of these species from the village at Rautahat district. The following are some of the details of the species I have been cultivating.

Paddy species: *Bhathi*

The paddy species called *Bhathi* was bought from the Uchidiha VDC from the village called Itawal at the price of Rs.15 per kilo. I have been planting this species of paddy for the last 10 years. Every year, I have planted this variety of paddy in about one *bigha* of land. The return has been 18 *maunds* (720 kilos of rice).

Bas and *Basthan*

These species of paddy can be cultivated in areas where the water is deep. Therefore, this variety needs a place where there is always water available. This type of farming can be done up to nine months only. The reason is that at the time when we sow the seeds, the land has to be dry and in the month of *Chitra* (March/April), the sowing of seeds is done. The harvesting season is always in the month of *Mangsir* (November/December) regardless of the time paddy may have been planted. The roots extend from the rice stalks on the water's surface so plants seem to balance on the surface of the water. Therefore, there is no possibility of the paddy plants falling, however deep the water level may be. The other good point about this paddy species is no matter how much the water level may increase during the night, the rice plants seem to grow in equal proportion.

External appearance

The length of the rice stalk is almost three meters high. Since the stalk is pretty thick, there is less possibility of the rice plants falling over. The leaves are broad and light green in color. The roots are quite strong so that the normal sort of flood can't drag them out and sweep away the plants. The rice grains are shapely and big. The rice grain is red in color and there isn't any *tunda*.

Method of cultivation

In the month of *Chaitra* (March/April), the tractor is used to plough the land and the seeds are sown. At this time of the year, the land is dry. A few days after the sowing of the seeds, the rain starts and the land starts getting filled with water. As the water level rises, the length of the rice stalks grow. As the species grow in water, there is less possibility of the plants being attacked by pests and diseases. But the rice plants are infested with insects called *gawaro*. This variety of paddy neither requires weeding out grasses nor the need of fertilizers. The harvesting time for this species is the month of *Mangsir* (November/December). In this month, the level of the water comes up to the knee and the paddy can easily be cut down with the help of a curved knife called *hasiya* or *kachiya*. After the paddy is cut down and carried home, it is dried, beaten, threshed, and stored well, ready for use.

Uses and its importance

The rice is soft and delicious to eat. It is readily digested. From this rice beaten rice (*chiura*) can be made, and varieties of local delicacies like bread, *thakuwa*, fried bread, etc., are prepared The paddy of this species is accepted in our sacred rituals and practices. This variety of rice is generally used in feasts and parties.

Possibility of improving the qualities of this species of paddy

I bought the seeds of this species of paddy at Rs.15 per kilo. Therefore, the market price of this variety of rice can't be less than Rs.18/- to Rs.20/-. During festivals, the price of this species of rice goes up to Rs.30/-. So there is no loss in cultivating this variety of paddy in our fields. This is very advantageous, especially if the land is being left unused due to water-logging conditions; thus, farmers can maximize their profit. Since the labor is less, any one can farm this variety of paddy.

Need for conservation of the species

This endangered variety of paddy, having such odd qualities, is in the process of being lost. If we do not direct our attention in time, its extinction is certain. Now there is an increasing tendency to fill up the water-logged land and convert it into residential areas. This is a really dangerous situation because it increases the possibility that this species will be completely wiped out. For this reason, both the government and the NGO must take the initiative to conserve this variety of paddy and work towards helping the farmers with the technology to improve their living conditions.

Name of paddy: *Amadhouj* and *Sakhar*

Both the stalks and the rice grains of these two varieties look the same. The two species are cultivated in fields that require less depth of water than for *Bhathi*, but the *Sakhar* paddy is shorter than the *Amadhouj* species.

Both are cultivated in a similar manner. They are sown by spreading the seeds on the prepared fields. They require less fertilizer but need to be weeded. If the fertilizer is too much, then there is the possibility of the paddy plants falling. If the cultivation is done well, the return harvest can be as much as four to six *maunds* (160–240 kilos) per each *katha* of land. The rice crop is long and the grains are fat and heavy.

This year I bought both these species of paddy from the village called Sonarniya in the Rautahat district. I cultivated *Amadhouj* variety on three *katha* of land and *Sakhar* on one *bigha* of land. But in the field there was too much water collected, and the paddy was good only in two *kathas* of land.

These two varieties of paddy are acceptable in our sacred rituals. From the rice straws, we can make floor mats. The cooked rice is good and any person who is sick can eat this rice without any problem.

In the *Amadhouj* stalks, three or four grains of paddy grow together, so that at a glance, the paddy crop looks almost like wheat. But there is a superstition attached to the cultivation of this paddy. It is believed that if the paddy grows in equal measures in the four corners of the field and the production is equal in all the four corners, then the farmer who has such a harvest will suffer some evil, like some one will be sick or some one in the family may die.

Species of paddy: *Khera*

In the month of *Jestha* (May/June), the seeds are sown, and in the month of *Asadh* (June/July), the rice saplings are planted, and in the month of *Mangsir* (November/December), the paddy is harvested. As the level of water is less, the paddy needs to be weeded. It can also be given fertilizers. I had personally used three kilos of urea and 2.5 of DAP in the paddy fields. As the paddy grains have *tunda* there is less possibility of disease and pest problems. But this year, the paddy was infested with both disease and pests, and I had to use the pesticides called *chelamin* and *metacid*. After taking all these measures, the harvest was three *maund* (120 kilos) per each *katha* of land.

This variety of rice is important from a religious point of view. In the worship of our family God, *Gobin Maharaj*, this variety of rice is absolutely needed and no other variety will do. The cooked rice from this species is equally delicious. From the rice straws, the floor mats are made and even the cattle have a special preference for this type of rice straw. This variety needs less fertilizer.

Role of Farmers in Selecting Crop Species

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Indrapuri, Chitwan

Abstract
Farmers describe their activities investing in and developing their agricultural output, with details of their production and Suwarna paddy rice (an improved variety).

Introduction

We have been following the traditional method of cultivating crops according to the methods used by our ancestors. In those early days it was not possible to know the kinds of soil, the type of crop that was suitable to the kind of soil, the types of pests and diseases, the methods of controlling them and how much fertilizer is required for a particular type of crop, and hence, the harvest was not satisfactory. I feel the government is not much interested in the agricultural sector, but without improvement in the agricultural sector, there can't be improvement in industries and commerce. In every country the role of agriculture is prominent. Because of the three basic human needs—food, shelter, and clothing—food occupies the prominent place in man's life. The basic need of all sorts of living beings, from the wealthy to the poor beggars and birds and animals, is food. Without food, nobody can live; it is a universal fact. This point is most significant for us to understand.

Nepal is an agricultural country, so the people here would be most happy if they were given knowledge about the formation of land, the types of soil, means of irrigation, and given the priority to develop improved seeds for local use. In 1929 we migrated from Lamjung to Geetanagar VDC, Ward no.8. At that time there was no irrigation system in the village. The field had mixed cultivation of different species of paddy in the same plot, like *Dudharaj, Aap jhuthe, Battisara, Gola, Mansara, Thapachini, Jetho buro, Ghaiya,* etc.

Development

In terms of harvest, there used to be 25 to 35 *muri* of paddy per *bigha* of land. At Tandi, we grew maize and mustard. There was no system of cultivation by rotation. Later on there came new species of paddy called *Achhami masino, Mansuli radha-4,* and *Radha-17.* Among them, the *Mansuli* was the best, so there was extensive cultivation of this species of paddy everywhere. Vegetable cultivation was limited to small kitchen gardens for vegetables like green vegetables and radishes, but later, from the year 1937, with the assistance of the Agricultural Development Branch Office, we began to grow vegetables on a larger, commercial scale: improved species like cauliflower snowball, Kathmandu local, snowcorn cabbages, radishes, carrots, mustard, etc. Now, these improved varieties require good irrigation systems, so we took a loan from the Agriculture Development Bank, dug out deep wells, kept motor engines, drew out water, and kept sprinklers to irrigate the vegetable fields.

Now we have at our rescue the LI-BIRD Organization, who, by keeping in contact with the different research centers, have made available for us new and better improved seeds, like *Rajma, Panta-11, BC 1442, PNR 381,* and *Sarvati.* These crop species are suitable for the soil at Tandi, but in water-logged fields where the paddy plants tend to fall easily, the *Sawarna* species of paddy seems to be appropriate.

Experiences regarding the *sawarna* species

This variety of paddy is excellent in churned fields. The plant stalk is strong and does not fall easily. The rice is tasty, good in texture, has weight, has solid grains, is easy at milling and at threshing prior to milling. Seventy-six percent of the rice grains remain during the processing period and do not break easily into pieces in the de-husking process, and unlike the *Mansuli* species, even when the plants are shorn of green leaves, there is no difference in the usual production of rice kernels. Last year for the research study, the LI-BIRD Organization and the Agricultural Development Branch office at Bharatpur made improved seeds available, and so we were able to cultivate the *sawarna* variety of paddy in 10 *katha* of land.

In terms of production, it gives us four *muri* of harvest per each *katha* of land. This year we harvested 80 *muri* of paddy. In the village of Indrapuri, for Tandi there are varieties of paddy species that can be cultivated, like BG 1442 and Panta-10, IR13155.

We farmers are very happy now because a mini-kit has been prepared for the farmers with the different species of paddy, exhibition of research results, trial checks, specimens, etc. From such programs, we have highly benefitted and learned that now we can choose by ourselves which of the species would be most suitable for our land, soil, and climatic conditions so we can be selective in cultivating crops ourselves.

Role of Farmers in the Improvement of Crops: New Species of Paddy in Maramche

Mr. Chandra Kanta Poudel
Assisted by
Mr. Dil Bahadur K.C. and Mrs. Sita Poudel,
Maramche, Kaski

Abstract

This paper describes the agricultural situation in Maramche. Village farmers have been participating with the Local Initiatives for Biodiversity Research and Development (LI-BIRD), testing improved varieties of paddy rice. Details of the qualities of the new varieties, qualities preferred by the farmers, and experiences with the participatory plant-breeding program are included.

Introduction

Maramche is a small hilly village in the Dhikur VDC near the Lumle Agriculture Research Center. It is about 30 kilometers from Pokhara, the tourist area in the Kaski district, to the northern side of the western Baglung Highway. It has a cold climate and a diversity of ethnic tribes. It is 1600 meters above sea level. In this village there are about 36 households only. Although the village contains a diversity of ethnic tribes, the majority of the people belong to the Brahmin caste. Just as Cheerapunji is the world-renowned place for rain, likewise Maramche is also the village in Nepal that has the highest rainfall.

Due to poverty in the country, many of the people have left their homeland in search of work, while the rest are dependent on agriculture. Looking into the picture of farming in this village, we find much diversity. The following table helps to illustrates the important crops and vegetables grown in this area.

Farmers		Land Area	
		Much	**Less**
	Much	Paddy, maize, wheat, millet	Potatoes, mustard, radishes, beans (bodi, simi, bakulla), gourds (ghiraula), pindalu, soybeans, iskush (squash), karela (bitter gourd), garlic, onions
	Less		Cauliflower, carrots, salgam (turnips), kerau (chick peas), sugar-cane, green vegetables (chamsur, palungo), jau (barley), uwa, gahat, lentils (arhar) tarul, turmeric, ginger

Among the crops mentioned in the table, paddy is most extensively cultivated. But unlike the other crops, paddy has the maximum number of local varieties. The following are the names of the local species:

1. *Kanthe*
2. *Kalo patle*
3. *Reksali*
4. *Mansara*
5. *Juwari*
6. *Silayam*
7. *Tarkange*
8. *Chhomrong local*

Introduction of M-3 and M-9

As the above-mentioned names of local paddy species show, they are many and they possess the qualities to withstand maximum rain and the cold climatic conditions of the place. Therefore, as the people had no other means to find out about species that have these qualities, the local people continued to cultivate the species available to them locally. In this context, in the year 1996 with the cooperation of LI-BIRD and the local farmers, the Participatory Plant-Breeding Program was initiated. Immediately after the program was started, LI-BIRD distributed improved seeds M-3 and M-9 to five farmers in the village. After the paddy was planted, it was found that these species of paddy were capable of withstanding the climatic conditions of this village. So the people of LI-BIRD and the Creative Mothers' Group went to the field area to inspect these species of paddy cultivated on an experimental basis. The inspection and study of the paddy was made on various factors, like production, the height of the paddy straws, and the shape and size of the rice grains. After thorough mutual discussions and giving priority to the farmers' interests, the species M-3 and M-9 were accepted as the right choice for cultivation.

The reasons for their acceptance

1. Maximum production
2. Tolerance of fertilizer
3. Tolerance of the cold climatic conditions
4. Ability to tolerate wet and moist conditions
5. Suitable in less water
6. Quick ripening period
7. Less wastage through falling (not that they will not fall with threshing)

Nature of the popularity of M-3 and M-9 species

1. After the inspection, the request for the improved seeds as per the needs of farmers
2. Based on the advice of the farmers who initially cultivated the improved varieties
3. Interest in cultivating new species of improved paddy, and by the distribution of seeds
4. Based on the request of local organizations to do the experiment again and mutually exchange and share ideas, and the system of taking away the improved seeds for cultivation

So the study of the popularity of M-3 and M-9 reveals that the local species of paddy do have some weaknesses, which are as follows:

1. Not able to tolerate fertilizer
2. Thin flowerings and smaller harvests
3. Less production and grains not full and solid
4. Not able to tolerate the cold
5. More time needed in cooking

The qualities that we farmers would want in our paddy

The paddy must have long straws, full and sold rice grains. It must be delicious to taste, fragrant, able to tolerate heavy rains, able to tolerate the cold, able to tolerate the fertilizer. It will not flower, not easily fall, give heavy paddy crops, take less time to ripen, and increase in volume in cooking.

As these qualities were not available in the paddy, we continued to cultivate the local variety. But in the year 1996, LI-BIRD not only brought the M-3 and M-9 varieties but also 144 other varieties of paddy. In the land that belonged to Indra Prasad Poudel, the nursery was made and all the different varieties of seed were planted in that plot of land. At that time, due to hailstones, the experiment suffered setbacks, but even then, among them, 30 species were saved and selected for our purposes. In this experiment, three groups were actively involved: LI-BIRD, the Mothers' Group, and the Progressive Youth Club.

In this way, in the year 1998, the 30 species—selected on the basis of discussions among the local organizations—were distributed among the 30 households of the village, so that each household got to cultivate one particular variety. On the other hand, in the year 1996, LI-BIRD had sent us 25 species of paddy and we had also cultivated them. Among the 25 species, our farming community had selected one particular variety on the basis of the harvest production, the height of the straw, the taste of the rice, the shape of the rice grain, etc.

Summary

Among the 144 varieties from 1996, only 30 species were selected, and from the 30, three (the process of selection is continuing).

In 1999, from among the 25, one variety was selected. This species was cultivated by Maheswor Poudel in 1999 in two separate fields, and in 2000, he is planning to cultivate it in three fields. Moreover, at the instigation of the local club, we are planning to cultivate that single variety at the rate of 5.5 and 9 by buying the seeds ourselves. We do not know the name of this paddy. Now in the year 2000, under the joint auspices of LI-BIRD, the Mothers' Group, and the Youth Club, we are going to give it a name.

The basis of selection made by the Youth Club and Mothers' Group

1. The height of the straws and the productivity of the paddy crop
2. Falling/not falling
3. Less chance of disease and size of the rice grain
4. Capable of tolerating the cold and wet conditions and quick ripening period

The above-mentioned basis for selection was made after the field inspection and discussions in the group meetings among our participant farmers and club members. In this, the local organization relays the information and also teaches us how to do the work. In the end, we review the whole matter and with the participation of the entire farming community, we select the paddy species.

Participatory plant-breeding program

We appreciate this program highly, for it respects our experiences and the traditional technology that we have been following in farming. When looking into the statistics available, we found that without the participation of the farming community at the national level, there had been recommendations made for more than 42 species of crops, although this sort of selection had not much affected the people living in the high hilly areas. Therefore, it is most necessary that we have a participatory plant-breeding program among us. For example, we can take the case of paddy species M-3 and M-9 that we have been cultivating in our own village.

Necessity of a plant-breeding program

1. A participatory program means the collective presence of the farming community: they can select for themselves the paddy species that suit their soil and climatic conditions.

2. The farmers themselves are more aware of their own needs and requirements.
3. In the selection of the paddy species, the farmers themselves are participants.
4. The farmers learn the technology about how to breed between two species to create several varieties.

Reasons

1. Climatic conditions differ according to altitude and have different affects on farming.
2. Land and climatic conditions differ in the hilly region.
3. When improved species are selected according to the suitability of the particular place and climate, they have a high degree of tolerance and survivability.

The drawbacks of the participatory breeding program

The disappearance of the local species. For example, after the introduction of M-3 and M-9, the local species called *Kalo patle* and *Reksali* have gradually disappeared.

Important suggestions

In the process of developing a plant-breeding program, we must remember to include the local species so that the genes of the local will not disappear completely.

Role of the local organizations

Important and active organizations in our village are the Progressive Youth Club and Creative Mothers' Group—two local organization that have worked closely with the Participatory Plant-Breeding Program since 1996. The most important work has been to develop M-3 and M-9 improved seeds and so we have sent to LI-BIRD and other agricultural organizations about 5 *muri* of improved seeds in 1998. The local organizations continue to develop the improved seeds and distribute them for cultivation. For example, in areas like Lumle, Paudur, and Salyan VDC, the improved varieties like M-3 and M-9 have already been sent.

Plan of the local organizations

- to give continuity to the work carried out by the Participatory Plant-Breeding Program
- to develop and distribute the improved Machhapuchhare-3 and -9 paddy species
- to conserve, develop, and distribute the selected species
- to distribute to the farmers the newly developed improved seeds sent by other research centers
- to increase the village's agricultural production under the leadership of local organizations
- to develop systematic and sustainable methods of paddy conservation from the nursery to storage
- to increase our own learning skills and technology among ourselves
- to develop new improved paddy species

Leaders among the farming community

Priority is given to persons who have been successful in order to encourage and bring maximum participation of farmers. Or the farmers have themselves selected one among them or have won the confidence of their farming community.

Among the 25 species, one variety was selected and it is cultivated in the field of Maheswor Poudel. This species of paddy was cultivated at his initiation. He has said that he took this initiative because this species has all the good qualities to be found in paddy. As he says, this variety has good taste to eat, long straws, solid grains of rice kernel and the grains are not likely to fall off easily from the plants. Therefore, this species of paddy without name as yet, has the great possibility of becoming popular in this village.

The official and scientific research from LI-BIRD was carried out under the leadership of Indra Bahadur Poudel.

The Importance of Crop Improvement in Conservation of Diversity

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Bagnas, Kaski

Abstract
In this paper, farmers describe the agroecology of Bagnas and the diversity of crops grown there.

Brief description of the Bagnas Village

Bagnas is a small hilly village to the northeast and 16 kilometers away from the well-known tourist center Pokhara. Facing the north-south direction, the village lies about 600 to 1400 meters above sea level. It lies in the mid-hill region, and like the rest of the other villages in Nepal, it is equally remarkable for agricultural diversity.

A variety of agricultural production and one single crop with a diversity of species is the greatest wealth of this village. Some time ago, farming was carried out in this village on the basis of absolutely personal interest and experience. But since the last 10 to 15 years, we farmers have been attracted to collective and participatory farming systems. Caste-wise, the village has a majority of Brahmins, and 97% of the population is dependent upon agriculture.

The land is such that in the north are the steep hilly areas, and there are plenty of gullies and hillocks with narrow strips of land between them. So comparatively speaking, the upper areas of the village are cold and dry/parched, and the lower belt is moist and hot. On the basis of our experience and experiments, in the north belt we grow millet, maize, and *Ghaiya* (a type of paddy), and in the lower part of the land, we cultivate paddy. There is no irrigation system, so we are entirely dependent upon the monsoon rain. Although during the monsoon months of Ashadh/ Srawan (June-September), we collect water in small man-made reservoirs and pools for farming. Since the main crop in this village is paddy, we are fully involved in cultivating paddy. We are not engaged commercially in agriculture but in terms of sustaining our lives.

The following is a proposal about the Participatory Plant-Improvement Program and our experiences and suggestions about paddy cultivation in our Begnas Village.

Common species of crops

We, the villagers of Begnas, have been cultivating crops according to our long traditional methods of trial and experience so that we have been able to study what sort of crops are suitable in one place and what crop at which time. Having observed these details, we have been cultivating our fields. The common crops that we have been cultivating are as follows:

- *Pakho* (hillside, slanted, uncultivable slope):
  Millet, maize, *Ghaiya* (paddy), *Pidalu*, sugarcane, buckwheat, and vegetables (potatoes, radishes, gourds)
- Field (for paddy plantation):
  Paddy (and also minimum cultivation of wheat and mustard)

Status of paddy species system

The procedures for cultivating the paddy species have been based on the traditional technology followed by our forefathers. Actually, the majority of the farmers in the village follow the same methods of farming. Even now, the local species of paddy have a greater influence in the choice of cultivation, although in some places, improved species of paddy are also being used by some farmers. The common varieties of paddy being cultivated are *Mansuli, Taichung,* and *Radha-7,* while some years back, we (one-third of the farmers) cultivated the varieties called *Mansule, Madhise, Chhote,* and *Radha-7* in order to make a better profit. But these improved varieties needed chemical fertilizers, good irrigation facilities, and pesticides to control pests and diseases. When these requirements were not fulfilled, we lost half the harvest in some years. So then we reverted to cultivating our own local varieties, and among the most popular ones are almost 35 to 40 species. That is why we cultivate the different varieties of the local species. We do not only work on an individual level but also collect ourselves into different groups and work towards preserving and protecting the local species. In our village, on the basis of our yearly experiences with these different varieties of local paddy, we continue to grow them and alternate the seeds in trying to create continuity to our work and efforts at conserving the local paddy species.

Diversity in the local paddy species

In order to fulfill different usage requirements and needs, we have been preserving different local species. At present in Begnas Village, we have 16 collective development groups. and among the participating farmers, there are from nine to 43 species of paddy that are being locally cultivated. (table 1). Now we are planting the following local paddy species (table 2). These local species have many qualities that are suitable for our soil and climatic conditions, so we are giving continuity to our local species. Yet there are some qualities that we think it would be great to improve upon, so we have asked for assistance from the INSITU Conservation Program. With the help of this program, the local species like *Aanga, Thulo gurdi, Sano gurdi, Biramful, Pahele, Ekle,* and *Mansara* are being crossed with improved varieties like *Savitri, Himali,* and *Khumal-4*. In this way, if we could cross local with improved varieties, the local species would not disappear. In fact, many of the local varieties like *Marsi, Pahele, Thulo Marsi, Seto,* and *Jadan* are in the process of being lost, and some other species like *Anga, Rate, Chobo,* and *Jhinuwa* have completely disappeared.

Table 1. Collective Development Groups and Participating Farmers, Begnas Village

	Group names	No. of paddy species received in exhibition
1	Darathar Collective Development Committee (CDC)	43
2	Bisaunathar CDC	30
3	Majhthar CDC	30
4	Chaur CDC	21
5	Kotbari CDC	24
6	Aduwabari CDC	20
7	Poudelthar CDC	2
8	Archalthar CDC	19
9	Paurakhe CDC	18
10	Adhikarithar CDC	18
11	Sundaridada CDC	15
12	Talbesi CDC	15
13	Kalimati CDC	14
14	Kholbesi CDC	12
15	Simalpata CDC	9

Groups	Names of farmers	Species of paddy under cultivation
Archalthar	Tara Tiwari	16
Adhikarithar	Goma Adhikari	13
Poudelthar	Padam Raj Poudel	11
Bisaunathar	Padma Kumari Adhikari	11

Table 2. Common Paddy Species Found in Begnas Village

Main species	Reasons for being selected by farmers	Drawbacks	Interest of the farmers
Ekle/Gurdi	Good taste, long straws, soft, good rice grains, *ganjaune*, heavy harvest	Less in areas where water is not available	Long straws, heavy harvest, early crop, less wastage through easy dropping of paddy grains, not easily crushed, more rice, increase in cooked rice volume, able to resist disease
Jetho buro	Fragrant, good for serving to guests, expensive market price, used during festivals	Needs plenty of water	
Kathe gurdi	Semi-irrigated fields	Comparatively greater chance of being reduced to tiny pieces	
Ramani	Long straw, good harvest, able to resist fertilizer and water	Must have good irrigation	
Lahare gurdi	Long straw, good harvest, tasty, able to resist fertilizer and water.	Needs plenty of water	
Bayami	For medication (sprain, in suffocation)	Needs plenty of water	
Jarneli	Excellent for beaten rice (*chiura*)	Needs plenty of water	
Anadi	*Siramla*, for medication in state of dizziness		
Naal tumme, mansara, pakhe jarneli, rate anga, aap jhuthhe, madhise, tunde, thapachini, etc.			

We farmers want improvement in the quality and quantity of the paddy according to our interests and needs. But we lack the knowledge and technology to do that. Therefore, the farmers must select the species through their own presence and participation in the process so that by crossing different species, a great variety of species can be obtained, yet also keeping the original breed, so that the improved species can be strong and withstand local conditions. Hence, we feel confident that with the help of the in situ Program we will surely succeed in improving the local species.

Conclusion and recommendations

Our conclusions and recommendations are that the in situ Program will surely assist the farmers of this small Begnas Village in conserving the diversity of the local species of paddy and inspiring the local farmers to participate in collective activities, so we not only conserve the local species but also bring together maximum participation of the farmers so that the standard of life of the local farmers will also improve.

Question-and-Answer Session with Nepali Farmers

Q. 1. Everybody stressed crossing but who is actually doing it? Farmers? Scientists? Or is it done jointly?

Ans: The farmers in the village initiated the crossing program with technical support from LI-BIRD as and when needed.

Q. 2. Where do the male and female plants come from in maize crossing?

Ans: The male is an improved variety—*ganesh-1*—from NARC, and the female is a local landrace—*Thulo pahelo.*

Q.3. Are you willing to share the seeds of your crossing? If 'yes,' why? If 'no,' why not?

Ans: *Farmer 1.* Seed from crossing is community property, so it's up to the community to decide whether or not to share it.

Ans: *Farmer 2.* We are willing to share and, in fact, have already done so by supplying 250 kg. If our new varieties help improve the production of other farmers, we will share it.

Q.4. Today, large companies have the potential to spread biotechnology as a form of imperialism. Gandhi used the spinning wheel as a symbol of freedom. What should be the symbol of the farmers to fight against such domination?

Ans: One way to be self-reliant is to improve our seeds/varieties so that they are more productive or competitive, before the large companies grab away our genetic materials. The farmers should have control over the genetic resources.

Q.5. How will the new lines coming out of crossing *sathi* be developed and studied?

Ans: The decision to select or reject the outcome of the cross rests in community. No individual holds absolute rights over developing the lines.

Diversity Versus Mono-Cropping

Bidakanne Sammamma
DDS woman farmer from Andhra Pradesh, South India

Abstract
A farmer from Bangladesh describes crop diversity in her fields and gives the reasons for encouraging diversity versus mono-cropping.

I am trying here to explain the soil type, the problems associated with the soil in my area. You will find a lot of stones there, so farming is very difficult. The soil is black and you can see the amount of stones. In the areas where there is red soil, the depth is very shallow—not more than five to six inches—and below it there is a complete sheet of rock. So keeping in mind the soil types and the problems associated with rainfed agriculture in my area, the women try to grow a lot of crops in a given area so that they can be sure of getting at least one crop in the crop season.

We store different types of seeds of different crops and mix all these crops. Women, especially, play a vital in this mixing. Keeping in view the soil fertility, we observe the soil—which type of crop can be grown in a certain patch of land the woman owns. So women play a vital role and they mix all the different types of crops that can give food, fodder, and add to the fertility of the soil.

We grow a range of crops—at least eight to 10 crops in a year in a given area: you can see crops like *jowar* (sorghum), red gram, field beans, and cow peas. We grow this many crops to get some of the crops at one time and others at another time. Some crops will mature first, so they are harvested first, so we get food when we are hungry.

The main reason behind growing so many crops in a given period is that even if, due to any reason, some crops fail, we are sure of getting something. So we will be harvesting different crops over a period of a season of six months. Every time we go to the field, we will get something to take back to our homes to cook. At the same time, there won't be much work because during the period of six months, one crop will be coming at one time and another the next time and another the next. So the load is spread evenly on the women and not all at one time.

The second reason is that there are different varieties of *jowar*—compact-headed and loose ones. In our area, we sometimes get rain at the harvesting stage. When we get rain at this time, the compact-headed seeds germinate in the head itself. So we also grow the loose-headed variety. Even if there is drizzle for two or three days, this variety can overcome that problem. Unless there is a big drizzle for one week, I am sure of getting at least some *jowar* for consumption.

Keeping in mind the soil fertility, I also mix legume crops like field beans and *jowar*. We grow *jowar* also because of the fodder requirements of the animals we own.

Cow peas and field beans may not be important to you, and although we sow these crops in just a few rows, they are very important to us because they take care of the soil fertility and we also get very good nutritious food out from them. So they are important to us even though they are grown in small quantities. Now I will explain about the multiple uses of crops like red gram. We use the pulse for *dhal*, a curry that we eat with our bread and rice. We use the stalks of red gram for fuel wood and for thatching. This crop is very important to us; it is useful to us in a number of ways.

In the *rabi* (winter) season, we also grow a range of crops. We grow mustard with wheat for pest control because some insects that attack wheat will be attracted to mustard, and in this way pests will be controlled.

Foxtail millet is the first crop of the season in our area. When we don't have anything to eat in our homes, this is the first crop that will meet our hunger needs because most of the things stored from the earlier season will have been used up.

When we grow crops, we also keep in mind the fodder requirements of the animals we own. That is the reason we grow some varieties that will give more fodder for our animals.

One agricultural practice in our area is this: after harvesting red gram, the farmers plow back the land, so that whatever leaf-fall there is from the red gram will immediately go back to the soil. We are conscious of whatever we extract from the soil and we try to give back the same amount of things that we are extracting from the soil. This is very important to us.

The more crops we grow, the more the load will be evenly spread on us for harvesting them. More than that, we will also get more employment. The greater the diversity of crops, the more harvesting there is for different crops at different times; people in the village will get more employment when there is more diversity.

Women in our area do not prefer mono-cropping. The greater the diversity, the fewer the grains of each crop, so the women won't want to sell this small quantity of grain in the market. Neither will the men bother because of the small quantity; they will think that "even if I take this to the market, what is it that I am getting?" When you see each crop individually, it will be very small, but when we compare the grain production for all of them, there will be more grain in total. If we have a range of different crops in our homes, then whenever we feel hungry, we can consume them. With a single crop, we may or may not get a good yield. If the crop fails, we will starve for most of the year. You may think that if you get good crop, you may purchase some of the grains of different crops to eat, but even if you can get it in the market, poor women will definitely not buy so many different crops. They would rather spend the money on other things than food. If we have grains in our own homes, the satisfaction is different than when we buy it from the market. Even if you want to eat, you may not have the money, and even buying from the market, we will eat less and the satisfaction will not be there. If we grow a range of crops and have the different grains in our homes, then whenever children ask, we can cook different recipes from the different grains and provide them with nutritious food at the same time, which is not possible when we grow a single crop.

Our food, our knowledge, and whatever we are doing should not be a threat to diversity, but should enhance diversity. The types of food we eat now should also help in increasing diversity.

Women organized a biodiversity festival (called a *jatra*). Farmers from 75 villages attended this *jatra*. Using all local materials, there were exhibits of different traditional landraces and how they were used—which part of the plant is used for what purpose, like thatching, etc. Many farmers were inspired by this and have collected nearly 72 traditional landraces. They are extending all these seeds in 75 villages. Now they can crop at least 2000 acres of land with these 72 traditional landraces. After seeing this biodiversity festival, many farmers left the area understanding the importance and uses of the different crops. They are coming forward to cultivate the landraces, and in each village 20 farmers are cultivating these 72 different landraces.

Whatever inputs we are using for farming, the resources should be available locally and the farmer should not depend on any external resources. We want to use our own products; we want to use some of the green-leaf manuring crops. We give a lot of importance to soil fertility management. Whatever variety you may grow, unless the soil is fertile, we cannot achieve anything; we cannot achieve the potential yield even though the genetic potential may be there. So soil fertility is one of the most important things we are trying to address.

Our way of looking at the productivity of a farm is different. We generally don't look at yield only or yield per unit of land only or only general yield. There are many things we get from the farm, like uncultivated greens, medicinal plants, vegetables, fodder. So if you monitor all these things, they will be more than what you would get from a single crop. Everything is equally important in this whole farming system, so we look at different things in farming and not at a single thing.

Experiences Growing a Modern Rice Cultivar

Raksya Begam
Woman farmer from Bangladesh

Abstract
A farmer from Bangladesh describes her experiences growing a modern rice variety.

I'm from Bangladesh and my name is Rabia. I am here to talk about our experiences. The scientists told us, the farmers, that you can take a variety and plant it in your fields and you will get plenty—20 mounds of rice per acre. We were very simple; we believed it and were very happy to hear the news. We actually planted this variety. It was a dwarf variety, and the kind of straw we got from these plants was the type that if there was rain then all the straw got rotten and was no good for fodder for livestock, not even as fodder for the scavenger chicken. Although the straw mixed with cow dung created many insects, which were useful for chickens to eat. We also had to use pesticides and fertilizers and soon the whole land became hard like rock.

Previously we used to cultivate the local rice varieties of *Aaush* and *Aamon*. The straw of these varieties was long—taller—and was very good for fodder. It ensured that we could keep livestock and poultry.

Now, the scientists have always made claims. They showed us the profit—what we will get from the production of their varieties—but they never actually calculated the losses, the other losses that the farmers have to pay the cost for. Now we, the farmers, have realized these other costs. The situation right now is that the soil has become just like rock and the fertility is not the same as it was before. Now it also requires a lot of money to cultivate paddy or to remain in agriculture and the returns to the farmers are very poor.

Previously, the kind of variety we used to cultivate was tastier, compared to the modern varieties. It was also not a source of disease: it did not contain any pesticide or pesticide residues. After consuming these new rice varieties, we are now suffering from many diseases, so there are health problems along with the other problems. There are health problems in the livestock and poultry also, so the management of livestock and poultry is more difficult now.

On the other hand, uncultivated food is not available any more, at least it has really become scarce. But the scientists never calculated this serious cost to the farmers. So we farmers have now realized that we have had to pay too much for these new varieties and it is time to realize that we need to get away from them.

The older varieties had many other uses. We could use them as sources of energy and also as a kind of organic fertilizer. The dwarf—or modern—variety is not useful as the older varieties.

There is a proverb in Bengal, "Don't go to the field in the east." This is a local saying, which means, "Don't go to a place where you will hear bad information; it looks like the sun but it is not the sun." Now we realize that to the scientists, the farmers were not their objective—their main focus was not really to serve the interests of the farmers.

Is There an Imminent Crisis in Agriculture?

Abu Taher Rahamani
Farmer from Bangladesh

Abstract

A farmer from Bangladesh, with 22 years of experience, predicts an imminent crisis in agriculture.

I have been practicing modern agriculture for quite a long time and received the Presidential Award twice. I am here to share some of my experiences with the different varieties, especially the modern varieties, that I have planted on my own farmland. In terms of the productivity of a single crop, I have been able to demonstrate that some of the varieties performed well, but economically, I did not gain. In my 22 years as a farmer planting modern varieties, one thing I would like to say is that we are heading for an imminent crisis in agriculture. And we need the collaboration of the government and the scientists with the farmers. As scientists have noticed, the organic matter is very low, now it is 0.50 (the lowest) and 1.63 (the highest). This is the range in one area. We can talk about plant breeding or talk about the introduction of modern varieties, but unless we take care of the problems of organic matter in the soil, we will not be able to resolve the crisis in agriculture.

On my farmland, I am trying to make available more organic matter from my farm and I am also reducing the use of pesticides. Despite the fact that many people are aware of the dangers of pesticides, the use of pesticides is increasing, partly because of the companies' aggressive marketing techniques. Farmers are sometimes confused with this type of aggressive marketing and eventually they pay the cost of using pesticides. In my experience and from the literature available to me, none of the pesticides I am familiar with can reduce the attack to 50% or 60%. In contrast, partly from my own experience, from my own practice, and at the same time from some of the training I got for integrated pest management (IPM), I have been able to reduce the attack of pests by 80%–90%.

At the same time, seed is a very vital issue. You have to have good-quality, healthy seeds for the farmers. So this is a very sensitive area for the farmers. You have to have good-quality seeds for the experiments that we are trying.

And now there is more promotion of hybrid seeds around the world. They say that the hybrid cannot contribute to the interests of the farmer because they cannot keep the seeds. The farmers will not know the characteristics of the seeds the way they know the traditional varieties. So eventually it cannot be good for the welfare of the farming community.[1]

My general feeling about the technology is that when you promote a technology, it is very important to understand the nature of the technology, whose interests it is serving, and how it is good for the farmer, or for that matter, who the constituencies of the technology are. Unless you know very clearly about that, then eventually the technologies will not be very fruitful.

When we decide about technology, certain characteristics are very important. One is that it should not be costly or it should be at least within the reasonable reach of farmers. Second, it should be verified by scientific procedures and by an indication that it can perform as they are claming it is going to perform. Third, it should be gainful to the farmer—the recipient who is receiving it. It should be sustainable and also should be used by a large number of farmers.

So I appeal to the scientists to note what I have said. I hope you will take it as coming from the farmers and that you will take interest in these issues.

1. *Translator's comment.* He (the farmer) is emphasizing the question of whether the farmers can really keep these seeds in the household or if they can have any control over the seed system.

Acronyms

ACAP	Annapurna Conservation Area Project
AICSIP	All India Coordinated Sorghum Improvement Project
BAU	Birsa Agricultural University
BBE	*Beej Bachao Andolan* (Save Seed Movement)
BCJ	Brahmin/Chhetri/Jogi (ethnicity category for LI-BIRD research)
BLB	bacterial leaf blight
CAZS	Centre for Arid Zone Studies
CBD	Convention on Bio-Diversity
CBDC	Community-Based Biodiversity Development and Conservation
CBDC-ITP	CBDC International Technical Programme
CBO	community-based organization
CBR	community biodiversity register
CC	CONSERVE cross
CCI	conventional crop improvement
CFFT	coordinated farmers' field trial
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo / International Maize and Wheat Improvement Center
CONSERVE	Community-Based Native Seeds Research Center
CPB	conventional plant breeding
CPR	common property resources
CRRI	Central Rice Research Institute
CVSCAFT	Central Visayas State College of Agriculture, Forestry and Technology
DDS	Deccan Development Society
DFID	Department of International Development
DUS	distinctive, uniform, and stability
FAMPAR	farmer-managed participatory research
FAT	farmers' acceptance test
FFT	farmer field trial
FGD	focus-group discussion
FOCUS	Focus Humanitarian Assistance
FPB	farmer participatory breeding
FSR	farming systems research
GAU	Gujarat Agricultural University
GMN	Gurung/Magar/Newar (ethnicity category for LI-BIRD research)
GRAIN	Genetic Resource Action International
HH	household
HLQ	household-level questionnaire
HPPS	high-potential production system
HYV	high-yielding variety
INGO	international nongovernmental organization
IARC	international agricultural research center
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIMOD	International Centre for Integrated Mountain Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDP	intensive data plot
IDRC	International Development Research Centre
IGAU	Indira Gandhi Agricultural University
INGO	international nongovernmental organization
INTACH	Indian National Trust for Art and Cultural Heritage
IPGRI	International Plant Genetic Resources Institute
IRD	informal research and development
IRRI	International Rice Research Institute
ITDG	Intermediate Technology Development Group
JPP	Jajarkot Permaculture Programme
KDS	Kami/Damai/Sarki (ethnicity category for LI-BIRD research)
KRIBHCO	Krishak Bharati Co-operative
KRIBP	Indo-British Rainfed Farming Project
KVK	Krishi Vigyan Kendra
LARC	Lumle Agricultural Research Centre
LI-BIRD	Local Initiatives for Biodiversity Research and Development
M&E	monitoring and evaluation
MAFFM	Ministry of Agriculture, Fisheries, Forests and Meteorology
MNC/TNC	multinational/transnational corporation
MSSRF	M.S. Swaminathan Research Foundation
MV	modern variety
NARC	Nepal Agricultural Research Council
NARS	national agricultural research system/s
NGO	nongovernmental organization
NMRP	National Maize Research Programme
NRCS	National Research Centre for Sorghum
NRRP	National Rice Research Programme
NSI	national systems of innovation
OPV	open-pollinated variety

OST	on-station trial
PAU	Punjab Agricultural University
PCI	participatory crop improvement
PGR	plant genetic resources
PGRE	plant genetic resource enhancement
PHILRICE	Philippine Rice Research Institute
PPB	participatory plant breeding
PR	Punjab rice
PRA	participatory rural appraisal
PRGA	Participatory Research and Gender Analysis (CGIAR systemwide program)
PTD	participatory technology development
PVP	plant-variety protection
PVS	participatory varietal selection
R&D	research and development
RD	recommendation domain
RRA	rapid rural appraisal
RRS	regional research station
SADC	Southern African Development Community
SANFEC	South Asia Network for Food, Ecology and Culture
SEARICE	Southeast Asia Regional Institute for Community Education
SRISTA	Society for Research and Initiatives for Sustainable Technologies and Institutions
TIP	Taro Improvement Project
TLB	taro leaf blight
TRIPs	trade-related intellectual property rights
TWN	Third World Network
UBINIG	Unnayan Bikalper Niti Nirdharoni Gobeshana (Bengali, Bangladesh)
UNCTAD	United Nations Conference on Trade and Development
UPLB	University of the Philippines–Los Baños
UPOV	International Convention for the Protection of New Varieties of Plants
USP	University of the South Pacific
VDC	village development committee
VRRC	Variety Release and Registration Committee
UD	Using Diversity Network
WTO	World Trade Organisation
WARDA	West Africa Rice Development Association

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International Symposium on:

Participatory Plant Breeding
and
Participatory Plant Genetic Resource Enhancement

An Exchange of Experiences from South and South East Asia

Venue: Pokhara, Nepal
Date: May 1–5, 2000

Co-hosted by:

The System-wide Program on Participatory Research and Gender Analysis (PRGA)
The International Plant Genetic Resources Institute (IPGRI)
The International Development Research Center (IDRC)
The Department for International Development (DFID)
Using Diversity Network (UD)
South Asia Network for Food, Ecology and Culture (SANFEC)
Deccan Development Society (DDS)
Local Initiatives for Biodiversity Research and Development (LiBird)
The Eastern Himalayan Network

Sunday, April 30

17:00-17:30	Registration
18:30-19:30	Welcome Cocktail
19:30	*Dinner*

Monday, May 1

07.00-08.00	*Breakfast*

Opening Plenary

08:30-08:45	Welcome Address *Mr. Dhruva Joshi, Executive Director, NARC*
08:45-09:15	Objectives and Organization of Seminar *L. Sperling, PGRA*
09:15-10:30	Presentation of Participants (Farmers, Scientists, and Development Professionals)
10:30-11:00	*Tea Break*

Session 1: Overview Papers — Moderator: D. Buckles, IDRC

11:10-11:40	Participatory Plant Breeding: A Framework for Analyzing Diverse Approaches *L. Sperling, PRGA*
11:40-12:10	Participatory Varietal Selection in High-Potential Production Systems *J. Witcombe, DFID, Plant Sciences Program, University of Wales*

12:10-12:40 Enhancing Biodiversity and Production through Participatory Plant Breeding

B. Sthapit, IPGRI; D. Jarvis/IPGRI; P. Ezyguirre/IPGRI; K. Joshi/LIBIRD; R. Rana/LIBIRD

12:40-13:10 Discussion

13:10-14:10 *Lunch*

Session 2: The Context of Participatory Plant Breeding — Moderator: Bhuwon Sthapit, IPGRI

14:20-14:40 Cultivating the Landscape: Enhancing the Context for Plant Improvement

D. Buckles, IDRC and F. Mazhar, UBINIG

Tuesday, May 2

07:00-08:00 *Breakfast*

Session 4: Starting from Farmers' Knowledge When Planning PBB/Participatory PGR Programs

08:20 - 08:30 Opening remarks and organization: Vanaja Ramprasad, Green Foundation

Session 4A	Session 4B	Session 4C
Moderator: Stephen Biggs	Moderator: Peter Hobbs	Moderator: KPS Chandel
08:40-09:00 Caecilia Afra Widyastuti, CIP-ESEAP Region, *"Using farmer knowledge for participatory sweet-potato variety selection in Garut, West Java, Indonesia"*	08:40-09:00 T. Paris, IRRI, Philippines, *"Listening to farmers' perceptions: experiences and lessons learned"*	08:40-09:00 Kirsten vom Brocke, ICRISAT, Germany, *"Opportunities and constraints for participatory breeding: farmer's seed management strategies in Rajasthan and their effects on pearl millet populations "*
09:00-09:20 R.B. Rana, LI-BIRD, *"Understanding agroecological domains: a key to a successful participatory plant breeding program"*	09:00-09:20	09:00-09:20 P. Chaudary, LI-BIRD, Nepal, *"Strength of farmers' knowledge and participation in crop improvement and managing agrobiodiversity on-farm"*
09:20-09:50 Discussion Period	09:20-09:50 Discussion Period	09:20-09:50 Discussion Period

10:00-10:30 *Tea Break*

Session 5: Farmers Speak for Themselves about Plant Breeding and PGR Management

10:40-10:50 Opening remarks and organization. Moderator: F. Mazhar, UBINIG

10:50-12:00 Need for Advocacy for Effective Participatory Crop Improvement and Plant Genetic Resource Enhancement: Case Studies on Rice-Breeding Processes from Khotang and Jajarkot Districts, Nepal

Y. Ghale, Action Aid, Nepal

Farmers from Action Aid and UBINIG speak for themselves about plant breeding and PGR Management

12:00-12:30 Discussion period

12:40-13:40 *Lunch*

Session 6: Focus on Methods on PPB: Breeding Concerns

13:50-14:00 Opening remarks and organization: V. Arunachalam

Session 6A	Session 6B	Session 6C
Moderator: Bhuwon Sthapit	Moderator: Dr. RP Sah	Moderator: Dr. DN Sah
14:10-14:30 D. Hunter, University of the South Pacific, W. Samoa, *"Beyond taro leaf blight: a participatory approach for plant breeding and selection for taro improvement in Samoa*	14:10-14:30 R. Kumar, Birsa Agricultural University, India *"Participatory plant breeding in rice in eastern India"*	14:10-14:30 J. Witcombe, DFID, *"Towards a practical participatory plant-breeding strategy in predominantly self-pollinated crops"*
14:30-14:50 A. Kumar, Birsa Agricultural University, India *"Participatory plant breeding in maize for the Chhotanagpur plateau of eastern India"*	14:30-14:50 SN Goyal, Gujarat Agricultural University, India *"Participatory crop improvement in maize in Gujarat, India"*	14:30-14:50 TP Tiwari, Nepal, *"Participatory crop improvement for intercropped maize in bari terraces with trees"*
14:50-15:10 Discussion Period	14:50-15:10 Discussion Period	14:50-15:10 Discussion Period

15:20-15:50 *Tea Break*

Session 7: Skill Building Opportunities (1)

16:00-16:10 Opening remarks and organization: Louise Sperling, PRGA

Skill Building Workshops			
16:20-18:35	16:20-18:35	16:20-18:35	16:20-18:35
Basic PRA Skills and Introduction	Gender Analysis and Practice in PPB/PGR	Guidelines for developing PPB programs	Assessing Impact in PPB programs
Facilitator: PK Shrestha	Facilitator: Thelma Paris	Facilitator: Louise Sperling	Facilitator: Nadine Saad

19:00 *Dinner*

Wednesday, May 3

07:00-08:00 *Breakfast*

Session 8: Lessons Learned, Evaluation and Impact in PPB

08:30-08:40 Opening remarks and organization: A. Sudebi, LI-BIRD

Session 8A	Session 8B	Session 8C
Moderator: D. Hunter	Moderator: Percy Sajise	Moderator: Dr. Ortiz-Ferrara
08:50-09:10	08:50-09:10 RK Singh, IRRI, India, *"Participatory varietal selection: results and lessons learned from East India"*	08:50-09:10 J. Singh et al., India *"Equity issues in varietal dissemination through farmers' fairs in Punjab, India"*
9:10-9:30 BH Halaswamy, AICRP on Small Millets, *"Participatory varietal selection in finger millet"*	9:10-9:30 DS Virk, DFID,*" A holistic approach to participatory crop improvement in wheat"*	9:10-9:30 BS Rana et al., India *"Participatory varietal selection in rabi sorghum in India"*
9:30-9:50 KD Joshi, J. Witcombe, *"Participatory varietal selection, food security and varietal diversity in a high-potential production system in Nepal"*	9:30-9:50 SS Malhi, DFID, *"Participatory varietal selection in rice in the Punjab"*	9:30-9:50 KD Joshi et. al. LI-BIRD, Nepal *"Impact of PPB on landrace diversity: a case study for high-altitude rice in Nepal"*
9:50-10:10 Discussion Period	9:50-10:10 Discussion Period	9:50-10:10 Discussion Period

10:20-10:50 *Tea Break*

Session 9: Focus on Methods in PPB: Social Science Tools for Understanding What End Users Need

11:00-11:10 Opening remarks and organization: Thelma Paris, IRRI

Session 9A	Session 9B
Moderator: Dr. S. Apparao	Moderator: Liz Fajber
11:20-11:40 M. Subedi, LI-BIRD, Nepal, *"Role of farmers in setting breeding goals"*	11:20-11:40 RK Singh, CRURRS, India, *"Sensory evaluation of upland rice varieties with farmers: an experience in eastern India"*
11:40-12:00 Mathur, IPGRI, India, *"PPB in relatio to genetic erosion monitoring"*	11:40-12:00 PK Shrestha, LI-BIRD, Nepal, *"Incorporation of users' perspective in farmer-led participatory plant breeding on maize: experiences from the western hills of Nepal"*
12:00-12:40 LI-BIRD	12:00-12:20 RK Sahu, IRRI, India, *"Understanding farmers' selection criteria for rice varieties: a case in Madhya Pradesh, India"*
12:20 -12:40 Discussion Period	12:20 -12:40 Discussion Period

12:50-13:50 *Lunch*

Session 10: Developing New PPB/PGR Programs

14:00-14:10 Opening remarks and organization: V. Arunachalam, MSSRF

Session 10A	Session 10B
Moderator: Farhad Mazhar	Moderator: Daniel Buckles
14:20-14:40 Iqbal Kermali, FOCUS, Afghanistan, *"Seed security in Badakshan, Afghanistan"*	14:20-14:40 O. Kafawin, University of Jordan, Jordan, *"Increasing the relevance of breeding to Small farmers: farmers participation and local knowledge in breeding barley for specific adaptation to Dry areas of Jordan"*
14:40- 15:20 J. Ransom, J. Adhikari, CIMMYT, Nepal, *"Involving farmers in the development process to improve adoption of varieties developed by national maize-breeding programs"*	14:40- 15:00 MR Bhatta and G. Ortiz-Ferrara, CIMMYT, Nepal, *"Present status of participatory plant breeding research on wheat at the national wheat research program of Nepal"*
15:00-15:20 L. Sperling, PRGA, Holland, *"Participatory plant breeding and property rights "*	15:00-15:20 Discussion
15:00-15:20 Discussion	

15:30-16:00 *Tea Break*

Farmers Speak for themselves about plant breeding and PGR Management (II)

16:10-18:10 Nepali farmers speak for themselves. Moderator: KD Joshi, LiBird

Summary remarks (organizers) and planning for field trip

18:10-

Thursday, May 4: FIELD TRIP

Friday, May 5

07:00-08:00 *Breakfast*

08:30-09:30 Feedback from Field trip. Moderator: DK Rijal

Session 12: Skill Building Opportunities (2)

Session 12: Skill Building Opportunities (2)			
09:40-12:40 Basic PRA Skills and Introduction Facilitator: PK Shrestha	09:40-12:40 Gender Analysis and Practice in PPB/PGR Facilitator: Thelma Paris	09:40-12:40 Guidelines for developing PPB Programs Facilitator: Louise Sperling	09:40-12:40 Assessing Impact in PPB Programs Facilitator: Nadine Saad

12:50-13:40 *Lunch*

Session 13: Dialogue

14:00-14:10 Opening and Rational for the Session. Moderator:

14:20-15:20 Interaction meetings between farmers, scientists, and development professionals

15:20-15:50 *Tea Break*

16:00-16:30 Interaction meetings between farmers, scientists, and development professionals

16:40-17:40 Conclusions from Interaction meetings

17:40-18:40 Closure, Reflections and Next Steps. Moderator: Organizing Committee

19:30 *Farewell Dinner*