27 Base-broadening for Client-oriented Impact: Insights Drawn from Participatory Plant Breeding Field Experience

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Introduction

Broadening of basic germplasm pools can only achieve its goal of promoting agricultural stability if the products are actually sown and resown by farmers on a significant scale. To achieve this end, varieties developed from based-broadened pools need to meet certain criteria: (i) they have to be adapted to farmers' local growing conditions; (ii) they must meet farmers' preferences[1]; and (iii) they have to remain accessible to farmers on a sustained basis, that is, in both the short and longer term. In practice, 30–50 years of fundamental base-broadening research will have little value if the resulting primary products remain solely in researcher-controlled fields, laboratories and genebanks. To anticipate some of the more downstream challenges implied by upstream base-broadening work, research and development (R&D) strategies need now to be tested and targeted for widening the base of germplasm use at the 'bottom', among end-users in rural communities. Strategies need to be contrasted and compared to ensure that diverse germplasm pools can provide varieties that are locally adapted, farmer acceptable and farmer accessible.

Current breeding pools offer greater variability than actually reaches the end-user. Further, out of hundreds of varieties in any single national agricultural research system

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(NARS), farmers typically receive a handful to be tested each season. For instance, in Rwanda, the initial experimental set of about 250 cultivars narrows down to three to five entries in on-farm trials (Sperling *et al.*, 1993); in Syria (S. Grando, personal communication), a pool of 200 is narrowed down to three or four; and in India (pearl millet), 30–80 entries may enter preliminary yield trials, with one or two reaching farmers only after official release (E. Weltzien, personal communication). The current narrow provision of materials to farmers offers fertile opportunity for testing the principles of 'local-level base-broadening' – in anticipation that even wider pools may be available in a 'base-broadened future'.

This chapter first briefly describes an emerging novel field, participatory plant breeding (PPB), which has among its central aims broadening the diversity of germplasm available to and used by farmers. In practice, upstream base-broadening efforts will have to be linked integrally to 'compatible' or 'like-minded' downstream R&D field programmes – if diverse and novel products are to be sown in thousands of site-specific contexts. PPB offers one such 'like-minded' paradigm, as programmes tend to work very interactively with farming communities and often build in capacity for continued evolution of both genetic materials themselves and farmers' skills to manage such materials.

Drawing from a large body of actual field experience, this chapter summarizes some of the lessons learned from PPB in terms of meeting the three fundamental principles of adaptability, acceptability and accessibility. While there is accumulating evidence to enhance our ability to meet these three preconditions, and thus to inform the design of base-broadening programmes, critical knowledge gaps remain. As such, each section of this chapter integrates analysis of 'steps made to date' with those that 'still need to be pursued'. Through such reflection, the chapter suggests a practical farmer-level research agenda for enhancing our capacity to widen the base of farmers' germplasm use.

Overview of Participatory Plant Breeding[2]

What is PPB?

PPB involves scientists, farmers and others – such as consumers, extensionists, vendors, industry and rural cooperatives – in plant breeding research. It is termed 'participatory' because users can have a research role in all major stages of the breeding and selection process. Such 'users' become co-researchers as they can help set overall goals, determine specific breeding priorities, make crosses, screen germplasm entries in the pre-adaptive phases of research, take charge of adaptive testing, and lead the subsequent seed multiplication and diffusion process (Sperling and Ashby, 1999). The fundamental rationale for a PPB programme is that joint efforts can deliver more than when each actor works alone.

While some have cogently argued that commercial, private-sector, plant breeding has long been client-driven, or 'participatory' under another name, the application of PPB to reach poor client groups, to breed for high-stress, hetereogeneous environments and to incorporate diverse traits to meet specific client preferences results in fundamental changes in the way in which plant genetic resources are managed by formal breeding programmes and farmers. It makes sense, therefore, to analyse PPB as a new approach to germplasm development, especially in the public sector. The Consultative Group on International Agricultural Research (CGIAR) Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (SWP/PRGA) currently has detailed documentation on 65 PPB programmes and projects (Hecht, 1999; McGuire *et al.*, 1999; Weltzien *et al.*, 1999). Most of the cases, whether located in public sector or non-governmental organization (NGO) crop improvement programmes, were begun in the 1990s.

Under the PPB rubric, two broad approaches have been defined: when farmers join in breeding experiments that have been initiated by formal breeding programmes ('formal-led PPB'); and when scientists seek to support farmers' own systems of breeding, varietal selection and seed maintenance ('farmer-led PPB'). Both formal-led and farmer-led work may prove key for enlarging the base of germplasm accessed, modified and evolved through use in farming communities. Table 27.1 indicates the range of crops on which PPB programmes have been initiated, as well as proposals received by the SWP/PRGA. Given its relatively short history, the range of crops is impressive – although few can be considered 'minor'.

Table 27.1. Crop foci of PPB programmes to date.

Crop	Formal-led	Farmer-led	PRGA small grant submissions
Barley	*	*	*
Bean	*	*	*
Black gram	*		
Cassava	*		
Chickpea	*		
Chaite rice	*		
Cotton	*		
Cowpea	*		*
Lentil	*	*	*
Maize	*		*
Pearl millet	*		*
Potato	*	*	*
Rice	*	*	*
Sorghum	*		
Sunflower	*		
Trees	*	*	
Wheat	*		
Peas		*	*
Sweet potatoes		*	
Faba bean			*
Native potatoes			*
Durum wheat			*
Yam			*
Crotelaria			*

What are the goals of PPB?

PPB programmes can have a diversity of overarching goals. The most common goal has been to contribute to increased production in farmers' fields and increased farmer incomes through the development and enhanced adoption of suitable, usually improved varieties. These are the basic goals of any formal-led breeding programme, and participatory approaches are often experimented with to achieve these goals more effectively and more efficiently. In this context, PPB programmes sometimes seek to refine their knowledge of farmers' needs or preferences or re-orient general breeding directions, such as the type of germplasm used, the priority traits sought, and the management of both on-station and on-farm trials.

Enhancement of crop diversity on-farm is another broad goal towards which some PPB programmes strive. Participatory breeding programmes having 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 pre-adaptive stages of research, either in on-station trials or in community plots. In several cases, PPB programmes have also released populations or have purposely promoted breeding strategies that result in heterogeneous materials. Chapter 26, this volume, by Witcombe discusses this subject further.

Another important goal of PPB programmes is to provide benefits for specific types of users (e.g. the rural poor, women, farmers with marginal soils) or to address deliberately 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.

While addressing issues related to improved adoption of breeding products and/or enhancement of crop diversity, PPB programmes often find themselves confronted with the need to address modifications in policy, whether these be 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 (see Louwaars, Chapter 5, this volume).

Finally, some programmes specifically work towards enhancing the farmers' own breeding process, i.e. 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 demand and derive benefits from the formal research institutions.

Overviews of PPB programmes show that, to date, primary goals set largely parallel those of classic breeding research: to increase production or increase the value of products through enhanced quality traits. However, an impressive 20% of PPB projects also have as an explicit goal varietal diversity enhancement in farmers' fields (McGuire *et al.*, 1999; Weltzien *et al.*, 1999). The strengths, shortcomings and overriding challenges of PPB programmes very directly herald those which might be expected to enrol in more general local-level base-broadening initiatives. Developing strategies for rendering adapted, appreciated and accessible materials to farming communities lies at the heart of both PPB and base-broadening work.

What are the environments in which PPB unfolds?

Based on an inventory of about 65 formal-led and farmer-led PPB cases, maps are being devised to indicate the range of environments in which PPB unfolds. One parameter of the conceptual map describes the type of agroecological context. This has been constructed on a scale for environments from high stress to low stress based on actual vs. expected yields coupled with an index for incidence of crop failure. Agroecological environments potentially range from those that are primarily subsistence-oriented and highly unstable, to systems in which crop production is predictable, highly controlled, and often shaped by significant input use.

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' use for home consumption and for sale. Contexts at the higher end (for example, 8 or 9) tend to correspond to a high degree of homogeneity in product and often favour a narrow range of grain, taste and cooking types. Such a strong degree of uniformity is often associated with contexts where farmers are producing for highly specialized markets.

Many plant breeders consider PPB as most appropriate for environments that are high-stress ('marginal') and where agriculture is low-input (i.e. where 'adaptability' is the key issue). Certainly, conventional breeding has been less effective in such difficult environments and in reaching farmers with few resources; so 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 programmes are being initiated in the intermediate areas where agroclimatic stress is less severe (Fig. 27.1). On the whole, these are cases where quality concerns, i.e. meeting exigent end-user preferences, is defined as the paramount challenge: acceptability is key. Figure 27.1 also shows that a significant amount of PPB work is now occurring in low-stress areas (Green Revolution-type zones) where homogeneous end-user preferences are well defined in the market (for example, the Nepalese Terai: J. Witcombe, personal communication). Two reasons explain most of the cases in these areas. First, some of these PPB programmes aim to expand intracrop varietal diversity in what have become relatively uniform farming areas. Secondly, some programmes 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 *et al.*, 1999, Salazar, Chapter 7, this volume). In these sites, the operative driving PPB principles are of increasing 'control' and 'accessibility' over germplasm and germplasm processes.

While the three prerequisites of PPB are integral to each programme, this broad look at the environments of PPB suggests that the weight of each may vary by site. In the harshest zones, adaptibility is the prime criterion to be met – that is, getting something that grows. In the mid-potential zones, identifying adapted germplasm is often of equal challenge to finding something that addresses producer and consumer needs (i.e. is acceptable). In the higher potential areas, acceptability holds some weight, but control over breeding and diverse breeding materials (i.e. accessibility) may lay at the base of many PPB programmes.

Unfavourable .... Favourable

Subsistence .... Market integration .... 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/NARC-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)
NARC/DFID Nepal *REST/Ethiopia* ICARDA/Syria CIMMYT Mexico Sure/ICRISAT India *Guanxi* Narendra Dev/India IER/KIT Mali ICRISAT/Namibia	ISAR/CIAT/COOPIBU Rwanda	

Fig. 27.1. Environmental contexts of PPB programmes.

Germplasm Adaptability at the Local Level: Lessons from PPB Field Experience

It is now widely accepted that to identify adapted varieties in the majority of the world's farming communities, much of the selection has to be done, on-site, under comparable agroecological and farmer management conditions. For example, Ceccarelli (1994) highlights the importance of genotype × environment crossover between farms and experiment 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 the barley programme at the International Center for Agricultural Research in Dry Areas (ICARDA) (Ceccarelli *et al.*, Chapter 6, this volume). In the overview paper on formal-led PPB (Weltzein *et al.*, 1999), many researchers cited high-stress, 'marginal conditions' (including low or erratic rainfall, unpredictable highland climates or low input due to remoteness) as a reason for employing participatory approaches in their programmes. 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. While some varieties identified through highly decentralized testing meet adaptation needs only in specific niches (see Sthapit *et al.*, 1996), others prove to be surprisingly widely adapted (Witcombe *et al.*, 1999). Obviously much depends on how representative the selection is and the heterogeneity of user preferences in surrounding zones. While, in principle, the need for site-specific screening is widely accepted, guidelines for the 'degree of decentralization' necessary (Witcombe, 1996) still have to be elaborated.

Those who use PPB specifically to enhance varietal diversity on-farm (both phenotypic and genetic diversity) face two sets of major challenges to putting into operation decentralization on a broad scale. These challenges will lie similarly at the core of most local-level base-broadening programmes.

Technical approaches to decentralization

The first set of challenges centres on general technical approaches to enhancing varietal diversity at the community level. Theoretically, diversity can be broadened through several strategies:

1. Many fixed lines can be proferred for screening in community-based plots. Farmers can then individually select lines which they project will perform well on their own farms and carry on all further home-based testing. This approach worked quite well in Rwanda, where 21 new bean phenotypes were adopted among three communities in a 3-year period (Sperling *et al.*, 1993).
2. Segregating materials or 'scientifically enhanced populations' can be made available to farming communities who themselves then guide the subsequent adaptation and selection. Berg (1996) describes the theory of this process, drawing from the famous experiment with composite cross populations of barley at the University of California at Berkeley (Allard, 1988, 1992; Soliman and Allard, 1991; see also Ibrahim and Barrett, Chapter 15, this volume). There, populations were exposed to natural selection over many generations and eventually showed good disease resistance and yield stability – although not high yield potential *per se*. In practice, excellent results were achieved in Nepal in identifying adapted and farmer-accepted chill-tolerant rice varieties through the placing of segregating (F_3 to F_4) materials on-farm. This work was heavily shaped by both researcher and farmer input (Sthapit *et al.*, 1996). In another case, in the Philippines, breeders gave F_3 to F_4 rice materials to farmers, with subsequent selection left entirely to communities to F_7/F_8. The advantages of such a schema is that it is easy to run and can be encouraged at many locations (Witcombe, 1996).
3. A third strategy might focus on upgrading local material itself (in terms of various traits) through recombinations/introgression. This is commonly employed across classic breeding programmes – but is a lengthy and costly process.
4. A focus of 'diversity enhancement' might also be on skill-building itself, rather than

on supplying germplasm. An experimental programme run by Zamarano and Cornell University for farmers from Honduras, Nicaragua and El Salvador considerably honed participants' ability to select and manage maize seed (Gomez, 1995; Gomez and Smith, 1996).

The point is that there are many different strategies that should be tested at the local level for working with farmers and giving them the means to choose among materials or develop and modify varietal materials themselves. The effectiveness of different strategies will probably vary according to such variables as farmer breeding/selecting skills (often related to the degree of previous exposure to diverse materials), the narrowness/leniency of the market environment, and the agroecological 'flexibility' (i.e. there may be few options in the harshest locales). Programmes need to be set up to compare and contrast different approaches simultaneously – and at a scale that allows lessons to be learned. Ultimately, we need sharpened insights into which base-broadening approaches are best for which ecological and socioeconomic environments.

Organizational issues in decentralization

The second challenge revolves around organizational aspects of the base-broadening enterprise. To date, there has been very little work exploring the organizational options for decentralization across many sites (namely the work of the local committees for agricultural research (CIALs) in Central and Latin America, Ashby *et al.*, 1999). This gap is glaring as it is generally believed that client-oriented programmes have to be decentralized to have local-level impact – simply because farmers have differing needs specific to their own agronomic and socioeconomic situations.

Effective decentralization of varietal testing is a task beyond the resources of most public-sector research services: in practice, most NARS' budgets are declining. Might NGOs possibly have an edge in decentralizing efforts – in just one or two communities? And what are the prospects for NGO scaling up? Might the farmer field school (FFS) model be a useful one to link with participatory and decentralized programmes? (The emphasis on skill-building in the FFS approach might be particularly relevant for these innovative breeding efforts.) Would organized groups of farmers have the comparative advantage in leading local testing – and for scaling up? Unless local-level programmes' efforts can enlarge their scale, they remain but interesting, perhaps productive, single-site experiments.

To date, within the field of PPB, there are relatively few cases where the process has been scaled up through the creation of multiple decentralized programmes: 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 250 CIALs, farmer research committees, in several countries have engaged in independent variety testing on a range of crops (A. Braun, personal communication). Another example of this is PPB work with cassava in Colombia developed around farmer cooperatives dedicated to drying cassava chips: in its 10 years, many cooperatives have been involved and in 1999 alone, the programme (assisted by the Corporación Colombiana de Investigación Agropecuaria (CORPOICA) and the CIAT) is working with 13 different communities (C. Iglesias, personal communication). PPB work in Rwanda also expressly experimented with different 'organizational options' for decentralization, comparing the strengths and weaknesses of collaborating with the formal extension service, women's cooperatives and self-organized farmer research groups (Sperling and Scheidegger, 1997). 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 labour, 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 overall, and the cost and benefits for each partner.

It is important to emphasize that almost all scaling-up work in PPB has been done in programmes 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 (just one to ten). Whether scaling up of farmer participation in these activities is necessary depends on the extent to which they can be centralized while still effectively addressing varietal needs over a broad area (Weltzien *et al.*, 1999; see also Ceccarelli *et al.*, Chapter 6, this volume).

To anticipate base-broadening work, there is a fundamental need to identify decentralization options. Chapter 13, this volume, by Goldringer *et al.* illustrates the potential role of high schools and agricultural colleges in decentralizing formal base-broadening programmes. Most likely, if they are to be cost-effective, they will have to be farmer-initiated and managed. However, this has to be examined systematically. Which organizational forms can handle which type of technical, decentralized experiments? What are the costs and for whom? What are the short-term and longer-term effects on farmer-held diversity?

Germplasm Acceptability at the Local Level: Lessons from PPB Fieldwork

It is easier said than done to identify appreciated varieties. Simply said: adaptation, which is often mistakenly equated with yield, is *not* an adequate predictor of adoption. An increasing number of studies show that traits other than yield strongly affect farmers' cultivar choice (e.g. Haugerud and Collinson, 1990; Nazarea-Sandoval, 1995).

Varietal traits farmers deem important

A great deal of qualitative evaluation has been generated within the course of PPB evaluations. In an overview paper synthesizing some of the critical social issues and analyses associated with PPB work, 54 criteria were highlighted as being routinely cited by farmers in their construction of ideotypes (Hecht, 2001). Table 27.2 outlines the elements mentioned by farmers across crop types, with the broad categories synthesized as 'environmental', 'agronomic' and 'cultural' trait groups. In her thought-provoking social analysis, Hecht comments that slightly fewer than half of these 54

Table 27.2. Farmer selection criteria.

Environmental criteria	Agronomic criteria	Culture, production and use	Ancillary features
Tolerant of soil limitations (fertility; variable water conditions; textural variability)	General (intercropping ability; shade; tolerance; flowering characteristics; dormancy features)	Labour demand (germination characteristics; planting ease; cultivation; weeding; harvesting)	Quality and palatability of leaves for humans
Tolerant of climatic factors heat; cold; wind; rainfall variability)	Yield (earliness of production; plant form)	Processing (ease of) (dehulling; pounding; peeling; milling; humidification; breakage characteristics)	Quality and palatability of leaves for animals
Biotic pressures (insect pests; animal pests; human predators; weed; competition; weed supression)	Tuber distribution	Culinary (taste; texture; aroma; quality of broths ritual uses; nutritional factors; quality in fermented products)	Calibre of stover fodder
Disease tolerance	Flexibility in planting and harvest	Storage	Ratooning ability
	Crop morphology (size of tuber, grain or cob (bigger is not always better); shape of plant; tillering habits; colour)	Exchange utility	Craft uses of fibres
		Commercial utility	Mulch materials
			Staking materials
			Construction materials

Source: Hecht, 2000. PRGA Programme.

traits are related to post-harvest, labour, ancillary, culinary or storage features – that is, the 'cultural' dimensions of crops. This suggests that farmers, especially women farmers, value these characters a great deal, since these are often highly gender-specific tasks (such as processing). These latter characteristics have rarely been taken into account in the usual pathways of technology development.

Salient among the various farmer criteria cited within PPB evaluations were the following:

1. Cultivar performance in intercropped systems.
2. The importance of ancillary products as food for both humans and animals.
3. Earliness of production.
4. Labour demand characteristics.
5. Post-harvest processing concerns.
6. Culinary dimensions.

While, yield analysis remains the measure of choice for many agronomists for assessing whether the variety is doing well (with some moving toward the measure of yield stability), the data from the participatory evaluation trials suggest other factors pertaining to household needs (i.e. early yield, ancillaries) labour and cultural demands are probably equally important as agronomic criteria.

Diagnostic methods to determine farmer needs

Accurate diagnosis of what users want and need can be effected through a range of techniques. These can include: farmer screening of diverse germplasm nurseries (Ipinge *et al.*, 1996); detailed analyses of 'weaknesses' and 'strengths' in the materials farmers are already sowing (Weltzien *et al.*, 1996); and exploratory trials using local and exotic material, which explicitly expose farmers to a wide range of traits and/or ranges within traits (ICARDA, 1994). These methods are in addition to the more common formal and informal surveys, focus group sessions or community meeting assessments. The choice of which method to use seems to depend more on the scale of investigation, money and time resources available, and training of the researchers involved – than on the actual results or degree of detail achievable through any one technique. Despite the importance of accurate diagnoses in guiding the development of a lengthy breeding programme, there have been few critcial analyses comparing and contrasting the techniques available (Weltzien *et al.*, 1996). One deliberate focus of a PPB programme currently funded by the UK's Department for International Development in five sites in eastern Africa and Latin America centres on comparing the results of different diagnostic strategies – within the same communities. It aims to evaluate the type of information received (e.g. specificity on varietal traits and trade-off assessments, insights into different user preferences) with the time, skill and scale on which the techniques can be used (L. Sperling, personal communication). One concern is that most diagnostic techniques can only be conducted on a very local level – with larger-scale diagnostic skills (such as conjoint analysis) demanding highly specialized training. This is a methodological area in which much fundamental work remains to be done – to sharpen both PPB and future base-broadening work.

Differentiating among farmers

Good diagnosis of farmers' preferred varietal traits (ranges of criteria/trade-offs) logically needs to be coupled with sufficient means for distinguishing among farmers: it does matter 'who wants what' – if a programme has aims relating to targeting specific groups of potential users. In differentiating between farmers, the current vogue often dictates a focus on gender differences (women may have different preferences to men) or wealth differences (the poor having divergent needs/wants from the rich).

Field evidence from PPB programmes shows that gender can be an important factor in determining differential preferences, but not always. In Mali, maize evaluations showed men putting production and early maturity as the main criteria, with women focusing on organoleptic and processing aspects (DeFoer *et al.*, 1997). Rice work in West Africa had a similar gendered division, with WARDA (West Africa Rice Development Associations) scientists reporting that men focused on yield and yield-related traits such as plant vigour, while women concentrated on quality attributes, such as bold grains (Lilja and Dalton, 1998). However, in many cases, gender-differentiated evaluations do not yield clear-cut preferences.

Field evidence also shows that wealth can be a key distinguishing factor. The review of formal-led PPB programmes showed a number of trends among the financially disadvantaged. Poor farmers often cited earliness as an important factor in shortening the hungry season and in maximizing production on their small landholdings. Poorer farmers also had important criteria related to multiple crop uses (such as cassava in Colombia, pearl millet in Rajasthan (India) and cowpea in Cameroon), as people relied on non-food parts for animal feed, or seasonal excess processed for the market (cassava flour/Colombia). Where farmers rely on selling some of their products for scarce household cash income, quality criteria proved to be determined more by market demands than by grower preferences. With potatoes in Peru and cowpeas in Cameroon, farmers grow modern varieties as cash crops, and benefit by earning as much as double for products with preferred size, colour or shape (Weltzien Smith, 1999).

However, farmers do divide themselves into groups (or construct images of self-identify) beyond gender and wealth. For example, caste, ethnicity or age may be important in any given region. The methodological concern centres on 'how can we find out which populations differences or "user" differences are really key in shaping preferences?'. That is, farmers may differ by age, wealth, religion and politics but not all of these variables are equally important in determining, say, lentil variety preferences. There is a compelling need to develop and refine diagnostic techniques that can be used at different stages of the breeding process (for example, shaping initial priorities and, at the other end, evaluating finishing lines), which can be used at various geographic scales, and which ensure that different user groups are given a voice.

Germplasm Accessibility at the Local Level: Lessons from PPB Fieldwork

PPB work suggests that the earlier farmers are involved in developing germplasm, the higher the likelihood that the resulting varieties and seed will have to be moved outside of formal channels. This proves to be true for several reasons – and especially if the work is truly participatory: (i) a large range of varieties may be identified for different kinds of users; (ii) the site-specificity of varieties may discourage formal-sector multipliers from devoting their efforts; (iii) the intravarietal heterogeneity might prohibit formal multiplication; and, if farmer–researcher collaboration is taken seriously and ethically; (iv) undefined or shared property rights would deter more routine multiplication.

Seed system issues

Participatory plant breeding programmes often have to go 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 proposed plans for decentralizing seed services – partly to accommodate more decentralized breeding (L. Sperling, personal communication). PPB programmes are also increasingly incorporating integrated and innovative seed production components to deliver rapidly 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 and with potato in Bolivia, Peru and Ecuador through a set of collaborations between the national seed projects and the International Potato Centre (CIP) (Iglesias *et al.*, n.d.; Thiele, 1999).

Overall, relatively little of the current PPB work ties site-specific breeding with seed multiplication work. Either it is assumed that products will go to formal channels (which has happened only in a single case each in India and Nepal) or it is assumed that local seed systems can handle PPB products well, that 'varieties diffuse by themselves'.

Formal systems have some obvious constraints. In addition to the four points listed above, formal systems generally deal with a relatively narrow range of crops – and reach out to a relatively narrow range of users. Global estimates show farmers accessing about 80–90% of their seed directly on-farm or through local channels (Cromwell, 1997). For non-hybrids, the figure has sometimes been cited as less than 2% of all seed used by small farmers coming from the formal system (CIAT, 1982).

Proponents of local systems sometimes point to the effectiveness of local-level exchange mechanisms and assert that 'varieties move themselves'. However, the authors know of few studies that actually assess the efficiency of local systems: how fast they move varieties, if they are equitable, if they can handle many new entries, and if they have wide geographic spread. Rather, one detailed case shows local systems to be: (i) variable in efficiency according to agroecological, socioeconomic environment, and degree of varietal appreciation; (ii) of restricted access – unless varieties are diffused in local markets; and (iii) susceptible to frequent loss of specific varieties – especially if genetic materials are in the early stages of diffusion (Sperling and Loevinsohn, 1993). Local seed systems fulfil a range of functions. They provide information about seed sources, seed availability, and new types of seeds and varieties. They govern the actual flow of seed and affect 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, local seed systems are the only system that provides seed to farmers, especially to poor farmers.

Each seed system (formal, farmer or something in between) has different strengths and weaknesses, and a base-broadening programme 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 material homogeneous or heterogeneous?

In sum, to accommodate both the products of PPB and other types of base-broadening work, there is a clear need to diagnose/test the ability of local systems, or new intermediaries (e.g. cooperatives), to handle multiple new infusions of material – and to distribute such material widely and equitably. This issue is particularly pressing for the cross-pollinated materials.

Property rights

Joint collaboration should mean joint benefit sharing. At this point, there are no ready-made arrangements or 'best practices' that one can suggest to guide the diffusion of materials emerging from farmer–researcher collaborations. Neither the farmers' rights debates nor the formal breeder-rights discussions fully match the bill.

The SWP/PRGA has recently started work to address property-rights issues within the participatory plant breeding arena. The process is unfolding briefly as follows. Eight to ten typical PPB collaborative type cases have been identified. For each case, analysis is taking place in three realms: (i) existing legal frameworks that might constrain or stimulate the PPB relationship; (ii) associated ethical concerns; and (iii) 'best practice' actions emerging from widespread public debate with practitioners.

At the moment, most of the PPB programmes have simply skirted the property-rights issues with two very different strategies: materials jointly developed by formal breeders and farming communities have been fed into the formal variety release and seed multiplication system (not recognizing farmers' input at all), or the PPB-developed materials have been 'released' or 'let go' into farming communities – with no official launch of any kind. This has had a 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.

Conclusions and Discussion

The term base-broadening most often conjures up images of longer-term commitments to basic evolutions of genepools. This chapter suggests that the success of base-broadening will be highly contingent on whether farmers' specific needs for adapted, acceptable and accessible germplasm are met. PPB programmes can provide an array of community-based (and tested) approaches for increasing the adaptation, acceptability/attractiveness and accessibility of base-broadened germplasm.

The research agenda for successful base-broadening needs to be considerably expanded to include such issues as identification of rigorous user diagnostic methods, effective decentralization options (technical and organizational), and creation/support of farmer-responsive seed channels. Intellectual property-rights issues will also require serious attention and consideration as they could pose significant obstacles to use of base-broadened pools and use of PPB products in general.

In several cases, for many crops, current breeding pools are already wide enough to start testing varied strategies for widening the base of farmers' germplasm use. However, it is not clear that they have been focused strongly enough on adaptation and acceptability/attractiveness for the non-commercial farming sector. Exploratory PPB programmes may be critical for moving base-broadened materials out to thousands of communities. However, they may be equally essential for feeding back critical end-user-oriented information to enhance the likely relevance of upstream base-broadening decisions – for rural populations.

Notes

[1]We use the terms 'preferences' and 'farmer-acceptance' in a dynamic sense. Obviously concerns of colour, taste and cooking time would be encompassed in these notions. Equally, however, preferences imply a sense of 'attractiveness'. To be used by farmers, base-broadened pools have to offer advantages not currently available to farmers: novel traits or trait combinations, or better levels of existing traits.

[2]This section draws from Weltzien *et al.*, 1999, and Sperling and Ashby, 1999.

[3]As one reviewer noted, one might expect that in isolated, economically marginal areas, accessibility would also be an issue – albeit in a different sense – since formal seed supply systems are rarely operating effectively in such areas.

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