Euphytica **122:** 439–450, 2001.

A framework for analyzing participatory plant breeding approaches and results

L. Sperling[1], J.A. Ashby[2], M.E. Smith[3], E. Weltzien[4] & S. McGuire[5]
[1]*CGIAR Systemwide Program for Participatory Research and Gender Analysis (PRGA) and the International Center for Tropical Agriculture (CIAT), Rome, Italy;* [2]*CGIAR Systemwide Program for Participatory Research and Gender Analysis (PRGA) and the International Center for Tropical Agriculture (CIAT), Cali, Colombia;* [3]*Department of Plant Breeding, Cornell University, Ithaca, New York;* [4]*Genetic Resources and Enhancement Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Bamako, Mali;* [5]*Technology and Agrarian Development group, Wageningen University, The Netherlands*

Received 2 February 2000; accepted 12 December 2000

Key words: plant breeding, farmer participation, client-driven, framework research

Summary

Participatory Plant Breeding (PPB) involves scientists, farmers, and others, such as consumers, extensionists, vendors, industry, and rural cooperatives in plant breeding research. It is termed 'participatory' because many actors, and especially the users, can have a research role in all major stages of the breeding and selection process. While some have 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, heterogeneous environments and to incorporate diverse traits to meet specific client preferences is resulting in fundamental changes in the way plant genetic resources are being managed. PPB merits analysis as a separate approach. The notion of 'PPB' is a relatively recent one: detailed inventories show that most of the 65 'longer-term' cases have begun within the last 10 years, whether they were located in public sector or non-governmental crop improvement programs. With such 'newness'comes a wealth of terminology and divergent technical, social and organizational strategies under the general rubric of 'PPB'. This article aims to set up a framework for differentiating among PPB approaches. Only by discriminating among cases can one understand how each PPB approach can lead to a different outcome, and so be able to make informed choices about which approach to pursue. The key variables explored for discriminating among PPB approaches include: the institutional context, the bio-social environment, the goals set, and the kind of 'participation' achieved, (including the stage and degree of participation and the roles different actors undertake). It is only when these variables are clearly described that current and potential practitioners can start to link the 'type of PPB' employed (method and organizational forms) with the type of impacts achieved. An ending illustration of ongoing PPB programs suggests the practical utility of this 'PPB framework'.

Introduction

Participatory Plant Breeding (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 & Ashby, 1999). The fundamental rationale for PPB programs 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 (Dr Don Duvick, pers. comm.), the application of 'PPB' to reach poor client groups, to breed for high-stress, heterogeneous environments and to incorporate diverse traits to meet specific client preferences results in fundamental changes in the way plant genetic resources are managed by formal breeding programs and farmers. It makes sense, therefore, to analyze Participatory Plant Breeding as a new approach to germplasm development, especially in the public sector. The CGIAR Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA) currently has detailed documentation on 65 PPB programs and projects (Weltzien/Smith et al., 1999; McGuire et al., 1999, Hecht, 2000). Most of the cases, whether located in public sector or non-government (NGO) crop improvement programs, were begun within the last 10 years.

A lack of consensus about terminology is common when a new science is in its early stages, and Participatory Plant Breeding (PPB) is no exception. Terms commonly used interchangeably include: Collaborative Plant Breeding (CPB) (Soleri et al., 1999) Farmer Participatory Breeding (FPB) (Courteois et al., 2000); and Participatory Crop Improvement (PCI) (Witcombe et al., 1996). The latter is sometimes subdivided into two areas, one for work with stabilized materials, termed Participatory Varietal Selection (PVS) and another referring exclusively to work with variable or segregating materials, confusingly also sometimes termed PPB. All labels presently used describe broadly the same activities of what is a multi-faceted technical and organizational collaboration in plant breeding by scientists and users of their results (Weltzien/Smith et al., 1999). This paper uses the term 'plant breeding' in an inclusive sense to refer to all the activities normally included in a plant breeding research effort, beginning with establishing the goals and objectives which define the traits of interest to be incorporated in the bred plant, and ending with the on-farm testing, multiplication and distribution of seed to farmers (PRGA, 1999a).

The most important reason for differentiating among approaches to participatory plant breeding is to understand how each approach can lead to a different outcome, and so to be able to make informed choices among approaches. This article sets up a framework for relating different participatory plant breeding approaches to breeding outcomes and impacts. The article lays out the key variables which are crucial for discriminating among PPB approaches: the institutional context, the bio-social environment, the goals set, and the kind of 'participation' achieved, including the division of labor among scientists and clients. It is only when these variables are clearly described that current and potential practitioners can start to link the 'type of PPB' employed (method and organizational forms) with the type of impacts achieved. Such clarity is essential if PPB is to have the scientific and organizational foundations to judge its utility for a given objective. It is also essential for choosing the appropriate PPB approach.

PPB and institutional context: formal-led and farmer-led

One of the most important differences among approaches to 'Participatory Plant Breeding' (PPB) is institutional, in the sense (following North, 1990) of the rules for behavior, the norms and values, and the incentives that govern how farmers and scientists will share the responsibility, the work and the benefits of a joint plant breeding effort. The key institutional difference lies in the built-in obligations which determine the locus of control or decision-making about the objectives of the plant breeding and the kind of results and data required to support these. We distinguish two main institutional approaches: one when farmers join in breeding experiments which have been initiated by formal breeding programs which we term 'Formal-led PPB' and another when scientists seek to support farmers own systems of breeding, varietal selection and seed maintenance, which we call 'Farmer-led PPB'. The incentive structure, and rights and obligations which characterize these two approaches can be expressed in different types of organizational arrangements. Among the 65 case studies reviewed, Formal-led PPB unfolded in public sector science bureaucracies and non-government organizations; examples of Farmer-led PPB are found in international as well as community-based public and non-government agencies.

Formal-led PPB has certain unique institutional characteristics. Researchers run formal-led PPB programs and invite farmer participation in the formal research. Researchers have an obligation and often a priority objective to feed information back to the formal research sector: this means that the scientific standards of replicability and validity of results must be met. There is the expectation that PPB will complement the formal sector research system, e.g. refining breeding strategies so that specific environments and varietal preferences are addressed, or re-orienting priorities. Generally, formal-led PPB programs also involve strong linkages to formal variety release and seed production systems. Finally, scientists involved in formal-led programs are usually expected by the scientific community to extrapolate their methods, if not the varieties *per se*, beyond the individual community with which they work. They often need to show what the advantages of PPB are compared to formal breeding approaches (Weltzien/Smith et al., 1999).

There are some distinguishing institutional characteristics of farmer-led PPB. Researchers or other professionals in farmer-led programs are expected to facilitate a process in which farmers establish breeding objectives. Farmers bear the main responsibility for and, often, the costs of conducting experiments, selecting materials for seed multiplication, and dissemination of these. Researchers are expected to take a support role in this process. Farmer-led PPB has the objective to provide varieties or populations which suit the specific local environment and local preferences and any broader applicability beyond local circumstances is fortuitous. Farmer-led PPB, with a few exceptions, tends to work for a specific client group or groups which have no obligation either to feedback information for wider geographical extrapolation, nor to feed products such as varieties into external formal release and seed systems (McGuire et al., 1999).

It is important not to confuse the scale (i.e., the size of the program or the extent of geographical coverage) of a PPB effort with the institutional approach. The fact that PPB is carried out at the village or local scale does not mean that it is *ipso facto* farmer-led PPB. Case study analysis indicates that there is a very wide range of collaborative arrangements in PPB carried out at the local or village scale (PRGA, 1999b) some of which can be described as using a farmer-led institutional approach, others of which are instead controlled by representatives of outside agencies, albeit small-scale ones like local NGO's for example (see Table 1).

Since most PPB is still experimental and most initiatives in their early stages are conducted in a few sites, it is not yet clear whether there is an inherent difference in potential scale between the formal-led and farmer-led approaches. Most farmer-led PPB is conducted at the community or local scale, and the locus of control over decision-making is local, but there are examples with broad geographical coverage involving several hundreds of communities or widely dispersed farmer groups (eg. SEARICE in southeast Asia, CIALs in Latin America, PTA in northeast Brazil). Farmer-led PPB might also produced broadly adapted varieties, although accomplishing this is not a priority. In contrast, formal-led PPB strategies are being implemented by large international or national public sector research bureaucracies, sometimes over large geographical areas, but these may deliberately build a mosaic of community-based and locally controlled varietal selection efforts which collectively service a large-scale production area (Iglesias, 1998, pers. comm.).

Bio-social environments of PPB

Two types of parameters have proved heuristic for characterizing the environments in which PPB programs are taking place[1] The first describes the type of *agroecological environment* in which PPB programs develop. This has been plotted along a crop-specific scale ranging from high stress to low stress based on actual versus expected yields, coupled with an index for incidence of crop failure (thus combining yield level and stability) (Weltzien/Smith et al., 1999). We hesitate to use the terms 'favored and unfavored' because these often mean 'favored for staple cereal crops' but lay usage tends to ignore the notion of crop-specific comparative advantage, i.e., a cool tropical highland environment is 'unfavored' for irrigated rice but highly favored for coffee, for example. Agroecological environments potentially range from those which 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 very controlled and largely driven by urban consumer and/or commercial processor needs.

The second parameter suggests the broad *economic environment* of PPB, that is the degree 'homogeneous demand versus heterogeneous demand' for varieties. Plotting was based on a nominal scale of '1' to '10' according to the 'leniency/narrowness of varietal characteristics demanded by end-users' and

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

Table 1. A comparison of scale of research organization, geographical coverage to date and size of the desicion unit for managing formal-led and farmer-led PPB. Examples are referenced in Welzien/Smith, 1999

Institutional approach	Scale of research organization	Geographical coverage to date	Size of decision unit for managing the PPB	Example
Formal PPB (researcher controlled)	Large (e.g. national program)	Multi-locational	Multi-community/regional	INIAP, Potato, Ecuador
			Community or smaller	CIAT Cassava/CORPOICA Colombia; CIAT/ISAR, beans Rwanda
		One or a few sites	Multi-community/regional	ICRISAT/SURE Rajastan CIAT, bean Rwanda
			Community or smaller	
	Small (e.g. local NGO or community organization)	Multi-locational coverage	Multi-community/regional	This would be an example of numerous small scale organizations, which have formed an inter-institutional coordinating body to manage formal led PPB, and cover a large area e.g. an NGO network.
			Community or smaller	This would be an example of numerous small scale organizations, each managing formal led PPB at the community level, working together to cover a large area.
		One or a few sites	Multi-community/regional	
			Community or smaller	
Farmer led PPB (farmer controlled)	Large (e.g. international center or NGO)	Multi-locational	Multi-community/regional	SEARICE Philippines; PTA Brazil
			Community or smaller	CIALs, Central and South America
		One or a few sites	Multi-community/regional	
			Community or smaller	SAVE Sierra Leone
	Small (e.g. local NGO)	Multi-locational	Multi-community/regional	PROINPA Bolivia
			Community or smaller	Zamorano, Honduras
		One or a few sites	Multi-community/regional	Deccan Development Society, India
			Community or smaller	Save the Seeds, India

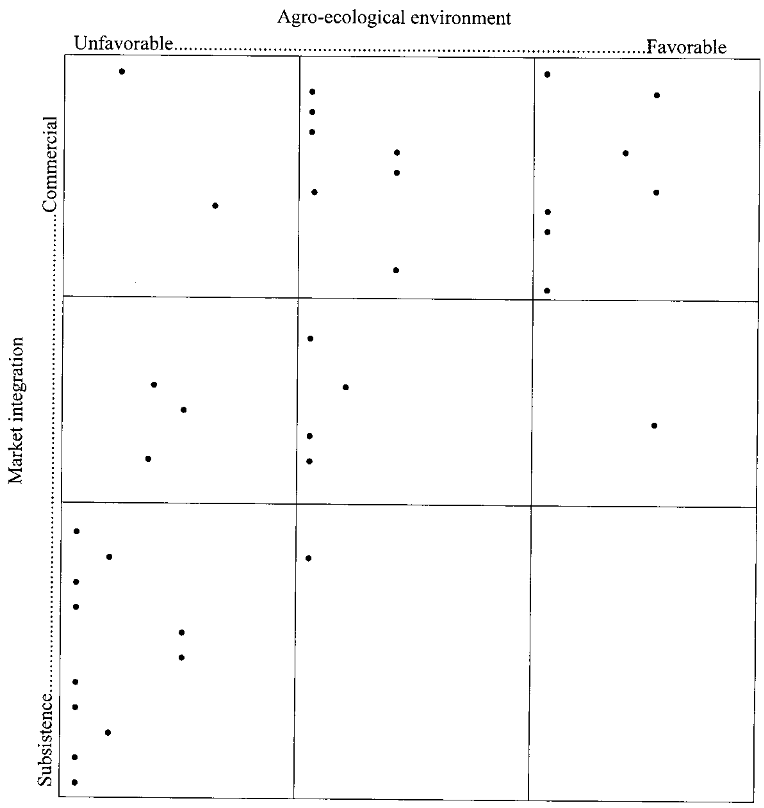

Figure 1. The distribution of participatory plant breeding (PPB) cases by type of environment. (For case identification, see Weltzien/Smith et al., 1999; for extensive description of each case see McGuire et al., 1999 and Weltzien/Smith et al., 1999).

the similarity/discordance between varieties used for home consumption and for sale (Weltzien/Smith et al., 1999). Contexts at the higher end (for example, 8, 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 which are high stress ('marginal') and where agriculture is low-input (for example, the editors of this volume). 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 (Figure 1). Not all PPB is concentrated in high stress environments with low input agriculture . An unexpectedly large number of PPB programs are being initiated in 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 (Weltzien/Smith et al., 1999, e.g., see cases of PROINPA work in Bolivia, CIAT/CIALS in Colombia).

Precise plotting 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 (for example, the Nepalese Terai; J. Witcombe, pers. comm.). 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 et al., 1999).

Goals of PPB

Over the last decade, PPB has been applied as a crop improvement strategy primarily in response to the need for impact in non-commercial crops and in very unpredictable, stressed production environments (as this volume suggests). Its successes in reaching highly diversified, very specialized and segmented markets have been less well publicized, albeit it is in this thematic area where the PPB challenges seem to be proliferating.

A range of other goals have also been defined within PPB programs: for instance, enhancing biodiversity and germplasm conservation; developing adapted germplasm for especially disadvantaged user groups (e.g., women, poor farmers); making breeding programs more cost-efficient, particularly through decentralization of programs which target more niches. Table 2 lists the broad goals around which PPB programs have been designed and some indicators which can be used to track whether these goals are being met.

Close analysis of the set of PPB cases shows that some goals are explicit and often attained (for instance, production increase) while others are poorly articulated and usually not addressed, unless they are explicitly built into the research design (for instance, reaching specialized interest groups).

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

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

Participation and PPB

Participation (like PPB) is a term used with a number of different connotations. However, it is essential to be clear about how to evaluate the separate dimensions of participation which 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 actors' roles in participation. The stage and degree of participation, together with the roles of the different actors need to be described in order 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 on the degree of participation.

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 taken either by the researchers, farmers or others. Role refers to the function performed: The role of actors in a participatory program specifically refers to the functions they undertake, for example, management role, information-giving role, or field labor provider.

These three dimensions of participation are elaborated further below.

Stage of participation

After having agreed that a joint farmer-researcher collaboration in plant breeding is desirable (i.e. 'yes', do PPB) and having set the overall goals of the PPB (e.g., biodiversity enhancement, farmer skill building, production increase), there are five stages which unroll, often cyclically (modified from Schnell, 1982):

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

Table 2. Potential PPB program goals and possible indicators for monitoring progress towards them

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

Table 2. Continued

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

The stage of farmer-researcher collaboration is one of the factors useful for comparing PPB cases. PPB may incorporate farmer input at various steps (esp. stages 1 to 4 in the above list) where it was not found in traditional breeding schemes. It may also significantly shuffle the order of these processes, e.g. breeders starting with 4 alongside farmers before solidifying stage 1, so that an iterative rather than linear research process is undertaken, with researchers, extensionists, farmers, traders or other kinds of participants taking different roles in each stage.

As many PPB efforts are linked to informal seed distribution, the need to understand existing seed systems can fit in with stage 1. Accompanying farmers in stages 4 and 5 can help breeders improve their role in stage 1 so that farmers may not subsequently need to be involved in 2 and 3 at all.

From examining stages of farmer involvement in the 65 cases, we observe that farmer participation can usefully occur at various times, depending on the crop, parent materials, target region, researcher capacity to assimilate farmer criteria, farmer capacity to handle different types of materials, traits of interest, and scale of the breeding program/number of materials to be screened. The stage at which farmer participation is first introduced to a conventional breeding program can lead to change in the program's objectives, or its breeding strategy (for example which steps are decentralized), or even its organization (in particular what activities are retained by the program or devolved to other actors). In many cases, the stages at which farmers participate or at which formal breeders participate changes as the program develops, as the understanding of each others' skills and priorities increases. This often applies to the other realms of classification as well, i.e. degree of involvement and roles may evolve as the program matures.

Degree of participation[2]

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., 2000). 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, 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 there is task sharing between researchers and breeders, 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.

Farmer-initiated work sometimes occurs at the later stages of formal-led PPB, usually at the very last stage of seed multiplication, distribution and popularization. Farmer-initiated activities are also occasionally carried out within PPB programs to support and strengthen farmers' local varietal selection, *in situ* conservation of germplasm, seed multiplication and distribution (McGuire et al., 1999, Weltzien/Smith et al., 1999).

Within the global review of PPB programs (McGuire et al., 1999; Weltzien/Smith et al., 1999), the most frequently observed degree of participation has been consultative (followed by collaborative) and this takes place at the very first stage of defining breeding targets (e.g., what is farmers' plant ideotype; what characters do they most value). If we separate out the later stages (i.e., variety testing on-farm, seed multiplication and distribution), we find that farmers are rarely involved in the PPB process in true sharing or decision-making roles at all. Nine cases were identified in which farmers worked with segregating materials.

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

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

Roles in PPB

Farmers' and researchers' participation in PPB (irrespective of stage and degree) may have them taking on different roles or functions. In the cases analysed, the way in which researchers worked with farmers is not clearly described making it difficult to link stage of the breeding process in which participation is implemented, the degree of participation and the roles performed by researchers and farmers – with specific outcomes.

Based on the PPB cases analysed, we identified the following roles taken on by farmers: management role: providing technical leadership, which involves a substantial technical contribution to the practical breeding process; management role: providing social organizational leadership, in which farmer-based institutions, e.g. cooperatives, kinship-based networks serve as an organizational base by which PPB can be effected and/or scaled up, information-giving participation in which key insights, such as preferences, are used by others, and laborer or input supply role, neither of which imply any active participation in determining the outcome of the breeding process. Finally, farmers play a key role, in providing germplasm to the breeding process. While formal breeding has used this farmer resource extensively, it has often been done without involving farmers specifically in the process of choosing germplasm, or in the subsequent process of evaluation and selection. In some PPB cases, farmers have explicitly generated new base material for a shared breeding program by making or facilitating crosses between chosen parents. Whether they are directly involved or whether farmer germplasm is used with direct farmer advice, the outcome of the programs should recognize farmers' contributions when attributing any property rights to the finished materials.

The possible roles of farmers in PPB work are described more extensively below. (Note that a parallel list might be devised for the researchers' role).

1. *Management Role: Provide technical leadership;* - Farmers can take a major role in matching specific varieties to specific environmental niches and uses. Farmers can interpret local G × E interactions, varietal performance through time and in different locations. In farmer-led PPB, community specialists may lead and manage the breeding work itself. Cases like this occur especially in the minor crops, in the very remote areas, where formal research does not have a strong presence, and in PPB programs where community empowerment is an important goal.
2. *Management Role: Provide key social organizational leadership;* – Farmers groups, and their organizational arrangements, such as cooperatives, often provide the key vehicles through which PPB can unfold efficiently. Without such organizational forms, on-farm testing may lack representative sites, and seed multiplication and distribution may be inadequate or even completely lacking.
3. *Information-giving role: Provide information on varietal preferences, plant types or desired traits to be maintained or introduced* – Farmers can offer often key insights into the trade-offs they are willing to make among characters in designing the desired plant ideotype. Farmers often have strong preferences – which greatly shape adoption and which need to be integrated into potential varietal entries. Clarity on preferences would involve understanding several different preference factors.
   - *Which characters:* which characters are most important to local farmers – and why.
   - *Honed within-character assessments:* the range of 'acceptability' within each character (e.g., how tall a stem, how short the cycle). The need to get very honed quality assessments would also fall in this category. (Breeders might use the terminology 'characteristics' here.)
   - *Trade-offs among characters:* an assessment of how much of one character (eg,yield) is at the expense of another (e.g., maturity or taste). ('Selection Index' might be the more specialized terminology here.)
   - Differences among farmers (e.g. *gender, wealth caste*) This would include differences in general characters and within-character *among* farmer groups. Because farmers' preferences may be highly differentiated, the involvement of a range of farmer/user groups can be key for broadening and targeting potential impact.
4. *Trainer/Skill Builder role:* While this role is often associated with researcher input (and can be key for empowering farmers to continue generating breeding materials themselves), farmers also can also play a central role in skill building. through farmer to farmer training; and farmer to researcher training.
5. *Field Laborer role: Provide labor.* Farmer labor may be needed when formal research cannot select with available resources. In all cases, farmers often do the routine land preparation, weeding, etc.
6. *Input supply role: Provide land for 'realistic' bio-physical sites.* Formal breeders sometimes have greater success by selecting directly in target environments. To do this, they may use actual farmers' fields in the same way they use more standard experimental stations: as researcher- designed and -managed testing sites.
7. Provide landrace or farmer material used for further breeding work.

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

Application

We illustrate how the framework presented above can be useful for classifying different PPB approaches, and for showing how particular approaches tend to lead to certain types of outcomes, by applying the framework to specific hypotheses developing within the PPB field. The hypothesis we choose to examine below is one of the more popular and accepted of the PPB 'findings'.

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

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

Within a program, with a strong or *sole* focus on 'production' results, using a classic 'development-oriented' or 'modernizing' framework, does the PVS-to-PPB progression, with a strong, or *sole* focus on 'production' results hold? Probably yes. This PVS-to-PPB model is becoming increasingly popular, particularly among the national agricultural research systems (NARS) which usually share such classic breeding goals: for example, WARDA's work with 16 NARS in West Africa starts with PVS, and will move to PPB only in more demanding situations (Dr Monty Jones, pers. comm.). It is worth adding that such situations were working with a range of existing MVs, with reason to believe that farmers (because of the structure of the seed system, or environmental variation) had not had sufficient opportunities to assess the varieties. Thus, starting with PVS makes further sense for such contexts.

Would the 'PVS-to-PPB progression rule' equally hold if 'germplasm conservation' were the goal? Probably not. Materials tend to be stabilized MVs, with only a few cultivars presented to farmers in the above model. Also, the 'PVS to PPB progression rule' would probably not hold if the goal were 'empowerment or capacity building' among farming communities. Farmers' role in the 'PVS-to-PPB' progression is to provide advice only at later stages: skill-building is very limited, if addressed at all. Finally, starting with PVS may not be the best approach when working with farmers whose crops or needs (i.e. bio-physical environments or quality preferences) fall outside the current area of focus of formal breeding. Much would depend on whether promising materials (modern or landrace) can be accessed.

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

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

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

Acknowledgements

We thank B. Sthapit for providing useful insights on the entire draft. Special thanks also to several anonymous reviewers, who made detailed and thoughtful comments.

References

Courtois B, R.K. Singh, S. Pandey, C. Piggin, T. Paris, S. Sarkarung, V.P. Singh, G. McLaren, 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. Mishra, J.K. Roy, D. Choudhary, K. Prasad, R.K.

Singh, P.K. Sinha & N.P. Mandal, 2000. Breeding better rainfed rice varieties through farmer participation: some early lessons from eastern India. In: Proc. 2 nd Int. Sem. Of the CGIAR SWP on Participatory Research and Gender Analysis Quito, Equator, September 6–9, 1998. CIAT, Cali, Colombia.

Hecht, S., 2000. Social issues in participatory plant breeding. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation. Working Document No. 5, Colombia, Cali, 30 pp.

Lilja, N., J.A. Ashby & L. Sperling (Eds.), 2000. Assessing the impact of participatory research and gender analysis. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation. CIAT, Colombia, Cali. 352 pp.

McGuire, S., G. Manicad & L. Sperling, 1999. Technical and institutional issues in participatory plant breeding: from the perspective of farmer plant breeding. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation. Working Document No. 2, October 1999. Cali, 87 pp.

North, D.C., 1990. Institutions, institutional change and economic performance. Cambridge: Cambridge University press. 287 pp.

PRGA, 1999a. Crossing perspectives: farmers and scientists in participatory plant breeding. Cali, Colombia. Program on Participatory Research and Gender Analysis. The Consultative Group on International Agricultural Research, 40 pp.

PRGA, 1999b. Guidelines for Participatory Plant Breeding. Working Document 1, draft three, April 2000. Cali, Colombia. Program on Participatory Research and Gender Analysis. The Consultative Group on International Agricultural Research, 62 pp.

Schnell, F.W., 1982. A study of methods and categories of plant breeding. Zeitschr Pflanzen 89: 1–18.

Soleri, D., S. Smith & D. Cleveland, 1999. Evaluating the potential for farmer-breeders collaboration: a case study of farmer maize selection from Oaxaca, Mexico. AgGren Network Paper 96a. London: Overseas Development Institute. pp. 1–8.

Sperling, L. & J.A. Ashby, 1999. Moving Participatory Breeding Forward: the next steps. In: M. Collinson (Ed.), History of Farming Systems Research, London, CABI. 15 pages.

Weltzien, E./M. Smith, L.S. Meitzner & L. Sperling, 1999. Technical and institutional issues in participatory plant breeding – from the perspective of formal plant breeding: a global analysis of issues, results and current experience. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation. Working Document No. 3, October 1999. Cali, 118 + IVIII pages.

Witcombe, J.R., A. Joshi, K.D. Joshi & B.R. Sthapit, 1996. Farmer Participatory Crop Improvement: I. Varietal Selection and Breeding Methods and their impact on biodiversity. Exp Agric 22: 443–460.