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The purpose of the CGIAR Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA Program) is to assess and develop methodologies and organizational innovations for gender-sensitive participatory research and to mainstream their use in plant breeding and in crop and natural resource management.

The PRGA Program is cosponsored by the International Center for Tropical Agriculture (CIAT), which serves as the convening center, and by the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Agricultural Research in the Dry Areas (ICARDA), and the International Rice Research Institute (IRRI).

PRGA Program activities are funded by the Canada's International Development Research Centre (IDRC), the Ford Foundation, and the governments of Canada, Italy, the Netherlands, New Zealand, Norway, and Switzerland.

The Program's members include international agricultural research centers, national agricultural research systems, nongovernment organizations, and universities around the world.

Cover photograph:

A woman farmer from Rajasthan, India, selecting pearl millet panicles from farmer and breeder populations during an on-station workshop held at the ARS Mandore, September 1998. (Photo by Anja Christinck.)

ISBN 958-694-051-9

Technical and Institutional Issues in Participatory Plant Breeding—From the Perspective of Formal Plant Breeding

A Global Analysis of Issues, Results, and Current Experience

PPB Monograph No. 1

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ISBN 958-694-051-9
Press run: 500
Printed in Colombia
March 2003

Weltzien R., Eva
Technical and institutional issues in participatory plant breeding—From the perspective of formal plant breeding : a global analysis of issues, results, and current experience / Eva Weltzien, Margaret E. Smith, Laura S. Meitzner, and Louise Sperling. -- Cali, CO : CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation ; Centro Internacional de Agricultura Tropical (CIAT), 2003.
208 p. -- (PPB monograph ; no. 1)
ISBN 958-694-051-9

AGROVOC descriptors in Spanish:
1. Fitomejoramiento. 2. Investigación participativa. 3. Estudios de casos prácticos. 4. Criterios de selección. 5. *Phaseolus vulgaris*. 6. *Oryza sativa*. 7. Arroz. 8. *Solanum tuberosum*. 9. *Manihot esculenta*. 10. *Zea mays*. 11. Maíz. 12. *Pennisetum glaucum*. 13. Colombia. 14. Tanzania. 15. Bolivia. 16. Nepal. 17. Rwanda. 18. Ecuador. 19. Honduras. 20. Namibia. 21. Entorno socioeconómico. 22. Análisis de género. 23. Impacto de la investigación. 24. Frijol. 25. Yuca.

AGROVOC descriptors in English:
1. Plant breeding. 2. Participatory research. 3. Case studies. 4. Selection criteria. 5. *Phaseolus vulgaris*. 6. *Oryza sativa*. 7. Rice. 8. *Solanum tuberosum*. 9. *Manihot esculenta*. 10. *Zea mays*. 11. Maize. 12. *Pennisetum glaucum*. 13. Colombia. 14. Tanzania. 15. Bolivia. 16. Nepal. 17. Rwanda. 18. Ecuador. 19. Honduras. 20. Namibia. 21. Socioeconomic environment. 22. Gender analysis. 23. Research impact. 24. Beans. 25. Cassava.

I. Tít. II. Smith, Margaret E. III. Meitzner, Laura S. IV. Sperling, Louise. V. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation. VI. Centro Internacional de Agricultura Tropical. VII. Ser.

AGRIS subject categories: F30 Genética vegetal y fitomejoramiento / Plant genetics and breeding
A50 Investigación agrícola / Agricultural research

LC classification: SB 123 .W45

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Preface

To achieve an impact that benefits poor people, the participation of farmers (especially women) is critical in technology development. In poor countries, women's access to technology appropriate for their needs vitally affects household food security, and especially the well being of children. For this reason, the Consultative Group on International Agricultural Research (CGIAR) system decided to strengthen, consolidate, and mainstream its participatory research and gender analysis. Thus it formed the Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (the PRGA Program)—a high-priority, high-visibility program that recognizes farmer participation as an important strategic research issue.

The Program's goal is to improve the ability of the CGIAR system and other collaborating institutions to develop technology that alleviates poverty, improves food security, and protects the environment with greater equity. This goal will be accomplished through collaborative research to assess and develop methodologies and organizational innovations for gender-sensitive participatory research. The Program's overall strategy is to introduce and strengthen the appropriate use of PRGA approaches and methods in the CGIAR's and partners' core research areas.

The Program focuses on participatory approaches to technology development and institutional innovation that use action research. The latter is defined as research conducted via hands-on involvement in processes of developing technologies or institutional innovations, in contrast to only studying or documenting this development. Priority is given to two main thrusts: (1) the participation of farmers, particularly rural women, in **formal-led research**, and (2) the participation of professional scientists in **farmer-led research**.

Over the last 10 years or so, substantial work has been done to introduce a user perspective into adaptive research. Recent evidence suggests that user participation can be critical in the **preadaptive** stages of certain types of research. This is when it brings users into the early stages of technology development as researchers and decision makers who help set priorities, define criteria for success, and determine when an innovation is “ready” for release. This new role changes the division of labor between farmers and scientists, and may dramatically reduce the cost of applied research. We have evidence that this novel approach can significantly improve the impact of research for poor farmers, especially women. However, evidence is patchy and how to replicate success on a large scale is not well understood. A key contribution of the Program is to develop clear guidelines on how to achieve this end, and to build the capacity to put novel approaches into practice.

Acknowledgments

We would like to acknowledge first and foremost the many farmers and farming communities involved in joint PPB research. While some individuals are named within this piece, thousands of others remain anonymous. Our thanks—and may this paper be of use for helping PPB work further achieve your goals.

Sincere acknowledgements also go out to our colleagues in formal plant breeding programs, and to institutes who have shared freely the results, experiences, reports and internal documents about their PPB work with us, with the aim that others could benefit, and further develop concepts, ideas, and good practice in PPB work.

In much the same way, we would like to extend our thanks to development workers, community organizers, and others involved in PPB and participatory research and development more generally with whom we have discussed experiences, bounced off new ideas, and reinforced our commitment to this work.

The support of various Information staff has been invaluable, particularly so because the authors have been working from four continents. Electronic mail has also allowed us to have detailed, insightful conversations and even to work together—with many whom we have never even met. In this regard, particular thanks to Carole Morehouse, Administrative Assistant in the Department of Plant Breeding, Cornell University, and to Kathryn Laing, former Assistant Coordinator of the PRGA, who have helped keep us on track. Fred Rattunde, a plant breeder of ICRISAT in Mali, has also given us generous bibliographic assistance.

Finally, special thanks to Jacqueline Ashby, Director of the Rural Innovation Institute at CIAT, former Coordinator of the PRGA, and a true pioneer in the PPB field, for both substantial intellectual insight on this particular document and, more generally, for making these syntheses possible at all.

This overview document draws from multiple sources (interviews, publications, email correspondence) and aims to have a worldwide purview. While the authors double-checked information with PPB

practitioners in the field and even fed back specific text for comment, errors of both fact and interpretation undoubtedly remain. We would greatly appreciate your bringing these to our attention so that future versions can be modified accordingly.

Executive Summary

This paper presents a review of what has been done in participatory plant breeding (PPB) from the perspective of formal sector institutions (such as national plant breeding programs, CGIAR institutes, or extension services). It includes an inventory of PPB cases worldwide, detailed description of about a dozen illustrative cases, analysis of key technical and institutional issues, and assessment of gaps in current knowledge regarding PPB methods, organization, and results. For the purposes of this document, PPB is defined as approaches that involve close farmer-researcher collaboration to bring about plant genetic improvement within a species.

The goals of PPB programs can include:

- Increasing production in farmers' fields and increased farmer incomes through development and enhanced adoption of suitable, usually improved varieties,
- Enhancing biodiversity,
- Providing benefits for specific types of users (e.g., the rural poor, women, farmers with marginal soils),
- Modifying variety release policies and procedures and seed regulations, and
- Enhancing farmers' own breeding efforts.

A range of reasons for involving farmers and other end-users in such an effort includes:

- Better understanding farmers' preferences,
- Sharpening the selection process to meet different end-user needs,
- Sharing the labor of evaluation trials, and
- Empowering farmers through strengthening decision making, skills, and access to local and exotic germplasm.

We anticipated that PPB approaches would be technically most beneficial in situations where traditional breeding efforts based on experiment stations have been less successful. Thus, PPB is expected to be beneficial in areas:

- Not dedicated to large-scale commercial crop production,

- Marginal for agriculture, where environments are highly variable and genotype by environment (GxE) interactions preclude widespread adaptation of one or a few varieties,
- Where end uses, and thus needed varietal quality traits, are diverse or locally unique, and
- For crops that are of only local importance or are not the focus of formal breeding efforts.

For farmer skill building and empowerment, the range of conditions under which PPB may be beneficial might be rather broader.

This report was prepared by drawing on materials from published results of PPB studies (both in formal and "gray" literature), interviews with those involved in such projects, comments drawn from the Systemwide Program (SWP) PRGA Plant Breeding Group's e-mail listserver, and the authors' own collective experiences with PPB projects. Information on specific cases was fed back at several stages to the practitioners involved. We apologize for any errors of fact or interpretation that may remain. Although not exhaustive, we believe this report represents almost the full spectrum of PPB practice, and regret any program omissions. The field is growing rapidly.

In examining PPB programs, we grouped them in various ways to detect and conceptualize trends. These groupings emphasized the key factors that have stimulated practitioners' interest in PPB: the goals that PPB can achieve, the environments in which it might have impact, and the nature and degree of farmers' participation in different projects.

Most programs focused on productivity enhancement, particularly in marginal environments. Often linked to this was a focus on better understanding farmers' selection criteria and varietal preferences. A third important goal was that of ensuring the possibility of releasing varieties adapted to specific (often marginal) production conditions through policy changes. Other goals, such as biodiversity enhancement and farmer capacity building, were secondary in most PPB programs.

Formal-led PPB programs tended to be clustered in production environments of high stress (marginal), and subsistence-oriented. Surprisingly, however, an increasing number of projects are addressing lower stress, more market-driven contexts. The latter include programs that aim to expand intra-crop varietal diversity in areas that have become quite uniform, that focus on areas where seed systems are inadequate, and that address diverse user preferences or needs for very specific products.

Farmers' participation in formal-led PPB can be considered in terms of the *stages* of the breeding process during which it occurs, the *nature* of farmers' contributions, and the *degree* of decision making. These three dimensions together describe the "quality of participation".

In terms of stage, in most PPB cases examined, farmer participation occurred during the testing of (genetically fixed) varieties. The involvement of farmers in setting breeding priorities and targets is also reasonably common. Much less has been done to explore farmers' potential contributions to setting the overall goals of a breeding program, generating variability, or selecting experimental varieties from among segregating populations. Participation between researchers and farmers in the variety diffusion process is beginning to receive more attention.

The nature of contributions that farmers made included those of key information based on their knowledge and experience, of genetic materials, and of involvement in the actual breeding process. The contributions of farmers' information provide breeders with insights needed to identify appropriate varieties and improve seed production and distribution systems. Involving large groups of farmers in contributing information is relatively easy. Contributions of genetic materials can provide germplasm with unique sets of traits and thus introduce new genetic variability into breeding programs, and broaden the genetic base of breeding populations. Farmer involvement in the breeding process has most often involved conducting trials and/or selecting and evaluating germplasm, leading to increases in research efficiency.

The degree of participation within formal-led PPB work was overwhelmingly consultative; that is, farmers give advice, but have no real decision-making power.

For this review, 48 cases were identified, studied, and inventoried (Appendix 1). Of these, 11 case studies are presented in greater depth in the body of the report. They were chosen to represent the diversity of crop types, geographic regions, and scales of PPB programs, and to show some of the different motivations for pursuing PPB from the formal breeding sector.

These cases show work in progress with farmers involved in different stages of the breeding process (i.e., testing and evaluating varieties, selecting in early generations, generating variability, identifying and focusing breeding objectives, and disseminating seeds and planting materials). They include work with cross-pollinated, self-pollinated, and clonally propagated crops. The research is located in Asia, Africa, Latin America, and Mesoamerica, and addresses farmers' needs in a wide variety of agroecological conditions (from extremely hot, dry desert margins to very high rainfall, high altitude, mountain conditions). Some cases deal with highly market-oriented production and others with subsistence-oriented systems where production shortfalls are frequent. Most of the case studies represent production systems in which the formal breeding sector alone, without the direct involvement of farmers, has achieved only limited success. Different institutional partners and collaborative arrangements are represented. The cases emphasized different broad goals (e.g., enhancing research efficiency, influencing productivity, changing seed production and variety release policies, conservation or enhancement of local crop genetic diversity, facilitating farmer learning and empowerment, and benefiting specific end-users). Some cases addressed issues or problems that farmers identified and initiated, while others merely consulted farmers and used the information so acquired to orient selection programs or other breeding activities.

Key outcomes described in these cases include the following.

- Farmers' selections strike a balance between productivity and marketability.
- Farmers have an advantage in selecting visually, considering a wide array of traits, and identifying the most promising trait combinations.
- Breeders are usually better placed to select for quantitative traits that are difficult to assess visually, such as disease resistance or yield potential.
- Involving farmers in the evaluation of larger sets of varieties before release, or before general recommendations are made, is extremely powerful in identifying the most beneficial options for farmers.
- Involving other stakeholders (i.e., women who process the crops, sales agents, or urban consumers) may reveal new options for producers.
- Farmer evaluations are a regular contribution to the variety evaluation process.
- Extreme stress conditions, as found in some farmers' fields and well understood by farmers, provide key selection conditions to identify tolerances and adaptations.
- Working with farmer groups or their representatives provides opportunities for scaling up the process of participatory selection.
- Farmers are interested in an array of varieties for different production niches and marketing opportunities.
- In areas of inherently low crop genetic diversity, PPB provides an avenue for increasing this diversity in farmers' fields.
- Farmers are very keen to test new varieties and to learn techniques for improving their own varieties.
- Understanding local seed systems can be the key for effective formal-led PPB programs.
- Those programs with the most immediate impact have a built-in seed component.

- Significant scaling up occurred only when PPB programs devolved much of the adaptive testing to farmers.

From examination of the case studies and consideration of all the PPB programs inventoried, the following generalizable lessons emerged.

In biophysical and socioeconomic environments:

- Many cases (about one third) took place in relatively marginal production contexts where conventional breeding had not been effective.
- The social context was an equally strong driving force, as reflected in PPB programs in the more favorable areas that aimed to increase varietal diversity, help farmers gain control over the seed supply, or hasten adoption of improved varieties.
- In semi-favorable areas, PPB has been introduced where marketed production must meet rigid consumer preferences or where subsistence crops are only recently being marketed and thus need to meet new quality demands.
- PPB is an approach that explicitly aims to reach the disadvantaged.

In breeding strategies involving farmers:

- Most PPB efforts to date are focused on major staple food crops in areas with locally important quality preferences. Most experiences are with self-pollinated crops, half as many with cross-pollinated crops, a quarter as many with clonally propagated crops, and only a handful with tree species.
- Sowing by tractor, broadcast seeding, and seeding of crop mixtures by mixing seed of the species involved, seriously limit the possibilities for on-farm variety evaluations or selections, simply because of complication in plot establishment and identification.
- Crops with low seed increase ratio can spread only very gradually through local seed systems, and may necessitate creative integration of formal and local seed systems to provide rapid availability of good varieties.
- About two thirds of the cases examined focused on identifying, verifying, and testing specific selection criteria, to ensure that varieties developed/selected truly meet farmers' needs. Many approaches to gaining an understanding of farmers' preferences and needs were investigated, involving either bringing farmers to the research station to view a broad range of genetic materials or asking farmers to grow and evaluate diverse materials in their own fields.
- Many projects focused on developing methodology for effective interaction with farmers and exploring options for sharing responsibilities and decision making with farmers. Most of this effort has addressed farmer involvement in variety testing and

evaluation. Much less effort has been devoted to developing and testing options for farmer involvement in early generation selection, and most of this has focused on self-pollinated crops with minimal work on cross-pollinated crops. Overall, farmers showed particular strength and ability to contribute to selection involving overall judgements about complex combinations of traits. Farmers have rarely taken part consciously in generating genetic variability for breeding programs.

- The need to test varieties in appropriate production contexts has been a key motivator for involving farmers in formal breeding programs. The PPB programs that were examined tended to use many more testing sites than a classical breeding program would use, but often with each farmer testing only one or a very few varieties in comparison to his/her own variety.
- The focus on comparison with farmers' varieties that is inherent in PPB approaches has encouraged a shift to improving specific traits in local materials in some breeding programs, and this has increased the genetic diversity in breeding germplasm pools in some cases.

In issues of participation:

- The literature on PPB provided only limited information regarding the quality of the actual participation of farmers.
- Farmer input can optimally occur at various points in the cycle of breeding stages, and will likely occur at different stages as a program evolves and matures.
- Whose input is most needed at what points during the annual crop cycle (i.e., men's vs. women's input during the cropping cycle, at harvest, during processing and use, and preplanting) must be taken into consideration. Identifying meaningful options for farmer input during the off-season, when demands on farmers' time and labor are fewer, would be extremely helpful.
- The degree of farmer collaboration can vary from simple responses to a survey, to a truly integrated, interactive, long-term involvement with formal breeders. The degree of farmer involvement is likely to change as a PPB program develops and as each partner identifies the more efficient forms of interaction.
- Cases examined show farmer involvement occurring primarily near the end of the varietal development process (variety testing and seed production/distribution) in forms ranging from consultative, to collaborative, to collegial, or as consultative input to definition of breeding objectives (variety ideotypes and key crop characteristics).
- Few of the cases analyzed have experimented with collegial participation involving a significant devolution of responsibility to farmers. This may be because many of the cases are still testing approaches. As yet, very few guidelines are drawn from experience on the degree of devolution to farmers that can be achieved in a

research program that needs to maintain certain standards of data quality, which affect the replicability and validity of results.
- Farmers' participation appears essential to successful plant breeding when their expertise is needed, their preferences are highly differentiated, they and their communities want greater control over the germplasm and seed supply, they need to take the lead in future breeding efforts (e.g., for minor crops), and desired impacts require large-scale farmer involvement in adaptive testing.
- Use of farmers' labor or farmer environments' per se do not constitute participation.

In gender/user differentiation and PPB programs:

- Farmer evaluators were chosen by diverse methods in the cases examined, but there was little rigorous discussion of the methods used. The rational for engaging in the PPB effort only rarely appeared to explicitly guide the choice of participants.
- Most collaboration is still conceived as between researchers and individual farmers. Few efforts have focused on organized farmer groups that could share research responsibility more fully and spread benefits more quickly.
- The treatment of gender as an analytical variable has been generally weak in PPB, particularly considering the key roles women play in breeding, selection, and conservation of crop varieties. A companion piece (Hecht 1998) focuses entirely on the social/gender perspective, so is not discussed in depth here.

For institutions in formal-led PPB:

- In most of the PPB cases examined, institutional arrangements have been little altered from the norm.
- Challenges under current arrangements include creating shared agendas, building in accountability for research outputs, creating effective inter-institutional linkages, and ensuring effective communication between researchers and farmers. In general, very few PPB efforts have focused on these challenges.
- Scaling up of the process and of PPB products is a potentially complex issue. A larger number of farmers have been involved in variety evaluation and dissemination in a few of the studied cases. Whether scaling up is necessary in generating genetic variability or in selecting in segregating populations depends on the extent to which these activities can be effectively centralized, but still effective, at addressing varietal needs over a broad area.

For outcomes, results, and impacts of formal-led PPB:

- Influencing breeders' selection criteria and methods is a significant outcome of PPB. Of the cases studied, 85% obtained results relating to farmers' selection criteria for new varieties, and these often enabled researchers to better focus their efforts on poorer farmers and/or on particular varietal needs through altering their testing conditions, modifying breeding objectives, or choosing new/different parents for breeding populations.

- Breeders also investigated methods for obtaining more accurate and realistic farmer assessments through group and individual processes, and for increasing the numbers and/or representativeness of participating farmers. Through this means, breeders gained confidence in farmers' capacity for evaluation, and the "scientist as learner" became a primary product of PPB.
- About half of the cases reported identification of farmer-preferred improved varietiess—often a highly significant breakthrough because, in many projects, no improved varieties had previously been available to farmers. The key to successful cases was an understanding on the researcher's part of the prevailing problems in the target zone, and the testing of a sufficiently broad range of genetic materials.
- In several projects where improved varieties were identified, increased adoption of these varieties was studied and documented. One case calculated 47% to 70% returns on investment in a PPB project based on the impact from a successful, farmer-preferred rice variety.
- Many PPB cases reported a difference in varietal preference among gender, social, wealth, or ethnic classes. With PPB, researchers can focus on the needs of the poorer sector, through such strategies as testing in low-input situations and emphasizing the development of early maturing varieties. This helps researchers attend to multiple crop uses, identify a diversity of varieties to stabilize production, and ensure that varieties grown for market have quality traits that can bring good prices.
- Promoting the formal release of many and more diverse varieties through PPB has contributed to increased varietal diversity in farmers' fields in several cases. In situations where diversity is already very high, various PPB efforts are addressing farmers' crop/seed management to provide the basis for designing PPB programs that combine productivity enhancement with crop diversity conservation and/or enhancement.
- A few cases have stimulated examination and changes in variety release and seed production procedures, to facilitate identifying differentiated needs, incorporating data from farmer evaluations, and exploring methods for coordinating with local seed systems.
- Institutional arrangements have evolved to incorporate decentralization in the breeding process for a few cases involving marginal production conditions.
- Scaling up the impacts of PPB is intricately linked to farmer empowerment. Only a handful of cases have addressed this need through involvement of farmers' social and political organizations in innovative partnerships.

In transfer of benefits:

- Among the formal-led PPB projects, only isolated cases have focused on enhancing farmers' skills and knowledge about specific breeding, varietal, or seed production issues.
- Seed system support is usually not explicitly planned within PPB projects, with a few notable exceptions. Local seed systems show evidence of working relatively effectively in a few cases, but breeders typically know little about how such systems work, what rules apply, and what channels and barriers exist for the flow of information and germplasm. A greater understanding of local seed systems seems essential to developing sound PPB projects.
- For PPB projects working in marginal production environments, which are not well-served by the existing formal variety release and seed production system, integration into the formal system will require changes in that system. These may occur too slowly to be of use to an active PPB program, necessitating creativity in integrating into local seed systems instead.
- Property rights and ethical issues surrounding PPB are lagging far behind technical advances. The collaboration inherent in PPB should imply joint benefit sharing. However, most formal-led PPB work has avoided issues of property rights either by feeding jointly developed varieties into the formal system (thus not recognizing farmers' input) or by letting the developed varieties diffuse into farming communities with no official release of any sort. Better understanding is needed of local property rights, ownership, and benefits' systems associated with varietal knowledge and seed production skills.

In gaps and further work:

The final section of this document focuses on identifying gaps in our understanding that must be addressed by future PPB research. Although far from exhaustive, it reflects those areas where additional research-based information can make the greatest contribution to furthering our understanding of PPB and enhancing the effectiveness of PPB programs.

Breeding methodology and other technical issues

- The process of goal setting needs be undertaken explicitly. At present, most programs implicitly aim for the same goal—production enhancement—as that of classical breeding programs. In a PPB program, all partners should be involved in the goal-setting stage implying that those involved, especially farming communities, have to be aware of what the potential options, and trade-offs, may imply for future benefits and costs.

- Assessment approaches are needed that allow researchers to realistically evaluate the potential benefit from PPB in individual situations, rather than having PPB be the method of recourse when classical breeding approaches have been tried and failed.
- Creative development of methodological options for effective interactions with farmers is needed, including exploration of optimal methods for obtaining farmer input and methods for enhancing farmers' skills in selection and breeding.
- Models are lacking for involving farmers in early generation selection, particularly for the cross-pollinated crops.
- Various technical details are deserving of consideration, including areas such as methods for assessing and comparing crop genetic diversity, models for incorporating farmer-generated variability into breeding programs, and creative field approaches for allowing farmer participation when crops are tractor sown, broadcast sown, or sown as seed mixtures.
- There is little or no data documenting the impacts of PPB programs on *in situ* conservation of local germplasm.

Institutional options

- The assessment of organizational options, options for scaling up, and particularly options for partnering with farmer organizations, leaves a significant gap in current PPB work.
- Models for decentralized seed multiplication have not been broadly studied.
- Development of more effective methods for ensuring both "feed forward" and feed back of information between researchers and farmers/communities is needed to strengthen linkages between research and development.

Participation and gender/user differentiation

- Presently there is little data allowing us to link in any meaningful way stage/degree/nature (or 'quality') of participation with results achieved. This leaves little basis for making logical choices of when/how to involve various partners (farmers and scientists) in a particular breeding situation. On-going studies of farmers' seed selection and management practices may shed some light on the potential contribution from farmer selection.
- Information is also scarce on numerous specific aspects of user-differentiation. For example, virtually none of the documented cases have addressed the question of **who** should be involved for which specific purposes. For example, who should evaluate genetic materials to offer technical expertise? who needs to be involved (and when) to ensure that the needs of poor are met? who should 'participate' to guarantee equitable and efficient diffusion of seed materials? Such gaps are astonishing for work which claims to be 'participatory' as all farmers are treated as a homogeneous mass.

Impact monitoring and documentation

- Data is generally lacking regarding impacts of PPB programs, in part because of the relatively recent initiation of these programs.
- Approaches and methods for monitoring and documenting impact from PPB programs are likely to be difficult to develop (as with classical plant breeding) but work in this area is clearly needed.
- The results and impacts of PPB should be directly matched against the achievements of classic programs (including an analysis of research efficiency).
- Evaluation programs need to embrace both western and grassroots indicators, quantitative and qualitative measurements. Perspectives must be able to encompass the effects of PPB on farmers own systems of breeding and seed maintenance—as well as the implications for classical plant breeding programs.

1. Introduction

Researchers are increasingly experimenting with farmer participatory approaches in plant breeding to strengthen farmer production systems in different ways. This experimentation is particularly taking place in cases where “improved” crop varieties have not benefited farmers, and as an alternative to traditional plant breeding based on experiment stations.

This document presents a review of what has been done in participatory plant breeding (PPB) from the perspective of formal sector institutions, that is, PPB linked to institutions such as national plant breeding programs, CGIAR institutes, or extension services. It includes an inventory of PPB cases worldwide (Appendix 1), a detailed description of 11 illustrative cases, analysis of key technical and institutional issues, and assessment of gaps in current knowledge of PPB methods, organization, and results. To serve as a basis for this discussion, this introductory section defines some of the terms being used and describes the general basis for researchers’ interest in participatory approaches to plant breeding.

Please note that Appendix 1 is a rough draft of a working document in process. It is attached here in its present form for the convenience of those who may wish to look for more details when the studies are referred to in the text.

What is “ PPB from a Formal-Led Perspective”?

Approaches that involve close farmer-researcher collaboration to bring about plant genetic improvement participatory plant breeding done from the formal plant breeding perspective includes those efforts initiated by or with primary leadership from the formal agricultural research sector. Note that we are using PPB to refer to the full scope of activities associated with plant genetic improvement. In the latter we include identifying breeding objectives, generating genetic variability, selecting within variable populations to develop experimental varieties, evaluating experimental varieties (often termed “participatory variety selection” [PVS]), and variety release, popularization, and seed production activities. Farmers can participate in breeding programs at many different points in this continuum of processes and to varying degrees. This has resulted in a broad spectrum of possible farmer-researcher interactions within what we have defined as PPB from the formal plant breeding perspective.

Compared to PPB from the farmer-led perspective, that from the formal perspective has certain unique characteristics, predominantly shaped by its institutional affiliation. Formal-led PPB programs have an obligation to feed information back to the formal research sector and to feed forward to farming communities. There is the expectation that formal-led PPB programs will improve/complement the formal sector research system, for example, refining breeding strategies or possibly reorienting entire programs. Usually, formal-led PPB programs also involve strong linkages to formal variety release and seed production systems. Finally, scientists involved in formal-led programs have a mandate to extrapolate their results beyond the individual farmer or community with which they work, and programs often need to show what are the advantages of farmer participation compared to breeding work centered on the research station or standard on-farm approaches. The comparative advantages of PPB versus traditional breeding approaches will factor into decisions about how research resources are spent, along with institutional and/or political priorities among different client groups. This dual need to focus on end-users, as well as on the formal-sector institutions themselves, shapes the types of participation, products used, and data needed for formal-led PPB programs.

Formal-led PPB programs are relatively new. Most of the cases identified date from the last 10 years, and only five were initiated earlier. Most of these programs have been relatively small in scale, working only at one or two sites, and usually involving relatively intense types of direct farmer and scientist interaction. In general, we would characterize much of this small-scale research work as functionally motivated and as aiming at "functional participation," that is, trying to better understand what farmers want/need in order to feed back insights to formal research so as to improve future on-farm productivity. Formal-led PPB programs that have addressed what may be called capacity building or empowerment ("empowering participation") are those programs that have tried to scale up the work to involve more farmers, representing more households and a larger target region. These programs have more often focused on farmers' skill-building needs, and have searched for a clear division of labor between farmers and scientists that builds on the comparative advantage of each and that ultimately devolves much of the decision making to farmers and their communities.

Motivations for Pursuing PPB: The Research Perspective

Formal-led PPB programs can have a diversity of overarching goals, and hence a diversity of anticipated impacts. The most common goal has been to contribute to increased production in farmers' fields and to increased farmer incomes through the development and enhanced adoption of suitable, usually improved, varieties. These are the basic goals of any formal-led breeding program and participatory approaches are often experimented with to achieve these goals more effectively and efficiently. In this context, formal-led PPB programs sometimes seek to refine their knowledge of farmers' needs or preferences or to reorient general breeding directions, such as the type of base germplasm used, the priority traits sought, and the management and organization of station trials. Institutional and organizational changes that facilitate decentralization and/or scaling up of the breeding program often come hand in hand with these efforts to meet farmers' location-specific varietal needs.

Biodiversity enhancement is another broad goal towards which some PPB programs strive. Participatory breeding programs with this goal tend to work more often with the farmers' own germplasm or a combination of local and exotic materials. Many also involve farmers in the screening of a wide range of varieties in the preadaptive stages of research, either in on-station trials or in community plots. In several cases, PPB programs have also released populations or have purposely promoted breeding strategies that result in heterogeneous materials.

Another important goal of PPB programs is to provide benefits for specific types of users (e.g., the rural poor, women, and farmers with marginal soils) or to deliberately address the needs of a broader range of users. Such a goal necessitates an extensive diagnosis among well-defined types of potential user and stakeholder groups. This goal is often in contrast to traditional centralized breeding programs, which work under the assumption that benefits from routine, station-based research or researcher-controlled on-farm trials are "user neutral," that is, suitable for all.

While addressing issues related to improved adoption of breeding products and/or biodiversity enhancement, PPB programs often find themselves confronted with the need to address modifications in policy, whether these are seed regulations or variety release criteria and procedures. Most modifications are sought to accommodate expansion and institutionalization of approaches that better serve farmers' aims. These may include modifications in the scale of testing and the scale of desired variety adaptation, the kind of data required for release, and the number of varieties released at any one time.

Finally, some programs specifically work towards enhancing the farmers' own breeding process, that is, providing technical knowledge and insights so that farmers themselves are more successful in their own selection and seed production efforts. This skill-building goal is often addressed together with a more general effort towards strengthening the capacities of farming communities to interact and derive and demand benefits from the formal research institutions whose mandates are to address local-level needs.

In conducting an overview of formal-led PPB programs, the authors became aware of how much the goals set for PPB programs shape the entire research design as well as the secondary effects that they achieve. What is on offer (skills or varieties), the type of germplasm used, the type of farmer involved, the scale at which one works, the trial design, and the seed multiplication procedures are highly influenced by the overall goal(s) that are set.

Like any type of plant breeding, PPB is a process that may take 2-5 years to have initial results and several more before its true impact begins to be realized. Recognizing this, a group of PPB practitioners (drawn from the Plant Breeding Group of the PRGA) have begun to conceptualize a set of intermediate goals/impacts. Table 1 presents examples of possible intermediate goals/impact indicators that are being used in two on-going PPB field programs. It is notable that the same PPB program may have impacts on both formal breeding and farmer breeding/seed systems and may have institutional as well as technical impacts. A challenge of the developing PPB work is to assess the trade-offs of aiming for different intermediary impacts, and ultimately different goals.

Motivations for Pursuing PPB: The People Perspective

Beyond a focus on varieties and seed per se, many compelling reasons exist for involving farmers (and other end-users) in this type of agricultural research. These range from technical imperatives (gaining insights), to equity concerns (reaching the needy constituencies), to ensuring collaboration in subsequent research phases. The objectives of such end-user involvement (Sperling and Ashby [1990]) are briefly sketched below.

- ***Relevancy:*** to bring about more demand-driven and client-oriented research and extension. End-user involvement should guide a system to address research themes that stakeholders see as priorities.
- ***Representativeness:*** to encourage that formal research systems (representing a range of stakeholder concerns) address a representative range of themes. Research systems usually have broad and varied constituencies that need to benefit from research programs.
- ***Equity:*** to address concerns of the more marginalized stakeholders. More progressive or even mainstream research directions rarely serve the disadvantaged population sectors. Simply their physical and economic resource base often necessitates tailored research approaches.

Table 1. Examples of intermediate impacts anticipated for major impact categories from two on-going research programs of participatory plant breeding.

Impact categories	Intermediate impact	
	Example 1	Example 2
Effects on formal breeding process (feedback to research)	Changes in the selection strategy: • Selection criteria • Selection environment • Type of germplasm used Gender-differentiated selection criteria identified	Positive change in the way formal breeders view PPB Strengths and weaknesses of available germplasm better understood (for researchers/farmers) Farmers' preferred traits, user- and gender-differentiated, better understood
Effects on acceptance (adoption)	Increase in adoption: • Number of lines requested for independent testing • Number of farmers requesting lines Greater number of requests from farmers of different wealth categories Farmers retain seed for further testing	Identification of farmer-acceptable varieties Particularly disadvantaged users (e.g., women) identify acceptable varieties Rate of varietal spread quickened Seeds of preferred varieties given to neighbors
Effects on farmer production	Varieties show yield advantage on-farm	
Effects on farmer-held diversity	Increase in the number of varieties used on-farm (number of varieties being a rough proxy for variety diversity)	Enhancement of diversity through deliberate cross-pollination in farmers' fields

(Continued)

Table 1. (Continued.)

Impact categories	Intermediate impact	
	Example 1	Example 2
Effects on farmer breeding/seed processes (technical/social)		Farmers' capacity to mass select is enhanced Farmers' ability to maintain open-pollinated varieties enhanced
Effects on how local people are organized to manage crop development • Breeding/selection • Seed supply issues	Farmer group formed to produce and distribute seed of preferred varieties in the village	Nodal seed experts in community identified Farmer ability to produce quality seed enhanced
Effects on how formal research organizations organize breeding • Effects on breeding organizations • Effects on seed supply organizations	Move to replicate farmer conditions on research stations Greater percentage of trials in farmers' fields The role of decentralization versus participation understood Changes in variety release procedure considered	Better understanding (by researchers) of farmers' seed flow system
Effects on "empowerment"		Farmers: • Set their breeding objectives • Have control over breeding methodologies • Perform breeding activities • Work through existing or newly-formed CBO or farmers' groups

- ***Research insights:*** to gain from the technical and social insights of those close to specialized research and development issues. Stakeholders may add precision in defining researchable constraints and their assessments of what is feasible or not may improve the quality of research projects.
- ***Ownership:*** to bring on board the range of stakeholders needed to encourage the success of a technical innovation. Research planning and its subsequent implementation phase will proceed more efficiently and effectively if those implicated have had a voice in the overall agenda and in discussion of subsequent agricultural research and development steps.
- ***Logistical imperatives:*** to make use of stakeholders, labor, land, or energy so as to scale up the research and development process.

Shaping the above list directly toward breeding concerns, there seems to be a basic cluster of roles that formal researchers hope farmers will fill in the PPB process. Farmer involvement first and foremost allows researchers to better understand farmers' preferences. Farmers may have different primary and secondary criteria from researchers, and farmers may assess the trade-offs among traits with different emphasis. Further, farmer involvement should help researchers better differentiate among farmers (women, men, poor, rich), sharpening the selection process to meet different end-user needs (research insight, representativeness, and equity concerns). As well as needing insights into varietal preferences and representativeness, formal researchers also hope farmers can help with some of the labor of evaluation trials and provide locally specific testing sites that replicate diverse planting conditions (i.e., farmers provide "inputs"). All of these first three reasons for breeder-farmer collaboration are broadly characteristic of what is called "functional participation," that is, participation aimed primarily at getting a better product.

Empowering participation, which is more process-oriented, is less frequently planned for within formal-led PPB programs. Within an empowering perspective, farmers might be particularly valued for their key technical insights and given a good deal of leeway to shape the research process itself, including which germplasm is used and how it is tested (e.g., the relevancy goal coupled with research insight) (Sperling et al. 1993). Farmers may also be recognized as having the key right to set the goals of the breeding work, including the last word in evaluating the end product (relevancy and ownership). Some more empowering perspectives also specifically aim to build on existing skills (both researchers' and farmers') aiming to change the research division of labor and devolve more and more of the actual research and decision making to farmers and their communities (goals of democratization or ownership) (Ashby et al. 1996).

Collaborating with farmers exclusively to decentralize testing and to draw on their labor and land has nothing to do with the issue of "participation" per se. Simple farmer-breeder interchanges are sometimes mistakenly grouped under the rubric of PPB. Utilitarian and farmer-passive paradigms are not de facto "bad," but rather characteristic of a classic breeding program that is aiming to scale up (the flipside of decentralize) its operations by contracting farmer labor without paying.

Whether aiming for functional or empowering participatory approaches depends on the goals set from the beginning. Most formal-led programs still see the formal research sector as taking the lead in plant breeding research. Farmer input helps develop a better product for farmers and helps then reshape the formal research strategies to more efficiently achieve such impact. Their goals are primarily for honed, targeted "feedback."

Situations in which PPB is Expected to be Beneficial

As with any other approach to agricultural research, PPB will not be the best choice in all situations. The question of what types of situations are most likely to benefit from PPB may be best examined by first considering the situations where traditional, experiment-station-based breeding efforts have been most successful. Major plant breeding impacts through widely accepted, improved varieties have most commonly occurred when a crop is produced over a broad, relatively uniform, agroecological area, and when crop end-uses are broadly similar. Good examples of this include the Green Revolution rice and wheat varieties, maize hybrids for temperate and mid-altitude tropical zones, and varieties for irrigated, commercial vegetable production that are used in both temperate and tropical regions.

Regions and crops that do not fit these circumstances are often those that traditional plant breeding approaches have not addressed well and that are expected to benefit from PPB. These include areas:

- Not dedicated to large-scale commercial crop production,
- Marginal for agricultural production, where environments are highly variable and GxE interactions preclude widespread adaptation of one or a few varieties,
- Where crop end-uses and thus needed varietal quality characteristics are diverse or locally unique, and
- Where crops that are locally important are/or not the focus of formal plant breeding efforts.

We would expect PPB to have its greatest comparative advantage for increasing productivity, improving cost efficiency, gaining knowledge, and promoting biodiversity enhancement and conservation in situations like these. However, even in Green Revolution-type areas, farmers are increasingly involved in PPB precisely to gain more control over the breeding process, including efforts to reintroduce local germplasm or enhance biodiversity more generally.

For farmer skill-building and empowerment, the case may be quite different. This motivation for pursuing PPB addresses educational, social, and political needs that may be prevalent over a much broader spectrum of crop production circumstances. Experience is needed to suggest where this aspect of PPB is most likely to offer benefits.

Terminology in the PPB Field

Finally, we give a note on terminology. Terminology proliferation, including competing terms, is typical of a developing approach and the field of PPB is no exception. Terms commonly used include collaborative plant breeding (CPB), farmer participatory breeding (FPB), and participatory crop improvement (PCI), among others. All describe the same, highly heterogeneous set of activities.

An additional distinction often made within the PPB realm is between collaborative work that focuses on stabilized materials or PVS and work with variable materials or PPB. Both of these are then put under the PCI umbrella. The authors find the PVS/PPB terms as somewhat limiting for diverse reasons. Most important is that the terminology seems to suggest that only two types of PPB activities exist (PPB and PVS) and that all PVS work is really the same. It also implies that a breeding program really only has two stages—a topic addressed in the next section. Our review of PPB work with stabilized materials shows that wide-ranging differences exist among these projects. The project activities, types of participation, and roles of farmers appear not so much to be determined by the stage of the breeding program. Rather, they seem determined more by the goals set, the organization of the farmer-scientist interaction, the methods for growing the crop, the knowledge already available on farmers' needs, and the interests in the program. Use of the PVS/PPB terminology gives highest priority to "germplasm type" in this complex farmer-researcher collaboration.

We also find the PVS/PPB divide to be imprecise on several smaller grounds. Biologically, the distinction between stabilized and variable materials is not always clear-cut. Further, the PVS/PPB distinction implies that breeders are not breeding at all if they deal only with fixed materials. Per se, the PVS/PPB terminology cannot really, in itself, describe a full "program", but is useful for describing one focused aspect.

Report Methodology

This reports draws material from a range of sources. First, those involved in formal-led PPB tend to publish their results and more general insights in both the official and gray literature (e.g., annual reports). Some 48 PPB cases have been identified that have written documentation, and a growing library of PPB materials has been deposited with the SWP PRGA program at CIAT headquarters. Interviews with those involved (breeders, social scientists, development workers, extensionists) formed a second key source of information. Because much of the official material focuses mainly on the "breeding aspect" of PPB (and is first-authored by breeders), the equally important component of "participation" is given less public attention (who was involved, how, and how their involvement linked to benefits). The e-mail listserve of the Plant Breeding Group of the PRGA, numbering about 150 scientists from 50 institutions, served to further flesh out specific concerns in PPB. However, in frankness, we found this less effective than expected, because the public sharing of insights is becoming more and more circumscribed (perhaps following the lamentable path of increasing germplasm restrictions). As occasional consultants, the authors have had the privilege of visiting a range of PPB field sites to help initiate, strengthen, and evaluate PPB collaborations. Finally, they have been directly involved in PPB programs for extensive periods in the field (21 years' cumulative experience) in Africa, Asia, and Latin America.

At several stages in writing this document, the authors have fed back information on specific case studies to the practitioners involved. We apologize for any errors of fact or interpretation that may remain. This report aims to present and analyze the broad swath of PPB cases worldwide, representing a range of institutions, PPB goals, crops, and environments. Although not exhaustive, we sense that we have represented the near-full spectrum of PPB practice and certainly regret any program omissions. The field is growing quickly and widely.

2. Formal-Led PPB: A Framework for Analysis

In thinking about the diverse and developing field of PPB, trends as a whole can be conceptualized by grouping programs in several ways. In the preliminary frameworks below, we have emphasized the key factors that have stimulated practitioners' attraction to the approach: the goals that PPB can achieve, the environments in which it might have impact, the types of broad contributions that farmers can make.

It is worth noting that we also tried to examine the specific type of "participatory relationship" involved in the PPB work, but had too little information available to map explicit trends. This issue is elaborated in the discussion of generalizable lessons regarding participation, where we present what we believe is a "failed" participation framework. The participatory role of both partners—farmers and researchers—is little reflected on in the literature and oral accounts. This perhaps stems from PPB work generally being led by breeders, and from the formal-led PPB bias to experiment with the approach primarily to achieve technical and functional aims. To stimulate discussion of possible types of participation, we end this framework and overview section with brief descriptions of "classic breeding" cycles and key intervention points where farmers' collaboration could indeed make a significant difference.

Goals of Formal-Led PPB

In conducting an overview of formal-led PPB programs, the authors became aware of how greatly the goals set for PPB programs shape the entire research design as well as the secondary effects that PPB programs achieve. What is on offer (skills or varieties), the type of germplasm used, the type of farmer involved, the scale on which one works, the trial design, and the seed multiplication procedures are highly influenced by the overall goal(s) that are set. However, we found that the goal-setting process itself was rarely articulated or transparent. That is, goal-setting was not seen as something that needed to be discussed within and between the scientific and farming communities in a PPB collaboration.

Table 2 summarizes the primary goals guiding 40 PPB programs that have been initiated or led by the formal sector. The comprehensive

Table 2. Formal-led participatory plant breeding: Goals of program development (no. = 40 cases[a]).

Goal (motivation)	Cases (no.)	Cases (%)
Productivity increase (better varieties)	31	78
Research efficiency (farmer varietal criteria, appropriate testing)	27	68
Biodiversity conserved/enhanced	8	20
Policy changes (release, seed multiplication)	5	13
Facilitate farmer learning	3	8
Other[b]	3	

a. Some cases are listed twice as they had multiple primary goals.
b. This category includes two different motivations: empowerment and benefits to specific users.

review shows that most programs (78%) have focused on various aspects of productivity increases, that is, the same goals towards which classical breeding programs strive. The programs examined have most frequently targeted marginal environments, where impact from classical breeding programs has been less than expected or completely unsatisfactory. Many of these programs have been oriented towards identifying better varieties: those that offer clear advantages over farmers' own local varieties or locally available varieties. Often linked with this objective has been the need of scientists to better understand farmers' selection criteria and preferences for a range of traits, possibly traits with which farmers have had no previous experience (68% of PPB programs). This knowledge usually feeds back directly into on-going breeding efforts, to change priorities for testing and selection criteria. Another closely related objective of specific importance to marginal environments is to ensure the possibility of releasing varieties adapted to specific zones of cultivation (13% of formal-led PPB programs).

While the review identified programs that targeted other goals, such as enhancements in biodiversity or direct farmer capacity-building, these were most often deemed secondary goals in the overall PPB program.

Environments in which PPB is Taking Place

Based on an inventory of about 65 formal-led and farmer-led PPB cases, the authors, in collaboration with the Plant Breeding Group of the PRGA, have been characterizing the environments in which formal-led PPB is unfolding. One parameter describes the type of agroecological environment in which PPB programs have been developed. Consulting with the practitioners involved, we constructed a scale for environments from high to low stress based on actual versus expected yields coupled with an index for incidence of crop failure.

We prefer not to use the terms “unfavored” and “favored” or “marginal” and “high potential” because these actually mean “favored for staple cereal crops”, but common usage tends to ignore the notion of crop-specific comparative advantage. For example, a cool tropical highland environment is “unfavored” for irrigated rice, but highly favored for coffee. Agroecological environments potentially range from those that are primarily subsistence-oriented and highly unstable, implying that farmers’ crop choices are governed by their own adaptive and preference needs, to systems in which crop production is largely driven by urban consumer and/or commercial processor needs.

The second parameter suggests the broad **economic environment** of PPB, that is, the degree of “homogeneous demand versus heterogeneous demand” for varieties. Mapping was based on a 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. Contexts at the higher end (e.g., 8 and 9) tend to correspond to a high degree of homogeneity in product and often favor a narrow range of grain, taste, and cooking types. Such a high degree of uniformity/homogeneity is often associated with contexts where farmers are producing for highly specialized markets.

Some plant breeders consider PPB is most appropriate for environments that are high stress (“marginal”) and where agriculture is low-input. Certainly, conventional breeding has been less effective in such difficult environments and in reaching farmers with few resources; thus, the rationale for testing “participatory approaches”, which are often site-specific, is a solid one. Analysis of actual PPB cases, however, shows a more complex picture. Not all PPB is concentrated in high-stress environments with low-input agriculture. An unexpectedly large number of PPB programs are being initiated in the intermediate areas where agroclimatic stress is less severe. On the whole, these are cases where quality concerns, that is, meeting exigent end-user preferences’ is defined as the paramount challenge. Figure 1 maps the environments of PPB cases on which the PRGA has more precise environmental information.

Figure 1 also shows that a significant amount of PPB work is now occurring in low stress areas where homogeneous end-user preferences are well-defined in the market (e.g., the Nepalese Terai; J Witcombe, personal communication, 1999). Two reasons explain most of the cases in these areas. First, some of these PPB programs aim to expand intra-crop varietal diversity in what have become relatively uniform farming areas. Second, several others are run by NGOs or organized farmer groups with the primary goal of helping communities gain greater control over their breeding process or seed supply (McGuire at al. [1999]).

Market integration	Unfavorable	....	Favorable
Commercial	CORPOICA/CIAT Colombia IRRI/India partners	CIAT/CIAL/Colombia (beans) PROINPA/Bolivia EAP-Zamorano/ Honduras Sokoine/CRSP Tanzania Ethiopia/Awassa Tanzania NARS/CIAT	SE Brazil/EPAGRI USA/popcorn *CONSERVE/* *Philippines* CAZS/LI-BIRD-Nepal PNAP/CIP/Rwanda *USDA* *Guanxi*
	IRRI India partners EMPMF NE Brazil KRIBHCO/ODA India	PNL/CIAT Zaire *BBA/India* *UPWARD/Philippines* *SAVE/Sierra Leone*	ICRAF/Burundi (trees)
Subsistence	NARC/DFID Nepal *REST/Ethiopia* ICARDA/Syria CIMMYT Mexico Sure/ICRISAT India *Guanxi* Narendra Dev/India IER/KIT Mali ICRISAT/Namibia ICRISAT/Niger	ISAR/CIAT/COOPIBU Rwanda	

Figure 1. The distribution of participatory plant breeding (PPB) cases by type of environment. Farmer-led PPB is in italics. (For acronyms, see page 206).

Formal-led PPB programs could also be appropriate in the more favorable, low stress, areas where existing seed systems are inadequate, where user preferences are highly diverse and not fully being met by conventional breeding, or where users are seeking highly specific products (e.g., more organic foods).

Stages of Plant Breeding

Before moving on to some detailed PPB case studies, we take time to reflect on classical breeding paradigms (writ large) and some of their parallels/disjunctures with the emerging PPB approaches. We consider both the technical and organizational processes.

The technical process

The technical process of variety development for any crop, of any pollination or propagation system, can be classified into three major steps or stages. These constitute the technical process of plant breeding and variety development. Schnell (1982) describes them as:

1) Generating variability,
2) Selection, and
3) Testing of experimental varieties.

The first stage is achieved in most programs by making deliberate crosses between diverse parents with complementary trait combinations. In some specific cases, this is also achieved by assembling germplasm on a larger scale, for example, at the beginning of a new program. Breeders might also use mutagenesis to induce new variability within a target breeding material. In cross-pollinated crops where population improvement methods are common, the building of base populations as well as the generation of new progenies for testing are part of this step of generating variability for further improvement activities.

The second step comprises the process of narrowing down the new variability generated from a few thousand or hundred plants or progenies to a limited number of potential new varieties, usually in the order of 10 to 40, and often referred to as experimental varieties. In self-pollinated crops, or while developing hybrid parents, this is usually referred to as selection in segregating generations. In population improvement schemes, this is the phase of progeny testing. For clonally propagated crops, this is the phase of narrowing down the large number of new clones to a lower number of clones for more detailed testing. During this process of narrowing down numbers, the quantity of planting materials is also built up to allow more thorough, multi-location testing of candidates that fulfill a set of minimum criteria, that is, experimental varieties. Thus the length of this stage is partly determined by the seed increase ratio of the crop.

The next phase is the testing of these experimental varieties for productivity traits, their range of adaptation, and acceptability. The experimental varieties are tested in replicated trials over an increasing number of locations with increasing plot sizes. This testing phase normally begins with trials that are named initial variety or hybrid trials, and continues until varieties are proposed for release and/or distribution.

This general classification is helpful for comparisons among different crops and crop types. It also allows for comparisons and optimization of resource allocation in the different stages of a program. Comparing results from long-term breeding research within this framework allows for comparisons across species as well as within a crop. Technical education in plant breeding is often conducted within the framework of these categories, and as education in plant breeding is mostly technical in nature, it is usually limited to these three stages.

A successful breeding program, however, needs two additional stages that go beyond purely technical issues. The technical process needs to correspond with, and address, a set of well-defined goals and objectives for the breeding program. Both primary and secondary goals must be identified, as previously discussed. To fulfill these goals, specific objectives for the breeding program need to be identified and prioritized, and targets set. Knowledge about the target farming system(s) and farmers' needs is important to identify appropriate objectives and targets for a breeding program; and understanding farmers' selection criteria is helpful. Although breeders are rarely trained to elicit this type of information, farmer participation can be a powerful tool to achieve a meaningful orientation of a breeding program.

The technical process of the breeding program, to achieve success, also needs to feed into an efficient system for varietal release and dissemination (i.e., an identified system for delivery of the technical product to potential users). Evaluations of past impact of breeding programs have often pointed out that lack of adoption or limitations to adoption are sometimes because of weaknesses in such delivery systems. Some estimates suggest that, worldwide, the local seed sector provides at least 80% of farmers with most of their seeds (Cromwell et al. 1992). In view of the weakness of large-scale, state-run, or state-directed efforts for seed production and distribution in many developing countries, thought must be given to strengthening the local seed sector or catalyzing more local seed suppliers (whether private sector or otherwise).

To examine potential and actual farmers' involvement in this whole breeding process, it may help to depict these stages of a breeding program in a cyclical fashion (Figure 2). This makes it clearer that feedback between the different stages is possible and should be institutionalized in programs. It is particularly important in participatory breeding projects, many of which are exploratory to a large extent, to envisage this feedback and to influence and open up opportunities throughout the whole breeding program cycle for farmer input, even if the degree of input may vary by stage.

Timing of farmer-researcher collaboration is one of the factors useful in analyzing the diversity of PPB cases. Participatory plant breeding may incorporate farmer input at various stages where it was not found in traditional breeding schemes. Information and experiences gained at one stage can and should influence other stages. It may significantly shuffle the order of these processes (e.g., breeders

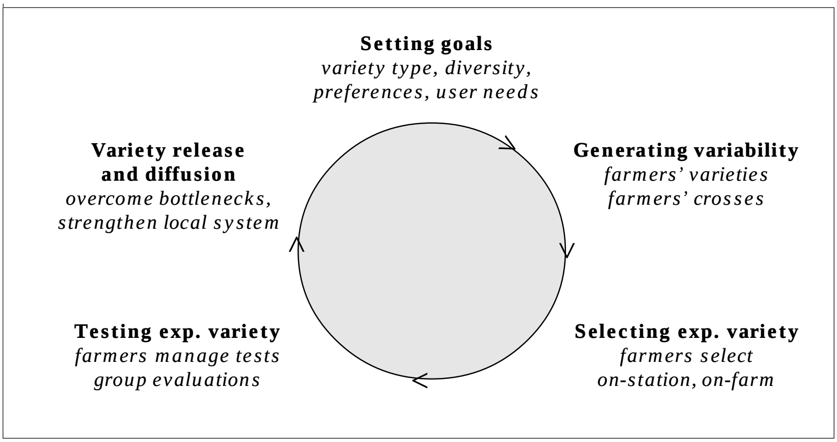

Figure 2. The cycle of plant breeding stages, with examples for farmers' contributions (in italics).

starting with variety testing alongside farmers before solidifying breeding goals, or carrying out these two stages and then generating variability and selecting in segregating populations only if necessary). Because some PPB efforts are linked to informal seed distribution, the need to understand existing seed systems can fit in with setting breeding goals. Accompanying farmers in selection and testing of experimental varieties can help breeders improve their goals so that farmers may not subsequently need to be involved in the selection and testing at all (J Kornegay, personal communication, 1998). A new breeding project, including a PPB project, can begin at any point on this cycle.

In conducting the overview of formal-led PPB work to date, it became clear that most programs involved farmers in the testing of varieties—materials that were genetically fixed and often already released. Several programs addressed the setting of breeding priorities and targets. However, as mentioned before, relatively little work has been done on exploring farmers' contributions to setting the overall goals of a breeding program, generating variability, or selecting experimental varieties from segregating populations. A step that has also received relatively little attention, but is starting to attract interest, is the variety diffusion process: how to multiply and move varieties to those who can benefit from PPB results.

The organizational process

Organizationally, classical and PPB programs form a continuum and share some of the same and some different features. The need to decentralize breeding to replicate actual planting conditions in many marginal environments has often blurred the participatory and non-participatory breeding divide. Table 3 shows how the elements of centralization, participation, and true devolution of decision making and responsibility to farmers can be combined in different ways in both classical and PPB programs.

Few of the PPB programs to date have considered organizational issues as a theme meriting applied research. This partly stems from the newness of programs, which have a primary focus on gaining technical insights. Most also have been on a small scale and have been research oriented rather than taking a broader developmental focus.

However, some practitioners believe that organizational issues should be researched from the start of a program, with the following broad questions guiding the work.

- Process: How will the process of PPB interactions be scaled up?
- Product: How will the product be scaled up (seed, skills)?
- Organizational forms: Through which entities can scaling up (or decentralization) take place?
- Research divisions of labor: What are the implications of "who does what" given the viable organizational options? That is, given the potential organizations involved, with their strengths and weaknesses, how should the "PPB labor" be divided?

If they are to deliver anticipated results, PPB programs should ultimately be designed to have the broadest possible impacts. This takes a great deal of organizational and technical creativity.

Participation and PPB

Participation (like PPB) is a term used with different connotations. However, it is essential to be clear about how to evaluate the separate dimensions of participation that together define what we term 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, and the roles or nature of participation. The stage and degree of participation, together with the roles of the different actors need to be described to link different types of participation with different kinds of results.

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

Table 3. Types of organizational strategies for plant breeding.

Type	Characteristics
1. Conventional "pipeline" approach Centralized location	Client preferences accurately signalled by markets, research, or strong grower associations Central locations represent grower conditions
2. Conventional "pipeline" approach Decentralized locations	Client preferences accurately signalled by markets, research, or strong grower associations Central locations do not represent grower conditions, but breeders selecting in decentralized locations, works ok Breeders have resources to do the decentralization
3. Conventional "pipeline" approach Decentralized locations On-farm selection devolved to farmers	Same as (1) and (2) above except breeders lack resources to decentralize and so devolve this to farmer organizations
4. Client participation Centralized location	Clients' actual preferences or future scenarios for plant ideotypes are difficult to capture secondhand by research, market signals, especially if there are complex tradeoffs among traits, or if one is looking for an innovation that is part of a future scenario for the users[a] Or the main objective of the breeding might be to benefit a specific client group in a specific way[b] Centralized location represents grower conditions The GxE effects are not major for the trait(s) of priority interest Biotechnology or other tools require central laboratory facility for the breeding process Or growers, donors, other contracting agency, or the research institute want central control and intellectual property right over the breeding product; may pay a contract to ensure this Note: a centralized program does not exclude client participation, it just means clients have to come to the central location

(Continued)

Table 3. (Continued.)

Type	Characteristics
5. Client participation	Clients' preferences as (4) above are in addition driven by microenvironmental conditions
Decentralized location	GxE effects important for the traits of interest
	Centralized location does not represent grower conditions
	Decentralized breeding affordable
	Or dissemination of planting material needs to be done efficiently from decentralized locations
	Or farmers are able to insist on local control over selection and breeding products
6. Client participation	Client preferences as in (4) or (5) above
Decentralized location	GxE important for traits of interest
Devolution to farmers	Centralized location not representative of grower conditions
	Or farmers want local control over selection and final product
	Decentralized breeding not affordable, or dissemination will be faster through farmer-to-farmer extension and seed distribution—so on-farm selection is devolved to farmers

a. This may be unclear (e.g., some options for postharvest use that require clients to make judgements along the way). Highly segmented markets (gourmet varieties) might also exist, very differentiated client groups.

b. For example, to develop varieties specifically designed to benefit poor rural women's postharvest production possibilities.

A second dimension of participation is therefore, the **degree** to which farmers or other users who participate actually influence or make decisions about the process at any given stage. Descriptions of this dimension of participation in the cases studied are usually vague, reflecting a lack of clarity among PPB practitioners about the extent to which the degree of participation at any given stage of the breeding process can affect the end results. More time spent on participation cannot be assumed to be necessarily better quality participation, from either functional or empowerment perspectives. Poor women, especially, have enough to do without "participating" in extra activities.

A third dimension of participation is the specific role or nature of the contribution. The **role/nature** of actors in a participatory program specifically refers to the functions they undertake (e.g., roles of information-giver, germplasm-provider, active researcher).

These three dimensions of participation, which determine its "quality", are elaborated in this document. The "stage" has been elaborated above. The "nature" of participation and the "degree" are explored below.

Nature of farmers' participation in formal-led PPB programs

A way of differentiating "participation" in formal-led PPB programs is by examining the nature of farmers' contributions. We have identified three main types of contributions:

1) Farmers contribute key information, based on their knowledge and experiences,
2) Farmers contribute genetic materials, and
3) Farmers are actually involved in the breeding process, typically by conducting trials and/or selecting and evaluating germplasm.

Farmers contribute knowledge and information. Farmers' descriptions of their cropping systems, major constraints, key aspects of the farming system, and social institutions make important contributions to the orientation of a breeding program. Breeding programs also need to understand farmers' preferences for specific crop traits and sometimes seek part of this information through analysis of varieties that farmers presently grow. Understanding of farmers' breeding and seed systems in PPB programs has led to descriptions of appropriate types of varieties, a reorientation of the breeding program in terms of selection strategy, and different choices of germplasm used for breeding. It has even led to recommendations for working through local seed systems and increasing their efficiency and ability to serve a wide range of farmers.

Several cases illustrate these points more clearly. In a western region of India, description of locally grown varieties in the target areas allowed breeders to choose materials for testing that differed distinctly from the locally grown varieties for key traits (Witcombe et al. 1996). Based on careful analysis of farmers' strategies for seed potato selection, production technologies for improved seed health and storage conditions were developed in the Andean region and in eastern Africa (Haugerud and Collinson 1990). Further, farmers' information played a key role in orientating the breeding program for pearl millet in the desert region of Rajasthan. Farmers there do not differentiate particularly between different varieties, but rather between different plant types, and associate specific plant types strongly with adaptation to specific growing conditions. Farmers who regularly produce their own seed often select panicles representing very different plant types for their seed lots. Breeding programs targeting this region now work towards offering farmers a range of different types of materials for use in mixed seed lots (Dhamotharan et al. 1997).

Information contributions from farmers thus provide breeders with insights necessary to identify the appropriate type of variety, both in terms of genetic makeup (hybrid or heterogeneous open-pollinated variety) and in terms of key plant traits. Similarly, research efforts aimed at improving institutional support for seed production and distribution can derive key interventions from a sound analysis of farmers' systems. These examples indicate that the impacts, which a PPB program can expect from farmers contributing their information, relate primarily to increasing the efficiency of the research and dissemination processes of new technologies themselves.

An important advantage of explicitly searching for and including farmers' knowledge at the core of PPB programs is that involving many farmers is relatively easy and, if appropriate care is taken, stakeholders can be involved who often are otherwise overlooked or excluded (i.e., women, poor farmers, minorities). Discussions with farmers on specific topics related to the breeding and seed system support efforts do not necessarily need to be conducted during the growing season, when farmers' time is often very limited and valuable.

Farmers contribute genetic materials. Farmers can also contribute genetic materials to breeding programs, especially participatory breeding programs focusing on adaptation to specific stresses, production systems, or niches. Specific quality traits or crops for which not much breeding has been done rely strongly on farmers' contribution of their own genetic materials to a joint breeding effort. In such cases, farmers' genetic materials are commonly key to success.

Farmers' genetic materials can be used in different ways. In a few cases with cross-pollinated crops, farmers deliberately create new variability by facilitating outcrossing between highly diverse types of varieties, often their landrace and an introduced modern variety. These outcrosses often reveal enormous genetic variation and many new combinations of traits. In the case of pearl millet in Namibia, one such population has been used as the base for creating a new breeding population (Bidinger 1998). In several cases, farmers have contributed landraces as parents for crossing, or for targeted improvement efforts. A good example for this is the project on breeding for chilling tolerance in rice in Nepal. The local landrace had been identified by breeders in a series of tests as highly tolerant of chilling temperatures during the early growth phase and during grain filling. This variety was crossed with a high-yielding, chilling-susceptible variety. Farmers used the progenies from this cross for selection of a new variety (Sthapit et al. 1996).

Farmers' varieties are usually the starting point for projects that aim primarily to enhance farmers' own skills for genetically improving their varieties or seed stocks. An example of this is led by the Panamerican Agricultural School in Honduras and Cornell University; it is a project that has, as one of its components, teaching techniques to farmers for pollination control in maize in a region with a high degree of local varietal diversity (Gómez 1995). The base material for the improvement efforts in this project is the farmers' own varieties or other genetic materials that are available to them.

Farmers' genetic materials often broaden the genetic base of the participating breeding program considerably. The material derived and disseminated from these efforts may represent a wider range of diversity than the products of previous efforts, and sometimes contributes to the conservation of landrace materials in the local farming system. The impacts that were observed or expected from using farmers' genetic materials have been mostly related to biodiversity enhancement or the conservation of local germplasm in the farming community, and as enhanced productivity in specific production systems.

Farmers are actually involved in the breeding process. Finally, farmers may be involved in the actual breeding and selection process itself. In almost all of the cases examined, farmers manage trials on their own land as a part of the PPB program and sometimes decide how to experiment. That is, they choose the field for growing the trial(s), manage the nutrients and other aspects of crop husbandry, choose the control variety, and often contribute to trial design.

The key impacts from farmers contributing trials to a participatory breeding effort are increases in research efficiency through providing appropriate testing conditions, sharing the management costs, and making honed, informed decisions. Through on-farm trials, farmers get early access to new genetic materials and have the option to adopt these varieties as an immediate result. Productivity increases and initial adoption can be immediate results from farmer-managed trials.

This initial adoption would normally lead to further dissemination and adoption of the new varieties. Farmers may also decide to use these new varieties in their own breeding work, and thus influence the level of genetic diversity in their farming system. Farmers' experimentation with new germplasm is a very powerful tool to create the basis for a range of impacts on-farm.

For example, potato farmers in Ecuador test varieties over a wide range of altitudes and fertility conditions. The research stations do not cover this range of altitudes and usually do not manage trial fields at different levels of inputs. In this case, farmers selected new desirable clones for adoption after only 2 years of testing, whereas officially released varieties had rarely been adopted (H Andrade, personal communication, 1999).

Farmers may also take the lead in selection or evaluation of materials, that is, decision making among a set of varietal choices. This contribution goes beyond providing information alone because it involves judgements based on multiple criteria. Farmers decide which trade-offs to make and which combination of traits to favor. These are often complex decisions because many traits can be considered and because differences between varieties may not be very large for individual traits. To identify materials that do contribute new opportunities for enhanced productivity or stability of production requires an intimate knowledge of the target farming system, production system, and social system.

In some PPB programs, farmers make the final selection decisions, for example, among entries in an on-farm trial or among entries in larger nurseries grown on-farm or on-station. Farmers are often the better judges for predicting which combination of traits may have potential use for specific growing conditions and production goals on their farms or in their areas of cultivation. Several well-documented cases show that farmers' selections indeed performed very well—better than breeders' selections—in the conditions for which they were selected (Sperling et al. 1993).

Most programs use several types of contributions from farmers. They may also change their organizational setup to adapt to the needs of the farming communities and to improve impact of the program. The rapid and comprehensive learning experience for the participating scientists is a basis for these rapid changes in the operational forms of PPB projects. The other basis is the rapidly increasing role of farmers in guiding the project towards other areas of work, such as toward seed system support, to improve the scope and scale for impact.

Degree of Farmer Participation

The degree of farmer participation is another dimension for classifying PPB. For the variable “degree”, we draw from a consultation meeting of the PRGA in Sept 1998 in Quito (Lilja et al. [1999]). There, the degrees of participation were conceived of 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, contract, consultative, collaborative, and collegial, through to farmer- or community-initiated.

In practice, three degrees of participation are generally found in PPB programs: consultative, collaborative, and collegial. “Consultative” means that information is sought from farmers and, sometimes, from other clients of the breeding program. “Collaborative” means that researchers and breeders share tasks, along lines determined by the formal research program. “Collegial” means that researchers support a farmer-initiated, farmer-managed program, which is accountable in a direct way to the farmers and other client groups with a stake in the results of the germplasm development.

How has “participation” translated on the ground? Select insights from dispersed field programs give an initial flavor (with the case studies in the next section pursing the issue more in depth). Selection of certain traits, especially those variably expressed or present at very low frequencies in the population, such as disease resistance or weevil susceptibility, may be more effectively done by breeders than by farmers or more effectively on-station than on-farm (cases 10 and 16). Efforts to test materials earlier on farm indicate researchers’ awareness for the need to conduct screening for adaptation under more typical growing conditions than those often found on research stations. Most of the cases studied indicated that farmers also should play a greater role in selecting for culinary quality for staple crops, and many included cooking and taste tests as part of the evaluation. Farmer selection for marketability and “cosmetics” of new varieties is also widely incorporated in PPB programs; the color, size, and shape of beans, potatoes, and cassava significantly affect farmers’ abilities to market their crops at premium prices. However, the literature to date reveals few cases in which breeders collaborate with farmers to improve varieties of cash crops, including vegetables, which are not consumed on the farm. Participatory plant breeding seems to have less application when growers are not users and the quality traits are defined by external market standards (P Hanson, Asian Vegetable Research Development Center [AVRDC] tomato breeder, personal communication, 1999).

Decentralization as Separate from Participation

Decentralization is often intertwined with participation in PPB programs in ways that make it difficult to separate out the effects of these two distinct phenomena. Whether to decentralize or not is initially a technical issue, which can be decided based on standard plant breeding criteria such as the extent of GxE interactions and the diversity of quality- and marketability-related traits required in the target region. If decentralization is deemed to be beneficial based on these technical considerations, then organizational issues come into play in determining how best to structure a decentralized program, how to share responsibilities, etc. Particular models of farmer participation may be especially appropriate for highly decentralized programs. But the degree and the nature of participation can and should be considered separately from decentralization. Because a program is decentralized does not mean, *a priori*, that it is participatory.

3. Case Studies

In this section, we look at a range of case studies in more depth, to get a sense of how the PPB field is evolving. Studies were selected to cover a diversity of crop types, geographic regions, and scale of programs and to show some of the different motivations for pursuing formal-led PPB. The varied role of farmers and their communities in the evolving work is also instructive: it ranges from highly restrictive, consultative participation to more encompassing forms in which farmers take over the full on-farm adaptive testing phase and subsequent seed multiplication and diffusion. We thank the many practitioners who shared their insights to help fill in the written literature gaps.

Farmer Selections within Segregating Bean Populations in Colombia

The source for this case study (inventory case 10) is Kornegay et al. (1996).

Meeting farmers' diverse and sometimes contrasting needs for germplasm poses a challenge to breeding programs, which may lack resources or expertise to develop varieties for such a range of conditions and preferences. Participatory research can improve the efficiency of variety development and the likely acceptability of released lines to farmers, but little is known of the potential for "*in situ* selection" under small farmers' often variable, low-input conditions. Over a 3-year period, CIAT (International Center for Tropical Agriculture) undertook a parallel breeding study "to compare overall performance and agronomic characteristics of farmer- and breeder-selected lines across environments, and to assess farmer perceptions of useful genetic variation." Breeders wanted to test the yield and farmer-acceptability of varieties developed on farms under farmer management of the selection process among and within segregating populations.

This work was conducted on common bean (*Phaseolus vulgaris*, a self-pollinating crop) in the mid-altitude, mixed farming systems of Valle del Cauca, Colombia. All sites were within a 2-hour drive of CIAT's main research station. Farmers Gerardo Valencia, Julio César Azcárate, and Hugo Guarín had previously collaborated with CIAT and were chosen to participate for their skills, interest in experimentation, and communication abilities. They expressed their selection criteria, practiced selections on-farm, and evaluated the varieties produced on two CIAT research stations (one favored, one less so) and on the three farms.

The parents and/or controls were 10 lines with variation in seed type and disease response, including two landraces, two regionally popular varieties released by the national program, and six modern varieties from CIAT. These lines were crossed in different combinations and the research stations and farms each planted the resulting 18 F_2 populations. Farmers and researchers followed the same simple methodology, combining bulk and pedigree breeding, to advance the populations to the F_6 using their own selection criteria throughout the process. Farmers were interviewed twice each bred generation for their spontaneous reactions at pod formation and harvest. In the F_6, 18 lines (six developed at each research station and six developed from the three farms) were tested across all sites, and the top 10 were ranked by yield and farmer preference. Eight of these selected lines were from crosses of modern varieties with local materials.

"Yields among groups of selections tested across all sites were not significantly different." On-station breeder selections had greater overall yield potential than farmer selections, but half of the farmer-preferred varieties were farmer-selected. Genotype by environment interaction was as great among farms as between farms and the experiment stations, so material selected on one farm did not necessarily excel on another. Farmer criteria centered on desirable seed quality traits for marketability, number of pods, and foliar disease, and farmers "were willing to sacrifice yield over small quality differences." Farmers chose beans with good commercial qualities, and the 30% higher market prices from their attractive seed types could offset some income losses from lower yields in the farmer selections. Breeders centered on yield potential and stress tolerance, including nationally required anthracnose resistance not found in all farmer-selected lines, but grain types from the station selections were not always acceptable. Researchers concluded that farmer selection criteria were important in the development of the varieties, but that breeders should be responsible for insuring that the lines selected contained a basic set of agronomic traits (such as disease resistance, good yield, acceptable maturity, etc.) in addition to farmer-selected market quality traits.

"A good breeder, cognizant of market forces and farmers' growing conditions, does not have to carry out an early generation selection and breeding program on-farm to produce successful and acceptable varieties. A more productive relationship would be to involve farmers in the final stages of the breeding process using fixed lines preselected by the breeder. Farmers can then assist the breeder to select for quality and local adaptation traits. Good lines can then be rapidly promoted for varietal release" (Kornegay et al. 1996). Note that this is a highly market-driven situation in which consumer preferences are very tailored and in which beans are produced mainly for sale.

This program was designed as a focused research experiment to answer a series of technical questions. It did not aim to institutionalize the PPB process: researchers worked with three individuals.

Comparing Farmers' and Scientists' Selection Criteria for Beans in Early Generations in Tanzania

The source for this case study (inventory case 15) is Butler et al. (1995).

In 1990, the Bean/Cowpea Collaborative Research Support Program (B/C CRSP) in Tanzania incorporated smallholders' evaluations of prerelease common beans to increase the acceptability and inclusion of their breeding products in farmers' mixtures. Women and men farmers evaluated promising F_6 lines to assist in release decisions, and researchers documented exact farmer responses to the varieties. After 3 years of this collaboration, researchers gained new understanding of 39 positive and negative criteria for bean evaluation by lowland farmers. The criteria are classified as relating to leaves (7); branches, stems, and plants (12); pods (5); seeds (9); or cooking qualities (6). Researchers now use these criteria to more systematically document farmers' and scientists' reasons for selecting materials. Farmers approved a variety that enjoyed popularity among growers and consumers because of its highly marketable red color, preferred over a previously released tan variety.

In 1994, the program expanded to include joint farmer-scientist evaluations in the F_3 and F_5 generations. The purpose in earlier farmer involvement was to assure that useful qualities were not lost in early stages of selection if they went unrecognized by the breeder. The objectives were to determine if farmers could detect variation not present in native varieties and to compare farmers' and breeders' criteria. The same number (12 each, both men and women in each group) of experienced bean-evaluator farmers and biological and social scientists (breeders and extensionists) participated in the evaluations. The generations were assessed for specific traits and overall plant quality, the F_3 by single plants and the F_5 by line. Each group separately marked the five best and five worst lines and the best plants within the best lines, and gave reasons for selection.

In the F_3, both groups had considerable agreement on priorities (with many pods as the most important trait), although farmers indicated some additional quality characteristics and scientists selected many additional traits related to pest resistances and seed quality at this stage. The F_5 showed less similarity in preferences, with a similar plant architecture in mind but different priorities in seed characteristics. Trait heritability and the value of visual selection versus direct measurement should be considered in the timing and utility of farmer evaluations. Plant type evaluations should be done in the F_3-F_4 by individual plant assessment, with seed characteristic evaluations in the F_4-F_5 by lines. Farmer participation in early generations was judged logistically more difficult than later evaluations. Researchers concluded that it might be optimal to have farmers evaluate early and late material, with breeders conducting yield and disease testing in between farmer evaluations. A discussion of traits among all the evaluators would also be useful.

This work in Tanzania is an excellent example of a functional PPB program designed to give feedback to station-based researchers. Although both men and women were involved, and their assessments were rigorously clustered, there were no significant differences in gender evaluation of the materials.

Increasing the Adoption of Modern Varieties in Northwestern India

The main sources for this study (inventory case 2) were Witcombe et al. (1996) and Joshi and Witcombe (1996).

This is a development project focusing on an area of three adjoining districts in northwestern India. The objective is to encourage uptake and adoption of modern varieties as a means of increasing productivity. The project formalized the terminology and procedures for PVS and carried it out with several crops, via interactions with different breeders and seed producing agencies as well as regulatory agencies (variety release). The project itself organized contacts to public and private seed producers to make seed of the farmer-preferred varieties available to farmers rapidly and with good quality.

This project is carried out by the Krishak Bharati Cooperative Ltd. (KRIBHCO) with assistance from the Government of India, the UK Department for International Development (DFID), and researchers from the University of Wales' Centre for Arid Zone Studies. We concentrate on the description of results from research conducted as part of this development project.

The project area focused in three adjoining districts (Panchmahals [Gujarat], Jhabua [Madhya Pradesh], and Banswara [Rajasthan]), covering 21,300 km^2 and including a population of about 5 million. This area receives a total rainfall of 700-1100 mm per year, mainly in the rainy season (*kharif*) during the months of June to September. Occasional rainfall during the remainder of the year is scanty and unpredictable. The terrain is hilly, soils are variable, and soil erosion is a problem over much of the project area. Fields are mostly on sloping lands with shallow, infertile soils. Farmers have average landholdings of less than 1 hectare.

The project worked with the main food crops grown in this area: maize (*Zea mays* L.), rice (*Oryza sativa*), chickpea (*Cicer arietinum*), pigeonpea (*Cajanus cajan*), black gram, soybean (*Glycine max*), and wheat (*Triticum aestivum*). We will mainly report the findings of the work with rice and chickpea. Both these crops are highly self-pollinated and major breeding programs in India are developing new varieties in different states. Farmers market both crops and consumer acceptability is of major concern to them. Rice is a crop with a potentially high seed increase ratio, especially when it is transplanted. Under direct sowing conditions, as is common in the project area, the seed increase ratio is lower (100 kg of seed are required per hectare, compared with 3-10 kg of seed for transplanted rice). Chickpea, especially the *kabuli* type, is large-seeded and thus has a low seed increase ratio. Chickpea yields are commonly measured as returns per kilogram of seed sown.

The project was an holistic development project covering community development and all natural resources. This component was designed to identify and overcome constraints that caused farmers to continue to grow landrace varieties. At the initiation of the project, farmer participation in the identification of these constraints and in variety testing was seen as the key to success and rapid impact.

At the start, detailed surveys were conducted in specific villages to understand the characteristics of the locally grown varieties, how they differ from each other, and what farmers value in them. This was done in selected villages in each district with group discussions using standard participatory rural appraisal (PRA) techniques such as matrix ranking and mapping. Village-level project staff and groups of 6-20 farmers conducted discussions, focusing on individual crops. Seven villages participated; men and women from different social groups (i.e., castes) were included.

Information about the local varieties was used to search for modern varieties that resemble them in their main characteristics (i.e., crop duration, grain type, or growth habit). The search focused on varieties that were already released at the national level or in other states. If no useful varieties could be traced among released materials, breeders working on these crops were contacted for advice. Once suitable test varieties were identified, efforts to procure sufficient seed for on-farm testing were made.

The project staff distributed seeds, usually 1 kg per new variety, to every participating farmer. Each farmer received only one variety for testing. Varieties were repeated 4-5 times within each village, so that all the varieties were exposed to a range of growing conditions. Trials were evaluated during farm walks with participating farmers in each village, so that they could compare the varieties. As a follow-up, group discussions were held to understand farmers' perceptions about these varieties. Also, each individual household was interviewed about the advantages and disadvantages of the test variety being grown. Project staff measured some traits in the farmers' fields. For the chickpea trials, data were also collected from individual households about which of the new varieties had been re-sown, as an indicator of varietal preference and initial adoption.

Note that almost no written reference was made to gender, except for the initial surveys on local varieties, but those involved indicate that attention was paid to it at all stages. Researchers also found that PRAs proved to be quick and effective in identifying and describing locally grown varieties, but a grow-out may have benefits in providing comparative performance data for complex traits among locally grown varieties and modern varieties.

Farmers rapidly identified new varieties that gave them opportunities for yield increases or improved marketability for rice, chickpea, and black gram. Farmers were usually interested in earlier maturing varieties as a means of achieving more yield stability or higher market prices. Early adoption of these preferred varieties occurred as a direct consequence of the farmers' trials; thus no delays occurred between variety testing and farmers' adoption. The adoption of a rice variety, Kalinga III, has been traced and documented in detail, showing that project activities enhanced the farmer-to-farmer transfer of seeds of this new variety.

For maize, no suitable new variety could be identified, and thus a new breeding program was initiated in collaboration with Gujarat State University, KRIBHCO, and interested farmers.

The project identified weaknesses (testing sites, crop management on test sites, frequency of releases, variety replacement rates) in the Indian variety release and dissemination system, which were thoroughly studied for several crops for the whole of India. Project personnel interacted with release authorities to achieve release of farmer-preferred varieties and/or certified seed production through the formal sector. This was needed to meet the very rapidly growing demand for seed of these preferred varieties.

Farmers' Evaluation of Late Blight-Resistant Potato Clones in Bolivia

Sources for this case study (inventory case 17) include Thiele et al. (1996, 1997), and Carrasco et al. (1997).

The Programa de Investigación de la Papa (PROINPA), Bolivia's Potato Research Program, works to select late blight (*Phytophthora infestans*) resistant potato (*Solanum tuberosum*) varieties for home use and sale in marginal regions. Social science researchers initiated efforts to identify and prioritize farmers' criteria in varietal selection to improve the targeting of breeding activities. The researchers also began with an interest in developing robust methods for PVS, so they tested an array of methods at different stages from 1990 to 1995 (Thiele et al. 1997), and in 1995 the breeders released six varieties with late blight resistance (Carrasco et al. 1997).

This work was conducted in two parts of the Cochabamba Department (2900-3300 m) in smallholders' marginal production regions with potato-based cropping systems and high late blight incidence. All evaluation sites were in farmers' fields, although in some years the trials were under researcher management. The focus was PVS, because farmers evaluated advanced lines from the Centro Internacional de la Papa (CIP) and the Instituto Colombiano Agropecuario (ICA), some of which had been released elsewhere.

Communities generally selected farmer-evaluators known to share information with other farmers and interested in collaboration with researchers. Between 20 and 82 farmers participated each year (1990-95), and on the average about 20% were women. The number of clones evaluated in the first year was 138, decreasing to 5-9 clones in the last season. The timing and method of evaluation changed each year as researchers learned which stages were most critical, refined the level of assessment, and employed various visual, oral, and written techniques for different information needs. Farmers evaluated a researcher-managed field trial (1990-91), evaluated trials with shared researcher management (1991-92), evaluated formal trials they managed in parallel with breeders' trials (1992-93), and selected preferred clones from the previous year's trial for informal testing and multiplication. Researchers monitored farmers' selections and diffusion of clones (1993-94), and evaluated breeder-managed trials (1994-95).

Through the course of this study, researchers gained many insights into the process of evaluating clones with farmers. When evaluating large numbers of clones, farmers' and breeders' choices tended to coincide, with similar priorities on health and vigor. Farmers compared observed varieties to local ones, but were unable to distinguish lesions of late blight from other leaf spots. Yield was the principal criterion for selection for farmers and breeders. In 1990-91, of 120 clones, farmers selected 46 at harvest, and these included nine of the 11 selected by breeders from the same set. In subsequent years with fewer clones, farmers' and breeders' choices diverged. Where choices did not coincide, farmers made selections based on market characteristics, while researchers noted disease resistances or desirable morphologies. There were no significant differences between men's and women's characterizations. Women's participation declined (after 1990-91) as farmers were left to self-select evaluators in the activities.

Participatory evaluations had only a moderate influence on varieties released. Their principal impact was to enable breeders to broaden their understanding of farmer-relevant criteria and incorporate these into their breeding strategy. The current recommended strategy is to first involve permanent groups of 8 to 10 male and female expert evaluator farmers in assessing 30 clones in several areas, in researcher-controlled plots. Later, with 8-12 clones, these same farmers conduct their own trials and remain involved with subsequent multiplication of varieties they select. Interested Comités de Investigación Agricola Local (CIALs, farmer-organized research groups) can also participate. Detailed knowledge of farmer criteria requires individual interviews (e.g., with short questionnaires), but matrix scoring by groups is more fun and appropriate when forms would be too cumbersome to fill out or process. Since 1997, researchers have moved to preference ranking with individual farmers when evaluating 8-12 clones, for speed and possibility of statistical analysis; matrix scoring was sometimes too vulnerable to "follow the leader" effects.

Participatory research in PROINPA has continued to evolve from 1996 to the present with increasing use of select participatory research methods (of the Investigación Participativa en Agricultura [IPRA]). The evolution includes evaluation methods being standardized to ensure comparability between sites and years, permanent mixed gender groups formed to evaluate germplasm, breeders and other researchers trained in IPRA methods, and breeders initiated PPB with farmers at a pilot site. Since 1996, farmers have evaluated material from PROINPA. Products have included potato varieties with good late blight resistance, high yields under marginal conditions, and acceptable tuber characteristics for sale to urban markets and for home use.

Breeding Rice for Adaptation to High Altitude Conditions in Nepal

The main sources for this case study (inventory case 4a) were Sthapit et al. (1995a, 1996).

This project was initiated by researchers of a regional research station of the National Agricultural Research Center (NARC), Nepal, to address the need for new varieties better suited to the growing conditions in the high altitudes of the Nepalese Himalayas. The researchers were faced with a situation where the research station had only limited available land and other resources suitable for conducting the evaluations needed to identify rice genotypes that tolerate chilling temperatures. The researchers had been using participatory approaches to disseminate new technologies as an alternative to the conventional approach to agricultural extension. Thus, the idea emerged to pursue farmers' involvement in the process of developing new varieties of rice for higher altitudes (1400-2000 m). Note that Nepal has a highly centralized and structured process for testing and releasing new varieties of rice (and other crops), although extreme agroecological diversity is found in this country. Certified seeds of modern varieties reach farmers very slowly, and varieties adapted to specific growing conditions, such as higher altitudes, have little chance of being officially released and promoted in this system.

In high altitude growing conditions in Nepal, low temperatures (0-20 °C) adversely affect rice productivity during the vegetative growth stages, panicle exertion, and pollination. Spikelet infertility caused by chilling can lead to severe yield losses. Chilling injuries can be caused either by cold air or cold water in which the rice is growing (Sthapit et al. 1995c). Sheath brown rot, a bacterial disease caused by *Pseudomonas fuscovaginae*, also causes severe losses under these growing conditions (Sthapit et al. 1995b).

Farmers in the project area grow rice mainly for their own consumption. They were particularly keen to change the color of the seed coat of their traditional varieties from red to white, so that the time spent on dehulling and polishing would be reduced.

The aim of involving farmers in this project was to develop genetic materials that were better than existing modern varieties or the commonly grown local ones. The expectation was that the new varieties, which were developed with farmers selecting them in their own fields, would also have better chances of adoption by other farmers. The project also aimed to dramatically reduce the time it usually took a new variety to reach farmers: varieties would already be with farmers at the time they were identified as being superior.

When the project started, only a single rice variety was commonly grown, Chhomrong Dhan. A farmer had introduced it to the area from India. As a result, rice was being cultivated in regions that previously had no rice. Thus there was (and is) a highly limited diversity of rice available to farmers and a strongly felt need for more varietal choices.

The researchers had initiated a high-altitude breeding program shortly before the start of this project. They had identified suitable testing sites in farmers' fields, selected parents that had the most suitable characters, produced crosses among them, and made initial selections among progenies derived from these crosses. During the F_4 generation, breeders selected six progenies for testing with farmers, based on superior spikelet fertility and sheath brown rot tolerance. These progenies retained variability of interest to farmers.

In the following generation, 13 selected farmers from two villages grew these six progenies (derived from two different crosses) on their own farms. One farmer per village evaluated each progeny. The farmers chose the fields for growing the test progenies and evaluated the materials according to their own criteria. Before harvest, farmers and researchers visited the trials of all farmers in the two villages and discussed the advantages and disadvantages of individual progenies. From the second year onwards, the farmers also ranked the varieties after seeing them all.

The farmers selected panicles from these plots to use as seed for the following season. Half the seed they selected was returned to the scientists for further on-station trials. Farmers removed about 10%-20% of the plants while roguing their plots, and harvested about 25% of the remaining plants for seed (i.e., an overall selection intensity of 20% resulted). Thus from the second year onwards, farmers had selected their own “versions” of the initial progenies given to them. In the following year, four new progenies were added and evaluated together with the three that farmers had retained from the previous season. Again, farmers selected desirable panicles from the progenies, sending half their seed to the scientists.

From the first year selections by farmers, one bulk was entered into the national trial system of Nepal in parallel with the on-farm tests in 1995. In 1996, seed production of this entry was begun by growing many individual progeny rows. This variety was officially released in 1997. Mr. R.B. Gurung and M.B. Gurung are the names of farmers who selected the varieties.

The farmers (18) who grew test plots came from three villages where the researchers had previously worked. They were expert rice growers and had a strong interest in seed issues. Both male and female members of the household participated in the variety evaluations. The scientists felt that for this type of participatory work, farmers with the best expertise would be the most valuable partners for the project.

Of the original 10 progenies, five were completely rejected after 2 years of testing, three were still grown by one farmer on a relatively small area, and two were grown on a larger area, some even by farmers who had not participated in the trials initially. One of these, M-3, was entered into the formal trial system and a formal seed production procedure was initiated.

The scientists gained detailed understanding of the selection criteria that farmers use and the wide range of different approaches that farmers employ for selecting panicles for seed. Farmers assess their crop during the whole growing season, and often test unknown material under the worst field conditions first. If the material looks promising, they will then grow it in better fields to evaluate its full potential. Scientists also began to differentiate fine quality preferences and identify approaches to assessing them under on-farm conditions.

Different farmers selected different panicles from the tested progenies and passed the seed on to others in their villages. Thus farmers in these three villages now have a wider choice of material to grow.

The further dissemination of seeds of varieties identified through this selection is being pursued by a nongovernment organization (NGO), Local Initiatives for Biodiversity Research and Development (LIBIRD), which is working in this area. The NGO is also further supporting farmers who want to continue their selection efforts. In an attempt to increase the scale at which products from this research are being used, the NGO is using a concept called "informal research and development" (IRD) (Joshi et al. 1995). The basis of this approach is to distribute small seed samples to many farmers in a potential target zone, with some written information about the varieties. Also a type of score card is supplied for keeping some key records about the performance and utility of the variety for return to the research station. A follow-up study of an initial seed distribution effort has shown that farmers have benefited from this in many different ways and have taken on the initiative for seed multiplication and dissemination on their own. The NGO has since used this approach in a variety of crops and circumstances with much success.

Moving from Technical Screening to Institutional Concerns: Bean Evaluation in Rwanda

The main sources for this case study (inventory case 24) are Sperling et al. (1993) and Sperling and Scheidegger (1996).

For applied researchers, decentralizing technology development implies a basic change in the way technologies are developed. Rather than focusing on fine-tuning a limited number of products and verifying them on selected farms, the scientist develops a larger range of prototypes that are tested and may be modified to suit specific needs and circumstances. Such a reorientation suggests that scientists working on experiment stations should have a relatively good idea of the broad range of client needs and constraints at the beginning of the technology development process. It also suggests that scientists have to be prepared to part with their technologies at a relatively earlier stage in their product development—before they have "the" answer. The Rwanda PPB case illustrates this approach.

Rwandan farmers have considerable experience in managing local bean diversity: some 550 varieties exist countrywide and farmers adjust mixtures of varieties for specific soil types and crop associations. Despite such dynamic diversity, the selection sequence of the Institut des Sciences Agronomiques de Rwanda (ISAR), paralleling western models, sharply narrows the range of varieties on offer: some 200 entries are initially screened, but only 2 to 5 enter on-farm trials—the sole node for client feedback. An experimental program sought to draw on farmers' experience early in the selection process, when varietal options were still extensive. During a first phase of an ISAR/CIAT PPB program (1998-90), local experts evaluated 15 varieties in on-station trials two to four seasons before normal on-farm testing. On-station evaluations revealed that women experts select bush beans along preference and performance criteria with many of the attributes not easily anticipated in a formal breeding framework. On-farm trials also showed farmers' ability to extrapolate from station fields to their own home plots; farmer selections outperformed their checks with average production increases of up to 38% while breeder choices in the same region showed insignificant gains. The number of varieties adopted from the first two-year period, 21, matched the total number of varieties released by ISAR in the 25 previous years. Although collaborative, the first phase of this program was very "research oriented," with a need for precise technical results driving the design of the joint work. The first phase highlighted farmers' ability and eagerness to screen large numbers of varieties early in the research/development process. It also heralded potential benefits of prototype screening: enhanced and diversified production on-farm and significant savings from reducing on-station research time.

During a second phase, participants screened a broader range of varieties even earlier: 80-100 entries in on-station trials 5-7 seasons before conventional on-farm testing. For 3 years (1990-93), farmers viewed a trial normally containing about 80 lines. To minimize risk, the CIAT pathologist screened this trial earlier than usual and eliminated the most disease susceptible entries (to anthracnose, *ascochyta*, bean common mosaic virus, and rust). So, in fact, farmers screened what researchers felt was the "largest possible reduced risk pool," including 79 lines in 1990, 41 in 1991, and 43 in 1992. Longer-term results suggest some of the advantages of offering options. From the subsequent community-managed trials in Phase II, 26 varieties were selected for home testing during the first two seasons alone.

In terms of broadening the PPB program on-farm, the concerns of Phase II focused on how to encourage communities to select their own expert representatives and how to devolve much of the on-farm testing to where it belongs—communities themselves. The move towards "devolution" was a healthy mixture of empowerment and economics. Communities should have the right to select their own delegates to screen on-station, and should control how those 20 or 25 chosen varieties are subsequently tested in rural areas. In practical terms, such a selection program can only be widely decentralized, targeting germplasm for many different areas, if communities bear the brunt of the local-level costs.

From early 1990 onwards, women experts coming to the station represented the interests of three types of local groups: farmers' research groups backed by NGOs, self-organized groups of "research-oriented farmers", and several groups of farmers united by geographic proximity in an administrative unit known as a "commune". The varieties women selected were then managed in various types of community plots, the NGO served several hundred farmers, and the commune units potentially reached up to 6,000 households. (Hence total potential population reached was 27,000 households or about 135,000 persons.) From 30 to 50 farmers were normally invited to review each community plot. One or two of the selected varieties were to be given to each evaluator at harvest, eventually to be tested in their home plots.

The most important insights during Phase II lay with institutional concerns. Turning over both the choice of on-station representatives to communities as well as subsequent community plot testing did not always mean that community needs were served. This certainly rang true in Rwanda where relationships even at the neighborhood or "hill" level are marked by hierarchy and where women fall near the bottom of the heap regardless of class or ethnic group. "Women have no race" states one proverb, indicating that their power derives from their relationships to significant male others (e.g., brother or father).

In practical terms, the power structures, and particularly male hierarchies, distorted the expansion of the experiment at several key points. In the selection of farmer representatives to screen on-station trials, researchers had the sense that some of the so-called community-selected experts were neither well informed nor very representative. For instance, the government agronomist's sister and the sector head's wife represented one community. The male authorities in charge linked power with knowledge, and imputed male knowledge to their female sidekicks. If he was an important official, she must be a farmer expert.

There was also concern that key figures in charge sometimes fell short on their obligations to community participants. The community plot was laid, evaluations were completed, but seed of selected varieties was never distributed. So, in theory, the data were in, but the seeds never got out. The advantages of working through administrative structures are many. These units exist countrywide, in all agroecological zones and potentially canvassing all farmers. They have the land and could incorporate a mandate of decentralized selection. "Control" rather than "service", however, sometimes govern the philosophy of such units.

The experiment throve when women themselves had some control and when the community saw itself as a true community. The women's cooperative was well organized and serious about the research. Experts were sent to the station, varieties chosen were subsequently tested on designated group members' plots, and the cooperative as a whole agreed what to multiply, what to discard, and what to test further. Over 1 ton of seed was multiplied before other communities had started to budge.

Programs of PPB are often viewed by scientists as technical experiments (e.g., do farmers have expertise? Can they effectively screen segregating populations?). Yet some of the greatest challenges may lie in identifying appropriate institutional forms. Within the CGIAR, institution building has principally been focused on national institutions; for instance, helping national agricultural research systems (NARS) become more client-oriented (Merrill-Sands and Collion 1993). However, equal if not greater challenges may rest at the community level: how to identify or help create organizational bodies that represent the full range of farmer interests and that can serve as on-going research partners to a welcoming formal sector.

Some key institutional findings of this second phase of PPB research are listed below.

1) Differences in varietal preferences among even closely-spaced farming communities suggest that participatory selection has to be coupled early with decentralized seed multiplication programs.
2) Scaling up of a participatory selection program implies that formal sector research must partner with organized groups of farmers, rather than individuals, to share the costs and responsibilities of widespread varietal research.
3) Working through community institutions does not guarantee that community needs are served. Local power structures (e.g., male hierarchies) can distort the fundamental premises of a "participatory" program.
4) Working with farmer groups demands that methods be developed which "feed forward" information to communities as well as feed back insights to the formal sector. There may be important methodological trade-offs between community and formal sector approaches of research or development.

User Participation in Selecting and Releasing Potatoes in Ecuador

The source for this case study (inventory case 34) is Andrade and Cuesta (1997).

The National Root and Tuber Program of the Instituto Nacional de Investigaciones Agropecuarias (INIAP), Ecuador, used PVS methods from 1992-97 to help them achieve more effective and timely use of new potato varieties. They also wanted to increase the flow of information to researchers, find a trial methodology more farmer-useful than traditional variety release, improve cost- and time-efficiency of varietal development, and decrease the official release of consumer-unsuitable varieties. Because potato is a commercial crop even for smallholder farmers in Ecuador, the researchers sought evaluations of clones not only by growers, but also buyers, consumers, and agroindustry. About 15% of the farmer evaluators were women.

The program established on-station and on-farm trials of new clones to assess maturity, yield, tuber aspects, eating quality, and resistances in farmers' socioeconomic context. Farmers planned and executed trials. Both rural and urban consumers were involved in culinary quality tests, and agroindustrial specifications on suitability for processing were also considered. Involvement in the early stages was intended to give broad criteria (through open-ended evaluations), and in the final stages to give "directed opinions" (via matrix ranking). Absolute evaluations (on a scale of 1-5) were used in early stages, with a criteria-based ranking matrix in the second selection cycle; open-ended evaluations recorded spontaneous reactions. Mini-surveys, written scoring methods, and colored flags were used according to farmer literacy.

Early evaluations dealt with plant size, commercial production, disease response, and tuber color and shape. Later stages indicated commercial importance of and market requirements for tuber color and shape. In 1992-93, 343 clones were evaluated and 13%-35% selected; in 1993-94, 75 evaluated and 29%-52% selected; in 1994-95, 29 were evaluated, 50%-67% selected, and four varieties released; in 1995-96, 39 were evaluated and 23% selected; and in 1996-97, 70 were evaluated, 48% selected, and one variety released.

The researchers recommend open-ended evaluations (with 30 clones) to understand criteria in early stages, absolute evaluations (10 clones) in the intermediate stage by farmers, middlemen/buyers, consumers, and agroindustries, and detailed users' criteria (six clones) from the four groups in advanced stages. This format is flexible and could change; stage three is not first because it is harder to conduct consumer evaluations with many clones. Dry matter content value is a quality parameter that can be used to screen clones for rejection in the early stages and thus reduce the numbers prior to consumer evaluations.

The potato program has been able to develop a variety profile on quality for processing and production regions. It has also established farmer group linkages to industrial processors. Users were better able to seek, evaluate, and apply research results as a result of their involvement in the research process. Although the technical team lacked expertise in effective participatory research, researchers viewed the process as cost-effective and mutually beneficial. Farmers appreciated the approach, kept good records, and ultimately helped disseminate new varieties to their communities.

Introduction of Improved Genetic Diversity into Cassava Farmers' Fields in Colombia

The sources for this case study (inventory case 11) are Iglesias et al. (1990) and Hernández-R (1993).

Two regions of Colombia, major growers of cassava (*Manihot esculenta* Crantz) were addressed in this work: a seasonally dry ecosystem in the north (an area with poor soils and 800-1000 mm rainfall annually, bimodally distributed) and, more recently, the highlands of southwest Colombia. Researchers from CIAT and a branch of the Corporación Colombiana de Investigación Agropecuaria (CORPOICA) initiated a participatory crop improvement effort. The aims were to:

1) Learn more about farmer criteria for choosing cassava varieties and about production and marketing systems,
2) Provide farmers with the opportunity to evaluate traits within a genetic base that had not been preselected, thus hopefully generating cassava varieties with better acceptability to farmers, and
3) Increase cassava varietal biodiversity by facilitating selection of a broader range of genotypes within an ecosystem, with adaptation tailored to different climate/soil combinations, cropping systems, end uses, etc.

The researchers assumed that farmer-based plant improvement would result in increased genetic diversity compared to typical researcher-managed variety development, thus leading to improved production stability and sustainability. The researchers also anticipated that a participatory approach would be more cost efficient, by providing farmers with a broader range of genotypes released over a shorter period of time and at less cost compared to traditional breeding and variety testing approaches.

Work was initiated in 1986 in northern Colombia. This region has poor soils, which are made even less desirable by excessive cultivation without fallow periods, and is peopled by a combination of cattle producers owning large expanses of land and poor smallholder farmers for whom cassava is one of the primary crop options. The crop is used for both home consumption and sale in urban markets. In the last 20 years, additional marketing options have emerged for products such as foliage for forage, cassava chips for livestock feed, and starch. This diversity of uses resulted in varied quality and yield parameters that cassava varieties must meet, with emphasis on dual-purpose varieties that meet both food and feed or starch needs.

The focus of this effort was a combination of diagnosis to better understand farmers' needs (via secondary sources, on-farm evaluation of advanced clones, and a survey) and on-farm, farmer-participatory evaluation of cassava clones derived from advanced stages of the breeding program. About 28 communities per year were involved in the clonal evaluation effort in northern Colombia, with community participation organized via chip-drying cooperatives. From each community, eight to 10 farmers helped in the variety evaluation by meeting with the researchers three or more times each season to evaluate the crop. The farmer-evaluators were chosen based on their history with the crop and their interest in participation and information sharing. They were rotated regularly, to allow many individuals to participate. Farmer-evaluators selected genotypes for further testing and breeders made their own independent evaluation for comparison.

The initial diagnosis used on-farm evaluations of a few advanced cassava clones to learn about farmers' management and to shed light on major production constraints. This information was used to design a survey that focused more precisely on areas highlighted by the initial on-farm evaluations. Researchers realized at an early stage that effective varietal comparisons could be made only if the planting material for local varieties and new breeders' clones was produced under similar conditions, to avoid bias caused simply by the health and vigor of the planting material. They addressed this concern by producing all planting material in a common location under conditions approximating those of the farmers. It also became clear that farmers and researchers often used different terms for variety evaluation; a glossary of farmer evaluation terms was compiled. Field books were designed to facilitate collection of information from farmer-evaluators, but standardizing information obtained from farmers was a challenge, since researchers did not want to direct farmer input about the varieties. A format that allowed for both "directed" and "open" information was devised, with a simple three-level (good, average, poor) scale used to record information. For "preference", which emerged as a highly important farmer criterion, farmers were asked to assign genotypes to three groups based on their desirability and then rank the genotypes within each group. To facilitate data analysis, a program was written and adapted for use on hand calculators in the field. Training materials were developed to help others apply these participatory evaluation methods.

Farmer evaluations of advanced clones from cassava breeding programs resulted in release of three new varieties in northern Colombia. Through this process, researchers acquired a better understanding of farmers' selection criteria and were able to quantify certain of them in ways that would facilitate researchers' selections. (For example, farmers' preference for "hard" roots corresponded to roots that were over 35% dry matter.) A unique aspect of this work was that researchers developed a cost comparison between their farmer-participatory approach and traditional variety evaluation, indicating that data points from farmer-participatory trials cost about US$0.50 while those from typical researcher-managed advanced yield trials cost about US$0.80. Improved understanding of farmers' varietal choices acquired through this project has led to incorporating farmer criteria into breeding programs and has stimulated the researchers to provide earlier-generation breeding materials to farmers for evaluation. The success of the effort in northern Colombia also resulted in expansion of the project in 1994 to encompass cassava-producing areas in the southwest (involving an average of 15 communities each year). Results from this latter work are yet to be reported. The researchers plan to evaluate the biodiversity impact of their work by assessing adoption of varieties by farmers and comparing it with similar regions where no participatory crop improvement efforts were used.

Conservation and Enhancement of Maize with Small-Scale Farmers in Honduras

The sources for this case study (inventory case 29) were Gómez et al. (1995) and Gómez and Smith (1996).

This project was motivated by the fact that most of the area planted to maize in the tropics is planted with farmers' saved seed, suggesting that many farmers have not benefited from scientific advances in genetics and plant breeding. The project was designed to evaluate alternative approaches to improving maize varieties for hillside farmers in Honduras while conserving the best of the genetic variation represented by their traditional varieties. It was conducted in two communities in the south-central part of the country: Galeras and Morocelí (700-800 m altitude, 1400-1800 mm annual precipitation, mean maize yields 1.0-1.5 kg per ha). The project was jointly designed and carried out by plant breeders at the Escuela Agrícola Panamericana-Zamorano (EAP) and Cornell International Institute for Food, Agriculture and Development (CIIFAD), at Cornell University. An anthropologist at EAP-Zamorano also contributed to the design and survey phases of the work.

The premise underlying the work was that farmers were not adopting "improved" maize varieties because such varieties were inappropriate for farmers' circumstances. The researchers hypothesized that this could result from inappropriate breeding objectives because of:

- Inadequate information concerning farmers' varietal needs,
- Inadvertent selection for adaptation to experiment station environments that are not representative of farmers' fields, or
- Excessive variability in varietal needs from farm to farm that could not be well addressed through a centralized breeding program.

Accordingly, three alternatives were explored:

1) Better understanding of what farmers need in their varieties so that appropriate breeding objectives can be incorporated into selection programs on experiment stations,
2) Use of farmers' fields and expertise to carry out breeding work on representative farms, and
3) Teaching the needed techniques for farmers to better select and save their own seed.

Work was initiated in 1993 with a survey of 10 male farmers (maize farmers in Honduras are predominantly men) in each of the two communities. Results indicated that ear size and grain traits (color, size, shape, freedom from pests and pathogens, and tortilla yield) were of predominant importance to farmers. Four collaborators were chosen from among the 20 farmers surveyed, and these farmers' varieties were the starting point for selection both on the experiment station (with selection criteria based on the survey results) and on farms (with each farmer making selections). In both cases, mass selection with pollination control was used among plants selected at flowering time, and then followed up by further selection from among the pollinated plants at harvest. Three to four cycles of selection were conducted with each starting variety, and comparisons were made through on-station and on-farm evaluations. On-farm evaluations were conducted only with the original and selected cycles of that particular farmer-collaborator's variety, while all varieties and cycles were evaluated on station.

On-farm and on-station selection showed improvement in grain yield and ears per plant after one selection cycle but in the second cycle, values of both traits decreased slightly, possibly because of inbreeding depression. No clear yield differences between on-station and on-farm selection emerged based on the evaluations on station. Significant differences were noted in days to flower, plant and ear height, and root lodging, but the nature of these differences is not documented.

For on-farm evaluations, results are documented for three farmer collaborators (the trial on one farm was lost). Yield differences among cycles of selection and between on-farm and on-station selections were not significant. However, for the farm with the lowest average yield potential, the on-farm selections made jointly with the farmer consistently yielded more than the selections made on station. Significant differences were detected for days to flower and 100-grain weight on all three farms and in ear height on two of the three farms. Varieties generally flowered earlier with cycles of selection regardless of the selection approach, possibly because of controlled pollination (where a tendency can occur to use the earlier flowering fraction of the population as the pollen source). Similarly, ear height decreased with cycles of selection for both selection approaches. Hundred-grain weight increased with cycles of selection for both on-farm and on-station selections for one farmer's variety, while for another farmer's variety it decreased only for the on-station selection. This may reflect the importance of grain size to farmers, whereas researchers tend to focus primarily on yield rather than yield components.

Only one farmer collaborator continued participating in the work for a fourth cycle—others had chosen to change varieties (an inherent limitation to the approach used in places where farmers change varieties regularly). The farmer-collaborator who continued with the work has the farm with the highest yield potential and his original variety had the highest yield among those of the four farmer collaborators. Trends for the fourth cycle of selection with this farmer collaborator were similar to those observed for the first three selection cycles.

The third approach taken to improving maize varieties for hillside farmers while conserving the best of the genetic variation represented by their traditional varieties was to teach the needed techniques for farmers to better select and save their own seed. This was done through a series of annual workshops oriented toward smallholder producers, whose participation was funded by NGOs. Ninety-six farmers from three countries (Honduras, Nicaragua, and El Salvador) participated in training workshops between 1993 and 1997. Based solely on the names listed for participants, it appears that the vast majority was men. The 1995 course included 14 smallholder farmers from six departments in Honduras. These farmers ranged in age from 18 to 82 and five of them reportedly used improved varieties. Similar data for other course groups have not been documented. Workshop participants improved their knowledge of maize breeding based on before versus after test scores. Follow-up interviews with workshop participants revealed that many passed on knowledge to other farmers, and a number fabricated their own pollinating bags to make controlled crosses for improving their own varieties. A survey of 31 former workshop participants indicated that all were practicing plant selection in addition to selection of ear and grain traits, and 60% were using some form of pollination control. Three workshop participants donated seed of their original varieties and their improved versions for evaluation on station. Selection over three cycles increased yield in one case. The second case involved only one cycle of selection, but yield decreased after selection. The third farmer made a cross between two varieties, and the resulting varietal hybrid had a yield intermediate between the two parents. Unfortunately, data on traits other than yield are not reported. A workbook was produced for use in the farmer workshops.

The major challenge to interpreting the results of this program is the limited data available that documents the work. Collection of the complete data set and thorough analysis would be beneficial. Nonetheless, response to the farmer workshops has been enthusiastic and farmers appear to be making use of the knowledge gained. Results from the parallel selection study provide preliminary evidence that on-farm selection may provide better results than on-station selection for farms where yield potential is relatively limiting.

Pearl Millet in Rajasthan: PPB and Farmers' Seed Management Strategies

The main sources for this case study (inventory case 25) were Dhamotharan et al. (1997) and Weltzien et al. (1998).

This case is primarily a research project carried out by an international research institute with a wide range of partner organizations. A main partner was the Department of Watershed Development of the Government of Rajasthan, interested in developing expertise with participatory approaches. Key to the work were several NGOs, working in different districts in Rajasthan: the Social Work and Research Center, Tilonia; URMUL Trust in Bikaner and Nokha; and the Society for the Uplift of Rural Economy (SURE) Barmer. Pearl millet breeders from Rajasthan Agricultural University and the Central Arid Zone Research Institute provided varieties and seed for these on-farm trials. The aim of the described work was and is to develop and test approaches for achieving increases in productivity and improvement in yield stability in harsh environments, where the formal approaches of plant breeding have been unsuccessful. The project focussed initially on seeking farmers' input into clarifying breeding goals and targets. The objectives of the project moved towards a more thorough understanding of farmers' seed management strategies, as a basis for collegial interactions during several further stages.

The project is focusing on the arid regions of the state of Rajasthan in northwestern India, the so-called Thar Desert. It is a region of low and highly erratic rainfall. The long-term average rainfall in this part of the state ranges from 500 to 200 mm. The target area for the breeding project as such was the pearl millet growing area of western and central Rajasthan, covering about 4 million hectares annually. Pearl millet is a highly cross-pollinated crop, well adapted to extremes of high temperature and to drought conditions. It has relatively small seeds, and can produce very high grain yields with appropriate crop management. Seed increase ratios of 1000 can be achieved regularly.

Modern varieties of the main cereal crop pearl millet (*Pennisetum glaucum* [L.] R.Br.) are available in many parts of the state in Rajasthan, and are widely grown in the higher rainfall regions, but much less so in the western part of the state. Marketing of pearl millet grain is rare, except for imports from other states. Pearl millet stover is marketed to some extent, as maintenance feed for livestock. Farmers sell other crops, like guar (*Cyamopsis tetragonoloba*), moth bean (*Vigna aconitifolia*), mung bean (*Vigna radiata*), and sesame (*Sesamum indicum*) more regularly. They are usually grown in crop mixtures with pearl millet.

One to two villages were selected from each of four districts. From each village, 20 to 30 participating farmers were chosen from a census list, stratified by landholding size. From 1992-94 every 90-120 farmers conducted variety trials. Care was taken to include women farmers in the samples at every stage, especially women-headed households. Similar numbers of farmers were involved in the subsequent studies.

Experimenting with a formal survey triggered the seeking of farmer participation in identifying targets for the breeding program. It became clear that it was difficult to discuss with farmers the advantages and disadvantages of traits (e.g., early maturity) if they did not have any experience with this type of genetic material. Thus farmers tested one of three to four highly different genotypes, and participated in discussions comparing varieties. Farmers were also invited to the research station to evaluate and select among a wider range of genotypes under more uniform growing conditions. Some of the same farmers and other farmers from the same and from other villages participated in discussions and village level workshops on seed management issues. After 5 years of breeding for this target environment, farmers evaluated new products from the breeding program. Farmers also participated in on-station trials evaluating outcomes of their own breeding efforts.

These efforts yielded a wealth of information on farmers' particular preferences for specific traits of pearl millet varieties, revealing big differences among men and women, better- and worse-off farmers, and farmers who farm in different districts of Rajasthan. A detailed understanding was gained of farmers' methods and strategies for selecting seed on their own farms, of their knowledge and experiences with different plant types of pearl millet, their strategies for coping with the large seasonal and spatial variation in growing conditions. How this information and understanding influenced the activities of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) pearl millet breeding program and those of its partners is outlined below.

Results from the programs initial on-farm activities geared towards understanding farmers' preferences for pearl millet variety traits could be reassessed and effectively interpreted. These results had shown that individual farmers are interested in a wide range of plant traits and plant types. Different members of a family had expressed different preferences, as well as different farmers from the same village. Thus a picture of a very broad range of non-compatible varietal trait preferences had emerged, which could not be combined into any single variety. The understanding that farmers grow mixtures of, and actively select for diverse plant types within their seed lots, provides a solution to this dilemma. Even the most incompatible plant traits and plant types can be combined in a physical mixture of seeds. It thus became more relevant for the breeding program to identify potential components of mixtures, which would be of most benefit to the local system of using and disseminating seeds.

One need was expressed very clearly—farmers were most interested in materials that are well adapted to poor soil conditions, which is the predominant soil condition in western Rajasthan. Poor farmers were keen, because they only own poor soils, and lack reliable sources of appropriate seeds; better-off farmers were interested because for them also production on their poor fields and in poor years is essential for food security. Thus ICRISAT's pearl millet breeding efforts for Rajasthan started to focus its activities on developing breeding populations that have the plant type best suited to these poor conditions.

Progeny testing for population improvement was only done in locations in Rajasthan, no longer at ICRISAT's headquarters in southern India. Fertility management at the research stations was changed so that only minimal application of mineral fertilizer was used, primarily to reduce experimental error. Efforts are underway to develop uniform fields that are more depleted of nitrogen and phosphorus, to better represent the growing conditions of farmers' fields. Selection indices were used to identify superior progenies, capitalizing on the traits with relatively higher heritability at each location and favoring the traits of the preferred plant type as described above.

Initial evaluations of these populations by farmers in the same villages where the interviews and discussions had been held, indicated that the new populations were getting closer to farmers' needs, but more specific effort for adaptation to poor fertility seemed necessary. Thus farmers' involvement in further improving these populations, specifically for adaptation to poor soil conditions was planned in cooperation with the national pearl millet improvement program for Rajasthan. Also, the testing and release procedures for pearl millet varieties were examined with the appropriate authorities, to allow for releases of a wider range of plant types, and for material with specific adaptation to harsh growing conditions.

The local NGO, Grameen Vikas Vigyan Samiti, interested in helping poor farmers in their target villages through appropriate seed supplies in emergency conditions, started a program to identify the most appropriate local variety for these villages. Through farmer-managed comparisons of local varieties from nearby areas and breeding populations based entirely on local germplasm, they strive to identify one preferred type, which they would then multiply in the village and use the seed for distribution to those in need at the time of sowing. In this effort, ICRISAT assisted the NGO as required.

In the villages in central Rajasthan, one of the test cultivars proved to be popular, because of its earliness, and good adaptation to poor soil fertility conditions. Farmers of all social groups were interested in growing more seed of this variety. They were prepared to pay twice the price for its locally produced seed, and quickly learned new techniques to maintain pure seed of this open-pollinated variety. Farmers from neighboring villages also obtained seed. At present, farmers in the two villages are forming a group to facilitate further seed production and to meet further needs for seed on their own.

The ICRISAT center initiated a detailed study of farmers' management of pearl millet genetic resources across a wider area in Rajasthan, and a more detailed assessment of farmers' utilization of modern germplasm in the development of their seed lots. These results are geared towards arriving at strategies for *in situ* conservation of local pearl millet germplasm in this state of India.

Building a New Breeding Program with Farmers' Participation: Pearl Millet in Namibia

The main sources for this case study (inventory case 1) were Ipinge et al. (1996), Lechner (1996), and Bidinger (1998).

This is a project initiated by the new national pearl improvement program of Namibia, formed after independence, with support from an international research center, ICRISAT. The big initial success of the program was the identification of a pearl millet variety for release, from an international pearl millet nursery sent from ICRISAT. Farmers involved in the evaluation of this nursery first selected this variety (Okashana 1) in 1987. It was further tested on-farm and then released in 1989. Okashana 1 is now grown by about 45% of pearl millet farmers in Namibia. The success of this variety is also because of the development of a highly effective farmer-based seed production program, which is briefly described below. The breeding project is now focusing on developing varieties that overcome some of the weaknesses of the initially released variety. Farmers have been involved in detailed evaluations of the advantages and disadvantages of the new varieties, as well as contributing germplasm to the breeding program.

Pearl millet in Namibia is a crop of the dry, sandy regions, and is rarely cultivated by commercial farmers, but is the preferred food for rural people. It is the most important cereal crop in Namibia, as conditions are too harsh for more productive cereals, like sorghum or maize. To date, processing and marketing for pearl millet grain or food products prepared from millet grain are poorly developed, so that the urban population utilizes imported maize meal, rather than locally produced pearl millet. Namibia did not have its own agricultural research system prior to independence. With independence, a national program for pearl millet improvement was created. Research was initiated with very few trained staff, which was one the reasons for seeking farmer involvement from the onset of the research. The Sorghum and Pearl Millet Improvement Program for southern Africa (of ICRISAT) played a key role in supporting these new activities. The breeders involved had varying levels of exposure to the pearl millet breeding activities of ICRISAT in Rajasthan, described in the immediately previous case. No formal seed production system that could produce and disseminate seed of an improved variety existed at the time the research service was initiated.

Pearl millet is a highly cross-pollinated crop, because of its strong protogyny. Self-pollination is possible, and usually selfed seed sets easily.

After the highly successful identification of Okashana 1, the primary objective of the program was to involve farmers in identifying priorities and setting objectives for the newly developing breeding program. Later, the program utilized farmer-generated breeding population in its program, and involved farmers in evaluation of specific breeding products. The main objective of the breeding program is to develop pearl millet varieties with a high potential for adoption in Namibia.

Farmers were initially involved in variety evaluations in on-station experiments. The numbers of farmers participating in these on-station visits varied from year to year. During the on-station visits, farmers were asked to score a set of varieties on a 1-5 scale. Later, in group discussions, reasons for farmers' choices and preferences were explored. The researchers used tools such as rank-scoring a set of traits and matrix-ranking of a set of diverse varieties during these interactions with farmers.

Realizing the importance that farmers place on adaptation of new varieties to particular conditions in their own fields, the program has moved from the on-station evaluation of sets of germplasm to conducting several on-farm evaluations of similarly diverse nurseries. The breeders select entries for this nursery. The nurseries are conducted in one or two farmers' fields per village (the number of villages is unclear). These nurseries allow farmers to do similar evaluations of potential parental material under growing conditions with which they are familiar. The results allow breeders to identify potential new materials for further testing, or for further breeding (i.e., for use as a parent of a new population). The breeders have also used these results as an insight into farmers' trait preferences, and thus for setting objectives for the selection program.

During these visits with farmers, the breeders identified a woman farmer near the research station, Maria Kaherero, who was consciously making selections within a population derived from outcrossing between the newly released variety and her traditional landrace variety. Breeders used panicles that they selected from her field as the basis for forming a new breeding population. Later, in the population development phase, 30 varieties selected by farmers from 200 entries were introgressed into this population.

The program is furthermore conducting routine on-farm trials for variety evaluation under farmers' field conditions.

Much of the success with the adoption of Okashana 1 is because of the committed efforts to develop a seed production program. The project is run on a commercial basis, where participating farmers became member of a cooperative. They had to pay for foundation seed. The project bought seed meeting certain minimum criteria back from farmers and cleaned and processed it. Seed was sold to other farmers at rates that covered production, processing, and transport costs. The government of Namibia has recently recognized the Northern Namibian Seed growers' Cooperative, which is now operating with a revolving fund provided by the government.

As women predominantly cultivate pearl millet in Namibia, and they are responsible for processing and food preparation, the program mainly involved women farmers. Experts were sought for evaluating grain quality traits for food consumption. Women constituted over half of the visitors to the research station.

The remarkable achievements of this young breeding program indicate that a targeted involvement of farmers at key decision-making points in the breeding program can have profound influences on its future course. This case also points most clearly to the importance of developing a suitable seed production and distribution system that integrates well with the outcomes of the research program.

Remarks on Case Studies

These 11 case studies give a representative insight into what has been attempted and achieved with formal-led PPB to date. The cases show work in progress with farmers in different stages of a breeding program, namely, testing and evaluating varieties, selecting in early generations, generating variability, identifying and focusing breeding objectives, and disseminating seeds and planting materials. The cases describe on-going or completed breeding work with crops representing the three main categories of propagation biology: cross-pollinated (maize and pearl millet), self-pollinated (upland and irrigated rice, beans, chickpeas), and clonally propagated crops (potatoes, cassava). The research is located in Asia, Africa, Latin America, and Mesoamerica, and addresses farmers' needs in a wide variety of agroecological conditions, ranging from extremely dry and hot desert margin regions to very high-rainfall, high-altitude mountain conditions. Some cases deal with highly market-oriented production and others with subsistence oriented systems with frequent production shortfalls. Most of the production systems represented by these case studies are systems in which the formal breeding sector alone, without the direct involvement of farmers, has only achieved limited success. Most of the case studies were initiated to explore new avenues for increasing the success of formal-led breeding programs.

The formal programs described include local national agricultural research institutes, international agricultural research centers, universities in the project countries, and universities with international programs located in industrial countries. Often two or more formal sector institutions work together in the projects, in collaboration with other institutions that represent in some way the farmers, their communities, and a committed development effort. One research project is fully integrated into a well-supported, geographically limited, integrated farming systems development project. Others are working with NGOs involved in a range of development activities, or with farmer groups and cooperatives, while some work with individual farmers over a long period of time.

The case studies presented pursued different types of broad goals, such as enhancing research efficiency, increasing productivity, policy changes with respect to seed production and variety release, the conservation or enhancement of local crop genetic diversity, facilitating farmer learning and empowerment, and benefits for specific end-users. Some of the cases address issues/problems identified and initiated by farmers, while in other cases farmers are merely consulted and the new information is used to reorient selection programs or other breeding program activities. The following chapter will examine the roles these different factors and conditions played in shaping the work in progress and the results achieved, including both technical gains and insights and institutional and inter-institutional developments.

Some of the key outcomes described in these cases include the following.

- Farmers' selections strike a balance between productivity and marketability.
- Farmers have an advantage selecting visually, considering a wide array of traits, and identifying the most promising trait combinations.

- Breeders are usually better placed to select for quantitative traits that are difficult to assess visually, such as disease resistance or yield potential.
- Involving farmers in the evaluation of larger sets of varieties before release, or before general recommendations are made, is extremely powerful in identifying the most beneficial options for farmers.
- Involving other stakeholders (i.e., women who process the crops, sales agents, or urban consumers) may reveal new options for producers.
- Farmer evaluations are a regular contribution to the variety evaluation process.
- Extreme stress conditions, as found in some farmers' fields and well understood by farmers, provide key selection conditions to identify tolerances and adaptations.
- Working with farmer groups or their representatives provides opportunities for scaling up the process of participatory selection.
- Farmers are interested in an array of varieties for different production niches and marketing opportunities.
- In areas of inherently low crop genetic diversity, PPB provides an avenue for increasing this diversity in farmers' fields.
- Farmers are very keen to test new varieties and to learn techniques for improving their own varieties.
- Understanding local seed systems can be the key for effective formal-led PPB programs.
- Those programs with the most immediate impact have a built-in seed component.
- Significant scaling up occurred only when PPB programs devolved much of the adaptive testing to farmers.

4. Lessons Emerging from Case Studies

This section draws from the full range of cases the authors were able to locate. Appendix 1 summarizes the details of the 48 cases in question: some have already been completed, others include only preliminary or partial information. Within the 2 years of writing this document, many new PPB programs have been initiated (e.g., in Malawi, Ethiopia, Mali, etc.). This document does not describe most of these because their results are still limited.

Overview: Biophysical and Socioeconomic Environments of PPB

About one third of the PPB cases reviewed unfolded in relatively high stress, "marginal" production contexts where conventional breeding had not been effective in finding adapted materials (e.g., cases 1, 8, 19, and 37) (see Figure 1, page 14). Programs formulated to address low-fertility or drought-prone conditions reported success in releasing farmer-acceptable varieties through PPB combined with more decentralized testing. Ceccarelli (1994) highlights the importance of GxE crossover between farms and gxperiment stations, advocating testing under more typical conditions to develop varieties that perform best locally with stable yield over time (Ceccarelli et al. 1991). This is a basis for early decentralization and selection under low-input conditions in International Center for Agricultural Research in the Dry Areas' (ICARDA's) barley program. Many researchers cited high stress, "marginal conditions" (including low or erratic rainfall, unpredictable highland climates, or low-input because of remoteness) as a reason for employing PPB in their programs. After 15 years of breeding work with little farmer adoption, cassava breeders in a region of Colombia with poor soils and 800-1000 mm rain used PPB to quickly release three farmer-tested varieties. A breeder at the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil, reflected: "PPB certainly pays off; it is a very powerful tool for cassava breeding in marginal environmental and social conditions as in (semi-arid) NE Brazil. On the other hand, it is a demanding process both in labor, time, and resources."

Surprisingly (to the authors at least), the social context of PPB proved as much of a "driving force" to use the approach as is the environment. A growing number of PPB programs are in the most favorable areas, as organizations seek varied (and directly opposing) goals in the use of PPB to:

- Increase varietal diversity,
- Help farmers gain greater control over breeding seed supply in what have become (alarmingly) uniform agricultural production areas (e.g., a farmer-led PPB project, the Community-Based Native Seeds Research Center [CONSERVE] in the Philippines), or
- Speed up adoption of modern varieties (which many would consider the contrary of the previous goal, e.g., Witcombe's work on irrigated rice in Nepal).

Witcombe, a most experienced PPB practitioner, has worked in five environmental contexts, from highly marginal to highly favored, and posits the question of whether farmer participatory methods apply more to high potential areas than to marginal ones precisely because of the opportunities for wider impact (Witcombe 1999). Further, an earlier breeder in PPB, Carlos Iglesias, spent over 10 years in the more marginal areas of Latin America breeding cassava in collaboration with chip-drying cooperatives. He now finds himself leading a popcorn program in the lush areas of Argentina and USA using nearly the same PPB methods in his work, but for very different reasons. Here, quality challenges have now taken precedence over adaptation demands (C Iglesias, personal communication, 1999).

Similar to the favorable areas, there has also been an upsurge of PPB in semi-favorable areas where much of the production is marketed and consumer preferences are very rigorous or narrow (cases 17 and 29). Participatory plant breeding is also being initiated in some instances where traditionally subsistence crops are becoming a marketed commodity with a new set of quality demands, as farmers seek certain processing traits and the possibility for increased income from consumer-acceptable varieties (cases 34 and 37).

Finally, PPB still is very much an approach that explicitly aims to reach the disadvantaged. A number of researchers are using PPB approaches as a means to target poorer sectors of the population, identifying characteristics of interest to that group and testing a wider range of germplasm in farmers' conditions (e.g., cases 1, 6, 8, 19, and 22).

Across environments within a program, some researchers noted differences in the relative effectiveness of the PPB program. In Colombia, the possibility of working with genetically diverse cassava populations in humid areas where different varieties are grown in mixtures was judged more feasible than in seasonally dry highlands, where farmers tend to test, but not develop new varieties (case 11).

Breeding Strategies Involving Farmers

Crop types

Most PPB efforts to date are focused on staple food crops primarily in areas with locally important quality preferences. Several PPB programs were found with the staple potato in the Andes (cases 17, 31, and 34), but not in Central America where potatoes are somewhat of a luxury vegetable. Rice PPB was found in Asia (cases 2, 3, 4, 6, 12, 44, 47, and 48) and Africa (case 5), but not in Latin America where it is grown with mechanized production as more of an industrial crop. None of the cases examined dealt with crops grown using fully mechanized production or with vegetables.

The cases examined also mostly address major food crops that are part of the mandate of formal sector breeding programs, with the tree species examples (cases 7 and 7a) being the only exceptions. The near dearth of PPB cases with minor crops likely reflects the limited investment in research for these crops, and the opportunities offered by PPB for improving these crops have hardly been explored. There are some examples with what might be considered minor crops (i.e., black gram in the KRIBHCO case (case 2) or the wide range of crops being covered in the Nepalese Informal Research and Development (IRD) project (case 4), some of which one would normally consider minor. There are, however, formal breeding programs for these crops in the respective countries.

Of the crop experiences examined, most (26 out of 50 examples)[1] are with self-pollinated crops, followed by cross-pollinated crops (15 examples), clonally propagated crops (7 examples), and agroforestry tree species (2 examples). For all crop types, most of these projects involved farmers in some form of evaluation of varieties, and very few involved farmers in generating variability or selecting among larger numbers of unfinished products to identify potential varieties for further evaluation (see Table 4). In numerous studies, the primary objective was to involve farmers in the identification of varietal needs and preferences to better focus breeding objectives. In-depth examination of local seed systems is the key objective of a few studies working in regions with very specific and particular agroecological and cultural conditions.

Although our working definition of PPB limits it to selection within a species, a few comments about between-species selection are in order. The inventory of cases examined includes two where farmer-participatory methods were used for selection among tree species for potential use in agroforestry breeding projects (Franzel et al. 1995,

1. Several of the PPB programs work with multiple crops. For purposes of tabulation, each crop was considered separately.

Table 4. Numbers of participatory plant breeding projects classified by crop pollination biology and general stage(s) of farmer involvement.

Pollination biology	Stage of farmer involvement[a]		
	Testing varieties	Selection in early generations	Setting targets / objectives
Self pollinated	19	7	7
Cross pollinated	9	3	7
Clonally propagated	6	1	4

a. Classification is, of necessity, approximate. We took Schnell's (1982) description of stages of breeding as a guideline. Several cases were working with multiple crops; each crop is considered separately in this table. Some projects worked during several stages of the breeding cycle, either by using results for dual objectives (e.g., identification of varieties and understanding farmers' selection criteria) or through the evolution of the project over time.

1996). Clearly situations exist where selecting the most appropriate species is a necessary first step before any type of breeding work is contemplated. The agroforestry tree examples mentioned above are a good example. Another example would be for green manure cover crop species in Central America, where there is much enthusiasm for their use in row crop production, but often it is unclear what species is most appropriate. The same types of techniques used for variety evaluation with farmers—on-station and/or on-farm—should be highly useful for selecting among species in these situations.

In addition to pollination biology, several other crop and cropping system characteristics may determine what can be done or achieved through PPB. The techniques that farmers use for sowing different crops will determine the types of experiments farmers can manage in their normal production fields. Hand-sowing (e.g., in hills as is done across West Africa for dryland crops) is highly conducive for farmers' trials with more than one variety sown in the same field and sowing of relatively smaller plots that allow easy comparisons. Hand transplanting of rice or other crops gives a similar flexibility.

Sowing with animal traction in individual rows lends itself to strip plots, even rather narrow ones. Farmers who are dibbling seed by hand into the animal-drawn planting device can also change their seed bag in the course of one length, but this requires some marking of the field before sowing. Strips of another crop can separate different varieties.

Tractor sowing, especially with a seed-box planter, requires cleaning of the seed box with every change in genotype and necessitates larger quantities of seed so that the box actually can be filled to a reasonable level. If time at sowing is very critical, farmers may not willing to do this with more than one variety.

In cases where farmers sow crop mixtures by mixing seed of the species involved, the mixture for the experimental plot has to be prepared separately. Here the same species would need to be mixed in the same proportions to arrive at similar growing conditions for the two varieties being compared. This can be a rather time-consuming procedure, demanding commitment to precision.

It is harder to structure on-farm variety evaluations or selection in segregating populations for crops that are broadcast-seeded than it is for row crops. Certainly the labor involved in establishing rows or plots of individual breeding families for evaluation of early-generation populations would be prohibitive for most broadcast crops.

These are all issues that arise when farmers are responsible for sowing the crop. If the breeders do the sowing in farmers' fields, this is not an issue (e.g., case 8). With certain farming systems, it is relatively easier for breeders to sow the plots. That is, if it is possible to "dry-plant", if the planting date can be planned without much influence of weather conditions, or if farmers have access to telephones to call the researchers when it is an appropriate time for sowing.

Seed increase or multiplication ratio is another important crop characteristic that affects the way in which and the stage at which breeders could consider sharing responsibilities with farmers. For crops with low seed increase ratios, seeds or planting materials are extremely limited during the first generations, thus seriously limiting the type of tests that could be planned. This would certainly limit the number of sites, and thus also the number of farmers that could participate and the possible plot sizes. The specific sowing methods used in the target region certainly may limit opportunities for farmer involvement in the early generations of a breeding program.

Seed increase ratio may also limit the rate of success of PPB efforts. Crops where seed increase ratio is low can only spread very gradually through local seed systems in the initial years after they are introduced or selected. It would be ideal if excellent varieties identified through PPB efforts could be rapidly made available to others who would benefit from them. This may argue for judicious exploring of ways to combine seed multiplication through the formal seed system with multiplication and spread via local seed systems for crops where the seed increase ratio is low.

Selection criteria

The PPB efforts initiated by formal breeding programs are often designed to improve the efficiency of the process of variety breeding and delivery. A commonly identified inefficiency in this process is the breeding of varieties that do not meet farmers' needs, are not adoptable, and thus represent wasted effort. The most common step taken by formal breeding programs to overcome this type of inefficiency through PPB is to seek farmers' input into guiding the program, by clarifying its goals and objectives.

The selection criteria reflect the goals and objectives set by a breeding program. Thus, the investigation and setting of appropriate selection criteria is key for the success and the efficiency of any breeding program. This key concern is clearly reflected in the objectives of many of the studied cases. Studies conducted in environments where no previous breeding efforts had been undertaken, or where efforts so far had shown limited success, were especially focussed on setting appropriate selection criteria. Thus for about two thirds of the cases, identifying, verifying, and testing of specific selection criteria was the main aim of the research (see Table 2).

Several cases examined farmers' own selection criteria in comparison with breeders' selection criteria (e.g., cases 15 and 24). A way of doing this was by observing and interacting with farmers while they were carrying out selection efforts for maintaining or improving their own seeds. Mostly projects with a strong focus on farmers' seed systems used this approach. More often, farmers' selection criteria were investigated during farmer visits to demonstrations or test plots, usually with a larger set of varieties. The methodology for interactions between farmers and breeders on these topics was also commonly a subject of research at this stage. Breeders primarily expect to receive information from farmers in this context. How the breeders use this information is usually beyond the farmers' control.

Breeders, often in collaboration with social scientists or economists, use a wide range of approaches to gain a better understanding of farmers' preferences and needs. Formal surveys and market analyses were used in some projects (cases 8 and 25). During such surveys, opportunities rarely develop for interaction between breeders and farmers beyond the interview. This is particularly so if the breeder does not participate in conducting the interviews, which is commonly the case. The discussions are driven by the breeders' concepts of the present situation, making it difficult for farmers to express their views in the context of their reality (viz, cassava in Colombia, case 11). The discussions are limited to the traits and genetic materials that the farmers are familiar with. Thus, in situations where farmers do not grow any modern varieties with new types of traits or trait combinations, exposure to the new genotypes would be a first requirement for effective interactions. Many PPB projects are working in regions where adoption of modern varieties is poor, and thus these formal survey methods would not be the most effective approach.

Among the PPB projects examined, breeders have used two different approaches to achieving this more effective interaction with farmers. One approach relies on bringing farmers to the research station to view a broad range of genetic materials. The other approach was to ask farmers to grow a set of highly diverse materials in their own fields.

In the first approach, farmers can usually see many different genotypes (i.e., 40 to 300). Thus they see more materials than during regular farmer field days, when only a select set of released or nearly released materials are being shown. These evaluations may also be of two types: (1) exploratory trials to get a broad idea of farmers' criteria and the range of acceptability within each criterion, and (2) actual evaluation of materials at the preadaptive stage to be subsequently taken for home testing. This latter approach (as in case 25) demands that breeders have a fairly precise idea of farmers' and other users' preferences, that is, that the initial pool on station is already "client-oriented". Evaluations on-station are only truly "predictive" when soil and management conditions parallel those on-farm.

In both types of on-station evaluation, farmers are asked in some cases to make selections among the materials they have been shown, and explain to the breeders the reasons for their selections (e.g., cases 1, 15, and 24). This allows farmers to express their observations and needs in their own terms, and gives the breeder an opportunity to enter into a dialog with farmers on specific questions. In some cases, the breeders ask the farmers to score individual varieties on the research station for a number of traits (cases 1, 22, and 35). Breeders usually ask farmers to score for traits that the breeders consider as key traits, and leave it open to farmers to use additional characteristics. This approach may limit farmers' opportunities to use their own system of evaluation or classification, and breeders may not be aware that it even exists.

When farmers view and evaluate genetic materials on the research station, they are taking on a breeder's role and performing tasks that breeders normally undertake. This appears to be a role reversal, but usually farmers' scores or selections are not the "final" choices, but rather serve as a basis for more detailed analyses of what farmers' preferences and needs are, rather than as selections per se. In some instances, the farmers' selections were used to identify genotypes for on-farm testing (cases 24 and 25). Thus farmers are consulted, more or less systematically or open-endedly, in this approach to setting goals for the breeding program with farmers' involvement.

The approach of having farmers grow a set of highly diverse germplasm in their own fields allows farmers to observe the new germplasm under growing conditions with which they are familiar and that they have created through their own management. Breeders visit farmers and their experimental plots regularly and discuss with them the advantages and disadvantages of certain traits and genotypes.

In-depth discussions are usually held with individual farmers who grow experimental germplasm and with members of their immediate household. Discussions with other interested farmers who do not grow any trials can also be conducted, often in smaller groups and often using standard PRA-type techniques like matrix ranking or pair wise ranking of genotypes and traits. Thus, in this approach, as in the first, farmers' choices and evaluations serve as a source of information for the breeder and the farmers' participation is more consultative. The regular visits with the farmers and to their plots, however, result in a more in-depth interaction between farmer and breeder on the farmers' "turf". Opportunities exist for iterative discussions of issues and many more opportunities for the breeder to understand the farmers' viewpoints in the full context of the farming system. This type of interaction may open further opportunities for more intense interaction in other stages of the breeding program (cases 1, 11, and 25).

This approach also allows farmers to gain some control over the germplasm evaluated, because they can use it for their own purposes (i.e., seed for the next season, for further testing under other growing conditions, or for sale to others). In this second approach, the farmer also has the chance to become more familiar with specific genotypes, as well as with the breeders and their institutional context. This puts a farmer in a stronger position to express specific demands for seed of specific genotypes or material with a certain combination of traits. Most breeding stations or institutes have a system to respond to such demands directly, and thus these requests will exert some influence on the direction of the overall program.

Selection methodology

Many of the cases addressed methodological issues for breeding new varieties with farmers. Some studies are primarily concerned with comparing farmer participatory approaches with conventional researcher-managed plant breeding approaches. Results of these studies will be referred to in a later section on results and impacts. However, many projects actually focused primary attention on developing methodology for effective interaction with farmers and on exploring different opportunities for sharing responsibilities and decision making with farmers in the whole plant breeding process. This realm of research in plant breeding is, despite the many documented cases, still wide open to further imagination and development.

Stage of variety testing and evaluation. Research on formal-led PPB has so far predominantly focussed on methodology for farmer involvement in the phase of testing and evaluating varieties. This is the stage in the breeding process where the genetic composition of the experimental variety will not change further, and/or where seed or planting materials are available in larger quantities. A conventional researcher-managed breeding program conducts multi-location replicated trials of a limited number of experimental varieties at this stage to accurately assess traits related to yielding ability, yield stability, and general superiority over existing varieties. Devolving this stage of variety testing to farmers was done with the intention of conducting these tests under growing conditions that represent actual production conditions in the target farming system or systems.

Major reasons for attempting this change in variety testing were fourfold. The first reason was to obtain the most appropriate growing conditions for testing the new varieties. This was frequently deemed necessary because research stations were insufficient and/or inappropriately located to conduct representative tests, or because the growing conditions on research stations tended to be too different from those in farmers' fields. Reasons for this were many: mechanization on research stations was much higher, fertility management very different, crop rotations on research stations were often highly limited, and simulation of intercropping or mixed cropping was too complex to manage on station.

A second reason for devolving responsibility for variety testing to farmers was the understanding that farmers' growing conditions for a specific crop are highly diverse, even within a small geographical area. This diversity may be biophysical in origin or may result from situations where farming systems are rapidly changing. Examples are incorporating types of soil management that are beyond the experiences of the traditional farming context in a region, introducing new cash crops or agricultural machinery, or capitalizing on emerging opportunities for double cropping, to name a few. In this situation, farmers' decision making includes both a choice of actual testing conditions that he or she assumes are relevant for specific genotypes, as well as the selection decision regarding which varieties to consider for further evaluation and seed increase. It is interesting to note that researchers involved in developing methodology for sharing responsibilities with farmers at this stage in the breeding program often learned about the complexity of production systems and the changes that they were undergoing through these intense and open interactions with farmers.

A third major reason for devolving variety testing to farmers was to attempt to shorten the lag period between technology development and its adoption. This will be discussed in more detail in the section on seed system linkages.

Finally, farmers sometimes took over adaptive testing simply because the lead institutions did not have the resources to conduct on-farm trials.

Methodological issues addressed at this stage in the breeding program included comparisons of village level plots including a larger number of varieties in one or a few central places in the village versus a large number of experimental plots located in many different farmers' fields. In the extreme case of the latter methodology, individual farmers compare only one experimental variety with one of their own varieties. In either case, the methodology for arriving at an aggregate decision, integrating many individual farmers' observations and considering diverse growing conditions is highly complex. It can be handled very differently, covering the range from highly complex statistical procedures (case 22) to careful institutional arrangements involving training with group processes as in the case of beans in Rwanda (case 24).

Selection in early generations. Much less effort has been put into developing and testing options for farmer involvement in early generation selection. At this point, the number of genotypes for evaluation is usually high, the genetic make-up of individual test-units may not be stable, and the amount of seed or planting material for each test unit is relatively low and rarely allows for replicated tests. This contradicts the notion and results of some studies on priority setting, which highlight the importance of farmers having exposure to large arrays of variability and many trait combinations to fully capitalize on their capability of identifying varieties that match a specific growing condition and/or need. This is also somewhat in contrast to the often-cited assumption that PPB can make a positive contribution to maintaining or enhancing crop genetic diversity in farmers' fields.

During the phase of the breeding program where intense selection is required to identify a few potential new varieties from the huge range and numbers of options, farmers' participation may take a variety of forms. For inbred materials (self-pollinated species and breeding programs that rely on developing inbred lines for use in hybrids or synthetic varieties), this stage lasts from four to six generations, and thus offers multiple opportunities for farmer input. However, experiences are extremely limited with only a few forms of participation described in past projects.

One model is to grow the first generations of segregating progenies on the research station to select for the traits for which a particular cross was made, and to increase seed for distribution to farmers. Farmers thus obtain preselected bulks that are approaching homozygosity. Farmers evaluate these bulks as a whole under their management and modify them further by selecting individual plants for use as seed in the following generation. Depending on how variable the bulks are when farmers receive them, and how intensely they select within them, farmers can have a substantial influence on the traits of a new variety as an outcome of such selection. No project has so far attempted to precisely quantify the changes that occur within variable bulks during farmers' selection. This procedure was followed for one generation in case 4a, however, before a farmer-modified bulk was entered as a new entry into the national trial system for variety release.

New varieties would be developed in this approach through strong farmer selection following breeders' selection for specific traits. All participating farmers who keep seed for re-sowing from these variable bulks would develop new varieties. Thus a potentially large number of somewhat related varieties, because they come from the same or similar preselected bulks, are the expected output of such a procedure. If farmers really like the products of their own selection in these bulks, these varieties will spread, usually first on the farmers' own farm and to family members, but also to other villagers or villages, depending on the efficiency of the local seed system. If breeders perceive specific advantages in releasing these new varieties, they could also consider taking back materials from farmers who have actively selected, and entering these materials into a trial system for variety release. Some further selection on the research station may be necessary to meet standards for uniformity and distinctiveness, or specific trait expressions like disease resistance for diseases that do not occur under the farmers' selection conditions.

Another approach would be to let farmers make the first selections within F_2, F_3, or F_4 bulks or open-pollinated population bulks, on the research station or in their own fields. The farmers would share some of the seed from selected individuals with the breeders. Farmers have the option to continue using these selected materials in their selection efforts. Breeders could devote specific efforts to testing key traits that farmers cannot evaluate easily, such as complex resistances to diseases or insects, chemical composition, yield potential, and key physiological traits. Breeders could also multiply seeds of the most promising experimental varieties for further testing by farmers.

What has been, and is being, tried with farmer involvement during segregating generations is mostly with self-pollinated crops (Table 4). With beans in Rwanda (case 24), expert bean farmers were brought to the research station to make selections within and among F_4/F_5 progeny rows. Farmers then received seed of the selected progenies for testing in their own fields. Another example involves selecting rice for high-altitude conditions in Nepal (case 4a). In this case, each farmer was given a segregating F_5-bulk for testing. Two farmers in two different villages tested each bulk. Each farmer decided whether to harvest from this progeny or not. Those farmers who decided to harvest discarded plants that were not desirable, and thus harvested a bulk of seed from all the desirable plants. The farmers returned half of the harvested seeds to the researchers. In the following year, farmers continued testing and selecting in their harvested bulk from the previous year. Newly participating farmers received a small quantity of seed from the progenies selected by other farmers. In this manner, within 2 years a clearly superior selected bulk progeny was identified, and it was then tested further by farmers and within the national testing system for variety release.

The barley project in Syria (case 8) is experimenting with a simulation of selecting in segregating generations by involving farmers in selection among a large number of small plots representing much of the diversity in the ICARDA barley breeding program. In this case a few farmers, barley experts with a long-standing relationship to the barley-breeding program, are testing 200 small plots in their own fields. Except for the sowing, the farmers take all other decisions on field operations and selection. For comparison's sake, breeders' selections are also made and farmers, party with the help of technical staff, score all 200 genotypes for individual traits.

Involving farmers in mass selection in cross-pollinated crops has been tried in two cases with maize. In one case (case 29) farmers were taught basic skills in pollination control for maize and were given an overview of possible consequences. As a result, farmers practiced selection in their own varieties and/or crosses among them. In another mass selection program with maize (case 2), farmers were brought to the research station and assisted the breeders with identifying individual superior plants. The pearl millet project in Namibia (case 1) used a similar approach to a joint mass selection program. In contrast to the limited experimentation with involvement of farmers in early generation selection of cross-pollinated species, several projects are examining in detail aspects of farmers' selection practices and maintenance of seed stocks, as a basis for designing such collaborative projects (cases 25, 30, and 42). These studies include comparisons of different traits and the relative contribution farmers could make to selection gains for these. We expect this area of research to develop further in the near future.

This short description of experiences with farmer involvement in selection in early generations indicates that it is potentially very powerful, as this is the stage where most of the selection decisions are made (i.e., where the largest proportion of materials is discarded). At this stage many key traits are fixed, usually those with higher heritabilities that can be identified visually. Breeders' selection decisions at this point are usually guided by their understanding of the potential of the specific cross that the progeny is derived from and by their concept of the most desirable plant type or "ideotype", including, in some cases, resistance to specific pathogens or pests. At this stage, selection decisions are mostly taken in the field upon visually evaluating a progeny row and individual plants.

Based on the experiences described by breeders who involved farmers in testing experimental varieties, it appears that farmers' particular strength and contribution to a joint testing program was the ability to make an overall judgment on a combination of traits. These usually related to what breeders describe as plant type, particularly in view of the multiple opportunities for using a specific variety. This specific skill appears to be the key to success in selecting in segregating generations, where a quick overall judgment on individual plants or progenies has to be made. We would thus like to postulate that more experimentation with farmer involvement in segregating generations may prove highly beneficial to breeding programs, especially those facing much diversity in growing conditions and production systems undergoing rapid changes.

Generating variability. In the PPB projects analyzed for this review, farmers rarely take part in consciously generating variability for the selection program (i.e., they rarely choose parents and make crosses). Breeders working with self-pollinated crops or otherwise inbred materials usually see it as their distinct advantage to choose parents and make the most promising crosses. For cross-pollinated crops, where crosses occur naturally, and when working with open-pollinated varieties, farmers who grow new materials generate new population crosses regularly. In cases where farmers produce their own seed and practice some type of selection, these population-crosses can be made available to others, including breeders, for further breeding activities. Two cases with pearl millet were reported (cases 1 and 25), where breeders have sought such farmer-generated population-crosses for further breeding activities. Here, the farmers take the initial steps towards generating new breeding material, often as a direct consequence of their interactions with breeders and of testing new germplasm on their own farms. The advantages of such an on-farm generation of population crosses are that usually very large population sizes are used during the crossing and the subsequent generations of intermating. Further, natural selection occurs under the target growing conditions, thus eliminating types from the population cross that are not adapted to the growing conditions in farmers' fields.

For these population crosses to be useful for further breeding (high degree of out-crossing and two to three random matings achieved without too much introgression of other germplasm), a close relationship between the breeder and at least one farmer is required. This is so that they can both decide which management options meet their goals best. The farmer practically controls one distinct and critical part of the variety development process. The breeder gains directly from farmers' own innovations at this stage, and has the opportunity to work with particular individuals who take a specific interest in activities related to seed and varieties. The breeder saves some of her/his own resources, and these are often precious ones, such as field isolations, well-trained technical staff, and specific materials for making these crosses and random matings under research station conditions.

It is most likely that a breeder will collaborate with an expert farmer for this purpose. The success from this sharing of responsibilities in the breeding process is thus largely determined by how representative the particular farmers' field conditions are, and by the farmer's views on, and preferences for, specific plant traits. Limitations imposed by these factors could possibly be overcome by working with more than one single farmer. Different options for this are conceivable, but none of the projects have taken more than initial steps. Farmers who work with breeders in this way of course have the option to use the material they generated for their own benefit directly, which has been observed in case 25. Any benefit sharing that may need to occur at a later stage between breeders and farmers could occur very directly, since the contribution of identified individuals is clear.

Site selection

Choice of sites for selection in early generations and for variety testing and evaluation is a key decision for the success of any breeding program. Depending on the diversity of the target region for a formal-led breeding program, a search for appropriate testing sites and a move towards more farmer participation might be triggered by the need to decentralize a breeding program. Thus genetic gains can actually be achieved within a relatively uniform and predictable set of environmental criteria. Considerations governing decisions regarding site selection for PPB projects follow the same theoretical principles as for classical plant breeding projects, including understanding GxE interactions in the target and potential selection environments. However, in most of the PPB cases examined, the body of relevant data necessary to be able to apply these theoretical guidelines is not readily available. Nevertheless, the need to test breeding material in the appropriate environmental context has been one of the key motivators for seeking farmer involvement in formal-led breeding programs. Breeders thus rely on farmers' knowledge and judgments for the choice of testing sites. Judging by the rapid successes from several PPB programs, which often have breakthrough characteristics, the PPB programs have certainly taken the right type of decisions regarding testing sites. Whether this could be improved upon is open to further experimentation and testing.

The examined PPB projects tended to use a much larger number of testing sites than a classical program could ever envisage, because in many of the cases each farmer was testing only one to three single varieties in comparison to his/her own. In these cases, replication and comparisons with other experimental varieties were achieved by comparing results from different farmers' fields. Selection decisions in these cases were made by at least as many persons as participated in the experiments and by taking into consideration a wide array of characteristics. In many cases, it became evident that farmers' contributions have gone far beyond providing appropriately managed testing conditions in their fields, and taking or consulting on selection decisions. It appears that the first step towards participation is often justified on the basis of appropriate site selection, but that often breeders get into far more interaction with farmers than anticipated, leading to modifications of the PPB program.

Germplasm used

An inherent feature of farmer participation in plant breeding programs is that the locally grown varieties are often the reference point, and thus frequently evaluated in as much detail as the new, experimental materials tested with farmers. As a consequence of knowing the advantages of the local varieties in more detail, they are commonly included in subsequent crossing programs. Some programs have shifted during the course of their evolution very much towards directly improving specific traits of the local materials (e.g., pearl millet in Rajasthan and in Namibia, cases 1 and 25). This is similarly the case with the upland rice-breeding project in eastern India (case 6). This is a source for increased variability in the breeding germplasm pool of a program.

Another reason why breeding programs have expanded the range of diversity with which they work has been the improved understanding of farmers' needs for specific variety traits or types. For example, the over-riding concern of farmers for adaptation to poor soil fertility conditions has led some breeders to actively search for specific new variability for this type of trait (e.g., pearl millet in Rajasthan, case 25). Thus it seems that germplasm used in breeding programs may undergo changes in response to more collaborative forms of farmer participation.

Issues of Participation

The quality of the actual "participation" is addressed relatively little in the growing literature on "participatory" plant breeding (viz. Thiele et al. 1997). Unfortunately, the published material tends to be germplasm-focused, and scarcely acknowledges issues such as the type of collaboration, its aims, or how the joint research process unfolded. In the section below, we piece together some of the scattered insights on participation in formal-led PPB projects and raise some questions on future challenges in this area.

Caution is needed in making broad statements regarding how farmers have been involved in PPB programs as the meaning of terms like "participation" and "collaboration" is open to interpretation. For example, collaboration in a breeding program can range from:

- Involving farmers in surveys (cases 7a, 26, and 47), to
- Surveys followed by on-farm trials (cases 19, 21, 27, 32, 33, and 40), to
- Station visits by farmers to choose varieties that they then test on their farms and follow-up visits by researchers to determine farmer interest in the varieties (cases 5, 22, 24, and 35), to
- Intense interactions involving focus groups, farm walks, on-farm trials, and on-going discussion of farmer preferences and interests in improved varieties (cases 2, 6, 25, and 31), to
- Any number of additional combinations of activities.

The interaction between farmers and researchers is also likely to change as a PPB program unfolds and matures, and as the most efficient forms of interaction are identified for both parties. This is expected and appropriate.

When researchers refer to “participation” within PPB programs, they are usually referring to the stage in the breeding cycle at which farmers have been involved. The nature of the participation (e.g., what role or function farmers actually undertake) and the degree to which they shape the process (e.g., have real decision-making role) is usually left analytically vague. In the sections below, we first present some of the PPB practitioners’ views on “stage” and “degree” particularly in reference to their own specific case material, and then synthesize the two variables, in tabular form, in a third section.

A first example might usefully illustrate how the dimensions “stage”, “nature”, and “degree” have to be combined together to understand the true “quality” of participation. Take the contribution of farmers, “information-giving”. Information sharing can be done in very different ways. At one end of the spectrum, formal questionnaires administered by short-term staff can be used to elicit farmer input at the beginning of the work, when defining preferences (stage). This process of information sharing (function/nature) is hardly even consultative (degree) and neither partner in the interaction is much committed to the accuracy of the information gathered and shared. At the other end of the spectrum are projects involving true dialogue in preference elicitation. In these, both partners are concerned about a specific issue and both are prepared to make changes in their views, etc. as a consequence of their dialogue (function: information sharing; stage: preference elicitation/defining objectives; degree: collegial).

Stage

The basic steps in a PPB program (Figure 2) are as follows. Having first established that a joint breeding collaboration is necessary and having agreed on the overall goals of the work (e.g., biodiversity enhancement, farmer skill building, production increase), the following five components unroll, often cyclically:

1) Setting breeding targets,
2) Generating (or accessing) variability,
3) Selecting in segregating populations,
4) Variety testing and characterization, and
5) Interacting with seed systems (release, popularization/marketing/ diffusion, seed production, distribution).

An initial observation from examining stages of farmer involvement is that it can optimally occur at various points, depending on the crop, parent materials, target region, researcher capacity to assimilate farmer criteria, traits of interest, and scale of the breeding program/number of materials to be screened. Farmer input can also change the structure of a formal breeding program, according to variable needs for input-feedback and products desired. Farmers and researchers have different realms of expertise, labor availability, and resources of time and financial support for plant breeding, and these factors are important in deciding appropriate activities for those involved. Logistics, participants' time, and resources for travel can limit the number of times farmers visit research stations, and several cases have attempted to examine the timing aspect of farmer involvement in selection.

Another issue of timing involves optimal timing for farmer participation during the annual crop cycle. Inputs from different family members may be relevant at different points in the crop cycle. For example, in Veracruz, Mexico (case 42), men did most maize selection in the field, women did most selection as the crop was processed, and both men and women participated in selection at harvest time and preplanting. The effectiveness of participation may well hinge on getting the right participants at the right point during the crop cycle.

Another timing issue relates to farmers' time constraints during the cropping season. Given the time pressure and labor shortages that many farmers face during the cropping season, it would be useful to investigate meaningful participatory activities that can be done during the off-season. Farmers in many parts of the world are under much less work pressure and are more at ease to think about broad questions and take time for in-depth discussions at times other than the cropping season. Off-season participatory activities also would facilitate the participation of poorer farmers, who may not have the extra resources to expend on experimentation, but who would be ready and willing to participate in discussions at times when their work load is less.

Selection stage. Breeders have sought farmer input on certain characteristics early in the selection process to capture sufficient variability and acceptable traits, but early selection for low-heritability traits is not meaningful (a distinction farmers may not recognize; case 15). With beans in Tanzania, researchers spent 3 years developing a list of farmer criteria to aid in understanding their assessments. Later studies comparing farmer and breeder selections concluded that it would be most useful to limit farmer evaluations to early and late generations, with breeders screening for resistance and yield between farmer assessments. Thiele and co-workers (case 17) found that farmer and breeder potato criteria diverged later in the selection process, so once breeders were aware of, and incorporated, farmer-important factors, the actual farmer involvement was not necessary until later selections involving about 30 advanced clones. Potato evaluations with users in Ecuador (case 34) were conducted early and late, with later selections particularly focused on commercial qualities. Iglesias and colleagues (case 11) report that collaborating farmers involved in on-station selection were eager to try observed varieties earlier in their own fields. Some breeders are hesitant to have farmers observe early stages of landrace improvement, because farmers will observe (temporary) physical decline in the varieties they entrusted to the researchers (Mario Fuentes, personal communication, 1999).

Stage of generating variability. After conducting one of the unique studies on farmer selection with several generations of segregating populations, Kornegay concluded that, "farmer evaluation of experimental (bean) lines should be more widely practiced". But she found that a "good breeder, cognizant of market forces and farmers' growing conditions, does not have to carry out an early generation selection and breeding program on-farm to produce successful and acceptable varieties. A more productive relationship would be to involve farmers in the final stages of the breeding process using fixed lines preselected by the breeder. Farmers can then help the breeder select for quality and local adaptation traits. Good lines can then be rapidly promoted for varietal release" (J Kornegay, personal communication, 1998). In a different model, Weltzien and co-workers (case 25) on pearl millet found it more efficient to have farmers first generate and screen new material under their own conditions for adaptation, with breeders assisting later with on-station selection.

Degree. As mentioned earlier, three degrees of participation are generally found in PPB programs: consultative, collaborative, and collegial. (The full range would span from "passive/extractive" to "farmer- or community-initiated").

Farmer-initiated work sometimes occurs at the later stages of formal-led PPB, usually at the 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 et al. [1999]). In the next section we look more closely at the issue of 'degree' by examining this dimension in relation to the stages in which farmers have been involved in joint PPB work.

Stage by degree: Synthesis of cases to date. Table 5 maps farmers' involvement in PPB programs by the two variables, stage and degree. (The "nature" of the involvement has varied from information giving to actual involvement in the technical processes of breeding). For "stage," we have used the stages of a breeding program elaborated above and in Figure 2. For the variable "degree," we again refer to the Quito wheel (Lilja et al. [1999]) in which workshop participants in September 1998 conceived of "participation" degrees in the form of a wheel, which could evolve through time and according to the stage of involvement. While the types of participation embraced the full range, from

Table 5. Classification of participatory plant breeding case studies: Stage x degree of participation.

Degree of participation	Case studies (numbers)[a] in type of participation				
	Defining breeding targets	Generating variability	Selection in early segregating populations	Variety testing	Variety/seed multiplication + distribution
Farmers provide land, responses (consultative)	2, 7, 7a, 14, 15, 19, 21, 22, 24, 25, 26, 27, 29, 32, 33, 35, 37, 39, 40, 46	—	1, 8, 39, 42	1, 2, 16, 22, 25, 32, 35, 37, 40	—
Joint management (collaborative)	—	—	4a, 15, 29	6, 29, 32, 33, 37, 39	—
Farmer-led research with formal support (collegial)	—	1	4b, 10	3, 10, 11, 17, 19, 21, 24, 25, 27, 31, 34, 40	4b, 11, 46
Farmers make all decisions (community-initiated)	—	—	—	3, 4a, 4b, 46	3, 4a, 4b, 11, 24, 46

a. See Appendix 1 for fuller details of case studies.

manipulative, passive, contract through to community-initiated, Table 5 focuses on the three degrees of participation generally found in formal-led PPB programs: consultative, collaborative, and collegial. Community-initiated work does occur within formal-led PPB, but only at the ultimate stage of seed multiplication, distribution, and popularization.

Perhaps not surprisingly, the table indicates farmer involvement in formal-led PPB as clustered near the end of the varietal development process, at the stage of variety testing and seed production and distribution. However, we also note an important number of PPB programs sought farmers' input into defining the breeding objectives, usually in the form of asking farmers about variety ideotypes, and/or which overall crop characteristics were key for them. In reality, a PPB program usually has several cycles and so the last stages of variety evaluation then feed back into the first of setting the breeding objectives (as the Figure 2 cyclical diagram indicates). As Table 5 also shows, an increasing number of programs are involving farmers in collaborative research even with segregating materials.

The "degree" of participation tends towards consultative (and less frequently collaborative) in current PPB programs, except at the final stages. Further, relatively few efforts had built-in evolution for the participatory process, that is, few have experimented with devolving more responsibility to farmers (exceptions are cases 24 and 11). Few of the cases analyzed have experimented with collegial participation involving a significant devolution of responsibility to farmers. This may be because many of the cases are still testing approaches. There are as yet few guidelines drawn from experience on the degree of devolution to farmers that can be achieved in a research program that needs to maintain certain standards of data quality that affect the replicability and validity of results.

A question often posed by and to PPB practitioners is whether it is realistic to involve farmers at the stage of setting overall objectives. This can be a tricky enterprise even for formal breeders (some of whom in the course of interview equated "setting of objectives" with "setting of defining characters for production gain"). Getting farmers and formal breeders involved in setting overall objectives implies that all should have some knowledge of options and trade-offs among goal options. An example is biodiversity enhancement with production gains versus production gains alone, versus breeding efforts to reach the most marginal niches, versus efforts to make farming communities more self sufficient in the breeding and seed selection practice.

During our study, some have also inquired whether "more participation" is always better: not necessarily. For example, models that are completely farmer-led (with only minimal interaction with researchers) may not have access to novel genetic materials for significant progress in selection. However, farmer-led activities could satisfy other local objectives, such as seed-sufficiency, and can be very valuable to communities (McGuire et al. [1999]). It is also problematic to quantify or generalize about how the amount of time or labor investment by farmers corresponds to desired outcomes. In certain circumstances, it may not be worth farmers' time to be involved in some stages of the breeding process, and certainly women farmers have many other agricultural activities that can potentially conflict with their "participating" time. Defining optimal timing and degree of interaction are important components in planning PPB programs.

In the introduction to this overview paper, we made reference to the "participation table" and suggested that the presentation, in our view, was a "failed one". There are two senses in which we feel it falls short. First, for most PPB cases, the authors had to make informed 'guesses' about the nature of the collaboration. The way formal researchers worked with farmers was not in the literature (nor in interviews), either transparently or analytically. Second, with the available material (and current PPB mindset), we have been generally unable to link the "degree" of participation with specific results achieved. There are two exceptions to this. It is quite clear that costs are significantly reduced when farmers take over on-farm testing. The scale of experimentation can also be greatly increased. Second, the direct impact of PPB programs for farmers (versus impact to research institutions) has been quick and palpable when farmers, their cooperatives, and communities have taken the lead in seed multiplication and distribution. Clearly, there is room for much more rigorous work on the direct tie between timing and degree of participation and results achieved. An aim of the SWP PRGA is to contribute centrally to filling this gap.

When participation is indispensable in plant breeding. We end this section on "participation" by reflecting on whether or not the issue of PPB is being overblown (as critiques often claim). Sceptics reason as follows. Classical plant breeding has always been, in theory, client-oriented (even if not successfully so) and private sector breeding should be considered PPB *par excellence*, only under another name. Commercial breeding **has** to be customer-oriented.

Having looked at the types of participation achieved to date, the authors reflected on whether conventional/classical breeding could achieve the same gains as PPB if formal programs just had the "right" goals, the right breeding objectives, and thorough knowledge of client preferences. We sense that part of the answer is "yes," for some current PPB cases. That is, if programs focused on farmer preferences and goals with true rigor, actual collaborative work (i.e., PPB) would not be necessary. This scenario would be similar to contracted research: client input could come at the beginning of the process (defining the overall goals and specific breeding targets of the program) and at the stage of evaluation. If no suitable product could be identified, then the client would not offer reimbursement. This contractual model assumes that:

1) Client-preferences are clear-cut and well-articulated (and methods for getting at these preferences are rigorous), **and**
2) Breeders can develop the client-oriented products using standard experimental designs.

We then further reflected on whether conventional breeding could achieve the same goals as PPB if formal breeding programs had the right goals **and** formal breeders selected in actual target environments. Again, we answered in the affirmative, perhaps for more current PPB projects. This contractual/decentralized model assumes that:

1) Breeders have resources to select in target environments, **and**
2) They have stabilized material adapted for the environments.

Finally, we broach the heart of this overview paper and reflect on the question, "For which types of circumstances might PPB **never** be replaced by conventional breeding?" Our review of cases suggests the following situations:

1) Cropping systems with highly rigorous quality standards, which need "judgement values," e.g., taste.
2) Systems in which client preferences are highly differentiated.
3) "Tough" marginal environments in which it is too expensive to formally test on a significant scale. The environments may be very heterogeneous, unfavorable, or perhaps the stress is sporadic.
4) Varieties/crops for which there are complex character trade-offs.
5) Most of the minor crops, which cannot very effectively be addressed by formal research.

This list suggests that direct participatory approaches in plant breeding are indispensable when:

1) Farmer expertise is needed: Farmers can project performance through time or assess trade-offs among characters.
2) Farmers' preferences are highly differentiated: Too costly for formal research to fine-tune the needed degree of information.

These are both functional aims. They might be added to the three "logistical imperatives" below, suggesting that direct participatory approaches are also indispensable when:

1) Farmer labor is needed: Formal research cannot select with available resources.
2) Farmer environments are needed.

3) The large-scale requirements of desired impact require that farmers take over much of the adaptive testing.

In addition, PPB is always indispensable when:

1) Farmers and their communities want greater control over the germplasm and seed supply.
2) Farmers need to take the lead in future breeding efforts (e.g., for minor crops for which formal research has no mandate).

These Empowering Approaches **have** to be participatory, by definition.

Gender/User Differentiation and PPB Programs

Overview

The profile above of needs and niches for PPB also starts to suggest the kinds of farmers who may be involved to meet different aims.

Theoretically, if the collaboration needs **expertise**, such as in screening segregating materials, the farmers involved should logically be the local germplasm/variety experts or the local seed experts, and/or people who can provide honed quality assessments (particularly judging character trade-offs). Note that “expert” farmers are usually described as farmers who take an exceptional interest in variety or seed issues, regularly supply seed to others, are regarded in their village for the quality of their seed, and/or spend more time and special effort on selecting and preparing their own seed.

If the collaboration most needs to understand a range of **preference differences**, then logically, farmers with potentially different varietal needs should be involved. Depending on the context, this may mean farmers of different wealth, caste, gender, ethnic groups, etc. If the collaboration basically seeks the **labor input** of farmers, for instance to expand the number of on-farm trials, then farmers who are powerful or respected in the community, those who can muster help, or who specifically work with groups may be contacted. For access to a **range of environments**, farmers with the “right” profile of environments/ sites may be contacted. (Note that seeking the “labor input” of farmers or access to a range of environments through them, has no link to “participation” per se). And finally, to achieve true **empowering gains** the field is wide open. Working with farmers who are particularly dynamic in skill building with other farmers may be one route. Working with representatives chosen by the communities, or with organized groups, cooperatives, or across a broad spectrum of farming society is another route to ensure that product and process gains resulting from PPB work are spread widely.

In analyzing the PPB work carried out to date, how explicitly have these different user needs been articulated and implemented? As the following sections show, differentiating among users has been a low priority. In discussing who has been involved in PPB work, we will focus on two areas: farmer evaluators and gender concerns.

Farmer-evaluators

Farmer-evaluators were identified within PPB programs by a variety of means. Some were chosen for past collaboration with the researchers or institution (case 10), while others were selected by their communities (cases 24 and 38) or self-selected based on their interest (resulted thus in case 17, but researchers were not pleased). Yet, for most cases, key methods were relatively little discussed at all; for example, whether farmers were selected for their representativeness of farming conditions, for their particular expertise, or just randomly. Several exceptions illustrate conscious farmer selection strategies.

In the Rwandan bean case, where a great diversity of bean varieties exist and local varietal experts are clearly recognized, researchers tried to combine issues of expertise and representativeness, along with practical needs. Criteria applied for farmer evaluators during the first phase included: community recognition or nomination as an expert evaluator, extensive experience with the crop, innovativeness/ experimentation or interest in new varieties, willingness, representativeness in key farming conditions, and known ability to communicate with researchers and their home communities. Note that when selection of evaluators was totally devolved to different types of communities during a second phase, power interests seemed to skew the choice, and expertise, known among key women, went down (case 24).

Representation of diverse ethnic groups was a factor in evaluator selection with cowpea in Cameroon where researchers also noted marked differences between male and female criteria (case 16). Here the program developed a variety with extremely high farmer preference (55%, compared to 6% for the currently extended variety) for yield and yield stability, improved storability, disease resistance, and cooking time and taste test qualities. In the Colombian cassava case (case 11), researchers were working with 28 communities simultaneously (a community being a chip-drying cooperative) and selection was left entirely to the farmer group, which had well-defined, relatively uniform interest.

Evaluators were sometimes selected (for either uniformity or diversity) by age, gender, proximity to the research station (cases 1 and 29), ethnic background, market access, special skills (e.g., carpenters for case 7), and socioeconomic status. The rice case in Nepal stated that on-farm variety evaluators “are not consciously selected while distributing the seed packets to avoid socioeconomic bias” (case 4b).

For beans in Ethiopia, farmers were specifically selected at random (case 32). On the other hand, researchers interested in farmers' evaluation of tree species did not select randomly because they wanted to ensure that participating farmers were interested in trees (case 7). Ensuring that not only innovators and community leaders have access to new varieties was an explicit concern for some researchers (cases 4b and 24). Some programs worked long-term with the same group of farmers (case 25), while others deliberately changed evaluators (case 16), and others had some continuity plus new participants each year (case 17). Where women were primary growers or processors of a crop, some programs included work with women's groups (cases 1, 4a, 11, 24, and 25). Only a few studies gave the names of farmer collaborators (cases 6, 10, 24, and 29).

Researchers employed a range of methods according to research needs, crop types, farmer interest, and program objectives. In terms of being able to predict results, more work needs to be done in this area of "who should be evaluators and to what end." Few programs explicitly examined needs and criteria of different socioeconomic strata within rural communities. Some selected collaborators based on landholding size (case 25) and wealth indicators like cattle ownership (case 7) or access to roads/markets/inputs (case 42).

Interestingly, most of the PPB collaboration is still being conceived as between researchers and individual farmers, with information feeding back to refine formal research. Relatively few experiments have taken place between researchers and organized farming groups (see cases 11 and 24) in which the aims were to share research responsibility more fully and spread benefits more quickly.

Gender concerns

There are compelling reasons to focus on gender issues within PPB programs. (A companion overview focuses exclusively on this social/gender perspective [Hecht 1998]). Here we simply outline some of the main gender threads that have woven in and out of PPB programs.

Involving women can make for better science. They are often plant breeders in small-scale farmer production systems, responsible for domesticating wild species, selecting germplasm, and saving seed. For instance, many of the world's landraces are maintained and reproduced by women, including cassava, beans, fonio, bambara, groundnuts, millet, and many of the minor crops. In Veracruz, Mexico, men selected maize in the field, women selected during food preparation, and both were involved in seed selection at harvest and preplanting (case 42). Women's prime roles in both variety and seed management have long been recognized.

Empirical evidence from the formal-led PPB cases shows that women's involvement in selection can confer benefits for the whole community; that is, female expertise is not just for women. Over a 3-year period, Rwandan experts selected a pool of varieties (21 separate bean types), which out-performed breeders' choices in their own production terms and met quality characteristics of interest to diverse community groups (case 24). In Namibia, the farmer Maria Kaherero encouraged outcrosses of her local variety with a station release "Okashana 1" over four seasons, producing a wonderful millet. Researchers swooped on her variety and crossed it with 30 varieties selected through a PVS exercise. This participatory breeding composite (MKC or Maria Kaherero composite) is now the foundation for the national breeding program (case 35).

In many instances, women's criteria may be so significantly different from men's that dual involvement in breeding/selection is necessary to meet each partner's needs. In Mali, maize evaluations showed men placing production and early maturity as the main criteria, with women focusing on organoleptic and processing aspects (case 19). Rice work in West Africa had a similar gender division, with the West African Rice Development Association's (WARDA) scientists reporting that men focused on yield and yield-related traits such as plant vigor, while women concentrated on quality attributes such as bold grains (case 5). In many cases, researchers reported that women's and men's criteria were not significantly different, except for culinary or quality-related criteria (cases 16 and 42).

An overview of gender in PPB work (Hecht 1998) synthesizes the range of criteria used in farmer evaluations and groups them roughly into environmental, agronomic, and cultural categories—some 54 headings in all. Almost half of these are related to labor, ancillary, culinary, or storage features—all highly "gendered" realms.

Finally, not involving women may bring negative, not just neutral consequences. For example, in the Gambia, men's production systems involved almost 100% adoption of high-yielding varieties of rice, while female production systems remained based on the use of *Oryza glaberrima*, a rice variety indigenous to West Africa. This wholesale adoption by men marginalized women's products and transferred other rice lands into the hands of men, who received all benefits from commercial sale. Eventually, women withdrew their labor, overextended by the double cropping regime (Carney and Dey, cited in Hecht 1998).

As a preview to the Hecht document, which analyses the same set of cases found within this formal-led PPB overview and the farmer-led PPB analysis (McGuire et al. [1999]), we quote the following passage to give an idea of the frequency of gender analysis/insights in the overall PPB field:

"Of the case studies analyzed, 68% incorporate gender in the research. About twice as many men as women are included, with roughly 61% of the informants being male, while the rest are women. Those that did not incorporate gender in the research included Andean countries and Ethiopia, where both academic and agronomic research has shown broad participation of women (Zimmerman 1996). Of cases that included gender, roughly half provide some substantive analysis, while the other studies mention gender, but in a nominal way, perhaps reflecting the general nagging about involving gender, yet not really understanding what this might imply. Much of the statistical treatment tends to "blur out" women's participation, and the logic for the differences between men and women is often not explored in much detail."

Certainly within the PPB field overall, the treatment of gender as an analytical variable has been weak—very weak considering how key women are to many breeding and selection activities.

Institutions in Formal-Led PPB

Most of the PPB work to date has been:

- Small-scale (less than 50 farmers involved at one or two sites),
- Designed to answer a series of focused research questions (e.g., can early farmer involvement help to sharpen breeding objectives?), and
- Conducted in basically the "consultative" mode of participation (i.e., researchers manage the entire program and consult with farmers on targeted issues).

The "participatory" aspect has been added under the umbrella of a normal or routine breeding program with several differences. There has been more intensive consultation with farming groups at the diagnostic and evaluation stages and, in some cases, farming communities have been given full charge of subsequent seed production and distribution. This has had very positive impacts as in the Ecuador and Bolivia potato cases (34 and 17), cassava in Colombia the CIAT/CORPOICA case (11), and the CIAT/Rwanda beans case (24). Various types of institutions have joined to achieve the work:

- International Agricultural Research Centers (IARCs)/NARs in Ecuador and Bolivia (cases 17 and 34)
- Universities/NARS: Collaborative Research Support Project (CRSP) cases, Malawi and Tanzania (cases 14 and 15)
- Universities and NGOs (KRIBHCO cases 2, 3; maize in Honduras case 29), and
- IARCs/NGOs (case 25).

In only a few cases has the inter-institutional arrangement involved a change in the way each institution works and/or in the power relations between groups (case 24). Researchers have fulfilled their normal functions as have collaborating farming communities. Few of the research-oriented programs tried to scale up through time (in contrast to the development-oriented ones, see "evolving institutional arrangements"). In effect, in most of the formal-led PPB cases examined, the set of institutional arrangements has been little altered from the norm.

Challenges under current institutional arrangements

Even under current institutional arrangements, however, a range of challenges should be addressed if PPB is going to develop effectively within standard breeding programs. We single out four for discussion here: creating shared agendas, building in accountability for the research, creating effective intra-institutional linkages, and ensuring effective communication between researchers and farmers.

Creating shared agendas. Successful PPB needs to be based on a common agenda shared by all participants. As noted in the discussion below, agreeing on a common agenda can be problematic even for just breeders and social scientists. No doubt the difficulty is increased when one considers all the other players who must be in agreement, including farmers, extensionists, NGO participants, and other participating institutions. It is a significant challenge to "level the playing field" in creating shared agendas; all those participating should equally understand the options. For example: can farming communities make informed decisions on, for instance, biotechnology assisted PPB? And mechanisms are needed to ensure that all negotiating parties have proportionally "weighted" voices (with the end-users or clients' proportionally being the strongest).

Several different approaches have been tried for arriving at shared agendas. An on-farm maize research program in Ghana set agendas in an annual workshop, where results from the previous year were reported and plans developed (Edmeades, personal communication, 1998). Participants in this program all had the opportunity to evaluate a common set of trials, which gave them a shared basis for their discussions. Cassava researchers in Brazil have helped to establish CIALs, groups of four locally elected farmers that determine local research priorities and establish farmer-participatory experiments to address them (Ospina et al. 1997). Discussion between the CIALs and researchers, who will be providing technical backstopping to them, leads to agreement on a shared research agenda in this case. There are other possible approaches for establishing a commonality, but these highlight options at different ends of the spectrum of farmer involvement (from a more researcher-driven process in the Ghana example to a more farmer-driven process in the Brazil example).

Building in accountability for the research. An important feature of true "participatory" collaborations, and particularly of what is sometimes called "client-driven" research, centers on sharing accountability. Those involved in research (state research/extension programs, NGOs, producer organizations, local communities, informal farmer groups) become liable for the relevance and quality of technology on offer. A big obstacle to institutionalizing participatory client-driven research and development in the public sector is that, presently, most agricultural research systems and their staff are neither penalized for producing technologies that farmers cannot use, nor are they rewarded for client-oriented research. A necessary feature of client-driven or demand-led research and development is that clients must have the right to "buy into" (or "sell out of") a research program via their control over a significant proportion of resources needed for that program (Ashby and Sperling 1995).

At present, no PPB program has explicit accountability-sharing mechanisms. Such mechanisms have been well-articulated in client-oriented commercial breeding as a well-known case from the Ivory Coast demonstrates. There, the cotton development agency, CIDT, and the research institute, IDESSA, jointly plan the annual research program, including the budget. All funds available to IDESSA for cotton-related research and operating costs for technology development and linkages are directly tied to a fee assessed on cotton revenues. Simply put, "the more effective IDESSA is in meeting CIDT's technological needs, the greater the financial resources it gets for research on cotton" (Eponou 1993). Over the last 30 years, cotton yields have more than tripled in the savanna zones. During the same period, gains in coffee and cocoa, subsectors with no client contract, have been insignificant (Eponou 1993). However, poor farmers, particularly those who are less market-oriented, organize less easily and their real ability to say "no" to a general agenda or even a specific technology makes itself felt only erratically (Roling 1989).

Creating effective intra-institutional linkages. To be successful, PPB efforts require good communication between researchers and farmers to help each arrive at a clearer understanding of the others' needs and abilities. Formally trained plant breeders are rarely trained in communication skills beyond those related to technical scientific communication. Social scientists are much more likely to have the needed communications background and skills, but lack in-depth plant genetics and breeding technical knowledge. Thus, collaboration between breeders and social scientists would contribute much to the success of PPB efforts. Institutional organization often gets in the way of this type of cross-disciplinary collaboration more than it facilitates it—a problem that is widely recognized. Organizing researchers into interdisciplinary units with shared goals, as opposed to disciplinary units, seems to help.

Among the cases examined in this study, there appear to be relatively few documented examples of truly successful collaboration between breeders and social scientists. Work done in the context of the Bean Cowpea CRSP in Malawi (case 14) involved close collaboration between breeders and social scientists from the start (S Temple, personal communication, 1998). They were part of the same national program team and they worked jointly on facilitating strategies for introducing new or improved components into mixtures and developing measures of adoption for those components. However, in a participatory maize improvement effort in Honduras (case 29), an initially successful collaboration between a breeder and a social scientist gradually ended when new researchers replaced those who had initiated the collaboration (M Smith, personal communication, 1998). The new researchers brought their own interests and styles to their jobs, which did not necessarily coincide with the collaborative approach previously taken. Further, the original collaboration had evolved out of a professional friendship, and that important basis for collaboration was not pre-existing between the new researchers. The Mexican McKnight Integrated Landrace Preservation Activity project (MILPA) project (case 39) was explicitly designed to include interaction between breeders and social scientists. However, the large group of researchers spread over two countries that are involved with this project drifted into an organizational structure that separated breeders from social scientists. This made dialog and planning possible (where they would have been nearly impossible otherwise among such a large group spread over such large distances), but it also made close connections between breeders and social scientists more difficult. Thiele et al. (1997) noted that integration between breeders and social scientists working on farmer-participatory potato evaluations in Bolivia was less than ideal at the outset. Differences of opinion about research design and appropriate research questions contributed to breeders and social scientists working and publishing separately. When social scientists helped breeders with participatory evaluation of materials in the breeders' trials, however, the value of better collaboration seems to have become apparent and interactions improved.

Note that interactions between breeders and social scientists are only rarely explicitly discussed in the PPB literature. The above examples are drawn from a few references or from the authors' personal experiences. This information gap leads one to wonder whether interaction only rarely occurs (even imperfectly), and is therefore only rarely discussed. Clearly, needed interactions between social scientists and breeders may not occur because of:

- Organizational structures that impede collaboration,
- Divergent professional interests,
- Lack of appreciation for the contributions other disciplines can make,

- Largely divergent expectations for the outcomes and the process of the joint work, and even
- Lack of professional friendship as an underlying basis for the collaboration.

Ensuring effective communication between researchers and farmers. Effective exchange of knowledge, experiences, and observations is key for carrying out participatory research. Its basic aim is to utilize knowledge and experiences of both farmers and scientists to more efficiently provide better solutions that effectively solve priority problems faced by farmers. Interaction between individuals representing often extremely distant knowledge and communication systems is essential for the success of such participatory work.

Communication, especially oral communication and dialogue, are rarely topics that concern biological scientists as methodologies for their work. Much of the success of modern science is because of standardizing information flows, creating systems of terminology and classification, and developing rules for scientific exchange, ethics, and responsibilities. As scientific knowledge is proliferating globally and becoming more and more specialized, different disciplines are developing their own classifications, standards, and terminologies. This is one of the explicit strengths of modern science and allows for international interactions and exchange to further understanding of specific processes. This is especially true for individual disciplines, but to a lesser degree across different disciplines. In fact, different disciplines develop their own terminologies and norms, making multidisciplinary research difficult.

If even researchers from different disciplines have difficulties understanding each other's terminologies and systems of classification (i.e., have difficulties communicating effectively), it is not surprising that the communication between farmers and scientists may not always be straightforward either. This is especially so if farmers and scientists are from different cultures, speak different languages, and use different knowledge systems to judge, classify, and communicate their observations, findings, experiences, or ideas. It seems obvious that scientists who want to work with farmers to achieve a common goal need to have an understanding of each other's systems of knowledge and communication. However, in the project publications of the PPB projects reviewed, the methodology that scientists use to gain such an understanding is rarely explicitly described.

For effective face-to-face communication with farmers, natural abilities are often not enough to achieve a sound understanding of farmers' concepts, management strategies, and ambitions. Several of the projects analyzed have social scientists as team members. Their roles and functions are often related to facilitating this interaction between biological scientists and farmers. Most of the direct interaction between farmers and scientists in many projects is really the direct interaction between farmers and social scientists (e.g., case 19). This may be especially true for projects that have an explicit focus on understanding rural people's knowledge (Friis-Hansen 1996) related to seeds and varieties (e.g., cases 19, 25, 39, 42, 47, and 48).

A good example of a research effort to enhance the effectiveness of the interaction between farmers and plant breeders is the communication techniques developed by Dhamotharan et al. (1997) as part of case 25. These techniques are based on asking farmers to simulate certain routine activities (e.g., preparing a seed mixture). A situation is created where farmers demonstrate something they may easily talk about, because it is just a routine task, but one that is essential to the biological scientists' understanding of farmers' concepts and practices. The farmer can explain things by doing them or showing them, with which farmers often feel more at ease. Besides explaining a specific task or process, such an approach easily creates an atmosphere of mutual trust and ease of communication that eases the transition into discussing related topics.

Communication tools of the PRA type that are commonly used by PPB projects are "matrix ranking" of a set of varieties (cases 2, 3, and 25), description of "ideal variety" (case 25), and pairwise ranking (cases 1 and 19). These techniques lend themselves to group discussions. Results of the discussion can be visualized while the discussion proceeds, providing the opportunity for the group to reconsider specific statements or to ask the input/opinion of a specific member on one particular item. These techniques often lead to discussions among farmers themselves without the direct interference of the scientists—a sure sign that a topic is relevant and of some importance to the participating farmers. Several projects relied mostly on structured or semi-structured questionnaires for interviews with individual farmers growing trials or visiting research stations (cases 1, 2, 3, 8, 9, 22, 35, and 46). In some cases, this information is used to triangulate information obtained from group discussions (cases 2, 3, and 25).

In some cases farmers are given a role that would normally be the breeder's (i.e., rating, scoring, or ranking a larger set of genotypes for a standard set of traits). Literate farmers can fill out forms for such ratings by themselves (case 1, 4, 8, and 9) or the researchers can fill out the forms themselves after asking the farmers to give their judgment (case 8, 9, 24, and 35).

Evolving institutional arrangements

A potentially complex issue for PPB is how to "scale up" the work so as to address the needs of more than a very limited number of farmers.

This might involve devising strategies for (1) scaling up the process of collaboration, whereby PPB teams may work in many agricultural micro-niches simultaneously, and (2) scaling up the product whether it be germplasm/seed, knowledge transfer such as improved farmer breeding techniques, or knowledge about specific varieties and seed sources.

Scaling up the process. There are select cases where larger numbers of farmers have been involved in fairly centralized PPB programs. Examples of this are not difficult to find for setting objectives or for variety testing and characterization. Broad farmer surveys, community focus-group discussions, and farmer evaluation of on-station variety trials are some examples of how large numbers of farmers can participate in setting objectives for a breeding program. Similarly, variety evaluation can involve many farmers through farmer evaluation of on-station variety trials (cases 1 and 24) or distribution of variety trials to many communities and/or farmers. An unusually broad-based example comes from Nepal, where over 1,800 farmers received seed of one of six new rice varieties for testing (case 4b). This work addressed a new cropping practice for rice, and thus basically a new environment for rice cultivation in which varietal diversity was lacking. The project goal was to evaluate “informal research and development,” a scaling up option whereby researchers selected varieties worth testing and multiplied their seed, and farmers were in charge of on-farm variety evaluation as well as selection, maintenance, and distribution of desirable varieties. A follow-up survey showed that all six varieties tested had been adopted and that the choice of which (if any) to adopt varied with locations. This seems to be an appropriate model for large-scale participation in the varietal testing and characterization phase of breeding.

In relatively few cases has the process been scaled up through the creation of multiple decentralized programs, that is, where the process of PPB work actually takes place at different sites, independently. The CIALs described above are one exception: as of 1999, about 500 in several countries have engaged in independent variety testing on a range of crops (A Braun, personal communication, 1998). As another example, PPB work with cassava in Colombia has developed around farmer cooperatives dedicated to drying cassava chips (case 11). In 10 years, many cooperatives have been involved, and in 1999, the CORPOICA/CIAT-assisted program is working with 13 different communities (C Iglesias, personal communication, 1999). The PPB work in Rwanda (case 24) also expressly experimented with different “organizational options” for decentralization, comparing the strengths/weaknesses of collaborating with the formal extension service, women’s cooperatives, and self-organized farmer research groups (Sperling and Scheidegger 1996). Evaluation or assessment of organizational options is one of the large and almost total gaps in current PPB work. The choice of collaborators largely determines how much the process can be scaled up and the technical divisions of labor (i.e., devolving responsibility and deciding who does what). The choice of collaborators (and the scale on which one works) also directly influences the cost of the PPB work, both the overall cost and the cost/ benefits for each partner. To date no rigorous cost analysis has been made of PPB work, although CIAT/CORPOICA has done some initial assessments of on-farm trial costs. The SWP PRGA is addressing this gap by currently funding six PPB programs, which should deliver cost/ benefit data by the year 2001.

It is important to emphasize that almost all scaling up work in PPB has been done in programs working with stabilized materials. When one considers generation of genetic variability and selection in segregating populations, there are few examples of farmer participation and all are with very small numbers of farmers (i.e., from one to 10). Whether scaling up of farmer participation in these activities is necessary depends on the extent to which they can be centralized yet still effectively address varietal needs over a broad area. To date, the evidence is inconclusive, especially for marginal areas where centralized on-station breeding programs have failed to deliver improved varieties. Evidence from the large-scale screening of rice varieties in Nepal (case 4b) suggests that farmers' varietal choices vary over geographic locations separated by fairly short distances. But a breeder-selected group of six varieties included at least one that was perceived as advantageous by 37% of the surveyed farmers (Joshi et al. 1995). It is unclear whether farmer participatory selection would eliminate varieties that would have been highly desirable in nearby areas but were not advantageous on the particular farm where the breeding was conducted. Thus it is unclear whether farmer participatory selection in segregating populations can be expected to generate varieties of broader, less broad, or equivalent adaptation to those coming from experiment station selections. Therefore, the need for scaling up remains in question with respect to farmer participation in generating genetic variability and selection in segregating populations.

Scaling up the products. It is only by widely diffusing the seed of PPB work that one starts to test the adaptability of any given selection (e.g., whether widely or narrow adapted). Obviously, the wider the adaptability, the more cost-effective is the PPB process. Although practitioners of PPB often cite one of its strengths as its ability to hone in on narrow adaptation, a well-documented case comes from India (case 2) where farmers in a relatively small project area identified an upland rice variety (Kalinga III) as most beneficial. This variety is spreading rapidly within the project area, as one might expect. However, the variety is also spreading rapidly in other upland rice systems, some in the same states as the project, some in Nepal, and some in other Indian states. Kalinga III has characteristics that many upland rice farmers appreciate, earliness being one. The variety was bred in eastern India and released by the state authorities, but not on a national level. The seed production agencies from the public sector in India never chose it for large-scale multiplication. The project staff is working on changing this situation, because this would make seeds available on a large scale at subsidized rates.

The mechanisms for scaling up products, whether skills or germplasm, are discussed in the section “Transfer of Benefits.” Seed regulatory frameworks and intellectual property rights (IPRs) have the potential to greatly alter the impact of PPB—either in positive or negative ways—as well as to crush the zeal for inter-institutional or inter-community collaboration altogether.

In summary, there is limited information to draw on in considering institutional structures that will facilitate PPB. Clearly cross-disciplinary collaboration must be encouraged, and the success of this collaboration seems to be influenced by researcher organization (disciplinary vs. objective-oriented teams) and individual researcher’s attitudes and personalities. The time-consuming process of arriving at a common agenda is a necessity, and several possible approaches to this have been described. The need for scaling up must be considered carefully, because it may not be necessary in all aspects of PPB, but much evidence that would shed light on this issue is lacking.

Changing inter-institutional arrangements is a long-term process, requiring the understanding of each other’s priorities and functioning. Creating new institutional arrangements (such as CIALs), and/or re-allotting work roles among institutions (including farming communities) takes both an explicit research process (to determine most suitable divisions of labor) and investigation into areas in which neither breeders, nor most public sector agricultural research institutions, have much expertise. Many projects are too short-term in nature to follow through on these issues, and/or have frequent personnel changes that are inconducive and/or simply do not have the specialized expertise to address issues that are at the core of scaling up concerns. Lastly, farmer-participatory approaches clearly must be valued by leading research institutions, and their support may only be gained by proving the value of the approach. Although results are beginning to accumulate, more successes will be needed before most research administrators are prepared to wholeheartedly support such a different approach to plant breeding.

Outcomes, Results, and Impacts from Formal-Led PPB

Changes in formal breeding programs

A significant outcome of PPB is the influence on breeders’ selection criteria and methods. A better understanding of new ideotypes based on farmers’ experiences, specific preferences, and needs will have an impact on the priorities of breeding programs, and on the process of formal variety development. A refined understanding of the predominant production conditions and their primary constraints may influence the choice and management of research stations. Many projects particularly examined the stage of farmer involvement in the breeding process as well as the roles and responsibilities of farmers and breeders in a joint program.

Selection criteria. Almost all (85%) of the cases studied obtained results relating to farmers' selection criteria for new varieties. A common result was that farmers were interested in large ranges of traits and of different combinations of traits, much broader than the breeders had expected or used (cases 15, 17, and 26 made direct comparisons). Farmers in those cases reported that they need varieties for diverse sets of growing conditions (i.e., specific crop mixtures, intercrops, fertility situations, and planting dates) in addition to quality concerns and marketability. In cases, however, where marketability was of overriding concern to farmers, farmer selections very highly focussed on a few relevant traits, with much less attention paid to all the other options. Farmers' selection criteria differed from each other when farmers from different agroecological zones were consulted, or when better-off and worse-off farmers were involved. In some cases ethnic differences in preferences and selection criteria were also found.

For cowpeas in Cameroon (case 16), farmers consistently used 26 criteria relating to yield, quality preferences, and labor savings. Beyond a minimum acceptable yield, the acceptability of a variety was determined by factors other than those related to yield. Peruvian potato farmers (case 31) used 39 criteria, which researchers divided into seven categories. Acceptability of a variety was poorly related to yield under optimum conditions, but rather determined by the adaptation to specific ecological conditions and market demands.

Weltzien and colleagues (case 25) found that farmers' criteria for varietal preferences varied widely across a region, according to growing conditions and poverty of farmers. Poorer farmers, owning predominantly fields with poor growing conditions for pearl millet, very consistently preferred high tillering materials with small panicle size. Better-off farmers, usually also owning some better quality land, were interested in materials with larger panicles and less tillering capacity, because they perceived that these materials respond better to good growing conditions. Also, in other cases, farmers were especially concerned about adaptation to poor soil fertility conditions (cases 8 and 36). Similarly, the work with potatoes in the Peruvian Andes (case 31) and in East Africa (case 26) showed that farmers were interested in very diverse criteria, not all of which breeders could satisfy.

Poor farmers often cited earliness as an important factor in shortening the hungry season and in maximizing production on their small landholdings. Several breeding programs have placed more emphasis on early maturity as a result of their interactions with farmers (cases 8, 25, 26, 31, and 40). The poorer farmers also used important criteria related to multiple crop uses (11, 25, and 26), as people relied on nonfood parts for animal feed, or seasonal excess processed for the market (11, cassava flour). In pearl millet and barley (cases 8 and 25) farmers' evaluation considered grain and stover uses as roughly equal in priority; thus stover yield and quality have become traits used in the breeding program.

Where farmers rely on selling some of their products for scarce household cash income, quality criteria may be more determined by market demands than by grower preferences (cases 10, 16, 19, 31, and 37). Consequently, researchers should be aware of farmers' intended uses for the crop. With potatoes in Peru (case 31) and cowpeas in Cameroon (case 16), farmers grow modern varieties as cash crops, and benefit by earning as much as double for products with preferred size, color, or shape. Youngquist and Mushi (case 21) sought to utilize farmer expertise on qualitative evaluations alongside researchers' quantitative data. They found that farmers are more concerned with characteristics related to market value (qualitative), than with yield (quantitative). Iglesias et al. (case 11) were able to correlate farmer quality judgments with quantitative equivalents (e.g., the percentage dry matter), so researchers could screen for important traits.

In some cases, it was found that farmers' criteria match breeders' criteria in principle (e.g., the Southern Africa Development Community (SADC)-ICRISAT sorghum and pearl millet program in several countries). These results strengthened the on-going selection strategies of breeders. In addition, breeders learned about specific traits that farmers use, which go beyond the productivity related traits the researchers use. In one example, farmers introduced breeders to their observations on grain traits that confer resistance to storage beetles (case 1).

In summary, the cases point to specific ways in which PPB has enabled researchers to focus their efforts on the poorer farmers, and highlighted some strategies for addressing their particular needs. The following have all resulted from PPB interactions with farmers:

- Testing in low-input situations,
- Emphasis on developing some very early varieties, often grown by farmers among an array of varieties that fill different use niches,
- Attention to multiple crop uses in the selection process,
- Identifying a diversity of varieties to stabilize production, and use-niche conditions, and
- Ensuring that varieties grown for the market have characteristics that can bring good prices.

Selection criteria and gender. About one third of the cases examined used gender differentiation to compare women's and men's criteria for choosing better varieties, and another three cases, focused exclusively on women as the primary cultivators of the crops being studied. Of the 12 cases that examined gender-differentiated varietal preferences, six noted that women emphasized quality and use considerations more than did men (cases 4a, 7, 16, 19, 22, and 25). One case (40) found that women carried out their primary selection activities as the crop was used, thus probably also emphasizing traits related to crop quality and use. For tree species in West Africa, researchers found that income from sale of different species' products was gender preferential. Cash from seed and fruit sales of two species went primarily to women and children, men received most of the cash for two other species, and receipts from sale of another species were shared roughly equally (case 7a). A farmer evaluation of potato clones in Bolivia (case 17) found no differences in preferences between women and men, but noted that women attended more of the post-survey information dissemination meetings than did men. One additional study noted no difference in criteria between women and men (case 1) for plant growth related traits. Only women evaluated quality and processing related traits.

Although women's and men's varietal selection criteria are not different for all crops in all situations, clearly in many cases criteria differ between women and men, and in additional cases gender differentiation among users reveals differences in crop management or information-seeking behavior. Methods to anticipate these possible gender differences have to be built into the design of PPB efforts.

Changes in sites for testing. As discussed above, in several cases, farmers were primarily concerned with identifying new varieties suitable for use under specific growing conditions. In many cases, the growing conditions that farmers use, create, and target cover a much broader range that those targeted by formal-led programs, as the discussion of the results on selection criteria revealed. Thus for several of the case studies there is apparent need to develop selection, and breeding schemes, that allow for the appropriate level of decentralization. Two related cases (8 and 9) are specifically addressing this research need. Other programs are modifying their routine testing procedures for variety development to include farmer-managed tests in their programs (cases 17, 34, and 35). Some other cases (25 and 37) reported that they explicitly changed the management of on-station trials, to improve the relevance of the selection program. For pearl millet in India, this meant reducing soil fertility and exploring options for truly depleting soil fertility from a field on-station. For cassava in NE Brazil, it meant a harvest at 18 months, rather than at 12 months after planting. In situations where farmers were relatively more concerned with quality and marketability related traits than with yield and productivity (cases 16 and 21), the breeders recommended reducing efforts for large-scale, multilocation yield testing. Instead, they recommended exploring and utilizing a wider range of variability for quality and marketability related traits, which can be evaluated earlier in the breeding process and require, or benefit from, farmers' contributions.

Overall, it seems that many more projects will begin to experiment with explicit options for delegating specific responsibilities for testing to farmers at critical points in the program, especially as needs for decentralization emerge more clearly. A more detailed discussion of the methodology options is part of the breeding methodology section.

Changes in germplasm used. Although only four cases explicitly reported changes in the germplasm used as a result of farmer participation, we sense that these are necessary in many more projects to address the stated needs of farmers (e.g., in cases where farmers preferences and selection criteria are very different and/or more diverse than those of breeders). If formal programs are prepared to meet these diverse and differing needs, changes in the composition of the base germplasm and in the type parents used for crossing, will be almost inevitable to generate the basis for advances from selection in farmer-desired directions.

With pearl millet in Namibia (case 1), a farmer-generated population cross between a traditional variety and a recently introduced improved variety was used as the basis for generating a base population for further variety development, because it already combined most of the attributes that farmers preferred. In initial comparisons of the genetic variance for key traits of this population with two other breeder-composed populations, the farmer-based population proved to be more variable. In case 2, a maize population was created based on farmer-preferred varieties and traits, to develop a variety that combined the most important traits that farmers had indicated during previous participatory variety evaluations. In case 27 with cassava, the breeder identified new parents for crossing among farmers' varieties during the participatory variety evaluations. The pearl millet case in India (case 25) reported dropping from its program several base populations with medium maturity and large panicles and creating new base populations based on farmers' selections among germplasm accessions. This case is also evaluating using farmer-generated population crosses between local and introduced varieties for further selection, by farmers and/or breeders. These cases all show that the genetic base of the breeding populations was broadened as a consequence of farmer participation in the breeding process. In the maize, cassava, and pearl millet (India) cases, the more widespread adoption of varieties derived from these base populations will most likely also lead to enhanced crop genetic diversity in farmers' fields.

Methodologies for farmer evaluations. Nearly half of the projects that reported results on farmers' selection criteria and preferences also reported developments and adaptations of methodologies for interactions between farmers and breeders: for exchanging information, for eliciting farmers criteria, and for the timing of these interactions in the breeding cycle, or during the growing season.

Usually each case reported some work on methodology development and modifications to suit the social, organizational, and technical conditions of the specific case. The methodological components addressed mainly two issues. On the one hand, researchers were concerned with ways to obtain more realistic, accurate assessments done by farmers during both individual and group processes. Another component was concerned with ways to increase the numbers of farmers participating or ways of achieving more, and better, representation among participating farmers.

What emerges, as a general outcome, is that the methods used for interaction between farmers and scientists need to be carefully chosen to match the cultural and agroecological context and all partners' needs. Formal surveys and market analyses were used in some cases (cases 8 and 25), but the results are limited if the scientists designing them are not intricately familiar with farmers' concepts, concerns, and production conditions.

Several projects have thus developed procedures for involving farmers in choosing preferred, acceptable varieties from a larger and/or variable set of varieties, either:

- Grown on station (cases 1, 7, 10, 17, 22, 24, 25, 32, 35, and 37), or
- In a village on communal field (cases 5, 11, 24, 27, and 37), or
- A participant's field (cases 1, 8, 9, 10, 17, 19, 21, 24, 25, 27, 31, 33, 34, 35, 39, and 40), or
- A rented field (cases 5 and 39).

A common approach in cases where farmers were evaluating a large set (40-300) of material was to let farmers select and mark a maximum of 5 to 10 varieties from the set. Then either individual or group discussions were held about reasons for their choices of either the individual varieties, or the selected subset. Usually, researchers recorded positive and negative characteristics, and tried to understand reasons for the farmers' judgements. In some cases, farmers chose the varieties also for further testing on their own farms or in a set of jointly planned trials.

In cases were farmers evaluated a smaller set of very diverse varieties in their own fields (cases 4 and 15), breeders usually evaluated every variety tested in detail, in individual discussions with farmers who grew the experiments and/or members of their families. Beyond open-ended interviews, breeders also used standard PRA tools such as matrix ranking or pairwise ranking to bring about in-depth discussions with individuals or groups on varietal issues. Some modifications to these tools and to methods for analysis for this type of data were reported (cases 5 and 22). All these evaluations of field trials can only be conducted during, and particularly towards the end of, the cropping season, when farmers' time is scarce. Poor farmers especially have very little time to spare during this part of the year. Thus, a simulation-type tool was developed, using a large and diverse set of dried panicles of pearl millet (case 25), which could be used for discussions about varietal traits, preferences, and characteristics of local cultivars during the off-season when farmers and breeders' time constraints are less limiting.

An output of these farmer selections and evaluations is that the breeder gains confidence in farmer capacity for evaluation. By observing farmer selection, the "scientist as learner" is a primary product of PPB.

Comparisons of PPB with classic approaches. Many studies included comparisons of farmers' and breeders' skills, concepts, knowledge, and the effects of their interventions on individual aspects of a breeding program's strategy (see above sections). Only a few cases examined the direct comparisons of approaches (i.e., the outcomes of a selection program with and without farmers' participation).

The two well-documented cases were both done with beans. One study (case 10) was designed to compare the effect of farmers' selection in segregating generations on their farms from F_2 to F_6, with breeders selecting in the same crosses, using the same methods for generation advance, and the same selection intensities. Experimental varieties from both procedures were evaluated across all sites (farmers' fields and research stations) and visually evaluated by all participating farmers. The results showed that farmers' and breeders' selection had the same yields across locations, but breeders' selection showed a higher yield potential on the research station. Farmers' selections were more marketable than breeders' selections. Overall, farmers selected half of the farmer-preferred varieties. These results indicate that breeders could well envisage devolving responsibility for selection in early generations to farmers if the effects of farmers' selection decisions are understood. Breeders could thus focus their efforts on selecting for specific traits that farmers may not be able to address effectively under their home conditions.

In the bean case in Rwanda (case 24), the program evaluated yields on-farm of varieties selected by both farmers and breeders from selections of on-station trials. Over the course of the project, the expert bean farmers identified 21 varieties, all of which significantly outyielded breeders' selections from the same trials in the conditions for which farmers selected them. In this case, it was clear that breeders had assembled appropriate germplasm, which provided a basis for making beneficial selection decisions. Farmers, however, had more knowledge and expertise in identifying varieties with the right trait combinations to match the needs of specific growing conditions.

These types of studies are costly, as they practically double the amount of breeding material that needs to be processed at a given time. They are also long-term in nature as they may entail several seasons of selection followed by trials designed to compare the output of the two procedures. Many of the cases examined were, however, conducted in situations where it was rather clear that the previously used classic approach was not yielding results beneficial for farmers. Thus, in these cases, breeders were more inclined to focus their effort and resources on developing and optimizing the promising new approach based on farmer participation.

Identification of improved varieties

Because most of the cases studied were primarily addressing production-related goals (see section on Goals of Formal-Led PPB), many projects (50%) reported results relating the identification of farmer-preferred improved varieties. In many of these cases this represents a breakthrough in itself, because many projects were conducted in environments where no improved varieties were previously available to farmers. Some examples are described in detail below.

Through farmers' involvement in the selection in segregating generations, a rice (*Oryza sativa*) variety was bred that combined the high level of chilling tolerance of landrace rice varieties of the mountains in Nepal with increased productivity from modern varieties (case 4a). So, for the first time, the farmers in these hilly regions could benefit from a plant breeding effort targeting their region (Sthapit et al. 1995a, 1996). Initial adoption of this variety was very high, and more interestingly, farmers were encouraged by the success of their own selection to continue further selection in this and other materials. They were thus carrying the process further, even with reduced support from researchers (B Sthapit, personal communication, 1998).

Bean (*Phaseolus vulgaris* L.) breeding in Brazil, was successful through the involvement of farmers to breed a variety that combined disease resistance (*Macrophomina*, and *Fusarium* wilt) with the preferred seed coat color, drought adaptation, and yield characteristics for the dry zone of northeastern Brazil. Farmers were involved in selection in segregating materials on-station, and later in testing experimental varieties on their own farms. Before the variety could be formally recommended for cultivation in this region, farmers were growing it and demanding more seed (Zimmermann 1996).

Rainfed rice in India is a crop that has seen little improvement in productivity compared with the big advances made in irrigated conditions in the same country. Through devolving the testing of experimental varieties to farmers (case 6), new rice varieties adapted to rainfed conditions were identified that outyielded the traditional cultivars very clearly. The selected materials all had acceptable quality characteristics. The range of yield superiority found in these farmer-selected materials truly represented a breakthrough for the concerned farmers and breeders.

In Ecuador, smallholder farmers grow potatoes over a wide range of conditions at different altitudes. The farmers market a proportion of their produce for consumption, but also some for processing. Adoption of higher yielding, late blight resistant materials had been very low among potato growers. With a concerted effort (case 34) involving farmers, consumers, and agroindustry in the evaluation of potato clones during early and later stages of testing, resistant and higher yielding clones with good adaptation to the specific growing conditions and meeting the key marketing criteria could be identified and released.

Researchers working with maize in the hilly Bako area of Ethiopia at intermediate altitudes interviewed farmers about their needs for maize varieties with specific traits (case 40). The need for earlier maturing varieties became very clear—to meet food needs during the period of regular food scarcity before the harvest of the staple crops occurs. Researchers gave farmers two new varieties for their experimentation. Farmers introduced these varieties into intercrops and double cropping schemes. After the second year of trials, farmers were saving seed from this variety, and distributing seeds to other farmers.

Another striking example is that of work with irrigated rice and wheat in Gujarat in India (case 3). This is a high-input, intensely managed agricultural system, where modern varieties have had a major role to play in the development of these systems. Farmers are generally well educated and are market-oriented; most of their yields are sold, and credit facilities for purchasing the major inputs are widely used. For both crops, farmers selected several varieties with significantly higher yields than the predominant varieties, selecting from trials they conducted with newly released varieties from different regions in India. The participating farmers in this case could, even in the first year, manage more complex trials then farmers in another area of the same state (case 2). Farmers recorded many of their own observations without regular visits by scientists. Information about the trials spread very fast beyond the participating farmers and their villages, so that the demand for seed developed very rapidly.

These examples clearly indicate that farmers', and other stakeholders', participation is very powerful in identifying new varieties in specific farming conditions, even those where previously no improved varieties were available. The case of rice and wheat in Gujarat indicates that even in farming systems that have benefited the most from formal programs, farmer participation in variety testing is extremely powerful, while also being relatively easy to organize. The key to the successful cases was the researcher's understanding of the key problems prevailing in the target zone, and the testing of a sufficiently large range of experimental varieties. It is notable that one of the most commonly used descriptions for the success of a program of variety identification was the early adoption of one of these varieties by the participating farmers, and not just the superior performance of this variety in a set of trials.

Increased adoption of varieties

As a direct consequence of successes in identifying superior variety with farmers, many projects started observing and recording information on adoption of these varieties, beyond the immediate participants in the breeding program. In four cases (2, 3, 4a, and 24) where the breeding project had established linkages to development projects or organizations, steps were taken to enhance adoption well beyond the initial participants in the variety evaluation trials, their relatives and neighbors.

A well-documented example for this is case 2. Here, farmers in a remote area of India, where soils are highly degraded and production is subsistence-oriented, could identify varieties of several major crops that provided them with new options, more food, and greater stability of production (Witcombe and Joshi 1996, Witcombe et al. 1996). The documentation of adoption of the rice variety Kalinga III is a good example of the spread of a variety identified through farmers' participation in variety testing. Adoption of this variety began in the study villages the year following the first trials conducted by farmers. Seed of the preferred variety started spreading to other villages in the second year following farmers' trials. While the project assisted the spread of the seed in several ways, much of the spread resulted from farmers' own initiatives in selling and giving away seeds to others, inside and outside the village. The spread of this variety is continuing, while official release in the state of Rajasthan, where the project is located, is still pending, and thus government subsidies for the production and distribution of seed of this variety are not available to farmers. A study of the impact of this single rice variety, identified through farmer participation, estimates rates of return for the overall project between 47% and 70%. This figure is as high or higher than for regular successful, nonparticipatory agricultural research. This thus indicates that participatory research, with a comparatively local focus and thus a smaller target region, can have similar rates of return. In this case, returns were mainly because this variety provided farmers with great yield benefits and more stability of production. It is precisely the advantage of participatory variety testing that these attributes of varieties can be rapidly identified, because varieties are being tested under a wide range of conditions that farmers are managing themselves.

Other examples report initial adoption by participating farmers, and others in the villages nearby, indicating similar types or potential of success. Much of the success in terms of adoption hinges on issues related to seed availability. These issues will be explored in more detail in a subsequent section on seed production systems.

Benefits for women and poor farmers

Breeders have often worked under the assumption that benefits of new varieties are scale and user neutral, that poor and rich farmers, or men and women can achieve the same type of benefit from new varieties. Many of the case studies reported gender-related differences in preferences and potential benefits, as well as differences among social, wealth, or ethnic classes. The classic approach to breeding—of variety release and then extension—has often been unable to offer effective solutions to meet these specific and diverse needs.

Participatory approaches are often designed to involve a wide range of farmers, representing different social, gender, or otherwise differentiated groups as partners in their program. They potentially have the built-in capacity to respond to specific groups' needs, and to make use of different user talents. Women, particularly, are often plant breeders in small-scale farmer production systems, responsible for domesticating wild species, selecting germplasm, and saving seed.

In many instances, women's criteria may be so significantly different from men's that dual involvement in breeding/selection is necessary to meet each partner's needs. In Mali (case 19), maize evaluations showed men placing production and early maturity as the main criteria, with women focusing on organoleptic and processing aspects (Kamara et al. 1996). Rice work in West Africa had a similar gender division (case 5), with WARDA scientists reporting that men focused on yield and yield-related traits such as plant vigor, while women concentrated on quality attributes such as bold grains and cooking quality. In these cases, both women and men need to be involved in the evaluation and selection process so that a new variety meets both the needs for good adaptation and yield characters, combined with appropriate quality traits. In other cases, women's selection contrasted directly with men's selections. In case 25, women were much more often selecting varieties with early maturity, with higher grain yield, and grain yield stability. Men, however, put relatively more emphasis on stover yield, higher grain yield potential, which in this case associated with more instability of production. The breeding program decided to put more emphasis on the needs of women, as they also were the needs of poor farmers. The needs of the men farmers are being partly met by the classic breeding programs, and the formal seed sector. In several of the cases it was noted that women put more emphasis on earliness, and more often stressed varietal needs that were related to improving food security throughout the year.

Women's involvement in PPB can confer benefits for the whole community, not just for poor women. Over a 3-year period, Rwandan experts selected a pool of varieties (21 separate bean types) that beat breeders' choices in their own production terms by up to 33%—and met quality characteristics of interest to diverse community groups (case 24). In case 25, a group of poor, low caste women identified a highly preferred variety in 2 years of testing in their own marginal fields, that proved to be of great interest and benefit to most other farmers in the village.

Not involving women or poor users may also bring negative, not just neutral consequences. In the Gambia, men's production systems involved almost 100% adoption of high yielding varieties of rice, while female production systems remained based on the use of *Oryza glaberrima*, a rice species indigenous to West Africa (case 5). This wholesale adoption by men marginalized women's products and transferred other rice lands into the hands of men—who received all the benefits from commercial sale (Hecht 1998).

Increases in varietal diversity in farmers' fields

In a number of cases, PPB has also promoted the formal release of greater numbers of varieties as breeders seek to make more choices available to farmers (cases 11, 24, and 25). Varieties may also be more diverse, and suited to varying local markets.

Many of the examined cases of PPB involve farmers in the testing of a larger number of varieties than is traditionally done during the adaptive or extension phase of formal research. It is commonly observed that farmers select a wide range of highly diverse materials, to address the variability in ecological and economical conditions they encounter. Women farmers often select more explicitly on grain quality characteristics, and often make different choices than do men farmers. It is usually the outcome of PPB programs that different farmers in different communities select different varieties, and thus PPB in most cases has made a contribution to increased varietal diversity.

A very clear example is the IRD program initiated in Nepal with the explicit objective of increasing the varietal diversity of rice varieties suitable for early planting under irrigated conditions (*chaite* rice). Potentially useful rice varieties, identified by researchers, were distributed to about 1800 households in the target area for this project. Farmers were given some written information about the variety they received, and were encouraged to compare this variety with their own variety in their own fields. Researchers did not participate in these evaluations, but returned 2 years later to a sample of the recipient farmers to assess the effect of the approach to variety testing with farmers.

The follow-up revealed that about 35% of farmers who had received a seed packet had adopted one to four of the six varieties distributed for testing. In this area, only one cultivar was dominating cultivation prior to the participatory work. Most of the farmers who decided to adopt one of the new varieties belonged to the group of farmers who produce regularly sufficient or surplus food for their families. Only 15% of the adopters belonged to the food deficit group. Interestingly, the preferences for specific cultivars seemed to differ between farmers belonging to these different groups, indicating that key varietal characteristics are important to them. A conclusion of this report is that no single variety could meet all these needs. The IRD approach proved to be a powerful tool for offering a wide range of diversity to a wide range of different farmers.

Similarly impressive PPB results relating to enhanced varietal diversity occurred in two major cassava-growing regions of Colombia: a seasonally dry ecosystem in the north (an area with poor soils and 800-1000 mm rainfall annually, bimodally distributed) and more recently the highlands of southwest Colombia (case 11). Researchers from CIAT and CORPOICA initiated a participatory crop improvement effort in 1996 to learn more about farmer criteria for choosing cassava varieties for consumption, marketing, and processing. They also aimed to evaluate traits within a genetic base that had not been preselected, hopefully to generate both more acceptable varieties, as well as varieties that were more “biodiverse”. An average of 28 communities per year was involved in the clonal evaluation effort in northern Colombia, with community participation organized via chip-drying cooperatives.

Researchers realized early on that effective varietal comparisons could be made only if the planting material for local varieties and new breeders’ clones were produced under similar conditions, to avoid bias due simply to the health and vigor of the planting material. They addressed this concern by producing all planting material in a common location under conditions approximating those of the farmers. It also became clear that farmers and researchers often used different terms for variety evaluation; a glossary of farmer evaluation terms was compiled.

Farmer evaluations of advanced clones from cassava breeding programs resulted in release of three new varieties in northern Colombia (a significant addition to the two varieties in use). Through this process, researchers acquired a better understanding of farmers’ selection criteria, and were able to quantify certain of them in ways that would facilitate researchers' selections. (For example, farmers' preference for "hard" roots corresponded to roots that were over 35% dry matter.) A unique aspect of this work is that researchers developed a cost-comparison between their farmer-participatory approach and traditional variety evaluation, indicating that data points from farmer-participatory trials cost about US$0.50 while those from typical researcher-managed advanced yield trials cost about US$0.80.

For the examples described above, the local variability among the traditional cultivars was comparatively low at the beginning of the program. An objective of these projects was to increase varietal diversity, to guard farmers against the risks of crop failures caused by this genetic vulnerability. Many PPB case studies, however, are conducted in regions where the local variability among and within the traditional varieties grown is very high. They are often placed in primary or secondary centers of diversity for the crop(s) under study (cases 5, 6, 8, 10, 12, 17, 22, 24, 25, 29, 31, 34, 39, 42, 43, 44, 47, and 48). In these cases, the issue of varietal diversity in farmers' fields may potentially be a different one—how to maintain this level of high diversity while achieving gains in productivity in farmers' fields through breeding and variety adoption. From the experiences described in the sections on selection criteria, variety identification, and adoption it seems that farmer participation in the process of variety development will greatly increase the chances for identifying a more diverse set of acceptable new varieties, compared to those chances for a centralized classic breeding program. However, none of the described cases has gone far enough to provide answers to this question. Several projects (cases 25, 42, 47, and 48) are well along in examining the specific characteristics of some key areas of high crop diversity. Examples are the local seed systems, farmers' crop management strategies and the agroecological diversity as a basis for designing breeding programs that could combine the dual goals of productivity increases and crop diversity conservation (*in situ*) or possibly enhancement through farmers' participation in the breeding process.

Changes in variety release procedure and the seed production system

Variety release procedures are usually enforced by centralized organizations for a country as a whole. Needs of specific regions, especially in marginal areas, and needs of specific consumers or users are not easily considered in such centralized procedures. Participatory plant breeding tends to reveal such differentiated needs, as well as needs for diversity. Consequently, recommendations for how to change the existing release procedures are often a direct result of working more closely with farmers. Participatory research also contributes to making farmers more aware about these procedures and can spur ways for farmers to initiate policy changes.

A PPB program in India is working to encourage formal committees to give greater official weight to farmer evaluations. The program argues that data synthesized from farmer varietal evaluations (i.e., qualitative assessments) should be used as a base for varietal release decisions. In many cases, such data may be more predictive of future adoption than the standard yield measurements that form the core of most release decisions (J Witcombe, personal communication, 1998).

Work with potatoes in eastern Africa (case 26) further demonstrates how standard, but rigid procedures can become more flexible. A thorough survey and enhanced interaction between farmers, breeders, and social scientists led to changes in the selection and release procedures for potato varieties in Rwanda. The main difference was that testing of varieties for release was done under no external input conditions. The program resulted in the release of several new varieties during the first 5 years, a very short time. Farmers readily accepted these varieties, and two varieties could be found countrywide 5 years later (Haugerud and Collinson 1990).

Often PPB goes hand in hand with recommendations to develop or build on local, more decentralized seed systems, which can provide location-specific varieties that farmers themselves effectively multiply and distribute. For instance, prior to the civil strife in the early 1990s, both Rwanda and Burundi Ministries of Agriculture and Rural Development tabled plans for decentralizing seed services—partly to accommodate more decentralized breeding. Also PPB programs are increasingly incorporating integrated and innovative seed production components to rapidly deliver the positive impacts that PPB can achieve. Good examples of this type of integration come from the PPB and seed work with cassava in Colombia (case 11) and with potato in Bolivia, Peru, and Ecuador through a set of collaborations between the national seed projects and CIP (cases 17, 31, and 34). A more detailed discussion on seed systems issues is part of the Transfer of Benefits section, later in the text.

Changes in institutional organization

Organizational innovation often proves central to the kinds of impacts PPB programs strive to achieve. Decentralization of screening can link testing to truly local conditions, and give a leap forward to the seed multiplication and diffusion process. Several PPB programs have considered organizational innovation to be at the core of their work.

An example is the barley breeding research of ICARDA, in collaboration with national programs in Syria and northern Africa (case 8). This work has shown that decentralization of the breeding program is essential for achieving genetic gains under growing conditions that are common in farmers' fields (i.e., low external inputs and high frequency of drought stress and frost during the flowering and seed set stages of crop development). The program has achieved initial forms of decentralization by developing new research stations that are located in the target region of the specific breeding programs (Ceccarelli et al. 1996). At present, it is experimenting with further decentralization through testing breeding material in the initial stages of the selection program in farmers' fields. In this case, a few farmers chosen for their interest in barley improvement and their willingness to accommodate a relatively large researcher-designed and researcher-managed experiment in their fields are the key partners in the research. Initial results of this work indicate that this further decentralization is highly effective, and the breeding program is further benefiting from farmers' involvement in the selection process.

The issue of decentralization (and its mirror, scaling up) was the direct subject of investigations in the Great Lakes' Region in both Rwanda and the Democratic Republic of the Congo (DRC). Several options for decentralization were "tested": through the extension service, through self-designated farmer research groups, and through farmers' cooperatives and women's groups. Several seasons of testing showed the most effective channel for both feedback to research and feed forward to farming communities to be the women's groups and the cooperatives (which, in this case, were female). In the Rwandan instance, the women's group (supported by an NGO, COOPIBU) had multiplied and distributed 1 ton of bean seed before the other organizations had made the final decision on which varieties to multiply. The DRC cooperative, "Women for the Development of Burhale," chose to multiply and market their selections, packaged in small packets of 50 to 100 g, to their 5,000-strong membership and sold all the material multiplied in a matter of weeks. However, using such groups results in sporadic rather than a more universal coverage.

The WARDA is also pursuing the issue of decentralization, and on an impressive scale. With its NARS partners in 17 West African countries, WARDA has initiated PPB programs with a focus on experimental varieties (and in some cases also released varieties) relatively late in the selection process. The 17-country group is evaluating the effectiveness of testing varieties with farmers' participation, with partners such as extension services, NGOs, development agencies, and cooperatives.

Empowerment of farmers

Farmers in many countries are hardly aware of the role of the public agricultural research sector and the benefits it could produce for them. Although farmers are generally perceived to be the key clients of these research systems, farmers usually have little influence on the goals, priorities, activities, and thus outputs of these systems, or their specific components. As participatory breeding efforts led by formal sector programs are actively interacting with farmers in their mandate regions and are placing trials and evaluations under the management of farmers, these programs are by default spreading some knowledge and awareness about the formal agricultural research sector among the participating farmers. Also, most formal-led PPB cases seek farmer input to guide their selection program, through identifying farmers' needs, preferences, and selection criteria. They are thus seeking to better meet clients' needs. However, formal breeders primarily expect to receive information from farmers. How breeders use this information is beyond the farmers' control.

Although the issue of control and decision-making power might appear to be primarily of political significance, results from some of the older PPB cases indicate that scaling up of the technical process of farmer participation in a breeding program is intricately linked to empowerment.

Most of the cases examined are primarily concerned with finding solutions to the technical process of identifying superior varieties. Many of the cases are also well advanced towards being successful in this way, as documented above. They are, or will be, thus facing the question of how to generate benefits from these advances for a larger section of their mandate farmers, usually without the chance of increasing the size or budget of their programs.

Case 24 uses an approach that has been well documented. To interact and reach more bean farmers spread over a wider range of agroecological conditions, the project experimented with different approaches to working with single expert farmers who were elected by a community, cooperative, or specific farmers' group. These elected bean experts selected varieties from the research station for local testing. It was their responsibility to organize the testing of these selected varieties in their communities, cooperatives, or groups. They were also responsible for initiating efforts for seed production, so that the members of their groups or constituencies could rapidly access potential benefits from this activity. These groups and communities thus had the responsibility and opportunity to shape the plant breeding process to meet their own needs during these stages of the breeding cycle. Through this sharing of responsibilities in the breeding cycle, the bean breeding program in Rwanda could thus interact with more than 20,000 farmers, while freeing up precious breeding resources that would have been spent on multi-location evaluations and seed production.

Similarly, a cassava project in NE Brazil (case 27) worked with farmer research committees or CIALs, elected by farmers from a village or groups of villages. The farmer research committees interacted with the breeders and decided about scale and conditions for testing of new cassava clones. Through this democratic process many farmers could participate and benefit from this research program.

The cassava project in Colombia (case 11) worked with organized communities in much the same way. As an additional step to involve more farmers and base the selection of new experimental clones in early generations on testing in a broad range of conditions, the program worked with new communities every year. Every community could thereafter utilize the materials they had worked with for their own benefits. They had contacts to the research institution, which could provide further advice and assistance as required.

These projects thus planned their PPB work beyond the purely technical phase of variety development, using types of participation that empower farmers and their social and political organizations. These examples of PPB make it clear that PPB research has the potential to benefit from and contribute to rural development processes relatively generally. Building new and innovative partnerships is key to generating benefits for farmers from research.

Transfer of Benefits

Knowledge and skills

It is not uncommon for breeders to find that new varieties, although they have been released and provide benefits to farmers as shown by the results of participatory variety testing, are not available through the common channels of seed supply. In countries with a highly centralized and hierarchical system of technology transfer and extension, only highly limited recommendations are made for crop production in any particular agroecological area or zone. Farmers thus do not easily get access to newly released official varieties and other new crop production practices that are not among the recommendations. In cases 3 and 4b, this issue was addressed directly by testing a concept of exposing many farmers to a wide range of technology options. This approach does not rely on official recommendations, but rather on farmers getting exposed to, and thus developing a demand for, specific products on their own, without the expectations that a development project will have to provide for all their input needs. Increasing farmers' knowledge about the options available can help to transfer benefits of the particular varieties/technologies of which they have become aware, but also may increase farmers' awareness of and ability to make demands on the research and extension systems.

Among the formal-led PPB projects, only isolated cases have focused on enhancing farmers' skills and knowledge about specific breeding, varietal, or seed production issues. However, among the cases described in the companion paper on farmer-led PPB, this issue is elaborated and described further.

Interface with seed systems

A motivation for pursuing farmers' participation in plant breeding is that the variety development process is placed on-farm, directly with farmers, and at least partly under their control. Breeders perceive that therefore no lag exists between learning about a new variety and initial adoption of the identified genotype. This is true for the farmers who directly participate in the breeding project, but for other farmers in the same village or other villages this may not be true.

Seed system support is usually not explicitly planned within PPB projects, with some notable exceptions (cases 1, 11, 24, and 31). This is rather surprising, as the pay-off to the joint breeding, just as with classical breeding work, hinges greatly on getting seed materials to those who will plant them.

Among the cases studied, there is some evidence that farmer-to-farmer, local exchange of germplasm actually works as an efficient diffusion mechanism—that varieties are spreading fast, and reaching farmers far beyond the initial participants (e.g., case 2). However, generally the case is that the breeders who initiate PPB projects have a limited understanding of how the local seed system works, what rules apply, and what channels and barriers exist for flow of information and germplasm (case 4a).

Breeders more often seek integration of participatory breeding efforts into the formal, national systems for variety release, seed production, and seed dissemination. Breeders working within formal sector institutions are necessarily familiar with the relevant national rules and regulations for varieties and seeds, and thus foresee more clearly the opportunities or problems for achieving meaningful integration of the participatory breeding effort into these systems of rules and regulations.

Each seed system (formal, farmer, or something in between) has different strengths and weaknesses, and a PPB program should actively understand the opportunities and limitations in each, rather than just slide into one strategy or another. Choice of seed system should be guided by such questions as:

- What number of varieties will be diffused?
- On what scale is diffusion desired and to which target groups?
- Are the property rights associated with each seed system acceptable to partners?
- Is the final PPB material homogeneous or heterogeneous?

Integrating participatory breeding efforts into the local seed system. The local seed system fulfills a range of functions. It provides information flows about seed, seed availability, and new types of seeds and varieties. It governs the actual flow of seed and affects farmers' seed security and use of external sources of seed. In many regions with marginal conditions for crop production, regions with a very high seasonal or ecosystem diversity, and for relatively minor crops, the local seed system is the only system that provides seed to farmers, especially to poor farmers.

There are basic assumptions among breeders about the functioning of local seed systems: that most farmers produce their own seed, that they do exchange seeds, and that farmers who have seeds of better varieties will share them in some form with others. There is rarely a detailed understanding of what rules and responsibilities govern these processes in local communities, how effective different parts of the local seed system are, and what the background of the existing rules and patterns could be.

The local seed system is often regarded as the key supplier of new varieties that were identified through a participatory project. Only a few of the described participatory breeding projects have reached the stage where the seed supply beyond the actual participants is a main issue. In case 2, the project staff initially supplied large quantities of rice and chickpea seed to farmers from the project area. The project is moving increasingly away from this supply role, and is instead revitalizing a traditional system of knowledge supply among the Bhil tribe, the main ethnic group with which the project is working. Wise men (*jankars*) specializing in particular areas such as seeds, water harvesting, or forestry acquire new relevant knowledge in their area of specialization through the project activities. They provide farmers with expert knowledge about specific new varieties, where seeds are available, and how to procure them, for example. Farmers pay them for these services. Local grain dealers are picking up seed sales of some of the most preferred and widespread varieties. Preliminary documentation of the spread of one rice variety shows that the system is working very effectively, after overcoming initial bottlenecks.

Case 4a is another example of where the seed system has been examined in the context of spreading seed beyond the participating farmers. Here, farmers quickly identified a new rice variety with beneficial traits for a specific production system. When studying the spread of this highly desirable new variety it became clear that the variety is moving mostly along family lines, within a specific family and later on also within the caste of these families. Seed movement across these community (caste) boundaries appeared very slow, and researchers expected that a special effort would be required to make the seeds accessible to other communities within the same villages, and of course other villages in this production system.

In case 25, similar limitations to seed movement have been identified in western Rajasthan in India. A collaborating NGO is intending to function as an intermediary to overcome this type of bottleneck to seed movement within a target region. However, a suitable variety and source of seed still need to be identified before this can be put to test.

In another region of Rajasthan (case 25), modern varieties are readily available through the formal seed sector and thus the functions of the local seed system are much reduced, at least for the crop under study. Farmers had identified a new variety in participatory variety evaluations that was highly desirable, but unavailable through seed supply system in the public sector. On realizing that the breeder with whom they were working was not in a position to continue to supply large quantities of seed of this variety, farmers from two villages each formed a village-level association for coordinating seed production and distribution within the village.

For beans in Rwanda (case 24), a local women's group, supported by an NGO, identified a promising variety, multiplied several tons of seed, and distributed it around the community before government officials even made a decision on its acceptability. However, in a companion study (Sperling et al. 1993) the local exchange channels that farmers normally use were shown to have their own biases: the poorer sectors most in need of seed were the most often excluded from "exchange" circles. Further, the speed of exchanges was just too slow for those who are chronically, rather than sporadically, "seed deficient".

As beneficial (or biased?) as some of these ad hoc seed arrangements have shown themselves to be, support for and interaction with local seed systems needs to be built in more systematically to a large range of PPB programs.

Broadly speaking, knowledge about the local seed system includes understanding farmers' concepts of selection, breeding, and maintenance of specific varieties; knowledge and concepts about varieties of different crops; and seed production, seed availability for specific groups of farmers, and seed exchange. If a project intends to involve farmers in the testing and selection process for variety development and identification, obviously understanding farmers' concepts of the underlying processes and who has what role and responsibility at the local level would make the design of such a program more efficient and better targeted. It would truly build upon the perceived strengths of local farmers, and would be placed within their own concepts of seed management and varietal improvement. Projects that have taken these factors seriously during the course of their research strongly recommend that this type of understanding is essential for developing sound PPB projects (cases 25 and 42).

Presently, some of the projects spend considerable effort and time in developing a detailed understanding and analysis of farmers' concepts with regard to genetic changes, seed management, and use of different genetic materials. This is often done in the context of understanding issues related to on-farm conservation of crop diversity (cases 42, 47, and 48). But, in some cases it is geared more specifically towards developing opportunities for effective participation of farmers in plant breeding projects (cases 25, 42, and new ICRISAT research with sorghum in West Africa).

Integration into the formal seed system. Formal seed systems have developed as a result of proliferating successes of plant breeding efforts. These usually are designed to achieve some form of quality control for farmers and a basis for quantifying royalties that might be due to the breeder of a specific variety in countries where the private sector is actively involved in the seed system. The formal seed system has two main components beyond the formal plant breeding activities: (1) variety release regulation, and (2) seed production and quality control (Tripp 1997). Most countries have rules and regulations that govern the testing of experimental varieties before any decisions on releases are made. Usually, seed of a new variety can only be produced under the rules of the formal sector and distributed through the formal channels after it has been released. The formal sector can be highly effective in providing large quantities of seed on a large scale, if a new variety meets all the criteria of the system and is being demanded by farmers. In some countries, public sector seed production is highly subsidized and thus may provide seed at lower costs to farmers.

Participatory breeding efforts are usually highly effective in generating a demand for specific new varieties, particularly projects that focus on identifying suitable new varieties as the main activity. If the varieties thus identified are already released for the project area, it is a matter of passing on the information about this developing demand and alerting the seed production agencies. If formal seed distribution channels beyond the open market exist in the respective country (i.e., farm cooperatives) these may also be involved. An example where this is working is with irrigated rice in Gujarat, India (case 3).

If the varieties bred and/or tested by farmers are not released, their integration into the formal seed system needs to occur through variety testing and release. The exception being if the country has a provision for allowing the production and distribution of uncertified seeds on a large scale (e.g., truthfully labeled seed in India). To achieve the release of a variety, it has to pass through a series of standard trials designed for this purpose. Breeders as part of the formal seed system usually have access to these trials, and know how to enter new varieties into this testing scheme. Thus also varieties bred with the participation of farmers could follow this route, as has been done in India and Nepal (cases 2 and 4). This approach to making such new varieties more widely available is likely to be successful if the varieties under question have already been released in another state or country with similar growing conditions, or where the national variety testing scheme represents the growing conditions on-farm for the crop under question (i.e., cases 2 or 4).

However, many participatory breeding projects work under environmental conditions that are marginal in some way or in regions where adoption of new varieties is very poor—thus in areas that are not well-served by the existing system for variety release and seed production. Under these conditions, integration into the formal system will require changes in the system that allow the newly farmer-bred or farmer-tested varieties to be successful. While such changes are highly desirable and necessary, they may come about too slowly for the active projects, which will need to find ways to integrate into the local seed sector until more integration with the formal sector becomes feasible. A detailed analysis of different options for regulations and their effects is provided by Witcombe et al. (1998) and by Tripp (1997). Other interesting examples are cases 11, 17, and 31 with clonally propagated crops in Latin America.

Intellectual property rights, ownership issues, and PPB

As in many other fields, the property right and ethical issues surrounding PPB are lagging far behind the 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.

The urgency to define property rights issues for PPB arises at an opportune time. The farmers’ rights debate seems stalled in many quarters on political, legal, and practical levels. Further, plant breeders’ rights legislation makes varied assumptions about how much formal breeders control the process (to the exclusion of farmers)—assumptions that have rarely been subjected to close scrutiny. Exploration of property rights and related issues within the field of PPB offers the possibility of giving a second mirror to these other realms. Participatory plant breeding 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, plant breeders’ contributions are given well-defined geographical and historical specificity. Participatory plant breeding has many variations, ranging from superficial consultation about farmer preferences to farmers being actually 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 of farmers’ and plant breeders’ rights.

Joint collaboration should mean joint benefit sharing. At this point, no ready-made arrangements or "best practices" can be suggested for the processes and materials that emerge from PPB collaborations. The SWP/PRGA has recently started work to address property rights issues by identifying a range of typical PPB collaborations (8 to 10 type cases) and examining:

- Existing legal frameworks that might constrain or stimulate them,
- Associated ethical concerns, and
- Suggesting "best practice" actions emerging from a widespread and public debate with practitioners.

Most of the formal-led PPB work to date has simply skirted the property rights issues with two very diverse strategies:

1) Materials jointly developed by formal breeders and farming communities have been fed into the formal variety release and seed multiplication system (completely not recognizing farmers' input), or
2) The PPB-developed materials have been "released" or "let go" into farming communities with no official launch of any kind.

This has had positive impact among farmers mostly with self-pollinated crops, where seed increase and quality issues are relatively easy for farmers to manage at their own acceptable levels. An innovative approach used by the maize program of EMBRAPA, Brazil (case 38) has been to officially announce a variety shaped within a PPB program as the product of joint, participatory work. This notation has appeared on the release announcement and promotion flyer of "Sol Da Manha NF (Nitroflint)". In a similar vein, in the DFID/NARC program at Lumle, case 4a the farmers who played a key role in the development of M-3 were joint authors with the breeders and the release proposal.

Breeders involved in PPB rarely have an understanding of ownership issues relating to varieties, seed stocks, and knowledge about them within which communities they work. For other commodities (e.g., land), very different ownership and inheritance systems are known in different cultures. It is plausible to expect that different cultures have also developed different practices, concepts, and mechanisms with respect to variety and seed issues, because these are a key commodity for farming. Meaningful discussions about benefit sharing and property rights would require a mutual understanding of the different partners' concepts. Practitioners of PPB are well placed to develop a better understanding of specific local systems of rights, ownership, and benefits arising from, or associated with, varietal knowledge and seed production skills.

5. Gaps and Further Work

A primary objective of ours in reviewing PPB cases has been to identify gaps in our understanding that must be addressed by future PPB research. In this section we summarize the most compelling gaps or research needs. The list is not exhaustive and is not meant to be, but is intended to reflect those areas where additional research-based information can make the greatest contribution to furthering our understanding of PPB and enhancing the effectiveness of PPB programs.

Goal-Setting in PPB

A most egregious gap—and of overriding importance—has been in the lack of attention to explicit goal-setting in PPB programs. As elaborated previously, PPB programs can potentially have a diversity of overarching goals (e.g., production increase, biodiversity enhancement, providing benefits for specific types of users, etc.). Not all these goals are mutually compatible and there are often trade-offs in giving primacy to any one option. Further, in analyzing PPB programs, the authors became aware how much the goals for which the work aims (whether implicitly or explicitly set) shape the entire research design. Up to date, most of the PPB programs do not have a transparent goal-setting process and implicitly focus on various aspects of productivity (i.e., the same goals towards which classical breeding programs strive). In a PPB program, all partners should be involved in the goal-setting stage, which implies that those involved, especially farming communities, have to be aware of what the potential options, and trade-offs, may imply for future benefits—and costs.

Breeding Methodology and Other Technical Issues

Numerous technical issues emerge as gaps in our understanding of PPB and the discipline would clearly benefit from rigorous study in a number of these areas. These ideas are roughly organized from the general to the more narrow and specific.

None of the cases examined dealt with crops grown using fully mechanized production, with vegetables, or with minor crops not being addressed in formal breeding programs. (The latter is unsurprising, given that this review was charged with examining PPB from the formal breeding perspective and there is unlikely to be a formal breeding perspective with regard to crops that are not part of the formal breeding system. Nonetheless, we note this gap in our set of cases.) Most of the cases we examined focused on staple food crops in situations where formal breeding programs had failed to develop varieties that were adopted by farmers. The absence of certain crops or cropping systems from existing PPB experience, and the tendency to resort to PPB only when other approaches have failed, suggests that a significant gap exists in our understanding of the circumstances where PPB offers clear advantages over classical plant breeding. We have outlined what we believe to be the cases where direct participatory approaches in plant breeding are indispensable. However, assessment approaches are needed that will allow researchers to evaluate individual situations realistically, rather than resorting to PPB only when it has been proven necessary through the failure of a classical breeding approach. Such approaches also might provide the justification a researcher needs to encourage PPB efforts in minor crops that would otherwise not be part of that individual's responsibilities.

A surprising number of the cases examined focused on developing methodology for effective interaction with farmers, including exploration of different options for sharing responsibilities and decision making with farmers throughout the whole plant breeding process. Considerable need remains for creative development of options in this area, including details such as optimal methods for obtaining farmer input (e.g., is PVS a more effective approach to eliciting farmers' needs than surveys or PRA methods? How can evaluation input from multiple farmers in multiple environments be integrated into one breeding/ selection effort?). Also, very few models exist for enhancing farmers' skills in selection and breeding, which would contribute to more effective interactions between researchers and farmers and thus more effective PPB programs. Of course this could also enhance farmers' skills as they apply to other crops that are not part of a PPB effort, and thus could have additional benefits beyond the confines of the PPB interaction.

Farmer involvement in the variety evaluation phase of breeding programs has been relatively extensively studied. Much less effort has been devoted to developing and testing options for farmer involvement in early generation selection, when the number of genotypes to be evaluated is typically high, the genetic makeup of each genotype may be unstable, and the amount of plant material available for each genotype is limited. The argument that farmers must be exposed to novel traits before they can consider them as options suggests that farmer involvement is important in these early generations, when genetic diversity is greater and novel traits are more likely to still be present in breeding populations. Exposing farmers to early segregating generations provides an opportunity for enhancing the genetic diversity in farmers' fields, by introducing farmers to potentially novel traits and trait combinations that they might not seek out otherwise. Involving farmers at this stage also capitalizes on farmers' generally recognized skills in visually integrating multiple traits—precisely the type of selection that must be made at the early stages. The lack of models for farmers' involvement in early generation selection is a gap that deserves attention, and it is especially acute for the naturally cross-pollinated crops.

In addition to these broad areas, numerous technical issues within PPB deserve further study, including the following (hardly an exhaustive list). Enhanced genetic diversity is often assumed as one of the benefits of PPB, however, it is unclear how crop genetic diversity is realistically assessed and compared between classical and PPB programs. We are generally lacking models for incorporating farmer-generated variability as sources for PPB programs and experience with outcomes from such efforts. Creative field approaches are needed for allowing farmer participation in evaluation of crops that are tractor-sown, broadcast, or sown as seed mixtures, where screening of individual varieties is greatly complicated by the constraints of the planting methods used. No doubt many other methodological and technical issues deserve attention, but these represent a small sample of the types of details that have not been extensively examined.

Institutional Innovations

Assessment of organizational options is a large gap in current PPB work. Partnering with farmer organizations would allow greater sharing of responsibility and more rapid spread of the benefits of PPB. However, models for such partnerships are lacking and examples are very rare. More generally, choice of collaborators and their roles are primary determinants of the potential for scaling up a PPB program, the costs of the program, and the likely cost/benefit ratios for each partner. To date, there have been no rigorous cost/benefit analyses of PPB, and certainly none that attempt to separate costs and benefits for different partners in the PPB effort. The SWP PRGA Program is addressing this gap through six funded PPB programs that should be able to provide data of this sort within the next few years.

Linkages to seed sectors

Decentralized methods for seed multiplication are needed to effectively capture the benefits from locally useful varieties, but little work has been done on this topic and few models exist. In many cases, national variety release regulations, testing sites, and trial management protocols mediate against official release of varieties with location-specific adaptation and benefits. Several projects have worked out ad hoc arrangements for seed multiplication and distribution that have been highly effective. However, support for local seed systems needs to be built more systematically into a broad range of PPB programs. Models will need to provide options for crops where seed increase ratios are low and are likely to limit the potential multiplication and diffusion rate of desirable varieties. Structures for partnerships with formal seed sector entities need to be explored for cases such as these.

Linkage between research and development

A few intriguing examples among the cases examined have attempted to broaden the linkages in PPB programs beyond farmers and researchers, to include consumers, processors, and other end-users. Such involvement could strengthen the link between research and development, but few programs have attempted this. Linkages between research and development also would be enhanced by development of more effective methods for ensuring both “feed forward” and feedback of information between researchers and farmers/communities.

PPB and in situ *conservation*

Often PPB is associated automatically with *in situ* conservation of local germplasm. However, this remains an assumption at present, with little or no data documenting conservation outcomes from PPB programs.

Participation and Gender/User Differentiation

A more glaring gap in the PPB literature is the lack of information on the nature of participation in PPB programs. Most cases were written from a technical breeding perspective, and do not discuss the details of who participated, how and why particular participants were chosen, and what impacts those choices might have had on the program outcomes. Much greater documentation and observation concerning the nature of participation is needed. Not unrelated to this observation, it should be noted that interactions between breeders and social scientists are only rarely explicitly discussed in the PPB literature. This information gap leads one to wonder whether interaction is only rarely happening. Desirable interactions between breeders and social scientists may not occur for a variety of reasons, some structural and some inter-personal. Addressing this apparent gap in professional cross-disciplinary collaboration could begin to provide the social science input needed to address questions concerning the nature of participation.

Data regarding the optimal stage, degree, and roles of participation (of farmers and scientists) in a given breeding effort are lacking. At present, we are unable to link the stage/degree and roles of partners (the "quality" of participation) with the results achieved in any meaningful way. For example, we have little or no information on the changes that result from farmers' selection in genetically variable bulks vs. those resulting from farmers' selection among stable or nearly stable varieties. We do not have data to support logical choices of when in a particular breeding process to involve farmers' given trait heritabilities, ease of trait assessment, numbers of materials to be evaluated, and other similar criteria. Several projects focused on seed systems are examining in detail farmers' practices for seed selection and maintenance and their impacts on genetic diversity and genetic change. These studies will begin to fill the gap that presently exists in our understanding of the relative contributions farmer selection could make to selection gains for various traits. Nonetheless, our inability to relate the exact nature of participation to results obtained from PPB programs represents a significant gap in our understanding of how best to work with farmers and in our ability to document impact from PPB programs. Not unrelated to this significant gap in our understanding of how best to involve farmers in PPB, there are also virtually no examples that provide models for long-term farmer involvement in PPB.

Information is also scarce on numerous specific aspects user-differentiation. For example, virtually none of the documented cases have addressed the question of **who** should be involved for which specific purposes. For example, who should evaluate genetic materials to offer technical expertise? Who needs to be involved (and when) to ensure that the needs of the poor are met? Who should "participate" to guarantee equitable and efficient diffusion of seed materials? Such gaps are astonishing for work that claims to be "participatory" because all farmers are treated as a homogeneous mass.

Following on this theme, a notable gap occurs in the treatment of gender and other user-specific perspectives (ethnicity, class, age) as **analytical variables** in PPB programs. As this is the subject of a separate report in this same series, we will but mention it as a glaring omission (see Hecht 1998).

Impact Monitoring and Documentation

Although clear and dramatic impacts are documented for a few of the PPB cases studied, there is a general paucity of data regarding both overall and specific intermediate outcomes and longer-term impacts. No doubt this is partly due to the relatively recent initiation of many PPB efforts. With time, impact data should accumulate. Monitoring impacts from classical plant breeding programs has been a continual challenge, and is unlikely to be simpler in PPB programs. Focused consideration of the best approaches and methods for monitoring and documenting impacts in PPB programs is clearly needed (see Lilja et al.

[1999]). Further, the results and impacts of PPB should be directly matched against the achievements of classic programs (including an analysis of research efficiency). Evaluation programs need to embrace both western and grass-roots indicators and quantitative and qualitative measurements, and perspectives must be able to encompass the effects of PPB on farmers own systems of breeding and seed maintenance—and the implications for classical plant breeding programs.

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Appendix 1. Inventory of Cases Examined: Working Draft

Case 1: Namibia/ICRISAT pearl millet

1. *Title*
   Namibia, Maria Kaherero Pearl Millet composite
2. *Institutions*
   Mahanene Research Station, Namibia; ICRISAT
3. *Country/region(s)*
   Namibia
4. *Year project began/Dates*
   1991/1992 (ongoing)
5. *Researcher(s) involved*
   S.A. Ipinge, E.S. Monyo, G.M. Heinrich, W.R. Lechner
6. *Farmers involved*
   Maria Kaherero, who produced the initial outcrossed population
   Tunetu women's cooperative (experienced farmers and successful in processing and marketing pearl millet products)
   Neighbors to the research station
   Farmers participating in field day
7. *Crop(s)*
   Pearl millet (*Pennisetum glaucum* (L.) R.Br.)
8. *Main objectives for pursuing farmer participation*
   Understanding farmers' preferences for specific traits
   Developing new, farmer-acceptable base population for breeding
   Assisting farmers' seed production efforts
   Releasing on farmers' request
9. *Nature of participation*
   Farmer (Maria Kaherero) made first population cross between local and newly released variety
   Farmers visit to the research station, selection in a special nursery
   Farmers selected in isolation plot, actual contribution to breeding
   Breeder selected in farmers' fields
10. *Method of involving farmers and types of output anticipated*
    Maria Kaherero was a participant in seed production program; her outcross population was used as the starting point to form a new breeding population.
    Invited women's group to evaluate diverse nursery, especially for grain quality characteristics, nice group approach

Farmers (200) who were visiting the research station during a field day also made selections in the diverse nursery, and indicated preferences.

- on-station farmers scoring varieties, matrix ranking
- pairwise ranking of few varieties in comparison to Okashana 1, for individual traits

11. *Summary of breeding methods used*

Generating new population: After two seasons of farmers' selection, the farmer-selected panicles were sown in a separate field (isolated) of the farmer. In this farmers' field the breeder selected 83 panicles. Seed from these panicles was bulked and sown on the research station; selection was made again by breeders.

Morphologically diverse nursery of germplasm was sown at research station. Farmers selected entries in this and other nurseries, and listed preferred traits. The most commonly selected varieties (30) which also met breeders criteria were used to constitute new population. Four random matings were conducted under the breeders' management, using farmer-identified criteria for mild mass selection.

This population and two others were evaluated for one season for agronomic traits, based on 324 S1-progenies each; further evaluation is on-going.

12. *Summary of results/experiences/impacts and products to date*

One farmer was identified, who had selected in an outcrossed population of Okashana 1 and the local variety for three seasons.

Clear information on farmer-preferred traits gained.

The information obtained from a small group of women (12) was essentially the same as that from the larger sample of 200 farmers.

Evaluation of productivity related traits in on-station trials of farmers' population, in comparison to other populations showed that the farmers' population was overall more desirable than other populations generated on-station in the same time.

Increased diversity in new population when tested on-station, preliminary

Recommend an evaluation of the varieties that farmers grow and use every 5 years approximately.

Increased diversity in farmers' fields following release of Okashana 1

Description of local varieties, groupings achieved, information same as what germplasm evaluation wants to achieve, infomation could be collected at the time of germplasm collection from farmers.

From a demonstration of six varieties, a new variety fared better then the released variety Okashana 1; no integration of farmer participation in breeding strategy description identified.

Variety also used to postulate a farmer-preferred ideotype for pearl millet in Namibia, through matrix scoring and pairwise ranking of new varieties in comparison to Okashana 1: they want an Okashana 1 type with improved lodging and storage pest resistance.

13. *Documentation/references*

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1998. MS Swaminathan Research Foundation, Chennai, India.

14. *Contacts/addresses*

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Maria Kaherero, W. Lechner, Mahanene Agricultural Research Station, PO Box 144, Okashati, Namibia

15. *Comments*

Very dynamic, quite a lot of exploration of how to involve farmers in the breeding process; methodology for that often not fully documented, especially on sharing of responsibilities.

Case 2: KRIBHCO project, India

1. *Title*

Project KRIBHCO East

2. *Institutions*

Krishak Bharati Cooperative, Indo-British Rainfed Farming Project, Dahod, Gujarat 389 151, India; Centre for Arid Zone Studies, University of Wales, Bangor, Gwynedd LL57 2UW, U.K.

3. *Country/region(s)*

India, three adjoining districts of Madya Pradesh, Rajasthan, and Gujarat

4. *Year project began/Dates*

1992

5. *Researcher(s) involved*

A. Joshi, J.R. Witcombe

6. *Farmers involved*

6-20 farmers from seven villages in focus group discussions on crop related issues

128 farmers tested new varieties

7. *Crop(s)*

Chickpea (*Cicer arietinum*), rice, maize, blackgram

8. *Main objectives for pursuing farmer participation*

Productivity, benefits for poor farmers, adoption of modern varieties

9. *Nature of participation*

Farmers needs identified (PRA)

Farmers testing individual varieties on their farms

Farmers evaluating varieties through farm walks

10. *Method of involving farmers and types of output anticipated*

Focus group discussions with women, men, and other distinct social groups to understand key characteristics of presently grown varieties in the project area

On-farm trials with one variety per farmer, to achieve farmer evaluation of new varieties

Focus group discussions with questionnaires for variety evaluations

Individual semi-structured interviews with farmers conducting trials, for variety evaluations

Farm walks with farmers conducting trials and with other farmers from the village, for variety evaluations

11. *Summary of breeding methods used*

Testing of experimental varieties, often materials released in other states

Introductory test, seed is given to farmers

In village where varieties had been tested and selected, seed is sold

System of village "wise-men" revived to spread knowledge about the new varieties in adjoining villages in the project area, and to announce possible sources of seed

Local seed merchants supported with start-up seed stocks

12. *Summary of results/experiences/impacts and products to date*

Chickpea: three cultivars identified, initial adoption documented, very impressive

Rice: one extremely successful cultivar identified, adoption study conducted by following seed flow from farmers-to-farmer exchange, and other local channels for seed supply.

Maize (white): Two varieties for different purposes identified, participatory variety development initiated, with farmer involvement in selection at the research station. Farmers' selection criteria and preferences shaped the composition of the base population for this breeding program.

13. *Documentation/references*

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Paper from IRRI workshop (has more methodological details)

14. *Contact addresses*

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J.R. Witcombe, CAZS, University of Wales, Bangor, Gwynedd LL57 2UW, U.K.

15. *Comments*

Linkages to formal sector explored
Adoption documented
Range of crops
Served as model for other projects
Research was conducted mostly by formal sector affiliated scientists, but research was carried out in the context of an interdisciplinary participatory farming systems development project; project partners perceived this close linkage between research and development as very positive, and one of the main reasons for the success of the project.

Case 3: Rice and other crops in high yield potential areas

1. *Title*

Participatory crop improvement in high potential production systems in India and Nepal

2. *Institutions*

In Nepal: LI-BIRD (NGO)
In India: KRIBHCO/West
Joint funding: DFID Plant Sciences Program and Natural Resources Systems Program and KRIBHP/West

3. *Country/region(s)*

Nepal, Chitwan valley and Nawalparasi 200-400 m altitude
India, Guajarat. Lunawada Subdistrict

4. *Year project began/Dates*

1996

5. *Researcher(s) involved*

J.R. Witcombe, D.S. Virk, D. Harris, K.D. Joshi (Nepal), B.S. Raghuwanshi (India)

6. *Farmers involved*

Farmers from all wealth categories included
In India: 203 farmers testing wheat varieties in 1996

130 testing summer mung bean varieties
Approximately 108 farmers testing rice varieties in Nepal

7. *Crop(s)*

Chaite rice, rice, wheat, maize, sunflower, lentil, wheat, chickpea, summer mung bean, rice

8. *Main objectives for pursuing farmer participation*

To identify varieties better suitable to farmers' needs, increased yield, increased diversity

9. *Nature of participation*

Farmers test new varieties in their own fields, under their management

Farmers evaluate varieties and report results to researchers, i.e., farmers measure yield of their experimental plots, researcher measure the area of the experimental plot

10. *Method of involving farmers and types of output anticipated*

Farmers in this project maintain weekly crop calendars for each of their fields, and record any inputs, or harvests. These records are later on used by researchers to conduct cost-benefit analyses of new technologies for the different social classes.

Farm walks and focus group discussions are held as described for case 3.

IRD as in case 4b and other methods for comparison of methods

11. *Summary of breeding methods used*

Testing of experimental or released varieties for their acceptability/usefulness to farmers

12. *Summary of results/experiences/impacts and products to date*

- Twelve introduced varieties of wheat yielded significantly more than the local check[1], Lok 1 by 7% to 17%
- All the five new varieties of chickpea significantly out-yielded the check variety by 5% to 13%. Variety ICCV2 was an early maturing *Kabuli* type that fetched a higher market price.
- Five new varieties of summer mung significantly out-yielded the check by 5% to 43%. The highest yielding variety JM 721 had similar maturity to the local check. The recommended (GM 3) variety for the area had 30% lower yield than the farmers' check. It also had a high susceptibility to yellow mosaic virus.
- Preliminary results from 11 varieties of rice (*kharif* 1997) showed that several varieties were higher yielding, earlier to mature, and less prone to biotic stresses than the most common check variety GR17. Focus group discussions with farmers revealed that they would re-grow these varieties and drop GR 17 from cultivation in the next year.
- Seed of the new varieties (wheat and chickpea) was sold in project and non-project villages. Quantities of seed available limited the distribution.

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1. 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.

- It is easier to build rapport with farmers in HPS than in marginal areas. In India, within 4 weeks of entry into the project villages, hundreds of participatory trials were in place.
- Farmers in HPPS can conduct participatory trials of a more complex nature to the highest standard.
- Farmers in HPPS can derive great benefit from IRD activity. Farmers in IRD villages conduct varietal trials on their own for comparing new varieties with their cultivar.
- Farmers in HPPS are growing inferior genetic material, and the varietal replacement rates are slow.
- A wider choice of cultivars can readily be found for HPS.
- Cultivars grown elsewhere can offer a potential source of cultivars in PVS. Sometimes the recommended variety by the formal system can yield less than farmers' varieties, e.g., GM 3 variety of mung.
- With inbreeding crops, farmers save seed of preferred cultivars and replace their local varieties. In India, a number of farmers have used farmer-saved seed of preferred PVS varieties of wheat in *rabi* 1997-98.
- Once convinced about the potential of a PVS variety, farmers readily buy the seed. In India, 2 tons of seed of farmer-preferred wheat varieties in *rabi* 1996-97 were sold in *rabi* 1997-98 in the project villages and villages more than 20 km away. The demand for seed was much more than the project could easily supply.
- Farmers spread seed of preferred varieties within and outside villages through relatives and friends.

13. *Documentation/references*

Virk, D.S., D. Harris, K.D. Joshi, and J.R. Witcombe. 1998. Should participatory crop improvement be adopted for high potential production systems. Informal project report. (Unpublished data.)

14. *Contact addresses*

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15. *Comments*

New project (only one year results available)

Case 4a: Lumle ARS, Nepal, high altitude rice

1. *Title*

High altitude rice breeding in Nepal

2. *Institutions*

Initially Lumle Agricultural Research Centre (LARC), NARC, Nepal; now LI-BIRD, Support from ODA, now DFID, U.K.

3. *Country/region(s)*
   Nepal, Lumle in western hills region
4. *Year project began/Dates*
   1993-1996, continuity threatened, because of lack of funds
5. *Researcher(s) involved*
   Bhuwon R. Sthapit, K.D. Joshi, J.R. Witcombe
6. *Farmers involved*
   1993: six expert rice farmers each from two villages; 1994: six more; procedure for selecting these
   Farmers not detailed; women from the same household included in post-harvest evaluations, men more involved in pre-harvest and yield evaluations.
7. *Crop(s)*
   Rice, high altitude
8. *Main objectives for pursuing farmer participation*
   More efficient development of farmer acceptable cultivars, increased genetic diversity of rice in participating villages
9. *Nature of participation*
   Farmers select in segregating F5-bulks; they thus identify an experimental variety, test and modify it at the same time.
10. *Method of involving farmers and types of output anticipated*
    Farmers were given 20-25 g of seed of one F5 bulk. Each bulk was tested by one farmer each in two different villages. Farmers were asked to grow and manage the test entry and keep it separate in the field and the store from their other seed and grain. Farmers were trained in principles of selection and heritability of different traits. After harvest each farmer was asked to return half of the selected seed to the research station for on-station testing.
    In 1993 all participating farmers in each village evaluated all F5-bulks during a 'farm walk'.
    In 1994 and 1995, non-participating farmers also evaluated test plots in each village.
    In 1994 and 1995, farmers ranked varieties individually on a 1 (best)-7 (worst) scale, both men and women separately.
    Post-harvest evaluation by women in 1994 for varieties that farmers intended to grow the following year, fully processing and cooking them. A questionnaire was used to capture the results.
    Varietal spread was and is monitored by interviewing individual participants every year.
11. *Summary of breeding methods used*
    In 1994, the most popular bulk from the 1993 evaluations was entered into the National Cold Tolerance Nursery, researcher-managed on-station trials
    Farmers were bulking their single panicle selections every year.
12. *Summary of results/experiences/impacts and products to date*
    Superior variety identified.
    - Superior variety entered into conventional variety testing system; released?
    - Good initial adoption recorded.

Farmers tested new bulks at worst plots first.
Several different varieties were adopted.
Women selected for taste and processing qualities, thus selection was a two-stage procedure.
Strong differences among farmers observed.
Farmers became enthusiastic about participating.
In one village, where high altitude rice is the only type of rice that can be grown, one preferred variety has spread widely within the village, and is spreading rapidly to other similar villages. In another village, normal rice is also grown, thus the white seeded, cold tolerant PPB variety does not have sufficient advantages over the other varieties available in this village, and the preferred variety has only been adopted by the participating farmers.
The most popular variety (M3) proved to shatter easily, thus at present a mutation breeding program has been initiated to identify earlier maturing, less shattering genotypes out of the original variety.

13. *Documentation/references*

Sthapit, B.R., K.D. Joshi, and J.R. Witcombe. 1996. Farmer participatory crop improvement III. Participatory plant breeding, a case study for rice in Nepal. Experimental Agriculture 32:479-496.

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15. *Comments*

Well documented involvement of farmers in the selection among and within segregating materials.
Adoption is being monitored by an NGO set up by researchers, who initiated this work. They are continuing some of the participatory breeding work, and are monitoring adoption of the farmer-bred varieties.

Case 4b: Chaite rice in Nepal

1. *Title*
   Chaite rice in the western hills region of Nepal
2. *Institutions*
   NARC, Lumle Agricultural Research Centre, Nepal, now LI-BIRD
3. *Country/region(s)*
   Nepal, western hills region
4. *Year project began*
   1991
5. *Researcher(s) involved*
   K.D. Joshi, R.B. Rana, M. Subedi, K.B. Kadayat, and B.R. Sthapit
6. *Farmers involved*
   1803 farmers received seeds of a new variety for testing, through various channels distributed by extension workers and by scientists during visits and monitoring tours. "Farmers are not consciously selected while distributing the seed packets in order to avoid socio-economic bias."
7. *Crop(s)*
   Rice, spring rice, early sowing and transplanting, lower altitudes
8. *Main objectives for pursuing farmer participation*
   Genetic diversification, productivity increase (not specifically stated, but those were the criteria evaluated)
9. *Nature of participation*
   PVS with no direct monitoring by scientists. Farmers were to return a response card to the scientists. 1992 initial monitoring of 242 households who received seed. In 1995, a stratified (for the variety that they had received) sample of farmers who grew trials was surveyed.
10. *Method for involving farmers and types of output anticipated*
    The focus of the paper is on evaluating the approach of "Informal Research and Development", by which a large number of seed packets of well-selected varieties (by researchers) is being distributed to a large number of farmers. "Variety testing, selection, maintenance, and dissemination activities are all done by farmers." "The role of researchers/extensionists is to select appropriate materials, multiply, and plan for distributing them and monitor crop varieties distributed."
    Classified households as "food surplus", "food balance" and "food lasts for 3-8 months."
11. *Summary of breeding method used*
    Variety testing in pre-release stage (F7), five new varieties, one released
12. *Summary of results/experiences/impacts and products to date*
    Farmers planted and managed new varieties in the same way as their normal variety.
    Farmers observed similar characteristics of new varieties as researchers on station (only three new varieties reported).
    Taste and processing characteristics could not be monitored ("farmers could not recall").

Approximately 55% of surveyed households were willing to continue growing a selected variety, approximately 40% of surveyed households continued growing the new varieties.

Individual farmers had very different preferences for specific varieties because of different adaptation, different requirements.

Some differences in adoption observed between "food surplus farmers" and "food balance farmers"

69% of farmers were interested to test two to three varieties at a time on their farm.

Mostly farmer who had a food surplus distributed seeds to others.

Mostly the seed was distributed in the same village.

Women have an important role in spreading the seeds from one village to another.

"On different scale "LAC and LI-BIRD are conducting IRD also with wheat, maize, normal rice, sunflower, and lentil in high potential areas of Nepal (DFID support), scaled with different institutions.

LARC Lumle also still continuing with IRD on their mandate crops (?) and also with fodder trees, vegetables, small ruminants, and other livestock.

Now LI-BIRD also partner for IPGRI's in-situ project (factors that determine whether farmers maintain a cultivar or not, find ways to assist the continued selection of local cultivars.

Using Diversity Award and Care-Nepal have supported PVS work of LI-BIRD on upland rice and other crops.

LI-BIRD was founded by scientists working previously at Lumle, to continue the PPB work.

IRD approach institutionalized at Lumle, for crops, vegetables, fodder trees, and small ruminants and other livestock.

13. *Documents/references*

Joshi, K.D., R.B. Rana, M. Subedi, K.B. Kadayat, and B.R. Sthapit. 1996. Addressing diversity through farmer participatory variety testing and dissemination approach: a case study of Chaite rice in the western hills of Nepal. In: Sperling, L. and M. Loevinsohn, eds. Using diversity—Maintaining and enhancing genetic resources on-farm. Proceedings of a workshop held on 19-21 June 1995, New Delhi, India. IDRC Regional Office for South Asia, 17 Jor Bagh, New Delhi, India.

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15. *Comments*
    Chaite rice is not a traditional crop, but a new cropping practice in a more productive environment; there is a lack of varietal diversity.
    The research is actually focussing on the approach, and thus is more oriented towards scaling up than many.

Case 5: Upland rice in West and Central Africa

1. *Title*
   Participatory Rice Improvement and Gender Analysis (PRIGA)
2. *Institutions*
   WARDA in collaboration with NARS, NGOs and extension services to 17 member countries in West and Central Africa
3. *Country/region(s)*
   West Africa; WARDA's direct focus is on Côte d'Ivoire (three sites) with work at 1-2 sites in each WARDA member country (17)
4. *Year project began/Dates*
   WARDA's program began in Côte d'Ivoire in 1996; collaboration with the NARS began in 1997
5. *Researcher(s) involved*
   Monty P. Jones, breeder; Timothy J. Dalton, economist; Nina K. Lilja, economist (WARDA), and national partners Dartey, Opoku-Apau (Ghana); Dogbe (Togo), plus many others
6. *Farmers involved*
   Nearly 200 farmers have participated in Côte d'Ivoire; no precise figures for the other countries yet.
7. *Crop(s)*
   Upland rice, *Oryza sativa*, *Oryza glaberrima*, and interspecific crosses
8. *Main objectives pursued (in farmer participation)*
   Identification of preferred varietal characteristics; farmer selection of segregating materials
9. *Nature of participation*
   PVS: farmers are invited to visit a rice garden of up to 60 lines (including traditional and improved *O. sativa*, *O. glaberrima*, and interspecific hybrids) three times during the growing season: at maximal tillering, maturity and a post-harvest visit. Farmer selections are recorded during each visit and the varietal characteristics for why each variety was chosen. Farmers are given 1 kg of seed of each of the varieties they have chosen (up to five varieties) for testing in their own fields during the second year. A complete agronomic and economic analysis is conducted during this phase. During the third year, farmer interest in the tested varieties is evaluated and farmer willingness to pay for seeds is elicited.
   Gender-differentiated varietal preferences research will make it possible to identify farmer groups in terms of the importance they give to a rice varietal characteristic when

making their selection decision. Furthermore, the results will provide priority setting recommendations to rice breeders and research managers. The research will provide an opportunity to conduct preference simulations and derive the answers to 'what if' questions, such as if the researcher release a number of new varieties, the calculated preference shares will indicate the percentage of male and female farmers that would be likely to select each of those varieties. This will allow the assessment of whether strategies to increase cultivar adoption require a particular focus on female production conditions and consumption preferences. During July-December 1997, gender-disaggregated participatory varietal selection (PVS) trials were carried out in Boundiali and Danane to determine: a) whether varietal characteristics are perceived differently by gender; b) whether men and women select varieties because they meet different preference criteria and production opportunities; or, c) whether general, gender neutral, selection rules can be developed for improved targeting of breeding efforts. The initial analysis of the PVS trials show that many frequently selected varieties are jointly selected by men and women.

10. *Breeding method and types of output anticipated*
11. *Summary of methods used*
12. *Summary of results/experiences/impacts and products to date*

However, some particular varieties among the top five most frequently selected among all participants, were selected only by women. Because farmers vary in individual characteristics and because they choose varieties to be planted in a heterogeneous environment, it is necessary to attempt to divide the farmers (by use of cluster analysis technique) into distinctive groups that may require different varieties.

13. *Documentation/references*
14. *Contact addresses*

Monty P. Jones, E-mail: M.Jones@cgiar.org
Timothy J. Dalton, E-mail: T.Dalton@cgiar.org
Nina K. Lilja, E-mail: N.Lilja@cgiar.org
WARDA, 01 BP 2551, 01 Bouake, Côte d'Ivoire.
Tel: +225 (63) 4514, Fax: +225 (63) 4714

Case 6: Participatory rice breeding in eastern India

1. *Title*

   Strategy for rice breeding in rainfed areas of India

2. *Institutions*

   Narendra Dev University of Agriculture and Technology, Faizabad, India

3. *Country/region(s)*

   India, rainfed areas of the eastern gengetic plain

4. *Year projpect began/Dates*
   1985
5. *Researcher(s) involved*
   D.M. Maurya
6. *Farmers involved*
   59 farmers of two villages, listed individually
7. *Crop(s)*
   Rice, rainfed
8. *Main objectives for pursuing farmer participation*
   Production increase, adoption
9. *Nature of participation*
   Farmers grow and evaluate trials
10. *Method of involving farmers and types of output anticipated*
    Seed of experimental variety given to farmers
    Each farmer grows one to three new varieties matching his own varieties
    All farmers visit all plots in a village
    Informal interviews held with individual farmers
    Second interview held after samples were milled and cooked
11. *Summary of breeding methods used*
    Experimental varieties were chosen by breeders to match local varieties collected from participating farmers in plant type and maturity
12. *Summary of results/experiences/impacts and products to date*
    Experimental varieties clearly outyield the locals
    Project extended to other crops
    Establishment of seedbank of successful materials
    <u>What follows now is not clear</u>
13. *Documentation/references*
    Maurya, D.M., A. Botrall, and J. Farrington. 1988. Improved livelihoods, genetic diversity and farmer participation: A strategy for breeding in rainfed areas of India. Experimental Agriculture 24:311-320.
    Talbot and N.W. Simmonds. 1992. TAG (re-analysis of Maurya's data).
    Maurya D.M. 1996. Participatory breeding, on-farm seed management and genetic resource conservation methodology: A sustainable agricultural R&D model. In: Sperling, L. and M. Loevinsohn, eds. Using diversity—Maintaining and enhancing genetic resources on-farm. Proceedings of a workshop held on 19-21 June 1995, New Delhi, India. IDRC Regional Office for South Asia, 17 Jor Bagh, New Delhi, India.
    Maurya, D.M. 1989. The innovation approach of Indian farmer first. In: Chambers, R., A. Pacey, and L.A. Thrupp, eds. Farmer innovation and agricultural research. p. 9-14. London: Intermediate Technology Publications.
14. *Contact addresses*
    D.M. Maurya, Dean of Agriculture, Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad 224 229, Uttar Pradesh, India

15. *Comments*
    One of the first documented cases

Case 7a: ICRAF/ISABU (Burundi)—Tree selection

1. *Title*
    Farmer participation in on-station tree species selection for agroforestry: A case study from Burundi
2. *Institutions*
    ICRAF/ISABU Agroforestry Project
3. *Country/region(s)*
    Burundi: Gitega (central Burundi, highlands—1400-1800 masl, 1200-1500 mm rainfall)
4. *Year project began/Dates*
    Trees established in 1989 and 1990, farmer evaluation done in 1992
5. *Researcher(s) involved*
    Steven Franzel, L. Hitimana, E. Akyeampong
6. *Farmers involved*
    On-station evaluation: 39 selected from regular meetings between local administrators and farmers, from participants in a local development project, and from on-farm trial collaborators. Included high and low income, 34 male and five female, young and old, with and without cattle.
    Surveys to determine selection criteria done with 25 farmers (most not in above group), including eight women, four carpenters
    Random sample not preferred—this choice insured interest in tree growing
7. *Crop(s)*
    20 tree species with upper-story agro-forestry potential evaluated on-station
    Eight species (six that were also in above trial) evaluated in surveys of selection criteria
8. *Main objectives for pursuing farmer participation*
    Cost efficiency: "Improve the efficiency of the research and dissemination process by involving farmers in species selection"
9. *Nature of participation*
    Farmer involvement in on-station trials to choose species to test on their farms
10. *Method of involving farmers and types of output anticipated*
    Testing experimental varieties: three methods tried—private interviews, focus-group interviews, voting by show of hands
    Goals identification: get farmer input on criteria used to select trees and reasons for their choices
    Anticipated output: less costly approach in terms of time and resources (compared to surveys or on-farm trials), farmer information available at an earlier stage of screening than for on-farm trials, facilitates direct interactions between

farmers and researchers, facilitates collection of statistically valid data
Weakness: quality of information likely to be lower than for surveys or on-farm trials

11. *Summary of breeding methods used*
    Trees grown on station, interplanted with crops (maize or bananas+beans) and provided with no "improved inputs, such as fertilizer" to simulate farmers' practices
12. *Summary of results/experiences/impacts and products to date*
    Farmer evaluation on-station useful, cost-effective way to learn which trees farmers preferred and why
    Private interviews and show-of-hands voting gave similar results; focus-group interviews gave different results (due to influence of a few strong-minded individuals?)
    Less consistency for "least preferred" species—farmers less interested in rating what they don't want to evaluate
    One species preferred by four of five women, but only three of 34 men (leaves used to treat childhood diarrhea)
    Criteria: speed of growth, competition with crops, wood quality for timber, poles, and firewood
    Researchers should share everything they know about the species with farmers during the station visit (generates bias, but it is "informed bias")
    More farmers (80-100) would allow systematic analysis of preference differences
13. *Documentation/references*
    Franzel, S., L. Hitimana, and E. Akyeampong. 1995. Farmer participation in on-station tree species selection for agroforestry: A case study from Burundi. Experimental Agriculture 31:27-38.
14. *Contact addresses*
    Steven Franzel, ICRAF, P.O. Box 30677, Nairobi, Kenya. E-mail: s.franzel@cgiar.org
15. *Comments*
    Nice example of PVS
    Comparison of methods for soliciting farmer opinions is unique

Case 7b: Priorities for trees in West Africa

1. *Title*
   Setting priorities among agroforestry tree species for domestication research: An example from the humid lowlands of West Africa
2. *Institutions*
   ICRAF, ISNAR, NARIs from Cameroon, Nigeria, Ghana
3. *Country/region(s)*
   Nigeria, Cameroon, and Ghana (general target = humid lowlands of West Africa: parts of 11 countries, <1000 masl, >1500 mm rainfall, >220 day growing season)
4. *Year project began/Dates*
   1993-1995

5. *Researcher(s) involved*
   Steven Franzel, Hannah Jaenicke, Willem Janssen, Elias Ayuk, Doug Boland
6. *Farmers involved*
   Initial survey: 94 groups (1-15 farmers/group) in three countries, 25% were female
   Value and use survey: 80 farmers in 12 villages in Cameroon, 72 farmers in 12 villages in Nigeria; also key informants interviewed regarding gender roles in production, prices, control over revenue
7. *Crop(s)*
   Agroforestry trees (farmer survey turned up 60 different species in Cameroon, 172 in Nigeria)
8. *Main objectives for pursuing farmer participation*
   Cost efficiency (?): obtain their input as stakeholders to prioritize tree species for domestication
9. *Nature of participation*
   Farmers involved as survey respondents
10. *Method of involving farmers and types of output anticipated*
   Goals identification: farmer survey of tree species most important to them, uses, locations on farms, desired improvements; subsequent survey to estimate value of products, other uses, expected adoption
   Anticipated output: identification of priorities for domestication of agroforestry trees
11. *Summary of breeding methods used*
   None
12. *Summary of results/experiences/impacts and products to date*
   Food is most important use of trees for farmers, followed by timber and medicine
   Income from sale of tree products is often gender-specific or at least gender-preferential
   Prioritization process was successful at identifying a short list of target species for domestication
13. *Documentation/references*
   Franzel, S., H. Jaenicke, W. Janssen, E. Ayuk, and D. Boland. 1997. Setting priorities among agroforestry tree species for domestication research: An example from the humid lowlands of West Africa. Draft (10/97) for submission to Agricultural Economics.
14. *Contact addresses*
   Steven Franzel, ICRAF, P.O. Box 30677, Nairobi, Kenya. E-mail: s.franzel@cgiar.org
   Hannah Jaenicke and Elias Ayuk, ICRAF, P.O. Box 30677, Nairobi, Kenya
   W. Janssen, ISNAR, P.O. Box 93375. 2509 AJ The Hague, Netherlands
   Doug Boland, SCIRO Froestry and Forest Products, P.O. Box E4008, Kingston 2604, Canberra, Australia

15. *Comments*
    Farmer surveys are the only farmer participation in this study
    Gender differentiation in terms of cultivation, use, and especially benefits (income) is interesting

Case 8: Barley in Syria

1. *Title*
    Decentralized, participatory breeding of barley in Syria
2. *Institutions*
    ICARDA, ARC Syria, University of Hohenheim
3. *Country/region(s)*
    Syria
4. *Year project began/Dates*
    1996
5. *Researcher(s) involved*
    S. Ceccarelli, S. Grando, R. Tutwiler, M. van Oppen, C. Pecher
6. *Farmers involved*
    Eight, initally increased to nine individual farmers from eight villages, selected as experts in barley cultivation, from “pool of participants” in their on-farm projects
7. *Crop(s)*
    Barley
8. *Main objectives for pursuing farmer participation*
    Testing role of participation vs. decentralization in achieving adoption of new varieties
    Understanding farmers’ criteria (for selection)
9. *Nature of participation*
    Each farmer is testing 200 lines (selected by breeders) in his farm
    Each farmer is selecting among these 200 lines on the research station
    Formal marketing analysis, involving surveys of traders and farmers (?)
10. *Method of involving farmers and types of output anticipated*
    Farmers were selected during planned group interviews
    Quantify the effect of participation vs. that of decentralized testing of variety
    Provide an understanding of adoption patterns, how farmers use the new germplasm
    Methods for eliciting farmers responses not clear
    <u>More detail on marketing study required</u>
11. *Summary of breeding methods used*
    Factorial comparisons of selections made by farmers and breeders in each site
    Simulation of early generation testing of breeding material
12. *Summary of results/experiences/impacts and products to date*
    Farmers very carefully take notes of their observations and score varieties very conscientiously

Several farmers selected only very few entries from the set of 200 on their own farm, i.e., they have very strict criteria and expectations for a new variety

Farmers select on research station more often; the varieties that yield well there do better than those that would yield well on their own farms (needs verification)

13. *Documentation/references*

    Ceccarelli, S., E. Bailey, S. Grando, and R. Tutwiler. 1998. Decentralized-participatory plant breeding: A link between formal plant breeding and small farmers. Euphytica. (Submitted.)

    Project proposal as submitted to BMZ/GTZ.

14. *Contact addresses*

    S. Ceccarelli, S. Grando, R. Tutwiler, ICARDA, P.O. Box 5466, Aleppo, Syria. E-mail: S.Ceccarelli@cgiar.org, S.Grando@cgiar.org, R.Tutwiler@cgiar.org

    M. von Oppen, S. Pecher, Universitaet Hohenheim, Stuttgart, Germany

15. *Comments*

    More results awaited soon

Case 9: Barley in Morocco and Tunisia

1. *Title*
2. *Institutions*

    ICARDA
3. *Country/region(s)*
4. *Year project began/Dates*

    1996
5. *Researcher(s) involved*

    S. Ceccarelli, S. Grando, R. Tutwiler, M. Amri
6. *Farmers involved*

    Similar to case 8
7. *Crop(s)*

    Barley
8. *Main objectives for pursuing farmer participation*

    Testing role of participation vs. decentralization in achieving adoption of new varieties

    Understanding farmers' criteria (for selection)???
9. *Nature of participation*
10. *Method of involving farmers and types of output anticipated*
11. *Summary of breeding methods used*
12. *Summary of results/experiences/impacts and products to date*

    No results received so far
13. *Documentation/references*
14. *Contact addresses*

    S. Ceccarelli, ICARDA, P.O. Box 5466, Aleppo, Syria. E-mail: S.Ceccarelli@cgiar.org
15. *Comments*

    New, no results, funded by IDRC

Case 10: Bean selection in Colombia

1. *Title*
   Farmer selections within segregating bean populations in Colombia, CIAT
2. *Institutions*
   CIAT
3. *Country/region(s)*
   Valle del Cauca, Colombia
4. *Year project began/Dates*
5. *Research(s) involved*
   Julia Kornegay, Jorge Alonso Beltrán, Jacqueline Ashby
6. *Farmers involved*
   Gerardo Valencia, Julio César Azcárate, and Hugo Guarín
7. *Crop(s)*
   Common bean (*Phaseolus vulgaris*)
8. *Main objectives for pursuing farmer participation*
   Compare performance and agronomic characteristics of farmer- and breeder-selected lines across environments and assess farmer perceptions of useful genetic variation
9. *Nature of participation*
   Express farmer selection criteria; practiced selections on-farm and evaluated varieties
10. *Method of involving farmers and types of output anticipated*
   Two research stations and three farms planted 18 F2 populations and followed the same methodology for selection through to the F6, using their own selection criteria. Outputs could include farmer evaluation criteria and farmer-developed lines.
11. *Summary of breeding methods used*
   See #10. Farmers interviewed twice each generation for spontaneous reactions at pod formation and harvest. Varieties were ranked in the F6 by yield and farmer preference.
12. *Summary of results/experiences/impacts and products to date*
   Yields among groups of selections tested across all sites were not significantly different. On-station breeder selections had greater overall yield potential than farmer selections, but half of the farmer-preferred varieties were farmer-selected. GxE was as great among farms as between farms and the experiment stations, so material selected on one farm did not necessarily excel on another farm. Farmer criteria centered on desirable quality traits (e.g., seed color and size) for marketability, while breeders could center on yield and stress tolerance (including nationally required anthracnose resistance). Better market prices from attractive seed types could offset some income losses from lower yields in farmer selections.
13. *Documentation/references*
   Kornegay, J., J.A. Beltrán, and J. Ashby. 1996. Farmer selections within segregating populations of common bean

in Colombia. In: Eyzaguirre, P. and M. Iwanaga, eds. Participatory plant breeding: Proceedings of a workshop on participatory plant breeding, 26-29 July 1995, Wageningen, The Netherlands. IPGRI, Rome, Italy.

14. *Contact addresses*
    Julia Kornegay. E-mail: Kornegay@fiu.edu
15. *Comments*
    Unique: what traits farmers don't catch, comparative selection, segregating populations, selection on favorable research stations overall better than marginal research station conditions or on-farm, cost compensation for quality/yield losses offset, what causes varieties to get rejected (in level of quality).

Case 11: CIAT/CORPOICA—Cassava in Colombia

1. *Title*
   Introduction of Improved Genetic Diversity into Cassava Farmers Fields
2. *Institutions*
   CIAT, CORPOICA, FIDAR
3. *Country/region(s)*
   Colombia: seasonally dry ecosystem in the north (800-1000 mm rainfall, bimodal; poor soils) and highlands of southwest
4. *Year project began/Dates*
   North: 1986; Southwest: 1994
5. *Researcher(s) involved*
   Carlos Iglesias, Luis Hernandez, Gustavo Jaramillo (CIAT); Antonio López (CORPOICA); José Restrepo (FIDAR)
6. *Farmers involved*
   North - average of 28 communities/year, via chip drying cooperatives; 8-10 farmers evaluated each trial, with farmer evaluators (rotated regularly) chosen based on history with crop and interest in participation and information-sharing
   South - average of 15 communities/year
7. *Crop(s)*
   Cassava
8. *Main objectives for pursuing farmer participation*
   Improve productivity: opportunity for farmers to evaluate traits within a genetic base that has <u>not</u> been pre-selected; genotypes with better acceptability to farmers
   Cost efficiency: broader range of genotypes released in a shorter time and at less cost
   Biodiversity: will be monitored for relationship to biotic and abiotic stress impacts on production
   Gain knowledge: about farmer selection criteria and production/marketing systems
9. *Nature of participation*
   Farmers and researchers meet three or more times/season to evaluate the crop, farmers select genotypes for further

testing and breeders make their own independent evaluation for comparison

10. *Method of involving farmers and types of output anticipated*

Selecting in variable materials: farmers conduct their selection in progenies from advanced stages of breeding program (more recently, farmers have been incorporated into earlier stages of selection)

Anticipated output: broader range of genotypes will be selected within an ecosystem, with adaptation tailored to climate/soil combinations, cropping systems, end uses, etc.

<u>Assumes</u> that farmer-based plant improvement results in increased genetic diversity and thus improved production stability and sustainability

11. *Summary of breeding methods used*

Selection among variable families for clonal propagation

Need for planting material produced under comparable conditions for local and improved varieties

12. *Summary of results/experiences/impacts and products to date*

Field books for data collection by farmers developed; glossaries of farmers' evaluation terms assembled; training manuals developed

Data analysis programs for ranking farmer preferences developed and adapted to hand calculators

Farmer selection criteria quantified and incorporated into breeding programs

Varieties released (three) and comparative costs for variety evaluation estimated

13. *Documentation/references*

Iglesias, C. Introduction of improved genetic diversity into cassava farmers fields. CIAT Project Proposal.

Iglesias, C., L.A. Hernández R., and A.J. López. Participatory selection with cassava farmers in Northern Colombia. CIAT Project Report and Proposal.

14. *Contact addresses*

Carlos Iglesias. E-mail: C.Iglesias@cgiar.org

Antonio J. López. E-mail: corpoica@monteria.cetcol.net.co

15. *Comments*

Plans to "assess genetic diversity" by assessing adoption of materials by farmers and comparing with similar regions where no PPB has been done

Case 12: IRRI participatory breeding project for rice in eastern India

1. *Title*

Farmers and scientists: building a partnership for improving rainfed rice

2. *Institutions*

International Rice Research Institute (IRRI); Central Rice Research Institute, Cuttack, Orissa; Orissa University of Agriculture and Technology, Bhubaneswar, Orissa; Central

Rainfed Upland Rice Research Station, Hazaribagh, Bihar; Indira Gandhi Agricultural University, Raipur, Madhya Pradesh; Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh; Rajendra Agriculture University, Pusa, Bihar; Local state extension services: Krishi Vigyan Kendra (KVK), the extension agent of the Indian Council of Agriculture Research (ICAR) in Hazaribagh, Masadha, and Cuttack; and Institutional Village Linkage Programme (IVLP, an NGO in Raipur, Madhya Pradesh)

3. *Country/region(s)*

   India. Rainfed areas of eastern India, including four rainfed lowland sites in Madhya Pradesh (Raipur); Uttar Pradesh (Masadha), Orissa (Cuttack); and one rainfed upland site (Bihar, Hazaribagh).

4. *Year project began/Dates*

   Phase 1 began in 1997. Phase 2 was scheduled to begin in 2000.

5. *Researcher(s) involved*

   B. Courtois (CIRAD); R.K. Singh; T. Paris; K. McAllister; S. Sarkarung; G. McLaren; V.P. Singh; S.P. Singh (all IRRI); and many from the six NARS involved in the project.

6. *Farmers involved*

   Two to three villages were chosen in each of the six research sites. These were selected for social diversity, dependence on rainfed rice production, and different levels of market integration. Farmer sampling ensured representation of men and women, different castes, farmers with different sized landholdings, etc. Where possible, results are being disaggregated for different "types" of farmer. Social science surveys involved interviewing 20-25 farmers (men and women) per village on crop production systems and agronomic conditions, etc. and 50 farmers per village on selection criteria and preferred varietal characteristics.

7. *Crop(s)*

   Rainfed rice

8. *Main objectives for pursuing farmer participation*

   - Test hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently,
   - Identify stages along a breeding program where farmer participation has the most impact, and develop and test a methodology for effectively involving farmers in the breeding program,
   - Improve understanding of men and women farmers' criteria for selecting specific rice varieties,
   - Differentiate between influence of farmer participation and decentralization of the breeding process.
   - Develop rice varieties suitable for heterogenous rainfed environments, which meet farmers' preferences.

9. *Nature of participation*
   - **Participatory Varietal Selection (PVS):** Farmers and breeders rank varieties on-station and on-farm at specific developmental stages, and criteria for ranking elicited. Agreement among farmers, among breeders, and between farmers and breeders assessed in several sites to differentiate between the influences of participation versus decentralization.
   - **Participatory Plant Breeding (PPB):** Farmers and breeders select individual plants from segregating populations of different varieties (on-station and in farmers fields), and these are grown until full fixation. Phase 2 will test the results of farmer and breeder developed varieties.
   - Women and men farmers interviewed on their preferences for different varieties or different rice characteristics and to assess the diversity of varieties grown. Weighted participatory ranking method used with women and men farmers to understand how they trade off between traits.
   - Women and men farmers involved in sensory evaluation to assess grain quality, taste, cooking quality, and so on.
   - Surveys conducted for information on the social structure and cropping systems in the research sites, to enable connection to be made between farmer characteristics (gender, size of land holding, land type, proximity to the market, caste, etc.).
   - Farmers maintained diaries to track and comment on the progress and characteristics of the different varieties they tested.
10. *Method of involving farmers and types of output anticipated*

    PVS: Effect of farmer participation and effect of decentralization of breeding process assessed by calculating agreement in varietal ranking among farmers, among breeders, and between breeder and farmers, as well as by comparing results of on-station and on-farm trials.
    Preferred varieties for specific micro-environments and for different "types" of farmer will be identified.

    PPB: Farmer-selected lines and breeder-selected lines have been developed, and these will be compared, ranked and tested on farms and on-station during phase 2 of the project.

    Social science survey: Surveys have been completed, and analysis of the data will enable development of a typology of farmers (according to caste, socio-economic status, land type, size of land holding, and so on), and will allow connections to be made between farmer preference of specific varietal characteristics and "type" of farmer.
11. *Summary of breeding methods used*

    PVS: Farmers and breeders evaluated between 15-25 fixed varieties on station and on farm at specific phenotypical stages and their criteria for ranking were elicited. The agreement between their respective rankings was measured and GxE interactions were assessed.

PPB: Farmers and breeders involved in selecting individual plants from segregating lines in trials on-farm and on-station. Pedigree selection method was used. Selected plants from breeders and farmers were run separately through several generations until fixed. Phase 2 will involve testing and comparison of the breeder-selected and farmer-selected material.

12. *Summary of results/experiences/impacts and products to date*
    - High number of rice varieties grown in each village. Trend to have a few dominant varieties suited to each hydrological situation along with significant number of secondary varieties. Number and nature of varieties grown is dynamic and changed considerably over a 10-year period.
    - Hydrological conditions and usefulness of the variety to meet specific needs were major factors determining farmers' choice. Hydrological conditions and land type defined most parameters required in a variety (duration, height, type of resistance to abiotic constraints, etc.). Different varieties fulfilled different livelihood functions (food, livestock fodder, thatching, and cash), and farmers responded to the multiplicity of needs by growing a range of varieties.
    - Number of varieties grown by an individual farmer is related to farm size. Larger landowners grow more varieties.
    - Farmers grow more modern varieties than initially thought. Adoption varied between sites, and was generally higher in more favorable conditions and higher in lowland than upland areas.
    - Location is a major source of yield variability. Therefore decentralization of the breeding process will have an important influence on varieties developed.
    - Good consistency among farmers' opinions about the tested varieties, but not always among breeders. Agreement between farmers and breeders varied and was better when there were obvious differences between varieties. Rankings was not always well correlated to observed agronomic performances of varieties, indicating yield was not the only factor taken into account by either farmers or breeders.
    - Women and men farmers commonly agreed that grain yield and duration are the most important traits they consider when choosing varieties for upland and lowland areas. Because of gender-specific roles in rice production, women (but not men) specifically mentioned competitiveness with weeds and post harvest quality as important criteria.
    - Sensory evaluation of grain cooking quality showed that mode of rice preparation (raw versus parboiled) influenced farmers' appreciation. Differences between men and women's opinions were insignificant. Sensory ranking did not correlate with results of classical physico-chemical analyses.
    - Interaction with farmers and social scientists improved breeders' appreciation of the multiplicity of farmer goals and complexity of the environment.

- Meeting different farmer needs might be better tackled by creating different varieties rather than trying to produce multi-purpose varieties.
- Both participation and decentralization play an important role in the breeding program for rainfed environments. Farmers' involvement in participatory varietal selection was very beneficial for identifying varieties that better suit farmers' needs.
- The PPB process has resulted in farmer-selected and breeder-selected lines, which will be tested in phase 2 of the project.
- In some sites, farmers have expanded the area under lines they evaluated to be superior, indicating that exposure to new varieties may have been a constraint to adoption.
- Weighted participatory ranking is a simple and effective method for assessing tradeoffs between different traits by different users.

13. *Documentation/references*

Courtois, B., B. Bartholome, D. Chaudhary, G. McLaren, C.H. Misra, N.P. Mandal, S. Pandey, T. Paris, C. Piggin, K. Prasad, A.T. Roy, R.K. Sahu, V.N. Sahu, S. Sarkarung, S.K. Sharma, A. Singh, H.N. Singh, O.N. Singh, N.K. Singh, R.K. Singh, R.K. Singh, S. Singh, P.K. Sinha, B.V.S. Sisodia, and R. Takhur. Participatory varietal selection for low-input environments: A case study of rainfed rice in eastern India. (Submitted.)

Courtois, B., R.K. Singh, S. Pandey, T. Paris, S. Sarkarung, S.S. Baghel. R.K. Sahu, V.N. Sahu, S.K. Sharma, S. Singh, H.N. Singh, A. Singh, O.N. Singh, B.V.S. Sisodia, C.H. Misra, J.K. Roy, D. Chaudary, K. Prasad, R.K. Singh, P.K. Sinha, and N.P. Mandal. 1999. Breeding better rainfed rice varieties through farmer participation: Some early lessons from eastern India. Proceedings of the International Seminar of the SWP on PRGA, Quito, Ecuador, September 6-9, 1998. Cali, Colombia: CIAT.

Paris, T.R., A. Singh, J.S. Luis, M. Hossain, H.N. Singh, and O.N. Singh. 1999. Incorporating gender concerns in participatory rice plant breeding and varietal selection: Preliminary results from eastern India. Proceedings of the International Seminar of the SWP on PRGA, Quito, Ecuador, September 6-9, 1998. Cali, Colombia: CIAT.

Singh, R.K., K. Prasad. N.P. Mandal, R.K. Singh, B. Courtois, and V.P. Singh. 1999. Sensorial evaluation of rice varieties with farmers, In: Ashby, J. and L. Sperling, eds. Participatory plant breeding and rural development. (Unpublished manuscript.)

Farmers and scientists: Building a partnership for improving rainfed rice. First annual report, April 1997-March 1998. (Unpublished project report.)

Farmers and scientists: Building a partnership for improving rainfed rice. Second annual report, April 1998-March 1999. (Unpublished project report.)

14. *Contact addresses*
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    Thelma Paris or Karen McAllister, IRRI, Social Science Division, MCPO Box 3127, 1271 Makati City, Philippines. Fax: +63 (2) 8911292 or 8450606, E-mail: t.paris@cgiar.org or k.mcallister@cgiar.org
    Brigitte Courtois; CIRAD-CA, BP 5035, 34032 Montpellier Cedex 1, France. Fax: +33 (04) 67615988, E-mail: brigitte.courtois@cirad.fr
15. *Comments*
    Project funded by the International Development Research Centre (IDRC). Phase 2 proposal is being developed, to begin in 2000.

Case 13: Bean breeding in Malawi

1. *Title*
   Component bean breeding systems in Malawi
2. *Institutions*
   Michigan State University
3. *Country/region(s)*
   Central Malawi
4. *Year project began/Dates*
   1986?
5. *Researcher(s) involved*
   Anne E. Ferguson, Susan Sprecher, Richard M. Mkandawire
6. *Farmers involved*
   Women highlighted as primary bean producers; smallholders.
7. *Crop(s)*
   Beans (*Phaseolus vulgaris*), bush and climbing
8. *Main objectives for pursuing farmer participation*
   Study traditional varieties, seed and varietal maintenance systems, and farmer preferences in order to design plant improvement programs that minimize the loss of genetic diversity.
9. *Nature of participation*
   Criteria listing, categorizing varieties.
10. *Method of involving farmers and types of output anticipated*
    Goal identification and variety release and dissemination. Component breeding: purpose is to provide improved components which farmers can then adapt to their systems, superior lines which each carry different improved traits representing as wide a range of classes as possible. Often, farmer-preferred traits are negatively correlated with high yield (e.g., large-seededness). For farmers' yield stability and taste requirements, we should support priorities for maintaining a large number of classes with one-few cvs. in each.

Goal: to quickly release many improved varieties with different characteristics so farmers can integrate them into their systems. Question on why certain varieties were grown in larger area than others.

11. *Summary of breeding methods used*

Collect and document farmer varieties (asking household producers, women); catalog and make accessible to breeders; have farmers sort collection into classes and select classes to improve; improve classes for desirable characteristics. Release a lot of lines quickly.

12. *Summary of results/experiences/impacts and products to date*

Seed/variety system study. Since farmers actively maintain desirable characteristics which would otherwise be lost in their beans, study current bean management; found 220 bush and climbing varieties in the region, with 12.9 varieties/household average. Older women had more varieties than younger women. *[Same as Bellon maize findings in Mexico] There are a limited number of cosmopolitan varieties, widely distributed (about 28), with a large number of other plants in less area and by fewer people (for food security, specific household needs, heritage, and lack of access to preferred seed/by default). Largest area goes to high-yielding, easily marketable, tasty, fast-cooking varieties.

Farmers understand important selection criteria. They often try new types in their fields. Most new types are purchased in markets, but also other supply sources. Criteria were (in order) yield, taste, cooking quality, etc. Market considerations increasingly important, although (good for maintaining biodiversity) the state marketing board did not pay premiums for certain varieties but some types are easier to sell than others.

13. *Documentation/references*

Ferguson, A.E. and S.L. Sprecher. 1987. Women and plant genetic diversity: the case of beans in the central region of Malawi. Paper presented at the session on Recent Agricultural Research in Southern Africa, American Anthropological Association Meetings, Chicago, Illinois, November 18, 1987.

Ferguson, A.E. and S.L. Sprecher. 1989 (draft). Designing bean breeding strategies for small-scale farmers in eastern Africa. Paper presented at the Symposium on Crop Breeding Criteria and Agricultural Development, AAAS Annual Meetings, January 14-19, 1989, San Francisco, CA.

14. *Contact addresses*

Anne E. Ferguson, B/C CRSP Women and Development Program, Room 200 Center for International Programs, Michigan State University, East Lansing, MI 48824, USA. E-mail: fergus12@pilot.msu.edu

15. *Comments*

Is there a more detailed write-up on the actual breeding process itself? (Did it happen?)

Researchers pressured to moderate their interest in empowerment and beyond-technical aspects of farming systems. In current political climate, need to develop locally-based seed multiplication/distribution channels, including NGOs.

This is exactly the kind of baseline seed system study that should precede PPB interventions. (Why aren't more done?) 1989, p. 6: 'Understanding the reasons for cultivar preferences and planting practices is a necessary prerequisite for formulating breeding strategies.' LSM/1989:

Maize is primary crop, intercropped with bush and climbing beans (as in Honduras). Bean stocks managed as a collection of individual varieties (unlike Honduras). As in Rwanda, farmers plant small monocrop observation plots before incorporating into mixtures. Low planting density is common as seeds are expensive and sometimes scarce (as in Honduras). Farmers may seek to maximize return/seed rather than return/land area. Who does component breeding favor? Smallholders, yes; other players? Are researchers negatively affected? Seed sales interests? Government programs (credibility, that 'aura of government sanction')? Why isn't this already the model?

Unique: proposes a new approach to variety release and management blends or multi-lines (deteriorate into undesirable factors), but lots of separate components. Would this be a feasible research strategy for cross-pollinators? Assumes that released lines will NOT be planted in conditions/mixtures known to the plant breeder.

David Wood (1985) (Ref?) advocates giving Andean/Mexican landraces directly to African farmers for trial. (And? Good results?)

Case 14: Comparing farmer and scientist trait preferences in early generation bean lines in Tanzania

1. *Title*

   Bean CRSP

2. *Institutions*

   WSU (Washington State University), UI (University of Idaho), SUA (Sokoine University of Agriculture), Tanzania Ministry of Agriculture and Livestock Development

3. *Country/region(s)*

   Low-middle bean-producing elevations of Tanzania

4. *Year project began/Dates*

   CRSP begun 1982; participatory component added 1990

5. *Researcher(s) involved*

   Lorna M. Butler, Jim Myers, Susan Nchimbi-Msolla, Evelyne Massangye, Zubeda Mduruma, Naftali Mollel, Peter Dimosa

6. *Farmers involved*
   Smallholder (particularly women) farmers
7. *Crop(s)*
   Beans (*Phaseolus vulgaris*)
8. *Main objectives for pursuing farmer participation*
   Varieties more acceptable to and more widely used by smallholders. Purpose in early involvement is to assure that useful qualities are not lost in early stages of selection as they go unrecognized by the breeder. Determine traits emphasized by both groups and if novel phenotypes are identified.
9. *Nature of participation*
   First few years: understanding 40 farmer criteria for breeder feedback; farmer F6 evaluations to assist in release decisions; input on quality traits for marketing. Recently (1994?) focus of this paper: joint farmer-scientist early generation evaluations, to determine if farmers can detect variation not present in native varieties and compare their knowledge and criteria to that of breeders. Selection considerations on population size, trait heritability, and visual selection versus direct measurement are potential limits on the timing and utility of farmer evaluations.
10. *Method of involving farmers and types of output anticipated*
    See #9. Evaluations in the F3 and F5 generations.
11. *Summary of breeding methods used*
    The same number (12 each, both men and women in each group) of experienced bean-evaluator farmers and biological and social scientists participated in the evaluations. F3 plants were assessed by single plants, F5 by line. The five best and five worst lines, and best plants within the best line, were marked by each group separately, and reasons given for selection were recorded and compared.
12. *Summary of results/experiences/impacts and products to date*
    In the F3, both groups had considerable agreement on priorities, although farmers indicated some additional quality characteristics and scientists selected many other traits related to resistance and seed quality at this stage. The F5 showed less similarity in farmer-researcher preferences, with many small differences although they had similar plant architecture in mind. It may be optimal to have farmers evaluate early and late material, with breeders conducting yield and disease testing in between farmer evaluations.
13. *Documentation/references*
    Butler, L.M., et al. 1995. Farmer evaluation of early generation bean lines in Tanzania: Comparisons of farmers' and scientists' trait preferences. From SADC Regional Bean Research Workshop, Oil and Protein Center, Potchefstroom, South Africa, October 2-4, 1995.

14. *Contact addresses*
    Lorna Butler, Washington State University.
    E-mail: butlerl@wsu.edu
15. *Comments*
    Report indicates tentative and preliminary findings. Any more recent publications? A great study—please fill in later/continuing work and findings! Unique: Division of labor, progress from criteria to earlier farmer evaluation. Were farmer evaluations of varieties done on-station?

Case 15: Cowpeas in Cameroon

1. *Title*
   Farmer criteria in cowpea in Cameroon
2. *Institutions*
   Bean/Cowpea CRSP: Purdue University; Institute of Agricultural Research for Development, Maroua, Cameroon
3. *Country/region(s)*
   Northern Cameroon
4. *Year project began/Dates*
   Project began in 1991 (descriptive study began in 1994).
5. *Researcher(s) involved*
   Laurie W. Kitch, Ousmane Boukar, Chevalier Endondo, Larry L. Murdock, Richard Shade
6. *Farmers involved*
   Local expert cowpea farmers selected to represent diversity of age, gender, ethnic background, and socio-economic status; 149 (43 women, 106 men) farmers over 2 years, representing 20 of the 42 regional ethnic groups.
7. *Crop(s)*
   Cowpea (*Vigna unguiculata*)
8. *Main objectives for pursuing farmer participation*
   Understand farmer storage practices to alleviate storage losses due to the cowpea bruchid, *Callosobruchus maculatus*; combining seed and pod resistance based on indigenous storage practices?
   Understand farmers' priorities for selection as feedback and priority-setting for formal breeders.
   Better understand farmer priorities and practices as regards selection, either in their own fields or in collaboration with formal breeding institution.
9. *Nature of participation*
   Farmers from diverse geographical areas selected breeding lines on-station and explained their criteria.
   PVS of F6 lines on-station at plant maturity.
10. *Method of involving farmers and types of output anticipated*
    Farmers walked through plots alone to make selections, then went accompanied by a researcher to explain their criteria, followed by the entire group walking through the trials.

11. *Summary of breeding methods used*

Breeding method used was a modified single seed descent with individual plant selection at F4. Researcher screening in early generations was largely restricted to resistance to major diseases and storage insect pests.

Average selection intensity of farmers was 6%-17%, similar to that of breeders. The 26 farmer criteria were related to yield, preference/quality traits, and labor requirements, and were consistent over years, location, and gender, with an emphasis on market demands for cowpea. Grain yields of selected lines ranged from 270-1244 kg/ha. Male and female criteria not significantly different except for quality criteria (edible leaves), which were emphasized more by women. Farmer selection criteria may be driven largely by market forces. Above a minimum acceptable yield, line acceptability is determined by factors other than yield; therefore, research expenses for additional yield trials over locations should be balanced by efforts to understand farmer preferences.

12. *Summary of results/experiences/impacts and products to date*

Cost-effective.

Two varieties resulting from the program were released in 1999 after endorsement by extension workers and farmers alike in extension and pre-extension trials covering over 50 locations in each of 4 years. Another unexpected result was the discovery by farmers of a high-sucrose level cowpea line that completely escaped notice by the researchers. This unique trait is currently being transferred to numerous lines with better agronomic adaptation to northern Cameroon.

13. *Documentation/references*

Kitch, L.W., O. Boukar, C. Endondo, and L.L. Murdock. 1998. Farmer acceptability criteria in breeding cowpea. Experimental Agriculture 34:475-486.

14. *Contact addresses*

Laurie W. Kitch, FAO Sub-Regional Office for Southern and Eastern Africa, PO Box 3730, Harare, Zimbabwe. Tel: +263 (4) 791420, E-mail: laurie.kitch@fao.org

15. *Comments*

Unique: reports farmer representativeness by ethnic group; selecting same lines with a different group in a different year; farmer selection intensity (and over locations); criteria categorized from interviews (e.g., pod size/seed number was for labor, not yield); M/F criteria; chi square analysis. On conservation: in a crop with improved varieties grown for market and local landraces grown for consumption, breeders should focus on regional market preferences (price advantage for farmers), and local criteria may still be met by landraces—thus discouraging landrace displacement by improved varieties. (Interesting alternative to Zamorano/improve the landraces model.)

Letter to Gigi Manicad (7/14/97; from Louise Sperling) mentions your new initiatives on using local materials in breeding programs, accessing large amounts of local germplasm, and also training farmers in basic breeding principles. Any more details or updates? [My thesis is on the latter, on climbing beans in Honduras!]

*It sounds to me like your work is at the forefront of what is needed, with a lot of interaction and wide use of farmer and breeder materials. Has your group been involved in any intellectual property rights discussions? (Has is become an issue in the field, or not?)

Case 16: CIP—Potatoes in Bolivia

1. *Title*
   Farmers' evaluation of late-blight resistant potato clones in Bolivia
2. *Institutions*
   PROINPA (Potato Research Program), part of IBTA (National Institute for Agricultural Technology)
3. *Country/region(s)*
   Bolivia; Cochabamba province, 2900-3300 masl
4. *Year project began/Dates*
   On-farm selection 1990-95: 1990-91 researcher managed, 1991-92 researcher/farmer managed, 1992-93 farmer managed, 1993-94 farmer managed, 1994-95 researcher managed.
5. *Researcher(s) involved*
   Graham Thiele, Greta Gardner, Rudy Torrez, Julio Gabriel, Carlos Bejarano
6. *Farmers involved*
   Smallholders in high-altitude marginal production regions in two regions of Cochabamba province with high late blight incidence; at least one woman per community; known for potato production; known to share information/knowledge with other farmers, and availability to attend 3 field days. 20 total (7 women).
7. *Crop(s)*
   Potato (*Solanum tuberosum*)
8. *Main objectives for pursuing farmer participation*
   Abiotic and biotic stress-tolerant varieties for marginal regions: evaluation of late-blight resistant clones
9. *Nature of participation*
   Identify and prioritize unfavorable characteristics of plants and tubers. Selected clones to conduct their own field trials 1991-92. From 1990-94, conventional and participatory on-farm trials conducted simultaneously: breeders selecting blight resistance in researcher-controlled on-farm trials, while social scientists led on-farm trials with farmer evaluations.

10. *Method of involving farmers and types of output anticipated*
    Relatively early in the selection process with promising clones, from CIP and the Colombian Institute for Agricultural Research
11. *Summary of breeding methods used*
    Farmers evaluated tubers from several clones before and during flowering and at harvest. The following season, zones were given promising clones to be tested by participating communities.
12. *Summary of results/experiences/impacts and products to date*
    Farmers and scientists had similar priorities on health and vigor. Farmers compared observed varieties to local ones, but were not able to distinguish *P. infestans* from other leaf spots. At harvest, 23 of 138 original clones were selected by both farmers and scientists (1990-91 cycle). Where choices did not coincide, farmers made selections based on market characteristics, while researchers noted disease resistances or desirable morphologies. Three clones were identified for initial on-farm, farmer-led trials. There were no significant differences between men's and women's characterizations, but women's attendance at subsequent information-dissemination meetings was much higher than men's. Participatory evaluations enable breeders to broaden their understanding of farmer-relevant criteria. Current recommended strategy is to first involve 8-10 male and female expert evaluator farmers in assessing 30 clones in several areas, in researcher-controlled plots. Later, with 8-12 clones, farmers conduct their own trials and stay involved with subsequent multiplication of what they select. Use CIALs. Detailed knowledge needs point to questionnaires, but matrix scoring is appropriate when forms would be too cumbersome to fill or process.
13. *Documentation/references*
    Watson, G., N. Estrada, and C. Bejarano. 1992. Andean farmers' evaluation of late-blight resistant clones. CIP Circular 19(2): 6-7.
    Thiele, G., G. Watson, R. Torrez, and J. Gabriel. 1996. Evaluación de clones resistentes al tizón: Experiencia con agricultores. Cochabamba, IBTA/PROINPA.
    Thiele, G., G. Gardner, R. Torrez, and J. Gabriel. 1997. Farmer involvement in selecting new varieties: Potatoes in Bolivia. Experimental Agriculture 33:275-290.
14. *Contact addresses*
    Graham Thiele, PROINPA, Casilla Postal 4285, Cochabamba, Bolivia. E-mail: g.thiele@cgiar.org
15. *Comments*
    Unique: analysis of optimal timing of tools (forms/PRA), division of labor (scientist and farmer criteria diverged late in process), farmer evaluation (more efficient if late and on fewer clones), and also *soc/bioscientist dynamics (1997).

Conclusion on timing: Initially, with large numbers of clones, farmers' and scientists' choices coincide, but subsequently diverge. Therefore, more efficient to involve farmers later in the selection process (or how about releasing greater number of varieties earlier?).

Excellent analysis of strengths and weaknesses of each stage.

Describes farmer analysis methods in detail.

Case 17: KIT-IER—Maize in Mali

1. *Title*
   Participatory research on corn in Mali
2. *Institutions*
   KIT, Amsterdam. Institut d'Economie Rurale, Mali
3. *Country/region(s)*
   Southern Mali, Sikasso
4. *Year project began/Dates*
   <u>Not given</u>
5. *Researcher(s) involved*
   A. Kamara, T. Defoer, H. de Groote
6. *Farmers involved*
   Expert maize farmers representative of different groups of farmers for studying local maize varieties.
   A total of 65 farmers from eight villages for variety testing.
7. *Crop(s)*
   Maize
8. *Main objectives for pursuing farmer participation*
   Understanding what local varieties are grown where for what purpose
   Understanding farmers' selection criteria
   Productivity increase
   Adoption of modern varieties
9. *Nature of participation*
   Farmers give information
   Farmer-managed on farm trials
   Farmers evaluate new varieties on their farm, in their village, in other villages
10. *Method of involving farmers and types of output anticipated*
    One field worker in each village, inviting expert farmers for group discussions on local varieties
    Farmers were given 1kg seed per variety, one variety per farmer
    Four times during the season farmers' preferences were studied (<u>need more detail of method for eliciting and comparing preferences</u>)
    Only one year reported
11. *Summary of breeding methods used*
    Variety evaluation, post release, pre-extension
12. *Summary of results/experiences/impacts and products to date*
    In the two zones, different varieties preferred - related to differences in rainfall, and marketing of produce.

Women had different preferences at processing stage than men at harvest stage.
Gender and region determine which local varieties are growing.
Most farmers grow several varieties.
Program extended to sorghum and rice.

13. *Documentation/references*

Defoer, T., A. Kamara, and H. deGroote. 1997. Gender and variety selection: Farmers' assessment of local corn varieties in southern Mali. African Crop Science Journal 5(1):65-76.
Kamara A., T. Defoer, and H. deGroote. 1996. Selection of new varieties through participatory research, the case of corn in South Mali. Tropicultura 14(3):100-105.

14. *Contact addresses*

A. Kamara, IER, Bamako Mali
T. Defoer, H. deGroote, KIT, Mauritskade 63 1092 AD Amsterdam, The Netherlands. E-mail: T.Defoer@wanadoo.fr

15. *Comments*

Only one year data
What is continuing?
Sorghum work with CMDT and ICRISAT is continuing, and shall be developed further.
High input area (irrigation, cotton farming)
Strong support from strong local organization CMDT, with village workers in many places

Case 18: CIAT—Beans in Tanzania

1. *Title*

Tanzanian Bean Research Program qualitative on-farm and quantitative on-station varietal evaluation

2. *Institutions*

CIAT and DRT-MOA in Tanzanian Bean Research Program, plus collaborating agencies including Heifer Project International and the Tanzanian Extension Service

3. *Country/region(s)*

Tanzania

4. *Year project began/Dates*

1992-1996

5. *Researcher(s) involved*

Wayne Youngquist and Clemence Mushi

6. *Farmers involved*

With 220 farmers; organized by collaborating field institutions into groups of four with one contact farmer, both men and women (who do most of the bean farming in Tanzania)

7. *Crop(s)*

Beans (*Phaseolus vulgaris*)

8. *Main objectives for pursuing farmer participation*

Elicit farmers' qualitative criteria to improve acceptance of beans in national breeding program, develop a lower cost method to incorporate farmer expertise, and utilize farmers as an integral part of varietal selection to improve the national bean program's ability to release varieties with good characteristics, which include farmer acceptability. On-farm qualitative varietal assessment under farmer management

9. *Nature of participation*
   PVS (participatory varietal selection) in advanced yield trials; understand farmer preferences in qualitative traits
10. *Method of involving farmers and types of output anticipated*
   Farmers grew four-five varieties (250 seeds of each) of 16 lines midway through the evaluation process (in advanced yield trials) on their own farms and under their management practices. A technician visited three times to distribute seed, during flowering to evaluate each line, and after harvest to obtain farmer evaluations via survey on farmers' choices and reasons. There were 177 farms assessed over 3 years. Yield was the most important farmer-cited criterion in preferring varieties, but yield did not correlate to the rank order determined by the farmers. Rather, days to flower and canopy height were favored.
11. *Summary of breeding methods used*
   Width and seed coat color were the traits that correlated most highly with the farmers' selections. Farmers are concerned about yield, but characteristics important for seed quality and high market value are relatively more important.
12. *Summary of results/experiences/impacts and products to date*
   This method proved to be an effective and low cost procedure for eliciting information useful to the breeding program and would permit reducing the size and number of locations of the high cost yield trials.
13. *Documentation/references*
   Youngquist, Wayne and Clemence Mushi. Relationship between qualitative on-farm and quantitative on-station bean variety evaluations. (complete citation?) (other publications?)
14. *Contact address*
   Wayne Youngquist, 1929 Devoe Dr., Lincoln, NE, 68506, USA. E-mail: W.Youngquist@cgiar.org

Case 19: ICRISAT—Farmer selection on-station in Niger

1. *Title*
   On-station farmer participatory varietal evaluation with pearl millet
2. *Institutions*
   ICRISAT
3. *Country/region(s)*
   Niger, near Niamey
4. *Year project began/Dates*
   1994

5. *Researcher(s) involved*
   J. Baidu-Forson
6. *Farmers involved*
   Total of 30 farmers from six villages
7. *Crop(s)*
   Pearl millet (*Pennisetum glaucum* (L.) R.Br.)
8. *Main objectives for pursuing farmer participation*
   Understand farmers selection criteria
   Identify superior varieties for on-farm testing
9. *Nature of participation*
   Farmers interviewed
10. *Method of involving farmers and types of output anticipated*
    Farmers visited research station once, structured questionnaire used for each participant
    Each participant was given 2 kg of seed for processing of all varieties at their home
    Follow-up with a second questionnaire
11. *Summary of breeding methods used*
    On-station trial with large plots with four replications
12. *Summary of results/experiences/impacts and products to date*
    Preferred plant type identified, no differences between villages/regions where farmers came from
    Clear gender differences related to processing qualities, implications not discussed
13. *Documentation/references*
    Baidu-Forson, J. 1998. On-station farmer participatory varietal evaluation: A strategy for client oriented breeding. Experimental Agriculture 33:43-50.
14. *Contact addresses*
    K. Anand Kumar ICRISAT Sahelian Center, B.P. 112404, Niamey, Niger
15. *Comments*
    Interesting statistical analysis
    One-time off study?
    Where these selected varieties actually tested on farmers' fields? With the same farmers, other farmers?
    Similar work with groundnut done, including other farming system interventions.

Case 20: CIAT/ISAR—Beans in Rwanda

1. *Title*
   Local Rwandan bean expertise in on-station, on-farm, and community-based varietal assessment
2. *Institutions*
   ISAR (Institut des Sciences Agronomiques du Rwanda), CIAT, COOPIBU (NGO), women's cooperative, Local-level Government Agricultural Extension Units, independent, self-organized farmer research groups, foreign-sponsored development projects (eg. Projet Kigali Nord, Project Agricole de Gikonogoro)

3. *Country/region(s)*

   Rwanda: Northern, Central, Southcentral and Southwestern Rwanda. Some 10 farming communities and three main research stations, at low, mid, and high altitude.

4. *Year project began/Dates*

   Phase I: 1988-90; Phase II: 1990-93

5. *Researcher(s) involved*

   NARS researchers/agronomists (main ones): Pierre Nyabyenda, David Cishahayo; Gaspard Gasana

   NARS technicians (main ones): Beatrice Ntabomvura, Leontine Uwimana

   CIAT team: Urs Scheidegger, Louise Sperling, Jeremy Davis, Robin Buruchara, Luis Camacho. (M. Loevinsohn helped with the analysis)

6. *Farmers involved*

   Phase I: 90 local bean experts, mostly older women; Phase II: community-selected representatives; reached up to 27,000 households.

7. *Crop(s)*

   Bush beans (*Phaseolus vulgaris*)

8. *Main objectives for pursuing farmer participation*

   Phase I: Early, more cost-efficient acceptability testing of varieties to be released, increased number of promising varieties offered to farmers, identification of varieties with higher on-farm yields, decentralization of varietal screening, increased compatibility of new varieties with local varietal mixtures (support biodiversity), improved farmer access to research, influence of general bean research priorities (e.g., climbers or bush beans) and specific directions (e.g., growth habit, earliness)

   Phase II: Further reduced testing; early screening/eliminating losers; shifting adaptive testing to communities themselves. Enhancement of site-specific adaption (crucial in this country of many many microniches). Identification of institutional models to scale up decentralized selection. Identification of institutional models to link decentralized selection with decentralized seed multiplication (e.g., the women's cooperative work in Rwanda—and substantial work in Kivu, Zaire). Collection of comparative cost/efficiency data: classic breeding program vs. participatory schema. Increased control and responsibility to communities for their preferred decentralized testing and selection (empowerment).

9. *Nature of participation*

   Phase I: Consultative/collaborative. Farmers select and test varieties of their own choice. Local methods of experimentation respected. On-station early screening of 15 cultivars and home testing of their two-three selected varieties, two-four seasons before normal on-farm testing.

   Phase II: Goal to shift decision-making to communities. Station considered as 'varietal supermarket' in which communities

choose what looks promising and then control all subsequent testing, including diffusion. Note: this worked well with the cooperative and, in a very manipulative manner, when under the government agronomist).
Community selection of expert representatives and emphasis in devolution of local trials, five-seven seasons before normal on-farm testing.

10. *Method of involving farmers and types of output anticipated*

Very different methods of varietal evaluation tested.

Phase I: Farmers scored preferred varieties and expressed their criteria; home testing and subsequent follow-up to assess incorporation of new varieties into mixtures. Evaluation methods designed to get quantitative assessments and analysis of specific criteria. First set of scoring methods designed to feedback to formal breeding program and radically influence breeding directions of NARS.

Phase II: Second set of evaluation methods designed for farmers —transparent use of ribbons, clustering of 'like' varieties in trial plots for direct visual comparisons; qualitative assessments to allow for screening large numbers relatively quickly. Aim to improved community capacity to screen larger numbers of cultivars. In terms of varietal assessments, researchers found that there is a trade-off between those that feedback to research and those which can feed-forward to the community. The first also tends to be more individualized/quantitative, while the latter facilitates communication among evaluating farmers themselves as well as to their broader constituency/ communities and tends to be more qualitative (or less specifically quantitative) as well as group oriented.

Output expected phase I:

- Understanding of technical division of labor: breeders/ farmers
- More varieties, better adapted, earlier
- Feedback to research/refining research program

Output expected, phase II.

- Cost/efficiency data: classic vs. participatory programs
- Institutional models for decentralization (and comparison of these)
- First trials to link decentralization with seed multiplication
- Community empowerment: skill building, greater control of selection, testing and diffusion

11. *Summary of breeding methods used*

Phase I: Farmer experts evaluated 15 trials in the last stage of on-station testing at flowering and physiological maturity; two-three selected varieties were then tested at home in pure variety stands under normal local trial management conditions. Later studies analyzed on-farm survival rate of farmer-selected cultivars.

Phase II: Community representatives of local groups selected 20-25 cultivars on-station from researchers' 'largest reduced-risk pool' which were then tested in community plots and reviewed by 30-50 farmers.

Other key analyses:

- Farmer selection: Comparison of 'experts' vs. community representatives (purposive selection vs. popular selection)
- Evaluation formats: comparison of different formats (see above)
  - Individual vs. group
  - Qualitative vs. quantitative
  - Researcher vs. farmer oriented
- Trial design in community: comparison of advantages/ disadvantages of:
  - Centralized community plots
  - Decentralized (e.g., on individual farms) trials, walking tours
- On-station: varietal 'pools', comparisons of:
  - Experiments starting with breeding/adaptation pools of various sizes;
  - Experiments starting with breeding/adaptation pools vs. disease nurseries
- On-station trial designs: comparisons of:
  - Sowing varieties in lines vs. clustering in boxes
  - Experiments comparing farmer evaluation of less vs. more fertile soils

12. *Summary of results/experiences/impacts and products to date*

Overview

Phase I: Farmers selected for a range of characteristics in diverse conditions, including early maturity, yield, performance in heavy rain or under bananas; they generally agreed on varietal performance with some regional and niche differences. Farmers predicted which varieties seen on-station would perform well at home in mixtures with greater success than breeders. Follow-up studies indicated that farmer-selected varieties continued to be grown on farms in new or incorporated into existing mixtures.

Phase II: Communities moved toward diverse preferences in their selection. Challenges in involving truly representative experts became evident in some areas, while other groups began to multiply seed in quantity.

Specifics

'Breeding'/variety results:

- Feedback to research: general farmer criteria, recognition of diversity by zone
- Performance of farm: more varieties identified (more stable?), more productive varieties; farmers get varieties sooner

Indication of possible cost/efficiencies

- early elimination of losers
- identification of winners earlier (less on-station testing)
- greater range identified (new biodiversity)
- compatibility with local cultivars promoted (protection of 'old' biodiversity)
- shifting of adaptive testing to communities
- more overall adoption (more varieties find microniches)

Institutional results

Better understanding of technical divisions of labor in Rwanda between formal breeders and farmers. Note: these will vary by context, by expertise of farmer, by 'severity' of environment. Also note: the 'best' technical division may not be the one which empowers farmers the most, or which costs the least.

Comparison of organizational models for decentralization

The government R&D system had most/easiest potential for scaling up, but it empowered farmers the least and had no side effect of seed multiplication.

The women's group had the best internal community links and seed multiplication spin offs, but existed in only one location.

The self-selected farmers' research group had the best technical results, but little scaling up and almost no links to seed multiplication.

Failed attempts to get cost/benefit comparisons of classic vs. participatory models. Trial design solid, but war/genocide broke out 1994 as the final variety comparisons were going into controlled plots.

13. *Documentation/references*

Sperling, L. and J.A. Ashby. 1999. Moving participatory plant breeding forward: The next steps. In: Collinson, M., ed. The history of farming systems research.

Sperling, L. and J.A. Ashby. 1997. Participatory plant breeding: Emerging models and future development. In Tripp, R., ed. New seeds and old laws. London: Intermediate Technology Publications.

Sperling, L. and U. Scheidegger. 1995. Participatory selection of beans in Rwanda: Results, methods and institutional issues. Gatekeeper Series No. 51. London: International Institute for Environment and Development.

Sperling, L. and P. Berkowitz. 1994. Partners in selection: Bean breeders and women bean experts in Rwanda. CGIAR Gender Program. Washington, D.C.: Consultative Group on International Agricultural Research.

Sperling, L., M.E. Loevinsohn, and B. Ntabomvura. 1993. Rethinking the farmer's role in plant breeding: Local bean experts and on-station selection in Rwanda. Experimental Agriculture 29:509-519.

Sperling, L. 1992. Farmer participation in the development of bean varieties in Rwanda. In: Moock, J. and R. Rhoades, eds. Diversity, farmer knowledge and sustainability. Ithaca, New York: Cornell University Press.

14. *Contact addresses*

Rwanda: Beatrice Ntabomvura/Leontine Uwimana, ISAR, c/o B.P. 259, Butare, Rwanda (senior researchers involved are dead or in exile)

Others: L. Sperling, CIAT, A.A. 6713, Cali, Colombia

Urs Scheidegger, Swiss College of Agriculture, Langgasse 85, 3052 Zollikofen, Switzerland

Robin Buruchara, CIAT/Eastern and Central Africa Bean Research Network, P.O. Box 6247, Kampala, Uganda

15. *Comments*

Institutional considerations; division of labor

Farmer selector analysis

Model for comparing cost-effectiveness of classic vs. participatory breeding

Case 21: ICRISAT—Pearl millet in Rajasthan, India

1. *Title*

Participatory breeding and farmers' management of genetic resources of pearl millet in Rajsthan, India

2. *Institutions*

ICRISAT, India; Central Arid Zone Research Institute (CAZRI), India; Rajasthan Agricultural University; Grameen Vikas Vigyan Samiti (GVVS); Social Work and Research Centre (SWRC) Tilonia; URMUL Trust, Bikaner and Nokha; Department of Watershed Development, Government of Rajasthan, Jaipur, India

3. *Country/region(s)*

Jodhpur, Bikaner, Ajmer, and Barmer districts, Rajasthan, India

4. *Year project began/Dates*

1992-2000

5. *Researcher(s) involved*

E. Weltzien R., M.L. Whitaker, M. Dhamotharan, H.F. Rattunde, K. vom Brocke, A. Christinck, M.M. Anders, and O.P. Yadav

6. *Farmers involved*

15-30 farmers from each of six villages, four villages continuously chosen (1992-1996) from a census of all farmers from each village, based on a stratification by landholding size.

Farmers who are interested in testing new seeds

1995-1997: Many farmers from three villages in western Rajasthan for seed system analysis

1997/98: 800 farmers in 18 (?) villages/groups of villages for analysis of key issues in seed management and germplasm collections

1994-1999: A total of 28 farmers from four villages (same as above) for study of farmer breeding

7. *Crop(s)*

   Pearl millet (*Pennisetum glaucum* (L.) R.Br.)

8. *Main objectives for pursuing farmer participation*

   Increase efficiency of breeding program (preferences, needs, variety evaluation, develop options for PPB selection strategy for the region

   Create basis for more rapid flow of improved germplasm

9. *Nature of participation*

   Farmers conduct trials, evaluate varieties grown on their farm, on other farms, on research station, contribute seed to a trial, participate in workshops and group discussions.

10. *Method of involving farmers and types of output anticipated*

    Access to villages through local organizations

    In each village one-two persons hired as village investigators, who maintain contacts with all participating farmers, maintain notes on crop management of individual farmers' experiments, administer interview schedules, relating to farming conditions and environment of each experiment.

    Each farmer receives 1 kg of one experimental variety.

    Experimental varieties used only (initially) as a reference point in discussions about preferences, so expose farmers to newly available traits, i.e. earliness, very large grain size.

    Individual discussions with farmers growing trials

    Group discussions with farmers growing trials, visiting plots of all varieties

    Group discussions with farmers not growing trials

    Group discussions with men and women farmers

    Variety evaluation on station with men and women farmers

    Village level workshops with farmers and scientists interacting on a specific topic

    Farmers contributing seed from their own farms

11. *Summary of breeding methods used*

    Understanding farmers' preferences

    Identifying constraints to productivity

    Understanding farmers' seed management strategies

    Supporting farmers seed management efforts

    Testing new experimental varieties

    Developing basis for participatory population improvement

    Develop model for in-situ conservation.

    Farmer visit on-station to evaluate experimental varieties to understand preferences

    Evaluate genetic gains from farmers' selection

12. *Summary of results/experiences/impacts and products to date*

    Farmers' preferences cover a very wide range of traits

    Farmers interested in a range of varieties

    Clear differentiation between farmers who own good and those owning poor (and less) land

    Women's preferences consider household food needs more strongly

Some expert farmers utilizing new germplasm very effectively
Good understanding of local selection practices, seed maintenance, seed exchange among farmers
Procedure for evaluating new experimental varieties under the conditions for sowing in western Rajasthan

13. *Documentation/references*

Weltzien R.,E., M.L. Whitaker, H.F.W. Rattunde, M. Dhamotharan, and M.M. Anders. 1998. Participatory approaches in pearl millet. In: Witcombe, J.R., D.S. Virk, and J. Farrington, eds. Choice of seed: Making the most of new varieties for small farmers. New Delhi: CAZS and DI by Oxford IBH and London: Intermediate Technology Publications.

Weltzien R.E., M.L. Whitaker, and M.M. Anders. 1996 Farmer participation in pearl millet breeding for marginal environments. In: Eyzaguirre, P. and M. Iwanaga, eds. Participatory plant breeding. Proceedsings of a workshop on participatory plant breeding, 26-29 July 1995, Wageningen, The Netherlands. IPGRI, Rome, Italy.

Weltzien, R.E., M.L. Whitaker, and M. Dhamotharan. 1996. Diagnostic methods for breeding pearl millet with farmers in Rajasthan. In: Sperling L. and M. Loevinsohn, eds. Using diversity—Enhancing and maintaining genetic resources on-farm. International Development Research Centre (IDRC), New Delhi, India.

14. *Contact addresses*

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K. vom Brocke, A. Christinck, H.H. Geiger, and V. Hoffmann, University of Hohenheim, Stuttgart, Germany

M.L. Whitaker, 76236 Highway 1081, Covington, LA 70435, USA. Tel: +1 (504) 8931736, E-mail: M.Whitaker@cgiar.org

M. Dhamotharan, Zeppelinstr. 41, D 65121 Heidelberg, Germany. Telefax: +49 (6221) 419245

15. *Comments*

Project evolution strongly influenced by social scientists

Case 22: CIP—Potatoes, East Africa

1. *Title*

Farmers' diverse potato criteria in east Africa

2. *Institutions*

CIP

3. *Country/region(s)*

East Africa: Rwanda, also Burundi and Kenya?

4. *Year project began/Dates*

1985-?

5. *Researcher(s) involved*

Angelique Haugerud, others?

6. *Farmers involved*
   Smallholders (M/F?); 186 farmers interviewed
7. *Crop(s)*
   Potato (*Solanum tuberosum*)
8. *Main objectives for pursuing farmer participation*
   Boost productivity of smallholders and improve research responsiveness to their needs. (1990). It is less effective for researchers to seek optimal ways to grow crops and expect farmers to adjust than to have a client-oriented approach in research.
9. *Nature of participation*
   Survey
10. *Method of involving farmers and types of output anticipated*
    Survey on farming systems issues: production, consumption, storage/marketing and household dynamics.
11. *Summary of results/experiences/impacts and products to date*
    Survey showed agricultural practices and highlighted 16 cultivar qualities of interest to farmers in potatoes, but relative significance should be disaggregated by region, altitude, climate, intercropping, wealth, end use, markets, etc. Farmers use diversity to address different needs and constraints in their production and use. For maturity classes, land and labor availability, rainfall distribution and reliability, and farmer wealth were determinants of optimal maturity classes.
12. *Summary of results/experiences/impacts and products to date*
    Highlighted program needs for short-duration and short-dormancy cvs to address land constraints; varieties suited to intercropping and cv mixtures; and reduction in regional biases in screening/selection and access to improved seed. Possibly 20% of regional names are synonyms across agroecological zones in Rwanda. Evaluations alongside farmers showed that researchers had too narrow criteria, that farmers accepted more than what had been presumed.
13. *Documentation/references*

    Haugerud, A. 1985. Farmers' criteria in selection and use of potato cultivars. Paper prepared for Regional Potato Germplasm Course, Nairobi, June 10-25, 1985.

    Haugerud, A. 1987. Social science and the management and selection of agricultural technology in Rwanda. Paper prepared for proceedings on the workshop The Role of Social Science in Managing Agricultural Technology, Pakistan, September 24-27, 1986.

    Haugerud, A. and M.P. Collinson. 1990. Plants, genes and people: Improving the relevance of plant breeding in Africa. Experimenal Agriculture 26:341-362.

14. *Contact addresses*

    Angelique Haugerud. E-mail: ahaugeru@du.edu

15. *Comments*
    *Preferences vary by farm size, family structure, gender, wealth, market opportunities, etc.

*Institutionally: CIP/Rwandan program very successful. In its first 5 years, released six improved cvs with high yields under no-external-input conditions (no fertilizer nor fungicide, yielding two-five times the previous national average), with tremendous acceptance by farmers. Success due to germplasm screening without fertilizers or fungicides, recognizing that farmers' only commercial inputs could be occasional seed purchases. Two re-released varieties found countrywide 5 years later.

1987: Comments on national research priorities imposed by bureaucratic elites, not by relative need of marginal zones. How to escape that as an IARC?

Do not overestimate extent and degree of choice by smallholders' limiting access, resources.

LSM: Again, a case of farmers maintaining cvs for sale (high water content) and cvs for consumption (high dry matter/starch content). Long and short cycles and their economic/food/land use implications (1985). Farmers often choose lower if faster yields, also in beans, pigeon pea, sorghum?, maize; farmer rationale on needs vs. researchers total-yield-only view. Importance of yield stability over time rather than maximal yield.

Bioscientists don't know how to operationalize getting farmer feedback.

Participatory research is a two-way flow, visiting each other's fields; even using station laborer-farmers in assessments was found very useful. While breeders cannot solve every problem in farmers' production circumstances, identification and ranking of producer/user-important traits can guide their selection. Scientists need to be willing to spend time in the field and learn directly from farmers, and not view farmers who do not 'follow orders' as problematic, but responding to their reality. Need to include social scientists in research design.

Case 23: Cassava CIALs in Northeast Brazil

1. *Title*

Ecologically sustainable cassava plant protection in South America and Africa: An environmentally sound approach (called PROFISMA in Brazil)

2. *Institutions*

CIAT and CNPMF coordinated; involved also three other EMBRAPA agencies, five Brazilian state research agencies, four Brazilian state extension agencies, four Brazilian universities, and IITA.

3. *Country/region(s)*

Northeast Brazil (West Africa work not reported here): states of Bahia, Ceará, Pernambuco, Paraíba

Tropical, rain-fed, low rainfall, low soil fertility, poor, calorie deficit, <2 ha farms, poor infrastructure

4. *Year project began/Dates*
   1993-1997 (only two crop cycles)
5. *Researcher(s) involved*
   B. Ospina, L. Smith, A. Bellotti (CIAT)
   30 Brazilian extensionists and 12 Brazilian researchers
6. *Farmers involved*
   Survey: 1672 farmers in 72 communities in four states
   Intensive survey in 18 communities where CIALs established (represent different priority problems)
   25 CIALs involving 300 farmers
7. *Crop(s)*
   Cassava
8. *Main objectives for pursuing farmer participation*
   Productivity increase: alleviate poverty, increase food security by increasing sustainable productivity through IPM, ICM, biological control using farmer participatory research (FPR) methods
   Cost efficiency: facilitate adoption of improved technology
9. *Nature of participation*
   Survey respondents
   Local Agricultural Research Committees (CIALs = four locally elected farmers, conduct FPR experiments, $400 rotating fund, one-two problems studied, farmers and FPR trainers evaluate results)
   CIALs visited each other and EMBRAPA cassava research station, some served as training/demo sites
10. *Method of involving farmers and types of output anticipated*
    Goals identification
    Testing experimental varieties
    Anticipated outputs: “Increase cassava yield, decrease soil deterioration, help increase rural prosperity, and increase the capability of NARS scientists and extensionists to solve production problems”
11. *Summary of breeding methods used*
    Generally, variety comparisons in one or more management systems
12. *Summary of results/experiences/impacts and products to date*
    Farmer survey showed top constraints to cassava production, but some priorities were “outside the scope of the project” (project focus was pest management)
    Putative root rot resistant variety failed; some other variety trials revealed promising new varieties
    Breeders identified good source materials among farmer varieties
    Not enough of farmers’ observation and opinions on different varieties had been recorded
    Need for elastic market development incorporated into future funding proposals
    Initially, researchers skeptical of FPR (increase in work load without compensation), extensionists enthusiastic (got

funding for travel to field sites, elevated their professional status)
More influential at individual than institutional level
Farmer groups organized; define, prioritize, communicate needs; collaborate with research, extension

13. *Documentation/references*
Ospina, B., L. Smith, and A. Bellotti. 1997. Adaptation of farmer participatory research methods for developing integrated crop management in cassava-based systems in northeast Brazil. Internal Workshop: CIAT's Experience with Systems Research and Future Directions, December 1-2, 1997.
14. *Contact addresses*
Tony Bellotti, CIAT, Apdo. Aéreo 6713, Cali, Colombia. Tel: +57 (2) 4450000, E-mail: A.Bellotti@cgiar.org
15. *Comments*
Funded by UNDP
Only six CIALs' experiments tabulated (five involved a variety comparison)

Case 24: Participatory maize breeding in Honduras

1. *Title*
Conservation and enhancement of maize with small farmers in Honduras
2. *Institutions*
Escuela Agrícola Panamericana (Zamorano), Cornell University
3. *Country/region(s)*
Honduras: Galeras, Morocelí
4. *Year project began/Dates*
1993-1997
5. *Researcher(s) involved*
Francisco Gómez (Zamorano), Margaret Smith (Cornell)
6. *Farmers involved*
Initial survey of ?? farmers
Four farmer collaborators involved in on-farm PPB (all men, smallholders)
75 farmers participated in training workshops between 1993-97 (mostly men)
1995 course: 14 smallholder farmers from six departments, ages 18-82, 36% use improved varieties
7. *Crop(s)*
Maize
8. *Main objectives for pursuing farmer participation*
Productivity increase
Germplasm conservation (biodiversity)
9. *Nature of participation*
Farmers responded to survey on varietal needs
Farmer-collaborators contributed seed of their own varieties for improvement, made plant and ear selections and worked

with breeders to make pollinations for on-farm PPB, evaluated varieties

Farmers participated in maize breeding workshops

10. *Method of involving farmers and types of output anticipated*

Goals identification, selecting in variable materials, knowledge transfer

Anticipated outputs: Improved versions of local maize varieties, *in situ* conservation of unique local maize germplasm

11. *Summary of breeding methods used*

Mass selection with pollination control on-station (using criteria elicited from the farmer survey)

Mass selection with pollination control on-farm, with farmer choice of plants to pollinate, ears to save

On-farm evaluation of original and improved cycles of selection with farmer-collaborators

12. *Summary of results/experiences/impacts and products to date*

Workshop participants improved knowledge of maize breeding based on before vs. after test scores.

Many workshop participants passed on knowledge to other farmers, and a number fabricated their own pollinating bags to make controlled crosses for improving their own varieties.

Survey of 31 former workshop participants indicated that all were practicing plant selection in addition to selection of ear and grain traits, and 60% were using some form of pollination control.

Workbook produced for use in farmer-training workshops ("Conservation and Enhancement of Maize Landraces with Small Farmers").

On-farm and on-station selection showed improvement in grain yield and ears per plant after one selection cycle but in cycle two values of both traits decreased slightly (inbreeding depression?).

NGOs have found the training workshop and workbook to be useful tools.

13. *Documentation/references*

Gómez, F. 1996. Conservation and enhancement of maize with small farmers in Honduras. 1995. Annual Report of collaborative project between Escuela Agrícola Panamericana Zamorano and Cornell International Institute for Food, Agriculture and Development (CIIFAD)

Maize breeding with smallholder farmers in hillside cropping systems. 1995 (?). p. 43-44 in CIIFAD 1995 Annual Report.

14. *Contact addresses*

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Tel: +1 (607) 2551654, Fax: +1 (607) 2556683,
E-mail: mes25@cornell.edu

15. *Comments*
    Need to check on 1996 CIIFAD Annual Report. Add theses to documentation?

Case 25: Cow/horse (large animal) breeding in Germany

1. *Title*
    No specifc case analysed, general type of organization, as a possible model for interaction between breeders and scientists
2. *Institutions*
    Breeder associations for a particular breed, University scientists, state government officials(?)
3. *Country/region(s)*
    Germany, similar in other European countries
4. *Year project began/Dates*
5. *Researcher(s) involved*
    University researchers, scientists employed at national level of the breeders association
6. *Farmers involved*
    Farmers are the breeders in the case of large animals.
7. *Crop(s)*
    Cows, horses
8. *Main objectives for pursuing farmer participation*
    To increase productivity and other agreed goals of breeding, as well as specific goals of each farmer. Through appropriate analysis of progeny trials, farmers can know better the breeding value of specific males for a range of traits.
9. *Nature of participation*
    Farmers become members of an association for breeding registered animals of a specific breed, e.g. Holstein Friesian cows. Farmers maintain a herd of female breeding animals for milk production and generating off-spring with a high value. The breeding association has district, state, and national committees, to which individual farmers are elected/selected (?). These committees decide on the overall breeding goals for the particular breed, and organize the evaluation of individual animals (e.g., at district, state and national animal fairs, through standardized record keeping and the analysis of progeny trials). Scientists develop genetic models for the analysis of such data, and improve the benefit that can be derived from coordinated data collection and record keeping. Individual farmers get regularly updated information on the breeding values of indivdual male animals, and choose to improve their own herd in a specifc direction.
10. *Method of involving farmers and types of output anticipated*
    Role of stud centers (semen banks) to be clarified
11. *Summary of breeding methods used*
    Details for selection procedures at the different stages (i.e., growth stages of the animals, and administratively) yet to

be received. These methods and the strictness with which policies have to be followed vary from association to association (i.e., breed to breed). For very local breeds that are threatened by extinction, farmers interested in maintaining them have formed associations that are small enough to work on the basis of regular meetings. They are usually not big enough to warrant contracted researcher input for developing selection indices and estimates of breeding values for male animals. Selection procedures for males are also less stringent, as effective population size, and consequent problems with inbreeding are a key concern.

12. *Summary of results/experiences/impacts and products to date*
    For the important breeds, very impressive progress could be achieved. Problems that arise are related to different farmers differing needs/preferences for varying levels of robustness as adaptation to different levels of intensification, e.g., udder health, hoof health
13. *Documentation/references*
14. *Contact addresses*
15. *Comments*
    So far only from oral communications with E. Zerbini (ILRI) and G. Gliem, Noervenich, Germany, A. Christinck, Hohenheim, Germany
    More detailed analysis may be helpful in the discussion of institutional arrangements for PPB.

Case 26: CIP, Peru—The friendly potato

1. *Title*
   Farmer selection of potato varieties for all occasions
2. *Institutions*
   CIP, INIAA-CIP-COTESU Seed Project?
3. *Country/region(s)*
   Peruvian Andes: five locations in the Mantaro, Cunas, and Yanamarca valleys, 3550-4000 masl
4. *Year project began/Dates*
   1987?-?
5. *Researcher(s) involved*
   Gordon Prain, Fulgencio Uribe, Urs Scheidegger
6. *Farmers involved*
   Smallholders; selected for previous good working relationships, variety interest; in one case, a group rather than individual; women/men? (no mention)
7. *Crop(s)*
   Potato (*Solanum tuberosum*)
8. *Main objectives for pursuing farmer participation*
   Improve relevance of researched varieties to entire food system; incorporate farmer criteria into the breeding process.

9. *Nature of participation*
   Testing experimental varieties (at what stage in testing process?). Trials of CIP and National Potato Breeding Program materials (CIP nematode and frost/late blight programs). Fifteen varieties? Were these released or pre-released lines?
10. *Method of involving farmers and types of output anticipated*
   Farmers selected fields, designed and planted trials. Researchers visited every 2-3 weeks to discuss performance. Farmers recorded observations in their own notebooks and visited neighboring farmers' plots. Group evaluations were conducted throughout as well and farmers received a summary of their comments through the season.
11. *Summary of breeding methods used*
   Strong GxE; station results not good predictors of farmers' field choices. Farmers used 39 evaluation criteria divided into seven categories. Modern varieties are grown as cash crops, so farmers judged yield on quality/price potential of tubers as well as quantity; there's a 60%->100% price differential from first to second size potatoes. (Do breeders ever use this form of judging yield, i.e., 'income per hectare'?) Varietal uniformity was important to farmers for the purpose of clear identification. Those that produced adequate seed tubers were also preferred.
12. *Summary of results/experiences/impacts and products to date*
   Conclusion: Yield under optimum conditions is a very poor indicator of likely adaptability or acceptability. Farmers seek a range of varieties which respond to various needs; they do not seek one perfect variety. The complexity of ecology and economy is reflected in diverse criteria; breeders cannot satisfy all the criteria; offer instead (Chambers') baskets of options and let farmers decide.
13. *Documentation/references*
   Prain, G., F. Uribe, and U. Scheidegger. Date? 'The friendly potato': Farmer selection of potato varieties for all occasions.
14. *Contact addresses*
   Gordon Prain. E-mail: G.Prain@cgiar.org
15. *Comments*
   Again, earliness. Farmers said 'it is acceptable to produce less if it is earlier.'

   Actual field techniques used to elicit rankings? Was this done with group consensus, or a composite of season-long interviews? At what stage?

   Unique: criteria - desired level; implication/explanation - importance in subsistence or marketing scheme excellent. Recommend that others use such a complete framework.

   In farmer experimentation, temporal (rather than spatial) replications are considered more relevant.

Case 27: Beans in Ethiopia

1. *Title*
   PVS in bean evaluations in eastern Ethiopia
2. *Institutions*
   AUA (Alemaya University of Agriculture) and Ethiopian MoA
3. *Country/region(s)*
   Eastern Ethiopia
4. *Year project began/Dates*
   1992-1995
5. *Researcher(s) involved*
   Frew Mekbib, others?
6. *Farmers involved*
   For on-farm testing: four farmers from each of seven areas (total of 28?), selected at random representative bean producers by extensionists of AUA or MoA; 98 farmers interviewed (random sampling) in one region on selection criteria;
   50 farmers evaluated 50 genotypes on-station at AUA; men/women?
7. *Crop(s)*
   Export and local food beans (*Phaseolus vulgaris*). Bush?
8. *Main objectives for pursuing farmer participation*
   Increase adoption of released lines by eliciting farmer criteria for acceptance.
9. *Nature of participation*
   Listed criteria for selection and preferred characteristics; tasted samples of each entry on-station; evaluated lines grown on-farm under farmer management.
10. *Method of involving farmers and types of output anticipated*
    PVS on promising lines selected on the basis of performance in yield trials, better understanding of farmer criteria as feedback for breeding program.
11. *Summary of breeding methods used*
    Interviewed for and ranked 19 farmer criteria to develop preferred regional ideotypes; farmers intercropped the beans with sorghum and made observations during the cycle, with final interviews in evaluation.
12. *Summary of results/experiences/impacts and products to date*
    Two lines had superior performance both on stations and on the farms of one region. Criteria varied greatly by region and season of cultivation. Researchers developed detailed composite ideotypes for each region by season to use in future selection decisions.
13. *Documentation/references*
    Mekbib, F. 1997. Farmer participation in common bean genotype evaluation: The case in eastern Ethiopia. Experimental Agriculture 33:339-408.
14. *Contact addresses*
    Frew Mekbib, Alemaya University of Agriculture, P.O. Box 138, Dire Dawa, Ethiopia. E-mail: alemaya.univ@telecom.net.et

15. *Comments*
    Did on-station selections translate into on-farm trials? What varieties were tested on-farm? Ideotypes, regional and seasonal.

Case 28: Farming Systems Unit/Zimbabwe

1. *Title*
   Experiences from participatory research and potential for participatory plant breeding in the communal areas of Zimbabwe
2. *Institutions*
   Farming Systems Research Unit, Zimbabwe
3. *Country/region(s)*
   Zimbabwe (no more detail given)
4. *Year project began/Dates*
   ?
5. *Researcher(s) involved*
   Chinaniso Chibudu
6. *Farmers involved*
   ? - Groups of 10-15 for maize variety trials
7. *Crop(s)*
   Groundnut, maize
8. *Main objectives for pursuing farmer participation*
   Productivity increase via involvement of farmers in problem diagnosis, technology testing, evaluation
9. *Nature of participation*
   Participatory rural appraisal for problem definition
   Collective farmer-researcher design of research trials
   Farmers and researchers evaluated varieties
10. *Method of involving farmers and types of output anticipated*
    Goals identification (both general farming systems needs and evaluation criteria for varieties)
    Testing experimental varieties
11. *Summary of breeding methods used*
    Participatory variety selection
12. *Summary of results/experiences/impacts and products to date*
    Some mixing of seed in maize variety trials (not clear whether this means physical mixing before planting or genetic mixing from saving open-pollinated seed for future evaluations)
    Farmers' criteria for variety evaluation identified
    Recommends clarifying farmers' and scientists' roles in PPB
    Farmers should do evaluations according to their own criteria
    Suggests appropriate scientists' roles in PPB as assistance in setting up trials, providing some inputs, suggesting technologies, naming and release of varieties identified through farmer participatory trials, production of breeders' seed for varieties to be released

13. *Documentation/references*
    Chibudu, C. 1996. Experiences from participatory research and potential for participatory plant breeding in the communal areas of Zimbabwe. Paper presented at "Supporting Diversity Through Sustainable Livelihoods: What Are Farmers' Choices", ODI/Sorghum Landrace Study, Workshop for Southern Africa, November 1996.
14. *Contact addresses*
    Chinaniso Chibudu, Farming Systems Research Unit, Box CY 550, Causeway, Zimbabwe
15. *Comments*
    Basically involves participatory variety selection
    Speculations on appropriate farmer and researcher roles is interesting

Case 29: Fortepapa, potatoes, Ecuador

1. *Title*
   User participation in selecting and releasing potatoes in Ecuador
2. *Institutions*
   INIAP, Ecuador
3. *Country/region(s)*
   Ecuador
4. *Year project began/Dates*
   1992-95?
5. *Researcher(s) involved*
   Héctor J. Andrade B., Xavier Cuesta S., others?
6. *Farmers involved*
   Farmers, businesspeople, consumers and agroindustry; some (%?) women evaluated clones. Farmers with commercial understanding (not smallholders?).
7. *Crop(s)*
   Potato (*Solanum tuberosum*)
8. *Main objectives for pursuing farmer participation*
   More effective and timely use of new cultivars; increase flow of information to researchers; methodology more farmer-useful then traditional varietal release; improve cost- and time-efficiency of varietal development; decrease incidence of officially releasing consumer-unsuitable cultivars.
9. *Nature of participation*
   Trials on new clones to assess maturity, eating quality, and resistances in farmers' socioeconomic context. Farmers plan and execute trials. Both rural and urban consumers are also given culinary quality tests. Agroindustrial specifications are considered as well. (Where were varieties grown? On-station? On-farm?)
10. *Method of involving farmers and types of output anticipated*
    Early stage involvement to give broad criteria (open-ended evaluations) and in final stages to give directed opinions (matrix ranking).

11. *Summary of breeding methods used*

Absolute evaluations (scale of one-five) in early stages; criteria-based ranking matrix in the second selection cycle; and open-ended evaluations to record spontaneous reactions. Mini-surveys, written scoring methods and colored flags were used according to farmer literacy.

12. *Summary of results/experiences/impacts and products to date*

Early evaluations dealt with plant size, commercial production, disease response, and tuber color and shape. Later stages indicated commercial importance of and market requirements for tuber color and shapes. In 1992-93, 343 clones were evaluated, 13%-35% selected; 1993-94, 75 evaluated, 29%-52% selected; and 1994-95, 29 evaluated, 50%-67% selected and some varieties were released. Recommend open-ended evaluations (30 clones) to understand criteria in early stages, absolute evaluations (10 clones) in the intermediate stage by farmers, middlemen, consumers, and agroindustries, and detailed users' criteria (six clones) from the four groups in advanced stages. (Why this format? Why not have stage three first?).

13. *Documentation/references*

Andrade B., H.J. and X. Cuesta S. Year? The role of the user in selecting and releasing potato varieties in Ecuador.

Other references?

14. *Contact accresses*

Héctor J. Andrade B., Programa Nacional de Raíces y Tubérculos, Papa del INIAP, Aptdo. Postal 17-21-1977. Fax: +593 (2) 690364, E-mail: andrade@cip.org.ec

15. *Comments*

Unique: Selection by comerciantes included. Industry involvement. Not marginal/smallholders as primary target group (changes over time?).

Easy to have researcher and farmer biases, imposing their criteria. ***From the 1994 Fortipapa Annual report (compendio), what is the report from Cañar, Resistencia a P.i. en campos de pequeños productores en la zona sur? Is this part of the same program as discussed above? Whose work? Interesting: selected yields varied widely!

Case 30: SADC countries and SMIP (ICRISAT)—Pearl millet and sorghum

1. *Title*

Sorghum and millet improvement program, network among southern African countries

2. *Institutions*

ICRISAT (SMIP); Department of Integrated Agricultural Research, Botswana; Department of Agricultural Research, Department of Agricultural Extension, Malawi; Department of Research and Training, Tanzania; Faculty of Agriculture, University of Zimbabwe

3. *Country/region(s)*
   Southern Africa: Tanzania, Malawi, Botswana, Zimbabwe
4. *Year project began/Dates*
   1997(?)
5. *Researcher(s) involved*
   ICRISAT: E.S. Monyo, G.M. Heinrich, A. Obilana, and D. Rohrbach
   Botswana: E. Modiakgotla, E. Makhwaje, C. Manthe, K. Molapong, and M. Abdulai
   Malawi: M. Chintu and M. Kausi
   Tanzania: H. Saadan, S.I. Mndolwa, E. Letayo, and Makali
   Zimbawe: K. Mazvimavi
6. *Farmers involved*
   Botswana: No results yet, ongoing work in the fields.
   Malawi/Tanzania: Extensionists will identify farmer groups to work with Zimbawe: Standard survey sampling techniques planned.
7. *Crop(s)*
   Sorghum, pearl millet
8. *Main objectives for pursuing farmer participation*
   Understand farmers' preferences for individual plant traits, and genotypes ranking
   Improve adoption of modern cultivars, and thus productivity
9. *Nature of participation*
   Farmers are consulted and interviewed.
   Selected farmers grow "Morphologically Diverse Germplasm Nurseries (MDGON).
   Farmers evaluate these nurseries.
10. *Method of involving farmers and types of output anticipated*
   In the planning, documents little about the actual methodology for working with farmers on the questions listed
   Zimbabwe (earlier work): Farmers were asked to tour the diverse nursery, with a scorecard. They were to rate each entry on a one-five scale for listed traits and to write down reasons for their ratings. Later on scientists evaluated the results from these score cards to identify which traits are of importance. Farmers were also allowed to take a panicle from the plot they most preferred after completing the exercise.
   Tanzania: Group interviews with techniques adapted from described PRA techniques
   Zimbabwe: Standard questionnaires on local diversity, product markets, and on diversity and productivity relationships.
11. *Summary of breeding methods used*
   Botswana: Existing modern varieties will be evaluated along with agronomic practices that should help to increase productivity.
   Malawi: Initially farmers will evaluate nursery, especially assembled germplasm for the region; later on such nurseries will be grown by farmers; farmers select varieties for on-farm testing.

12. *Summary of results/experiences/impacts and products to date*

In earlier work from Zimbabwe, most important traits in sorghum varieties were short stature, drought tolerance, earlier maturity, large grain size and grain yield, i.e., yield is not the most important.

While evaluating the nurseries, farmers can only evaluate what they see, but not such hidden traits as disease resistance, or certain qualities, nor can they comment on plant types not grown.

Depending on the growing conditions in a particular year, farmers value different traits and varieties differently.

Preferences may change when market opportunities or other factors in the cropping system change, thus such interactions with farmer should be a regular feature of a breeding program.

It has a number of advantages—not only on a research station, but to grow them also in farmers' fields.

One the biggest changes in the breeding program has been that work is being done now on a range of plant types, not only one ideotype, as is commonly the case.

The work in the other SADC countries is a result of the initial experimentation with this approach in Zimbabwe.

13. *Documentation/references*

Based on approved work plans for SMIP for 1997/98 growing season

ICRISAT Annual Report 1996, p. 76-80.

14. *Contact addresses*

ICRISAT: E.S. Monyo, G.M. Heinrich, SADC/ICRISAT, P O Box 776, Bulawayo, Zimbabwe.
E-mail: E.Monyo@cgiar.org and G.Heinrich@cgiar.org

A.B. Obilana, ICRISAT, Nairobi. E-mail: A.Obilana@cgiar.org

15. *Comments*

SMIP operates in many ways like network, and thus achieves initial forms of institutionalization of farmer participatory approaches. There may be more results than apparent from the work plan document that was used to extract information for this inventory.

Case 31: Cassava in Northeast Brazil

1. *Title*

Pesquisa Participativa em Melhoramento de Mandioca: Una Experiencia no Semi-árido do Nordeste do Brasil

2. *Institutions*

EMBRAPA; EBDA, IPA, EPACE, CPATSA (state agencies); CIAT, IICA/CNPMF, PROSERTAO

3. *Country/region(s)*

Northeast Brazil: states of Bahia (Itaberaba), Pernambuco (Petrolina, Araripina), Ceará (Quixadá). Semi-arid, marginal environmental and social conditions

4. *Year project began/Dates*

   1993/94, 1995/96; funded through 1999

5. *Researcher(s) involved*

   Wania Maria Gonçalves Fukuda (EMBRAPA/CNPMF), José Anfrísio Magalhães (EPACE), Josias Cavalcanti (CPATSA), Paulo Roberto Pina (EBDA), José Alves Tavares (IPA), Carlos Iglesias and Luis Alfredo Hernández Romero (CIAT), Elvis Edson Montenegro (IICA/CNPMF)

   Wania Fukuda, Anfrisio Magalhães, Marcio Porto, Pedro Mattos, Sizernando Oliveira (Iglesias trip report contacts listed)

6. *Farmers involved*

   Average of 17 farmer communities per year were surveyed, in marginal environmental and social conditions, most involved in production and marketing of dry flour for human consumption, but a fair number also growing for fresh market. Generally farmer-leaders were chosen to work with

   From survey group, interested farmer-innovators chosen with strong input from extensionists (chosen to be representative of different production systems, crops, soils, markets, uses)

   Trials conducted in 17 communities (each trial on one farm/community, with evaluation and selection involving the whole community)

   Five farmers invited to experiment station for selection of early-generation materials

7. *Crop(s)*

   Cassava

8. *Main objectives for pursuing farmer participation*

   Productivity increase: Improved adoption of new clones, establish linkages between farmers-extensionists-researchers

   Gain knowledge: Identify producers' primary criteria for clone adoption (identify "real demands" for new varieties), learn about crop production/marketing systems in the region

9. *Nature of participation*

   Survey to determine needs for new varieties

   Joint farmer-extensionist-researcher evaluation of trials two times during the growing season; farmers responded to open-ended questions on their opinions of each variety plus ranked varieties.

   Farmers came to experiment station to select new germplasm from advanced yield trials.

10. *Method of involving farmers and types of output anticipated*

    Goals identification

    Identifying experimental varieties (six chosen from among 30 clones in advanced yield trials on station)

    Testing experimental varieties

    Anticipated output: Distribute new clones with greater probability of adoption; better definition of farmers' criteria for adoption as feedback to extensionists and researchers; better farmer-extensionist-researcher linkages.

11. *Summary of breeding methods used*

Nine clones and local checks evaluated on-farm, farmers' management.

In second trial, worst three clones (farmers' ranking) were replaced with clones breeders chose as more promising given what they had learned about farmers' criteria for adoption.

12. *Summary of results/experiences/impacts and products to date*

Glossary of local farmers' terminology

Profile of "ideal" cassava type for the semi-arid region based on farmers' selection criteria: stability, root size, initial vigor and canopy closure, short internodes and many buds (reduced need for planting stakes), ease of harvest (short/no peduncle, and soils dry and hard at harvest), ease of peeling (flour processors don't accept if hard to peel—done mostly by women), external and internal root color, canopy production (for animal feed during dry season), fresh consumption quality, flour yield and quality

Adaptation of a CIAT field notebook for scoring the most important cassava traits for semi-arid zones

One variety (BGM260) being multiplied in five of six study communities in Quixadá for its fresh consumption quality (dual purpose: fresh consumption and flour)

Farmers in one community selected BGM549 for adaptation, yield, and profuse development of foliage for forage (dual purpose: forage and flour)

Breeders' changed harvest of on-station evaluations from 12 to 18 months (farmers' will not harvest at 12 months, dry matter production per hectare increased by 100% from 12 to 18 months)

Researchers adding studies on forage production (varieties and management), greenhouse test of germination/establishment under harsh conditions (to avoid unexpected variety problems in a bad year), participatory research on root rot (varietal resistance and management)

Maximum of 10 genotypes for farmer evaluation, given the need for flour quality evaluation

PPB a very powerful tool for cassava breeding in marginal environmental and social conditions, but very demanding in time, labor, resources

13. *Documentation/references*

Gonçalves Fukuda, W.M., J.A. Magalhães, J. Cavalcanti, P.R. Pina, J. Alves Tavares, C. Iglesias, L.A. Hernández Romero and E.E. Montenegro. 1997. Pesquisa participativa em melhoramento de mandioca: Una experiencia no semi-árido do nordeste do Brasil. EMBRAPA Mandioca e Fruticultura, Documento CNPMF No. 73, August 1997.

Trip Report, Carlos Iglesias, 14-23 July 1997.

14. *Contact addresses*
    Carlos Iglesias, CIAT, Apdo. Aéreo 6713, Cali, Colombia.
    Tel: +57 (2) 4450000, Fax: +57 (2) 4450073,
    E-mail: c.iglesias@cgiar.org
    Wania Fukuda; Tel: +55 (75) 7212120, Fax: +55 (75) 7211118,
    E-mail: wfukuda@cnpmf.embrapa.br
15. *Comments*
    Funded by IFAD (this funding ends in 1999)

Case 32: Participatory maize breeding in Brazil

1. *Title*
   Rescue, evaluation and selection of local maize varieties within an agroecological zone
2. *Institutions*
   EMBRAPA
3. *Country/region(s)*
   Brazil: 12 locations around the country in areas that varied in genetic erosion of maize (10% were areas with high genetic diversity, 60% had moderate diversity, 30% had low diversity—no local varieties)
4. *Year project began/Dates*
   1984-present
5. *Researcher(s) involved*
   Altair Toledo Machado
6. *Farmers involved*
   Up to 250 farm families involved in each of the 12 locations for initial selections
   Working with 42 NGOs and through them with 30,000 farm families to scale up effort
7. *Crop(s)*
   Maize
8. *Main objectives for pursuing farmer participation*
   Sustainability of production, encouraging farmers to stay in the area
   Conserving genetic diversity and local germplasm
9. *Nature of participation*
   Farmers selected among and within varieties in their communities
   Farmer-collaborators might contribute space on their farms for community evaluation plots (otherwise evaluations were done on representative community plots)
10. *Method of involving farmers and types of output anticipated*
    Selecting among varieties and in variable materials. This process allowed for farmer learning about concepts such as isolation, contamination, genetic drift, effective population size.
    Anticipated outputs: Varieties with improved stress tolerance and performance based on both farmer and researchers selections, conservation of local maize germplasm.

11. *Summary of breeding methods used*

    Mass selection among and within varieties by farmers in communities (two cycles), followed by three cycles of selection by researchers (half sib selection either on-station or on-farm; full sib and S1 selection on station and in greenhouse screens for specific stress tolerance)

    Goal of the combination of breeding methods is to minize loss of genetic variation in the early selection cycles, and gradually increase selection pressure in later cycles

12. *Summary of results/experiences/impacts and products to date*

    ? - Results are not published.

13. *Documentation/references*

    Milho Crioulo. Date? Conservação e Uso da Biodiversidade. AS-PTA Assessoria e Serviços a Projectos em Agricultura Alternativa.

    Toledo Machado, A., R. Magnavaca, S. Pandey, and A. Ferreira da Silva, eds. Simposio Internacional sobre Estresse Ambiental: O Milho em Perspectiva. 8-13 March 1992. Belo Horizonte, Minas Gerais, Brazil.

14. *Contact addresses*
15. *Comments*

    Local communities paid for costs of initial variety evaluations, including visits by A. Toledo Machado; EMBRAPA paid for site characterization, soil analyses and advanced generations of evaluation.

    Harvest festivals were organized in each community to coincide with final evaluation at harvest time.

    One delegate from each community attended a national meeting to share the community's evaluation results.

Case 33: McKnight MILPA Project

1. *Title*

   Conservation of genetic diversity and improvement of crop production in Mexico: A farmer-based approach (Project MILPA, or McKnight Integrated Landrace Preservation Activity)

2. *Institutions*

   PI institutions (and emphasis):

   - Universidad Nacional Autónoma de México, UNAM (beans, maize, quelites, socioeconomics)
   - University of California, Davis, CA (beans, socioeconomics)

   Additional institutions (and emphasis):

   - Colegio de Postgraduados en Ciencias Agrícolas, Montecillo, CP (maize)
   - Instituto Nacional de Investigación Forestal y Agropecuaria, INIFAP (beans, maize)
   - Universidad Autónoma de Chapingo, UACh (maize, squash)
   - CIMMYT, Mexico (maize, socioeconomics)
   - Cornell University, Ithaca NY (maize)

North Carolina State University, Raleigh NC (maize)
University of Maine, Orono ME (squash)

3. *Country/region(s)*
   Mexico (central highlands): Chalco-Amecameca-Cuautla, Sierra Norte de Puebla, Jalisco (range from market-integrated to relatively market-isolated)
4. *Year project began/Dates*
   1995-present, with PPB activities initiated in 1995 for maize, 1997 for squash and 1998 for beans
5. *Researcher(s) involved*
   PIs: Robert Bye, Cal Qualset
   Maize: Fernando Castillo, Miguel Angel Martínez, Rafael Ortega-Paczka, Jesús Sánchez, Major Goodman, Margaret Smith; consultation from Melinda Smale and Suketoshi Taba (CIMMYT)
   Bean: Jorge Acosta, Alfonso Delgado, Paul Gepts
   Squash: Timoteo Valdez Hernández, Salvador Montes, Clemente Villanueva, Laura Merrick
   Quelites: Robert Bye, Edelmira Linares, Cristina Mapes
   Socioeconomics: Mauricio Bellon, Antonio Yuñez, Steve Brush, Ed Taylor
6. *Farmers involved*
   Surveys of 208 households (166 in Chalco, 42 in Sierra Norte de Puebla)
   Maize on-farm variety trials with four farmers in four communities
   On-farm maize selection with eight farmers (five in Chalco, three in Sierra Norte de Puebla)
7. *Crop(s)*
   Maize, beans, squash, and edible wild greens (“quelites”) in traditional mixed cropping system
8. *Main objectives for pursuing farmer participation*
   Productivity increase and biodiversity. Crop genetic improvement concurrent with conservation of biological and cultural diversity; in situ conservation and improvement of local, intercropped landraces
   Study extent and mechanisms of gene flow from wild or ‘improved’ germplasm to local varieties
9. *Nature of participation*
   Farmers provide field space for variety evaluations, on-farm selection and studies of gene flow
   Farmers provide germplasm (maize, beans, squash) for characterization and use in breeding
   Survey respondents: socioeconomic and ethnobotanical surveys
   Joint planning with researchers of maize variety trials, and joint evaluation and selection from trials
10. *Method of involving farmers and types of output anticipated*
    Goals identification: Survey to understand farmers’ criteria for variety choice
    Testing varieties (maize)

Anticipated outputs: Better understanding of what farmers need from improved varieties, greater improvement than with farmers' traditional maize seed selection (based only on ear traits post-harvest)

Note: Selection within farmers' local maize varieties is being done on-farm, but with selection by breeders to demonstrate efficacy before requesting farmers to commit time and labor to such work.

Note: Farmers are also providing land (renting it in some cases) for on-farm studies of gene flow.

11. *Summary of breeding methods used*

Maize: Mass selection using informal grids, based on plants (in field) and ears (post-harvest)

12. *Summary of results/experiences/impacts and products to date*

Maize: Farmers seem enthusiastic; one said he could see improvement already, several applied selection methods to other maize fields.

13. *Documentation/references*

1996 Annual Report to the McKnight Foundation

1995 Annual Report to the McKnight Foundation

Conservation of genetic diversity and improvement of crop production in Mexico: A farmer-based approach, Proposal to the McKnight Foundation Collaborative Crop Research Program

14. *Contact addresses*

Robert Bye, Instituto de Biología, Jardín Botánico, UNAM, Aptdo. Postal 70-614, 04510 Mexico, DF, México. Telefax: +52 (5) 6229046

Calvin O. Qualset, Genetic Resources Conservation Program, University of California, Davis, CA 95616, USA. Tel: +1 (916)7578921, Fax: +1 (916)7578755, E-mail: coqualset@ucdavis.edu

15. *Comments*

(Analysis based on 1996 Annual Report)

To date, MILPA seems to be mostly researchers' studies done in farmers' fields, but increasing farmer involvement is anticipated in maize, bean, and squash breeding work in the next few years.

Gene flow studies are a unique aspect.

As with many projects, interactions between breeders and socioeconomists have been challenging.

Case 34: Ethiopia—Early maturing maize

1. *Title*

The introduction of an early maturing maize (*Zea mays*) variety to a mid-altitude farming system in Ethiopia

2. *Institutions*

Bako Research Center of the Ethiopian Institute of Agricultural Research

3. *Country/region(s)*
   Ethiopia - Bako area (Welega and Western Shewa Regions), >1300 masl, 1000-1500 mm rainfall, undulating topography
4. *Year project began/Dates*
   1986-1989
5. *Researcher(s) involved*
   Asfaw Negassa, Benti Tolessa, Steven Franzel, Gemechu Gedeno, Legesse Dadi
6. *Farmers involved*
   Informal survey of 35 farmers
   Formal survey of random sample of 69 farmers
   Researcher-designed trials: 12 sites in 1988, two sites in 1989
   Farmer-designed trials: 12 farmers in 1988 and 89 farmers in 1989, selected randomly "in accessible areas" considered representative of the area
   Follow-up survey of 55 participant farmers
7. *Crop(s)*
   Maize
8. *Main objectives for pursuing farmer participation*
   Productivity increases? (to fill a hungry period before the primary maize harvest)
9. *Nature of participation*
   Informal and formal farmer surveys
   On-farm researcher-designed trials
   On-farm farmer-designed trials
   Follow-up survey using a "repertory grid" to obtain farmers' evaluations of alternative technologies
10. *Method of involving farmers and types of output anticipated*
    Goals identification through surveys
    Testing experimental varieties
11. *Summary of breeding methods used*
    Compared two varieties in on-farm trials
12. *Summary of results/experiences/impacts and products to date*
    Survey indicated need for earlier maturing maize to harvest during period of food scarcity
    New early variety tested was shorter and earlier, resulting in weed and animal damage problems, and did not store well, but farmers tried it in new intercrops and double cropped it to address land shortage problems
    Most farmers saved some seed of the new variety and planned to plant it the following year
    49 non-participating farmers got seed of the new variety from participating farmers
13. *Documentation/references*
    Negassa, A., B. Tolessa, S. Franzel, G. Gedeno, and L. Dadi. 1991. The introduction of an early maturing maize (*Zea mays*) variety to a mid-altitude farming system in Ethiopia. Experimental Agriculture 27:375-383.
14. *Contact addresses*
    Steven Franzel, ICRAF, P.O. Box 30677, Nairobi, Kenya. E-mail: s.franzel@cgiar.org

15. *Comments*
    Mainly participatory variety selection based on a comparison of one new and one local variety
    Funded by Institute of Agricultural Research of Ethiopia and IDRC

Case 35: Mexican maize seed systems work

1. *Title*
   Maize variety management in small-scale farming in Mexico
2. *Institutions*
   CIMMYT, Centro de Ecología - Universidad Autónoma de México (UNAM), Instituto Manantlán de Ecología y Conservación de la Biodiversidad - Universidad de Guadalajara (IMECBIO), Proyecto Sierra Santa Marta (PSSM), Ecole Nationale Supérieure Agronomique de Montpellier (ENSAM), Institut Français de la Recherche Scientifique pour le Développement en Coopération (ORSTOM), University of California - Davis, University of California - Santa Barbara, University of Arizona, Cornell University
3. *Country/region(s)*
   Mexico
   - Vicente Guerrero, Chiapas (800-900 masl, 864 mm rainfall)
   - Guanajuato (80- and 140-day growing seasons)
   - Cuzalapa watershed, Jalisco (buffer zone of Biosphere Reserve, hot and subhumid, moderately fertile soils, around 600 masl, 1500 mm rainfall)
   - Central valleys of Oaxaca
   - Sierra Santa Marta, Veracruz (steep in places, humid tropics, 2000-3500 mm rainfall)
4. *Year project began/Dates*
   Chiapas: 1988-1989, Guanajuato: dates?, Jalisco: 1989-1991, Oaxaca: 1997, Veracruz: 1994-1996
5. *Researcher(s) involved*
   Alfonso Aguirre (UNAM), Mauricio Bellón (CIMMYT), Julien Berthaud (ORSTOM), José Luis Blanco (PSSM), Stephen Brush (UC-Davis), André Charrier (ENSAM), David Cleveland (UC-Santa Barbara), Dominique Louette (IMECBIO), Elizabeth Rice (Cornell University), Melinda Smale (CIMMYT), Daniela Soleri (University of Arizona), Steven Smith (University of Arizona).
6. *Farmers involved*
   Chiapas: 97 farmers (104 fields, including differing socioeconomic status and different farmer-recognized soil types) from a market-integrated ejido with extensive use of modern technologies
   Guanajuato: 160 farmers from 25 communities classified into four areas according to growing season length (80-day vs. 140-day) and market access (isolated and integrated)

Jalisco: 39 farmers (20% of farmers in the region) from a largely indigenous ejido that is relatively isolated from major roads and urban areas; subsequent selection studies involved 25 farmers

Oaxaca: Small sample of farmers from two communities

Veracruz: 16 farmers surveyed in two communities. The Proyecto Sierra Santa Marta targeted four communities and introduced techniques to nearly 100 farmers in a series of workshops. Farmers received improved varieties to evaluate and some training in seed selection and management. The 16 surveyed farmers used the introduced selection practices for several cycles. The communities are indigenous Popoluca (Spanish is a second language) and have low literacy; off-farm work and migration are uncommon.

7. *Crop(s)*

Maize

8. *Main objectives for pursuing farmer participation*

Gain knowledge: Improve understanding of farmers' seed management and its genetic consequences, and test methods for achieving this understanding as a contribution to participatory breeding

9. *Nature of participation*

Survey respondents (Chiapas, Guanajuato, Jalisco, Oaxaca, Veracruz)

Participated in exercises designed to elicit genetic perceptions (Jalisco, Oaxaca)

Plant measurements made in farmers' fields and/or on farmers' seed (Chiapas, Jalisco, Oaxaca)

Farmers conducted seed selection for use in comparative studies (Jalisco, Oaxaca)

10. *Method of involving farmers and types of output anticipated*

Gain knowledge: Surveys to provide background information that might shed light on how/if participatory breeding would be useful

Selecting in variable materials: Studies of farmers' vs. random selections or vs. breeders' selections used to elicit detail on farmer selection criteria

Output anticipated: Understand seed flows into and within communities, the genetic nature of farmer-saved varieties, farmers' fundamental genetic perceptions concerning maize population management and seed selection and procurement practices, and the relationship of variety introduction to biodiversity

11. *Summary of breeding methods used*

None used

12. *Summary of results/experiences/impacts and products to date*

Chiapas:

- Farmers maintained 15 varieties (including both "high yielding varieties" and "traditional varieties") that met

different needs and knew specific management requirements of each.
- Even within one community, farmers varietal requirements differ (e.g., wealthier farmers who sell their entire crop and buy maize for food care more about yield than storage quality).
- Varietal traits are maintained through seed selection (since lack of temporal or spatial isolation together with small field size allows extensive cross pollination), based on harvested ears.
- Farmers exchange varieties for experimentation or due to seed loss
- Landrace displacement was not associated with economic differences; landrace conservation was associated with micro-environmental differences (especially marginal soils) and with farm size and fragmentation; off-farm employment was negatively associated with area in improved varieties.

Guanajuato:
- Farmers had three strategies for seed management (save seed every generation to maintain security of production, mix their own seed with that from other sources to improve their maize, and get new seed for each planting season to increase grain and fodder yield).
- Strategies varied with market access but not with growing season length: in market integrated areas, farmers commonly get new seed for each season, while in market isolated areas they commonly mix their own seed with that from other sources.
- In market isolated areas, farmers use more local and colored varieties and emphasize security of family food supply, while in market integrated areas they use more improved and non-colored varieties and emphasize economic returns to maize production.

Jalisco:
- Seed lots are the appropriate units of analysis for studying seed flows and genetic impacts since variation among seed lots of a single variety can be considerable due to farmers' exchange and mixing of seed from lots that are phenotypically similar.
- Farmers maintained 26 varieties for different agronomic traits and end uses (six local, three commonly- and 17 occasionally-used introduced); local varieties occupied 79% of the maize area.
- About half the seed lots sown came from other farmers within (37%) or outside (11%) the region, usually for introduced varieties that were occasionally used and rarely for truly "local" varieties.
- Few farmers expressed any preference for their own saved seed over seed from others.
- Farmers classify seed as a given variety based on morphology and phenology. Mew varieties are often

integrated into older ones, "local" varieties include a morphologic and genetic continuum.
- Farmers select based almost exclusively on ear traits in harvested ears.
- Farmers seem to encourage genetic contamination among varieties; seed selection strongly limits gene flow for traits that farmers select, but does not appear to limit it for non-selected traits.
- Farmers' purpose for seed selection is primarily to ensure seed quality, good germination, and purity (ideotype); the idea of modifying varietal traits by selection was met with disbelief. Traits are altered by changing varieties or replacing seed of a variety, not by selection.
- Plant breeders could complement farmer selection with concepts such as increased selection intensity, gridding, and plant selection; however, impacts may be minimal given the fluidity of farmers' seed systems and will result only <u>if</u> farmers perceive benefits from the collaboration.

Oaxaca:
- Heritability of traits like plant height, stalk diameter, days to anthesis, and ear dimensions indicates sufficient genetic variation to obtain gains from selection.
- Some farmers may perceive genetic variation within a population for some traits of interest; however, environmental variation is acknowledged as so substantial that even when genetic variation is perceived, it is considered as inaccessible. Between seed lots of the same variety, farmers do perceive variation in maturity.
- Farmers clearly make the distinction between high and low heritability for some traits of interest, and some farmers note phenotypic segregation among progeny of heterozygous parents.
- Despite significant selection differentials for some traits, and because of large environmental variation and low heritability, farmer selection appears to be random rather than directional, achieving primarily maintenance of selection criteria, not positive change.
- Selection is done entirely post-harvest (by women while preparing food, and pre-planting by both men and women) based on clean grain, grain and ear color, size and shape.

Veracruz:
- Farmers grew 30 different varieties to fulfill different production requirements and end uses.
- Farmers often obtain new seed of both traditional and modern varieties (more often for modern than for traditional varieties), and the family and community are probably the relevant levels at which seed conservation occurs.
- Recommended seed selection practices (plant plus ear based selection) were used more on modern than traditional varieties, and their use declined with time (possibly due to weather-related crop loss, land reform resulting in more

distant fields or fields with different production constraints, and conflicting demands for labor).

- Seed selection is iterative and continuous, including selection from plants in the field (mostly done by men), from harvested ears, during food preparation primarily by women (more common for traditional than for modern varieties), and pre-planting.
- Seed selection is such an intuitive process for farmers that often they don't volunteer information about it because they consider it obvious.

13. *Documentation/references*

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14. *Contact addresses*

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Daniela Soleri, 344 South Third Avenue, Tucson AZ 85701, USA. Tel: +1 (520) 8848565, E-mail dsoleri@ag.arizona.edu

15. *Comments*

An interesting group of studies carried out by different institutions and collaborators, most with significant parallel aspects (by design). (Louette and Soleri/Cleveland work was independent).

Does not involve any breeding, but results shed light on some of the issues a participatory breeding effort would need to address if it is to integrate with farmers' seed systems

Case 36: ROCAFREMI or WCAMRN (network for pearl millet in West and Central Africa)

1. *Title*

   West and Central African Millet Research Network
2. *Institutions*

   West-African NARS of 14 countries, ICRISAT
3. *Country/region(s)*

   Benin, Burkina Fasso, Cameroon, Cape Verde, Central African Republic, Chad, Côte d'Ivoire, Ghana, Guinea-Bissau, Guinea-Conakry, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Niger, Mali
4. *Year project began/Dates*

   Network in 1990, participatory breeding component in 1996(?)
5. *Researcher(s) involved*

   Coordinator B. Ouendeba
6. *Farmers involved*
7. *Crop(s)*

   Pearl millet
8. *Main objectives for pursuing farmer participation*

   Increase adoption of research products
9. *Nature of participation*

10. *Method of involving farmers and types of output anticipated*
11. *Summary of breeding methods used*
12. *Summary of results/experiences/impacts and products to date*
13. *Documentation/references*
    Except very general annual reports, no documents available yet
14. *Contact addresses*
    Ouendeba, ICRISAT Sahelian Center, BP 12404, Niamey, Niger.
    Tel: +227 722529/ 722626, Fax: +227 734320,
    E-mail: B.Ouendeba@cgiar.org
15. *Comments*
    More info needed

Case 37: Rice breeding in Bihar

1. *Title*
   Rice breeding for rainfed lowland conditions
2. *Institutions*
   Rajendra Agricultural University (Pusa), Patna, Bihar 848125, India
3. *Country/region(s)*
   State of Bihar, India
4. *Year project began/Dates*
   1989-??
5. *Researcher(s) involved*
   R. Thakur
6. *Farmers involved*
   Two-four villages with varying numbers of farmers
7. *Crop(s)*
   Lowland rainfed rice (*Oryza sativa*)
8. *Main objectives for pursuing farmer participation*
   Develop varieties with adaptation to the varying stress conditions and superior yielding ability than the predominant local varieties
9. *Nature of participation*
   Information not clear
10. *Method of involving farmers and types of output anticipated*
    Normal variety trials conducted in farmers fields, with farmer contributions to evaluation before harvest (details not described)
    Farmers (with breeder input?) selected varieties for testing in farmer managed trials
11. *Summary of breeding methods used*
    Extended testing of advanced breeing lines
12. *Summary of results/experiences/impacts and products to date*
    One superior variety released, others identified, on the basis of yield advantages in farmers fields across years
    Weaknesses in variety release procedures described
    Detailed description of key characteristics of important local varieties

13. *Documentation/references*

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    Thakur, R. 1995. Prioritization and development of breeding strategies for rainfed lowlands: A critical appraisal. In: Fragile lives in fragile ecosystems. Proceedings of a conference held at IRRI. Los Baños, Philippines, IRRI.

14. *Contact addresses*

    R. Thakur, Department of Plant Breeding, Rajendra University (Pusa), Samastipur, Bihar 848125, India

15. *Comments*

Case 38: Seeds for organic farmers, Germany

1. *Title*
2. *Institutions*
3. *Country/region(s)*

    Germany

4. *Year project began/Dates*
5. *Researcher(s) involved*
6. *Farmers involved*

    Several farmer initiatives, working groups, and some commercial enterprises

7. *Crop(s)*

    Cereals, vegetables

8. *Main objectives for pursuing farmer participation*

    To make varieties with specific advantages for use inorganic farming available, i.e., competitive against weeds.

9. *Nature of participation*
10. *Method of involving farmers and types of output anticipated*
11. *Summary of breeding methods used*
12. *Summary of results/experiences/impacts and products to date*
13. *Documentation/references*
14. *Contact addresses*

    Georg Schmidt, Hera Forschungsstelle fuer oekologischen Landb, Eschenhof, Hauptstr. 10, D 56767 Uess/Eifel, Germany. Tel: +49 2692 8295, Fax: +49 2692 727

    Karl-Joseph Mueller, Biologisch-dynamische Getreideforschungsstelle Darzau, Darzau 1, 29490 Neu Darchau, Germany. Telefax: +49 5853 1397

    Anbau Thomas Heinze, Initiativkreis fuer Gemuesesaatgut aus biologisch-dynamischem, Kronstr 24, D 61209 Echzell, Germany. Tel: +49 6035 81216, Fax: +49 6035 81275

15. *Comments*

    No substantial info yet

    Widespread interest of farmers in the concepts of PPB

In 1/99 conference in seed issues held, bringing together organizations interested and supporting bio-dynamic farming practices in central Europe (mainly)

More interactions with individuals may be interesting

Case 39: ICRISAT/ISPA Dual-purpose sorghum in Andhra Pradesh

1. *Title*
   Assessment of farmers' preferences for dual-purpose sorghums
2. *Institutions*
   Indo-Swiss Project Andhra Pradesh (ISPAP), ICRISAT
3. *Country/region*
   India, Andhra Pradesh, Mahbubnagar and Warangal Districts
4. *Year project began/Dates*
   1991-1996
5. *Researcher(s) involved*
   M.M. Anders
6. *Farmers involved*
7. *Crop(s)*
   Sorghum (*Sorghum bicolor*)
8. *Main objectives for pursuing farmer participation*
   Assist breeders to better define dual-purpose type sorghums
   Know farmers' preferences for specific agronomic traits
9. *Nature of participation*
   On-farm varietal trials, discussions with farmers, interviews, close observation
   Understanding causes for low adoption of modern cultivars.
10. *Method of involving farmers and types of output anticipated*
    66 farmers from three villages in Warangal district were sampled based on census data, stratified by landholding size, and were interviewed about their methods for sorghum crop management and livestock feed management.
    36 farmers, owning livestock, similarly stratified sample participated in variety evaluations for 2 years. Each farmer growing a single variety adjacent to their local. Two farmers, owning more land, conducted demonstrations with all six varieties.
    In 1993, 260 farmers purchased seed of two varieties for further evaluation in the same villages.
    In 1994, seed of these two varieties was given to 500 farmers in 12 districts of Andhra Pradesh for wide-spread testing.
11. *Summary of breeding methods used*
    Testing of experimental cultivars
    Farmers' seed production
12. *Summary of results/experiences/impacts and products to date.*
    Livestock numbers declining over the past 10 years because of problems with fodder availability
    Sorghum stover is the second most preferred feed, preferably fed without chopping (requires less labor)

Farmyard manure most commonly used fertilizer; inorganic fertilizer used frequently
Grow only rainy season, rainfed sorghum
Only one farmer had tried hybrid sorghum
Farmers use only poorer fields for sorghum production; good fields are used for cash crops
Most farmers intercrop sorghum with pigeonpea
Sorghum grown at high plant density
All farmers produce their own sorghum seed
Variety evaluations
Many plots sown late (seed arrived late), thus poor yield compared to normally sown local variety
Farmers wanted several improvements in new varieties (shoofly resistance, drought resistance, longer panicle, taller plant height, shorter crop duration).
Two varieties preferred for grain production in comparison to local variety
(Not many results from farmers' evaluation reported)
In 1993, varieties (two, plus local) differed in chemical indicators for stover quality (local best). One improved variety was similar to local in stover quality, but higher in grain yield.
Often farmers did not harvest seed because they thought that the new varieties were hybrids.
Mini-Kits (demonstration plots of all varieties on one farmers field) not useful. Variation in farmers' fields was too big to allow for genotype comparisons.
Different farmers preferred different varieties.
Farmers need to be exposed to a range of varieties, differing in plant type.
Exposing varieties to farmers and seed supply are main issues - appropriate varieties are available.

13. *Documentation/references*

Anders, M.M., H. Mulder, and M. Satyanarayana. 1998. Improving sorghum production in mixed livestock-crop farming systems. ICRISAT. Draft report.

14. *Contact addresses*

M.M. Anders. E-mail: M.Anders@csi.cgiar.org
Venkateshwarlu, Indo-Swiss Project, Andhra Pradesh, VBRI Premises, Shantinagar, Hyderabad 500 0, India

15. *Comments*

No results from Mahbubnagar district study
Little reference about interaction with breeding program

Case 40: IRRI genetic resource project

1. *Title*

Integrating indigenous technical knowledge and *in situ* conservation of rice in the Philippines

2. *Institutions:*
   IRRI, Los Baños, Philippines; ORSTOM, Paris, France; PhilRice, Maligaya, Munoz, Philippines
3. *Country/region(s)*
   Philippines: Cagayan Valley
4. *Year project began/Dates*
   1995-1998
5. *Researcher(s) involved*
   S. Morin, M. Bellon, J.L. Pham, L.S. Sebastian, G. Abrigo, D. Erasga, M. Calibo, P. Sánchez
6. *Farmers involved*
   180 households from 15 villages
7. *Crop(s)*
   Upland, rainfed, lowland and irrigated rice (*Oryza sativa*)
8. *Main objectives for pursuing farmer participation*
   Understanding indigenous knowledge regarding the management of rice diversity
9. *Nature of participation*
   Farmers respond to formal surveys
   Key informants participate in more in-depth discussions on indigenous varietal knowledge
10. *Method of involving farmers and types of output anticipated*
    Mostly exploring farmers' information, and sampling local germplasm
11. *Summary of breeding methods used*
    No breeding, developing strategies for *in-situ* conservation
12. *Summary of results/experiences/impacts and products to date*
    A large number of varieties are grown in rainfed lowlands
    Women's knowledge and their communication about it differed from mens' detailed descriptions of characteristics of locally grown varieties, as experienced/perceived by farmers.
13. *Documentation/references*
    Bellón, M. 1996. On-farm conservation as a process: An analysis of its components. p. 9-22. In: Sperling L. and M. Loevinsohn, eds. Using diversity—Enhancing and maintaining genetic resources on-farm. International Development Research Centre (IDRC), New Delhi, India.
    and several draft papers from J.L. Pham. IRRI/ORSTOM
14. *Contact addresses*
    J.L. Pham. E-mail: J.Pham@cgiar.org
15. *Comments*
    In-depth analysis of farmers' seed management and on-farm diversity in different rice ecosystems in the Philippines
    Get more info.

Case 41: IPGRI—In-situ conservation project

1. *Title*
   Strengthening the scientific basis of *in-situ* conservation of agricultural biodiversity on-farm

2. *Institutions*
   IPGRI, and NARS
3. *Country/region(s)*
   Nepal, Vietnam, Peru, Hungary, Burkina Faso, Ethiopia, Mexico, Morocco, Turkey
4. *Year project began/Dates*
   1996
5. *Researcher(s) involved*
   Coordinator: D. Jarvis, IPGRI, Rome
6. *Farmers involved*
   Different strategies pursued in each country
7. *Crop(s)*
   Burkina Faso: sorghum, cowpea, pearl millet okra, *Solenostomum* ssp.
8. *Main objectives for pursuing farmer participation*
   Add value to local landraces, so that farmers have more reasons to continue to grow them
9. *Nature of participation*
10. *Method of involving farmers and types of output anticipated*
11. *Summary of breeding methods used*
12. *Summary of results/experiences/impacts and products to date*
13. *Documentation/references*
   Jarvis, D.I. and T. Hodgkin, eds. 1998. Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm: Options for data collecting and analysis. Proceedings of a workshop to develop tools and procedures for *in situ* conservation on-farm. 25-29 August 1997, Rome, Italy. IPGRI, Rome, Italy.
14. *Contact addresses*
   Devra Jarvis, E-mail: d.Jarvis@cgiar.org
   Bhuwon Sthapit, E-mail: b.Sthapit@cgiar.org
15. *Comments*
   The document gives an overview of options and geographical descriptions of the selected sites, not crops nor methods choices in detail. More information?

Case 42: CIRAD inrab-Rcf—Cotton breeding

1. *Title*
   Participatory cotton breeding in Benin
2. *Institutions*
   CIRAD, Inrab-Rcf
3. *Country*
   Benin, cotton growing area (Borgou, Atacora and Zou)
4. *Year project began*
   1996
5. *Researcher(s) involved*
   E. Sêkloka, M. Djaboutou, J. Lançon
6. *Farmers involved*
   3 grower-breeders (one per main cotton growing area) plus a group of about 10 farmers per village

Bio Orou Moussé (Kandi village), Daouda Takpara (Moné), Luc Assogba (Koutago)

7. *Crop(s)*

   Cotton

8. *Main objectives for pursuing farmer participation*

   Competence transfer towards individual or groups of farmers
   Strengthening researcher-grower relationships
   Better (and cheap) selection for genotype x environment interactions

9. *Nature of participation*

   Each grower-breeder grows a plot of 1000 cotton plants
   With his group, he selects 200 plants
   After the fiber has been analysed in a conventional laboratory, the final choice is made by the institutional- plus grower-breeders

10. *Method of involving farmers and type of output anticipated*

    Although voluntary, each grower-breeder has been chosen by the area farmers union
    Meetings/field discussions
    Field visits
    A group is in charge of coordinating the participatory breeding activities, it gathers representatives of research and farmers unions

11. *Summary of breeding methods used*

    Initial population constituted with 14 genotypes intercrossed at random
    Massal selection (open pollination)
    Recurrent selection (no further crossing within each population)
    Selection is also run by research on station
    Lots of the initial population are left unselected as checks on research plots next to the grower-breeders villages

12. *Summary of results/experiences/impacts and products to date*

    Three cycles of selection have been completed
    Nine populations obtained (Kandi 96-1, 96-2, and 96-3; Savalou 96-1, 96-2, and 96-3; and Djougou 96-1, 96-2, and 96-3)
    Quantitative evaluation has just started
    Grower-breeders are quite keen to carry on, but they tend to get isolated from those who chose them to do this job (a coordinating cell has been set up to fill the gap)

13. *Documentation/references*

    Lançon J., E. Sêkloka, and M. Djaboutou. 1999. La sélection participative: Un outil pour l’amélioration du cotonnier. In: CIRAD-CA, Place de la recherche cotonnière dans des filières en évolution. Montpellier, France: CIRAD-CA, à paraître.

    Sêkloka E., M. Djaboutou, A. Hougni and J. Lançon. 1999. Sélection participative du cotonnier au Bénin. In: Université Hohenheim, Paysans et chercheurs dans un environnement en mutation Communications & posters. Cotonou, Bénin.

Lançon J. 1998. Participatory cotton breeding in Benin. In: ICAC, World Cotton Research Conference II. Communications & posters. Athens, Greece.

Lançon J. 1998. L'amélioration génétique participative: Une autre approche de la sélection du coton au Bénin. In: ICAC, World Cotton Research Conference II. Communications & posters Athens, Greece.

Lançon J. 1998. L'amélioration génétique participative a-t-elle une place en sélection cotonnière? p. 164-174. In: CIRAD-CA, *A*ctes des journées coton du CIRAD-CA. Montpellier, France, CIRAD-CA.

14. *Contact addresses*

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Emmanuel Sêkloka, Parab, Recherche coton et fibres, BP 1022, Parakou, Bénin

Mossibaou Djaboutou, Recherche coton et fibres, BP 1022, Parakou, Bénin

15. *Comments*

The project has been designed by breeders and there is a need for a sociologist or socio-economist to have a look at the method.

Multilocal trials for testing GxE interactions to be conducted next growing season (2000-01)

Appendix 2. List of Acronyms and Abbreviations Used in the Text

Acronyms

AID	Agency for International Development
AVRDC	Asian Vegetable Research and Development Center
BBA	Beej Bachao Andolan, farmers' group, India
B/C CRSP	Bean/Cowpea Collaborative Research Support Program of USAID
CAZS	Centre for Arid Zone Studies, University of Wales, UK
CGIAR	Consultative Group on International Agricultural Research
CIALs	Comités de Investigación Agrícola Local (Local Agricultural Research Committees)
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CIDT	Cotton Development Agency, Ivory Coast
CIIFAD	Cornell International Institute for Food, Agriculture and Development of Cornell University, NY
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center), Mexico
CIP	Centro Internacional de la Papa (International Potato Center), Peru
CITESGRAN	Centro Internacional de Tecnología de Semillas y Granos, Honduras
CONSERVE	Community-Based Native Seeds Research Center, a nongovernment organization, the Philippines
COOPIBU	a nongovernment organization in Rwanda
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
CPRO-DLO	Centre for Plant Breeding and Reproduction Research-Dienst Landbouwkundig Onderzoek, Neths
CRSP	Collaborative Research Support Project of USAID
DFID	Department for International Development, UK, previously ODA
DRC	Democratic Republic of the Congo
EAP-Zamorano	Escuela Agrícola Panamericana-Zamorano, Honduras
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise for Agricultural Research)
EMPMF	Empresa Brasileira de Pesquisa de Mandioca e Feijão
IARCs	International Agricultural Research Centers
IBTA	Instituto Boliviano de Tecnología Agropecuaria
ICA	Instituto Colombiano Agropecuario

ICARDA	International Center for Agricultural Research in the Dry Areas, Syria
ICRAF	International Centre for Research in Agroforestry, Kenya
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IDRC	International Development Research Centre, Canada
IER	Institut d'Economie Rurale, Mali
IIED	International Institute for Environment and Development, UK
INIAP	Instituto Nacional de Investigaciones Agropecuarias , Ecuador
IPGRI	International Plant Genetic Resources Institute, Italy
IPRA	Investigación Participativa en Agricultura/Participatory Research in Agriculture of CIAT
IRD	Informal Research and Development Program, Nepal
IRRI	International Rice Research Institute, the Philippines
ISAR	Institut des Sciences Agronomiques du Rwanda
ISNAR	International Service for National Agricultural Research, Neths
KIT	Koninklijk Instituut voor de Tropen (*Royal Tropical Institute*), Neths
KRIBHCO	Krishak Bharati Cooperative Ltd., India
LIBIRD	Local Initiatives for Biodiversity Research and Development, a Nepalese NGO
LUPE	Land Use and Productivity Enhancement project, Honduras
MILPA	McKnight Integrated Landrace Preservation Activity project, Mexico
MSSRF	MS Swaminathan Research Foundation, India
NARC	National Agricultural Research Center, Nepal
ODA	Overseas Development Administration (formerly); now DFID, UK
ODI	Overseas Development Institute, UK
PNAP	National Potato Improvement Program, Rwanda
PRGA Program	Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation of the CGIAR
PROINPA	Programa de Investigación de la Papa, Bolivia
REST	Relief Society of Tigray, an NGO, Ethiopia
SADC	Southern Africa Development Community
SAVE	Sustainable Agricultural and Village Extension project, Sierra Leone
SRN	Secretaría de Recursos Naturales, Honduras
SURE	Society for the Uplift of Rural Economy, an NGO, Rajasthan, India
SWP	Systemwide Program of the CGIAR
UPWARD	Users' Perspectives With Agricultural Research and Development, Manila, the Philippines
USDA	United States Department of Agriculture
WARDA	West African Rice Development Association

Abbreviations

CBO	community-based organization
CPB	collaborative plant breeding
FPB	farmer participatory breeding
GxE	genotype-by-environment
IPRs	intellectual property rights
IRD	informal research and development approach
NARS	national agricultural research systems
NGO	non-governmental organization
PCI	participatory crop improvement
PPB	participatory plant breeding
PRA	participatory rural appraisal
PVS	participatory variety selection