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

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

PPB and production environments

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

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

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

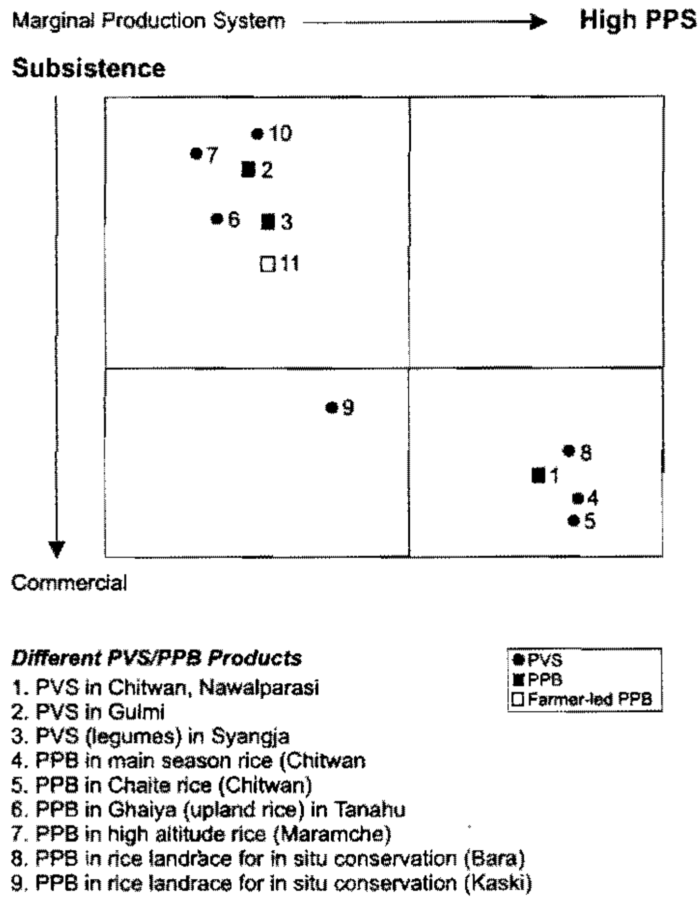

Figure 1. Distribution of LI-BIRD's PVS/PPB by production environment

PPB and breeding goals/objectives

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

PPB and participation

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

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

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

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

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

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

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

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

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

Lessons and issues

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

Emerging breeding objectives resulting from participation

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

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

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

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

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

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

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

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

Diverse production environments within HPPS

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

Diversity through PPB

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

Participation

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

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

Concerns about the institutionalization of PPB

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

Concerns about the seed regulatory framework

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

Concerns about pests and diseases

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

Conclusions

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

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

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

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