

4 Participatory crop improvement and supporting informal seed supply

4.1 Participatory crop improvement and informal seed supply: general introduction⁸⁷

Walter S. de Boef and Juliana Bernardi Ogliari

Participatory techniques applied in plant breeding can have an impact on the development of improved crop varieties, making it faster and more cost-effective. Targeted beneficiaries of such breeding programmes may be resource poor farmer households in marginal environments who previously solely cultivated local varieties or landraces, or farmers in more productive environments where they were dependent on old improved varieties. This section gives the historical context of participatory approaches in crop improvement and delineates the differences between participatory varietal selection (PVS) and participatory plant breeding (PPB). It goes on to elaborate on the participatory tools involved in starting participatory crop improvement (PCI), and to provide an overview of the structure and components of PCI.

Participatory crop improvement in an historical context

PCI emerged as an alternative plant breeding approach for developing countries in response to the recognition that conventional breeding by formal sector institutions had brought little benefits to small-scale farmers in agro-ecologically and socio-economically marginal and variable environments.⁸⁸ Formal breeding in developing countries concentrated on cereals and cash crops in favourable, high-input agricultural systems. It was expected that at least some of the materials which were developed for high-input production systems would also be successful in low-input environments. However, apart from wheat, maize in parts of South East Asia, and Eastern and Southern Africa, and irrigated rice in South East Asia, these expected spill-over effects have been limited. Farming systems in marginal environments are too different from those in the more favourable production areas. Improved varieties that are currently being used by farmers in marginal areas are usually part of a portfolio of varieties. In most situations in developing countries, local varieties tend to remain the primary source of germplasm for a majority of small-scale farmers. In the case of minor crops, in which formal crop improvement organizations have invested limited resources, farmers usually rely entirely on local varieties.

Limitations of formal crop breeding

Formal breeding has tended to concentrate on increasing yield potential in favourable environments with access to agro-chemical inputs and irrigation, and to pay little or no attention to the importance of adaptation to variable and risky low-input rainfed conditions, secondary crop uses and cultural preferences. For example, when improved maize varieties that are bred at high plant densities are planted at low density in less favourable environments, they can show incomplete ear-cover by the husk, which makes them vulnerable to field and storage pests and diseases. Farmers' common use of variety mixtures and their preference for specific bean colours have also been important reasons for the limited impact of improved bean varieties in Africa and Central America, respectively.⁸⁹ While breeders concentrated on grain yield in barley, other locally important uses have been disregarded or overlooked; this is explained by the breeders' focus on breeding for high yields and wide adaptation, and their lack of knowledge about the importance of other characteristics for small-scale farmers.⁹⁰ In view of the relatively large area still planted with local varieties, it can be concluded that formal breeding in many countries and for many crops has failed to address the agro-ecological diversity of low-input farming systems in a satisfactory manner.

For cost benefit reasons, formal breeding attempts to develop varieties that are broadly adapted and can be released over large areas. The broad adaptation of such varieties often gives them yield stability over time and space. In developing countries, breeding programmes are largely carried out on-station under well-controlled conditions, thus reducing environmental variation and increasing heritability and expected genetic gain. However, most small-scale farmers operate in environments in which variable, complex stresses dominate crop performance. The common usage in formal breeding of relatively high input levels to minimize abiotic and biotic variation and to target moderate to high-input agriculture, not only reduces the ratio of environmental variance to genotypic variance in comparison with lower input levels, but also increases the discrepancy between on-station and on-farm conditions.⁹¹

The control of variation in the environment with the objective of creating uniform experimental areas is a positive aspect of formal breeding programmes; it allows for the identification of those superior genotypes by their genetic traits rather than by their phenotypic expression of the traits. When management practices creating uniform research conditions are also distinct from farmers' management practices, the material selected often appears inappropriate for cultivation in stress-prone environments. The genotype x environment (GxE) interaction causes these discrepancies. Therefore, products from breeding programmes are not necessarily adapted to the marginal environments dominant among small-scale farmers in developing countries,⁹² nor to, for example, low-input or organic growing conditions among organic farmers such as those in Europe.⁹³ If environments are sufficiently different, G×E interaction can result in different yield ranking of evaluated germplasm, representing the so-called cross-over effect.⁹² In such as case, on-station selection does not result in the most productive materials for the specific conditions in the farmers' fields.

In addition to differences in growing conditions, differences in selection criteria contribute to diversity in the materials selected by breeders and farmers. G×E interaction is normally determined for one characteristic, most often yield. The overall performance of a certain genotype is, however, determined by a complex of characteristics whose relative importance further determines the ultimate ranking. In formal breeding, the relative importance of the various characteristics can be described by means of a selection index. Rejection of varieties by farmers points to situations in which the selection index as used by the breeders does not correspond with the farmers' own weighting of preferences. This is explained by the fact that farmers tend to pay more attention than breeders to yield stability, and characteristics related to quality and secondary uses.⁹⁴ Because the criteria other than yield appear to be very important factors in variety adoption and rejection, it is logical to include them explicitly in the analysis of G×E interaction and related issues in the context of PCI.

Participatory crop improvement: strategy and definitions

PCI aims to link formal and informal seed systems through crop improvement, identifying complementary capacities and expertise, and seeking to combine the improvement of productivity with the supply of agrobiodiversity needed by farmers. A common strategy is to insert useful genetic diversity into the local systems and to build on farmers' capacity for seed selection. Rather than trying to increase the impact of conventional breeding that generates a limited number of genetically uniform varieties at the end of the breeding pipeline, the idea is to introduce larger amounts of materials into the farmers' fields, thereby providing access to a wider range of genetic diversity. PCI builds on the recognition of farmers' capacity to select what best fits their environment and on improved development of local crop adaptation through farmers' variety and seed selection.* It relies on farmers' seed production and exchange to maintain and diffuse varieties, thus creating a larger independence from the formal system of distribution of seeds of improved varieties.

The main advantage of PCI over conventional breeding is that it involves farmers in developing, adapting and adopting new varieties, in setting breeding goals, and in selecting parents according to their requirements. Levels of participation vary, however, with the nature and objectives of the projects and the availability of resources. Among some organizations and farmers, there develops a spirit of close collaboration and of appreciation for each other's capabilities and contributions. The strengths and capabilities of different stakeholders can then be fully utilized in an integrated form. This is why these processes are now gaining worldwide acceptance.

A common functional distinction within PCI is between participatory variety selection (PVS), and participatory plant breeding (PPB). PVS is the term used for selection from among advanced or genetically stable populations and lines in self-pollinated species, or among populations in open-pollinating species, while PPB denotes selection from within segregating populations,⁹⁵ with different degrees of inbreeding after the F₁ generation or within cross-pollinating populations based on

* Niels P. Louwaars and Conny Almekinders address the issue of farmers' selection and maintenance of varieties more in detail in Section 2.1.

selection of full-sib, half-sibs etc, according to the selection strategy. In PVS, farmers are given varieties (finished products from plant breeding) for testing in their own fields. After a successful PVS programme, the varieties preferred by farmers can be used as parent or composite populations in a breeding programme where farmers participate as active collaborators. This involves breeding and selection to create new varieties and is called PPB. However, the distinction between PVS and PPB is not always clear. Especially in the case of cross-pollinating populations, selection among populations (PVS) is usually combined with within-population selection (PPB). On-farm evaluation allows for weighting of preferences and needs by the end-user of the products, and enables exploitation of G×E interaction through seeking location-specific adaptation to the complex and variable environment.

Participatory varietal selection

PVS is defined in different ways for different crop reproductive systems. In self-pollinating crops, it is the selection of released or pre-released advanced lines. In open-pollinating species, it is the selection of cross-pollinating populations, and in vegetatively propagated crops, it is the selection of advanced clones. The selection is performed by farmers in their target environments using their own selection criteria. Landraces or local varieties are included in all types of trials. Basically, PVS provides varietal choices to the targeted farmers under their specific environmental conditions, promotes participatory approaches to variety testing, and selects and disseminates the preferred variety. Essentially, a PVS programme follows four logical steps, applying several participatory appraisal tools²³ and community practices as is illustrated in Table 4.1.*

PVS is about testing new varieties with farmers; this can be done in many ways. No set protocol exists: methods vary for different crops and for different researchers' and farmers' circumstances. Nonetheless, generalizations can be made concerning the resources required for different methods. PVS is widely used and accepted in breeding programmes. In the literature, PVS is more and more accepted as common practice in breeding. Gary Atlin, who was in charge of the IRRI upland rice breeding programme, stated that all breeding programmes should include participatory on-farm trials.

There are many ways of carrying out participatory trials. A common methodology is the mother and baby system, the design of which can vary considerably. CIMMYT and its partners in Southern Africa apply a three replication mother trial with 12 entries. The trial is repeated twice in two different management regimes (for example high and low fertility). The baby trial has four entries in an incomplete-block lattice design. However, the total of baby trials includes all the entries within the mother trial that year. WARDA and its partners in West Africa use a single replicate mother trial of about 60 entries in rice PVS, sometimes repeated twice in two management regimes (high input and farmer managed). The baby trials are planted in the next growing season, with the number of entries in line with the number of entries selected by researchers and farmers in the mother trial. In the work

* Bhuwon Sthapit and colleagues describe some practices supporting community biodiversity management and the relevance to participatory crop improvement in Section 3.7.

of the Centre of Arid Zone Studies (UK), public and non-governmental research and development organizations in India use single-replicate mother trials grown under a farmer-managed regime, and baby trials in which each farmer grows only one test entry alongside his or her local control. Thus, experimental designs vary according to the crop, the experience of researchers, technicians and farmers with PVS, and the degree of farmers' organization. The diversity of approaches shows that there are many forms of PVS that need to be adapted to the conditions and the resources available.

Table 4.1 Outline of steps of a PVS programme and the participatory appraisal tools and community practices applied⁹⁶

<i>Step</i>	<i>Participatory tools and community practices</i>
1. Situational analysis and needs assessment	<ul style="list-style-type: none"> • A participatory rural appraisal (understanding community and demands) • Documentation of local practices (maps, flow charts) • Documentation of local materials (matrixes, flow charts, four cell analysis)
2. Search for genetic materials	<ul style="list-style-type: none"> • Inventory of local and improved materials (crop diversity and variety maps and matrixes) • Inventory of pre-released material • Brainstorming for identification of characteristics and preferred varieties • Various ranking tools to identify characteristics and materials
3. On-farm experimentation	<ul style="list-style-type: none"> • Diversity blocks and diversity fairs • Cultivation of introduced materials aside with local materials under farmer management • Farm walks • Focus group discussions (selection criteria, meta plan, matrix ranking)
4. Wider dissemination	<ul style="list-style-type: none"> • Post-harvest evaluation • Community meetings • Dissemination through kits and fairs • Monitoring spread and diffusion

Participatory plant breeding

PPB is a breeding process in which farmers and plant breeders jointly select cultivars from segregating materials under a target environment. Other forms of PPB include activities such as germplasm enhancement through pure line or mass selection, stratified mass selection within composites, selection of half-sibs when breeding cross-pollinating crops, or the identification of mother trees or plants when breeding perennial or vegetatively propagated crops. Although many people claim to work with PPB, in fact most of them conduct PVS. PPB can either be consultative or collaborative. Table 4.2 illustrates the differences between these two typologies for farmer participation. A basic differentiation exists in the division of responsibilities in decision making on selection criteria and in selection itself.

Table 4.2 Typology of farmers' participation in PPB

<i>Consultative PPB</i>	<i>Collaborative PPB</i>
<ul style="list-style-type: none"> • Farmers are consulted to set breeding goals • Farmer choose appropriate parents and testing sites • Farmers indicate demands that are translated into selection criteria by breeders 	<ul style="list-style-type: none"> • Farmers set breeding goals • Farmer choose appropriate parents and testing sites • Farmers grow segregating genetic material • Farmers indicate selection criteria • Farmers contribute to the selection of best plants

The success of PPB rests on the blending of the comparative strengths of farmers, local extension agents, breeders and social scientists involved in the process. The use of consultative or collaborative methods and the right choice of the level of farmers' participation depend on: crops; the capacity of the participating farmers; the willingness and availability of breeders, extension agents and farmers; the degree of farmers' organization; and the research resources available. However, there is a commonly applied law in PCI that PPB only commences after several years of successful PVS implementation, as farmers first need to learn to work with genetic diversity and gain some experience in formal experimentation.⁹⁵

PPB becomes an option when efforts with PVS are reaching their limits because the possibilities of PVS have been exhausted, or the search process in PVS failed to identify any suitable cultivars for the testing. Another reason to move from PVS to PPB could be because farmers identified a new problem in existing cultivars that requires the recombination of local varieties with other germplasm. Then a PPB strategy becomes a demand-led approach.

Due to their access to the global pool of germplasm and the often genetic make-up of certain traits within that germplasm, breeders are better equipped to make an effective choice of parents. In the case of self-fertilizing crops, this means that at least one parent in the PPB programme should be a landrace or locally adapted cultivar. In the case of cross-pollinating crops, local varieties should contribute to the development of composite populations. Screening takes place in the target environment, utilizing farmers' selection criteria and knowledge.

In PPB, farmers are involved at much earlier stages of the breeding process. In the case of self-fertilizing crops such as wheat, rice or beans, this could be at the stage of F_3 or F_4 ,⁹⁵ while in cross-pollinating crops such as maize, farmers could, for example, be involved during various cycles of stratified mass selection within a composite variety, or recurrent selection of half-sib families of a composite population generated by farmers. In perennial crops or vegetatively propagated crops, few farmers could be involved in the identification and testing of, for example, super trees in the case of cocoa or coffee, or the selection within trials including large amounts of research materials in the case of potato.⁹⁴ When selection in PPB advances and the degree of genetic variation to be evaluated diminishes, PVS components follow. In the early stages of PPB, few knowledgeable or experienced PPB farmers join in, whereas more farmers and locations are involved in PVS.

Mother-baby trial designs can be used for generating scientific data using the mother trials for generating quantitative data and the baby trials for qualitative data. Baby trials can also be used for replication of quantitative data. The mother-baby trial format can be adapted to the crop, whether they are self-fertilizing crops (rice, teff, wheat or beans), cross-pollinating crops (maize), perennial crops (coffee or many fruit trees), or vegetatively propagated crops (banana, enset, sweet potato or cassava). As indicated, the mother-baby trials serve a dual purpose: the generation of research data, and the dissemination of PPB results or the primary dissemination of improved PPB materials. With this second purpose, PCI directly links the formal breeding system with both the indigenous knowledge system and the informal seed system for the evaluation and direct dissemination of material.

A wide range of diagnostic tools and community-oriented practices are used throughout the whole process of PCI. Table 4.3 provides a general outline of the steps involved in a PCI programme (not specified for crops with different reproduction systems). The table provides some options for the range of participatory diagnostic tools and community management practices applied during a PCI programme. The tools ensure community and farmers' participation and empowerment during the different steps, while the practices are ways to speed things up, particularly the initial process of identification of materials and farmer-partners. They also upscale the final part of the PCI programme (PVS), empowering farmers during the evaluation of promising materials and facilitating their large scale dissemination.

Roles of farmers and benefits

The benefits of farmer participation in plant breeding processes are not universal, and attempts have been made to create a balanced view of the need for such participation and the benefits it brings. Using the qualitative labels 'participatory' and 'conventional' for breeding programmes implies an 'either/or' approach to their definition, whereas what is needed is to build a bridge between the two camps by focusing on the degree of farmer or client orientation.^{97,98}

A key issue in the discussion around the potential of PPB and roles of farmers is the acceptable level of complexity of PPB programmes. The first PVS experiences indicate distinct roles for farmers and breeders. It is not clear yet how these roles change over time as PCI programmes develop and move from PVS to PPB. As indicated, over time, yield will become a more important component of PCI and will be subjected to the same consequences of G×E interaction as in formal plant breeding.⁹⁹ This may imply more complicated selection schemes for the farmers in order to ensure continued progress in performance. The farmers' willingness and capacity to invest time and resources in selection and participation with breeders will depend strongly on the benefits they derive from it. Benefits are: access to materials with increased yield, yield stability or other improvements, status, knowledge and increased capacities (empowerment), and benefits from seed exchange.⁸⁴ The latter benefit is based on the assumption that locally selected materials have a wide agro-ecological adaptation and are attractive to a larger group of farmers. Farmers' empowerment is considered an important social benefit from PCI. The type of participation presumably influences the empowerment impact on the farmers.

Table 4.3 Outline of steps of a PCI programme and participatory tools and community practices used⁹⁶

<i>Step</i>	<i>Participatory tools and community practices^{23,*}</i>
1. Need identification and setting breeding goals	
<ul style="list-style-type: none"> Understanding the reasons for growing diverse varieties Setting breeding goals and roles jointly to meet immediate needs 	<ul style="list-style-type: none"> Participatory rural appraisal Community meetings Focus group discussions Ranking exercises
2. Parent selection and generating new diversity	
<ul style="list-style-type: none"> Identification and use of locally adapted varieties as parent materials 	<ul style="list-style-type: none"> Participatory rural appraisal Focus group discussions Diversity blocks
3. Selection of research plots and expert farmer role identification	
<ul style="list-style-type: none"> Identification and selection of innovative farmers with an interest in PPB Decision making on selection criteria 	<ul style="list-style-type: none"> Focus group discussions Farmer network analysis Transect walk Diversity fairs
4. Early selection	
<ul style="list-style-type: none"> Management of research activities under farmers' condition Farmers assume a role of selection: <ul style="list-style-type: none"> within segregating materials within composites or for example of half sibs among super trees among clones within trials including large amounts of diversity 	<ul style="list-style-type: none"> Researcher-designed, farmer-managed trials Focus group discussions Selection of materials jointly by farmer breeders Preference ranking
5. Participatory varietal selection	
<ul style="list-style-type: none"> Management of research activities under farmers' conditions Mother baby trials in diverse formats Distribution of promising material among large amounts of farmers 	<ul style="list-style-type: none"> Focus group discussion Ranking exercises Diversity blocks Diversity kits
6. Variety release and distribution	
<ul style="list-style-type: none"> Varietal spread through informal seed supply Release variety on the basis of mother baby trial results and monitor varietal spread 	<ul style="list-style-type: none"> Mother baby trials Diversity kits Participatory rural appraisal monitoring variety performance

If farmers are only consulted and do not share in the process of decision making during the identification of parental material, the setting of selection criteria and the

* Bhuwon Sthapit and colleagues describe some practices relevant to participatory crop improvement in Section 3.7.

selection itself, there is neither true participation nor an empowerment benefit.⁸⁴ Empowerment or the capacity of farmers to work on improving their own situation is recognized as an important condition for sustainable agricultural development in less favourable marginal production environments,⁹⁹ organic or low-input conditions,⁹³ and even high input production systems.¹⁰⁰

PVS and supporting informal seed supply

During PVS, farmers, extensionists and breeders evaluate improved released, pre-released or local varieties on-station and/or on-farm. These components of breeding programmes have been shown to enhance farmers' access to varieties (improved or local) from other areas. The best and most suitable materials can be disseminated quickly through the informal seed system, although the organization of seed supply for variety maintenance and distribution beyond their breeding areas through PPB may require some help from the formal system.²⁷ Linking the participatory approach with informal distribution methods will enhance the availability of and access to seed of varieties that farmers want. It is clear, then, that participatory crop improvement and supporting informal seed supply are interdependent and complementary efforts.

4.2 Opportunities for participatory crop improvement and supporting informal seed supply in Oromia region, Ethiopia

Adugna Wakjira, Gemechu Keneni, Musa Jarso and Bulcha Weyessa

Participatory Crop Improvement (PCI)* can broadly be defined as approaches that involve close collaboration among breeders, researchers, farmers, and other stakeholders, to bring about plant genetic improvements within a given plant species. It covers the whole research and development cycle of activities associated with plant genetic improvement: identifying breeding objectives, generating genetic variability, selecting within variable populations to develop experimental materials, evaluating these materials, releasing promising materials, and producing seed, whether through formal or informal channels. The component relating to the evaluation of materials is also referred to as participatory varietal selection (PVS). PCI also includes assessing existing policy and/or legislative measures, and designing new ones where needed. In other words, farmers, breeders, and other relevant stakeholders such as traders, processors, and consumers can take on distinct roles at various points in the crop improvement cycle, and pool their knowledge and skills to bring about meaningful changes and impacts.

* Walter de Boef and Juliana Bernardi Ogliari provide detailed definitions and descriptions of approaches to participatory crop improvement in Section 4.1.

The idea of involving farmers in the development of plants and their varieties is not new in Ethiopia, where several crops (for example, teff, noug, enset, Oromo potato, anchote, etc.) have been domesticated and perpetuated along with their production techniques. Unfortunately, in plant breeding programs the indigenous knowledge of the farmers has not been fully appreciated and farmers' experiences have been ignored. In this paper, we assess the past and present PCI and informal seed production efforts in central Oromia region, Ethiopia to suggest applicable and useful strategies that can benefit target users in line with the current agricultural development direction of the country. To this end, experiences were gathered and synthesized, and relevant publications were consulted, including the proceedings of several workshops and conferences.*

Developmental phases in participatory crop improvement

The agricultural research system of Ethiopia in general and Oromia region in particular have passed through several developmental phases. Improved production techniques have been generated and adopted, and various participatory approaches have been used, based on the policies, institutional set-ups and global knowledge and experiences of the time. So far, the research and development approaches that have been used can be categorized into four phases, based on major institutional reforms and degrees of farmers' and other clients' participation:

- Conventional on-station research/ breeding scheme (1966-1974)
- Package testing and multi-disciplinary survey approach (1975-1983)
- Farming systems research/ breeding programme (1984-1998)
- Client-oriented or participatory research/ breeding programme (1999-2007)

The first phase coincides with the establishment of the former Institute of Agricultural Research (IAR) in 1966, which is now renamed the Ethiopian Institute of Agricultural Research (EIAR). During this phase, a top-down approach was dominant where almost all plant breeding activities were undertaken on-station with little involvement of the farmers via demonstrations and field days. During the second phase, on-station-developed packages of crop improvement techniques were tested on the farmers' fields to verify their compatibility and performance under farmers' conditions. This stage played a vital role in creating a better understanding of the complexities of the farming system, and better linkages among breeders, extension agents and farmers. The farming systems research approach, phase three, dominated the mid 1980s, and increased farmers' participation in problem analysis, on-farm variety testing and evaluation. This stage increased the role of farmers in the variety selection processes and changed the attitudes of many breeders and extension workers.

It was from this phase that we moved into the fourth, contemporary stage, which is known as client-oriented participatory on-farm variety evaluations. It was first implemented in Ethiopia through Dutch-funded projects on barley, vertisol and cool season food and forage legumes. This approach attempted to modify farmers'

*The reference list does not include all workshop and conference proceedings used for this section.

participation from the consultative to the collaborative mode,* involving the ultimate beneficiaries in the varietal development processes, from the initial planning stage to the evaluation stage. This does not mean that PCI has been put in place in the central highlands of Oromia region. Various social, institutional, financial, and infrastructural constraints pertain, which have limited the scope for working in this participatory manner.¹⁰¹ Despite these limitations, both current and stretching back over the past forty years, some encouraging changes have been achieved in terms of agricultural technology generation and varieties released (Table 4.4).¹⁰²

Table 4.4 Summary of crop varieties released by the Ethiopian Agricultural Research System, Ethiopia (1970-2005)¹⁰²

<i>Crop</i>	<i>1970-79</i>	<i>1980-89</i>	<i>1990-99</i>	<i>2000-05</i>	<i>Total</i>
Cereals	15	23	56	101	195
Pulses	11	21	30	42	94
Oilseeds	6	9	8	15	38
Vegetables & spices	-	4	15	41	58
Fruits & stimulants	-	12	5	9	26
Fibre crops	4	5	4	-	13
Forage crops	3	5	1	-	9
Total	39	69	119	208	435

Why the interest in participatory crop improvement and support to informal seed supply?

To ensure food security and sustainable economic development

Ethiopia's current human population of an estimated 77 million (35% in Oromia) is increasing at a rate of 2.62% and is expected to reach 84 million by 2010.⁵ The broad thrust of Ethiopia's strategy for sustainable development and poverty reduction (Plan for Accelerated and Sustainable Development to End Poverty [PASDEP, 2005/06-2009/10])⁵ consists of an overriding focus on agriculture, especially on production and productivity of crops, as the sector is the source of livelihood for 85% of the population. Agriculture is also believed to be a potential source for generating primary surplus to fuel the growth of other sectors of the economy (industry and services).

The main components of the PASDEP economic development plan place a great emphasis on crop production. Table 4.5 presents the estimates of cultivable land, total production and productivity that are envisaged through area expansion and intensification (integrated use of agricultural inputs and better management practices). All these measures will be effective if implemented jointly with farmers and other stakeholders. And this is where there are significant roles for PPB and informal seed multiplication in putting the envisaged plans into action and ensuring food security and sustainable economic development.

* See Table 4.2 in Section 4.1 by Walter de Boef and Juliana Bernardi Ogliari for an explanation of the different typologies for farmer participation.

Table 4.5 Projected area, production and productivity of major crops in Ethiopia over five years (2004/05-2009/10)⁵

<i>Crops</i>	<i>Area (x1000 ha)</i>		<i>Production (MT)</i>		<i>Productivity (t/ha)</i>	
	<i>2004/05</i>	<i>2009/10</i>	<i>2004/05</i>	<i>2009/10</i>	<i>2004/05</i>	<i>2009/10</i>
Cereals	9053	9250	12.99	32.25	1.44	3.23
Pulses	1615	1689	1.56	2.13	0.97	1.26
Oilseeds	1223	1244	0.51	0.98	0.42	0.79
Fruits & vegetables*	367	419	1.55	2.72	4.22	6.51
Cotton	23	43	0.05	0.13	2.11	2.93
Total	12281	12649	16.66	38.21	-	-

Note: * under irrigated condition

To adapt plant varieties to their specific environments

The basic problem in plant breeding is the relationship between selection and target environment. Direct selection, i.e. selection in the target environment, is always the most efficient. But in indirect selection, i.e. selection in an environment different from the target environment, the selection efficiency decreases, with genotype x environment interaction (GxE) limiting the efficiency of breeding programmes.¹⁰³ Plant breeders can either avoid GxE by selecting materials that are broadly adapted to a range of target environments, or exploit them by selecting a range of materials, each adapted to a specific target environment.¹⁰⁴

The participation of farmers in the very early stages of selection offers a solution to the problem of adapting the crop to a multitude of both target environments and users' preferences.¹⁰⁵ Although decentralized selection and farmers' participation are unrelated concepts, the acceptance of the former as a breeding strategy almost inevitably leads to the acceptance of the latter as a tactical necessity. It is worth mentioning that, although farmer participation is often advocated for reasons of equity, there are sound scientific and practical reasons for farmer involvement too, as it can increase the efficiency and the effectiveness of the breeding programme.¹⁰⁴ Decentralized participatory plant breeding could be particularly effective in those situations where seed is supplied by the informal seed system, as is the case for several crops in the marginal environment of central Oromia (i.e. degraded, very cold and rugged mountains).

To promote effective adoption and to address specific needs of clients

Although PCI programmes are relatively recent, they have had some impact.^{104,105} In environments where no improved varieties were available, farmers have selected varieties according to their own preferences. A linseed variety combining frost tolerance with higher yield and good stand has been much favoured by the farmers in the mountains of Jeldu district, central Oromia, and the variety verification is under way for its specific release in 2007/08. Faba bean varieties combining disease resistance with desirable traits like large seed sizes were also much preferred in central Oromia (Welmera, Ejere and Degem districts) even before they were formally released. Other good examples in Ethiopia include varieties of field pea, chickpea,

potato, barley, maize, and onion selected by farmers. Through farmers' participation, desirable varieties have been identified at earlier stages than is usual in the conventional breeding system. Understanding the crop production problems and research priorities of local farmers in various agro-ecological and socio-economic conditions is a prerequisite for the selection of varieties for long-term adoption by the farmers. PVS has been successful in facilitating adoption by poor farmers in marginal environments who were not previously reached by formal plant breeding.^{104,105}

Information on farmers' selection criteria is one of the most common outputs of participatory crop improvement programmes.¹⁰⁴ Farmers are interested in a wider range of traits or combinations of traits than breeders expected. Although farmers nearly always rank yield as their most important criterion, they select for several other traits as well. In many cases, farmers' selection criteria vary according to the physical and socio-economic environment. For example, in Eastern Ethiopia, farmers' selection criteria for common beans varied with each growing zone and season, giving high priority to growth habit, reaction to diseases, suitability for intercropping and seed yield, out of about twenty criteria.¹⁰⁶ Similarly, farmers' selection criteria for teff varieties have given top priority to white seed colour (for marketability), seed yield and panicle length.¹⁰⁷ Women farmers in west Shewa Zone selected field pea varieties for the qualities required for *kik* (split pea) and *shiro* (crushed pea), whereas the male farmers emphasized yield and yield attributes, showing that selection criteria may differ between the genders.

To ensure sustainable seed supply

For many centuries, Ethiopian farmers have been relying on their own seeds, selecting appropriate grains, storing them, and then using them as seed for the following season. They have been doing this with a great diversity of crops, including vegetatively reproduced crops. By choosing seeds or planting materials that meet their needs, they have developed local varieties that suit their specific farming circumstances and preferences. As a result, hundreds of local varieties of several indigenous Ethiopian crops (teff, Niger seed, sorghum, barley, durum wheat, field pea, etc.) have developed. According to some estimates, up to 95% of the farmers in Ethiopia still produce and use their own seeds and thereby depend on their skills acquired through generations.¹⁰³ Hence, building on local resources, knowledge and abilities will maintain and increase the continued supply of seeds for the small-scale farmers. Technical support for the informal seed supply from researchers, development agents and NGOs is crucial in this regard.

In order to ensure the continued supply of improved seeds of several crops, the Ethiopian government has launched a plan for producing improved seeds on farmers' plots during a five-year development period (PASDEP, 2005/06-2009/10).⁵ Accordingly, the Ethiopian Seeds Enterprise (ESE) will ensure the continued supply of improved seeds, with a focus on pre-basic and basic seed multiplication activities. The emphasis is on promoting seed multiplication activities on farmers' plots (farmer-based seed production). Moreover, the private sector is encouraged to participate in the multiplication of improved seeds. By the end of the plan period, a total of about 0.18 million tons of seeds of improved varieties is expected from these sources. Of

this, 90 thousand tons will be produced on farmers' plots, while 72 thousand tons will be supplied by the ESE. The remaining 18 thousand tons is expected to be produced by private seed producing organizations.

To enhance biodiversity

Genetic diversity at farm level plays an important role in ensuring household food security for smallholders in Ethiopia. Diversity of crops and varieties serves diverse household needs for consumption and other uses. Farmers also need crop genetic diversity to cope with such variable environmental conditions as outbreaks of new crop pests and diseases, changing climatic conditions, soil erosion, changing market conditions and increasing population pressure.

One of the most common outcomes of participatory crop improvement is that farmers select different varieties of crops for different purposes. Examples are available for a range of Ethiopian crops, including barley, haricot bean, faba bean, and linseed. This practice gives rise to substantial increases in the numbers of available cultivars and populations.¹⁰¹ Hence, farmers' local crop improvement or PCI is required to continue evolving valuable germplasm for future breeding and specific uses. In short, genetic diversity has been and will continue to be valuable in both modern and traditional agriculture, both for increasing productivity and for ensuring sustainability, and determining future progress.

Recent efforts to promote participatory crop improvement and support informal seed supply

Since the mid 1990s, the national research system, international donors and NGOs have provided strong support to participatory research and development efforts in central Oromia region, Ethiopia. Typical examples include training programmes delivered by the International Centre for Development Oriented Research in Agriculture (ICRA, Wageningen) and the research support of the Royal Netherlands Government for Barley, Vertisol and Cool Season Food & Forage Legumes projects. The CGIAR centres, like CIMMYT, ICARDA, CIAT, IFAD and ICRISAT have also contributed a lot to the Ethiopian research and development programmes. Projects like the African Highland Initiatives (AHI) and Soil and Water Management Network (SWMnet) of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) have played significant roles in supporting PCI and informal seed production. As a result, there has been significant progress with this approach and with informal seed production of potato, lentil, haricot bean and wheat crops.

Breeder and pre-basic seed that was produced at Holleta Agricultural Research Centre has been supplied to the ESE, farmers, NGOs and other users together with trainings and similar technical back-up. For instance, 2,309 tons of potato seed tubers were produced in three districts from 1999 to 2005 and 116 tons of chickpea and lentil seeds were produced in west Shewa zone of central Oromia in 2006/07. Similar efforts are currently underway with other field crops (cereals, pulses and oilseeds) in various districts of central Oromia, with the full assistance of the research institute. Another important step being taken is the ongoing decentralization of PCI activities

from the main research centre to sub-centres, research sites and farms. In fact, many farmers in several districts in the central highlands of Oromia are currently involved in the informal multiplication of seeds for improved varieties of crops like wheat, barley, chickpea, lentil, potato and linseed. Research and development agents now need to capitalize on these efforts for positive impacts.

The main success factors for these recent developments include the positive attitudes and commitment of the stakeholders (researchers, farmers, development workers, NGOs, etc.) towards PCI and supporting informal seed supply. Increasingly, resources and inputs (funds, vehicles, breeder/pre-basic seeds, and fertilizer) become available for supporting such efforts. Technical support (training, skill/experience sharing, and follow up) is becoming more effective. Materials released meet specific needs (environment, preference, quality, etc.) better, and market opportunities for informal seeds are increasing.

Major challenges faced in further promoting these approaches include how to work with farmers' socio-economic realities, i.e. dwindling farm sizes, free grazing, poverty, high illiteracy, poor infrastructure and farm tools. Another challenge is how to guarantee institutional support, i.e. incentives, strong direction and influences. Currently researchers and extensionists involved in these approaches face lack of funds, vehicles and skilled technicians; so a re-allocation of resources supporting the approaches is required. Variety release and seed policies still pose significant constraints for the further institutionalization of PCI and promotion of support to informal seed supply. Supportive policies and guidelines are needed.* A further challenge is how to channel quantities of germplasm and segregating populations/lines into different areas and design ways of formal and informal multiplication of the products of PCI.

Reflections on the future

Recent experiences with PCI and supporting informal seed supply, and the on-going up scaling of technologies in central Oromia region, Ethiopia clearly demonstrate the effectiveness and efficiency of both approaches for enhancing the availability of improved seeds and farmers' access to them. These approaches have the potential to foster the economic development of the country and to contribute to attaining the goals of the Plan for Accelerated and Sustainable Development to End Poverty. The decentralized national system of agricultural research has created a situation conducive to supporting the development of both approaches in accordance with the specific physical environments and socio-economic circumstances of farmers. Opportunities must be seized to develop and release specifically adapted varieties, and to convince policy-makers re-adjusting variety release requirements and seed production policies to promote and encourage PCI and support the informal seed system. Conducive environments and technical support from the formal sectors could also encourage the establishments of community-based and small-scale seed enterprises. Both intra and

* In Section 7.5, Walter de Boef and Anthony van Gastel share the recommendations as formulated by a significant group of policy makers during the policy workshop of the Tailor Made Training Programme on Informal Seed Supply in Ethiopia.

inter diversity of crops (useful landraces, improved varieties, well-adapted populations) need to be enhanced and utilized to meet the current and future needs in a sustainable manner.

4.3 Participatory varietal evaluation and breeding of the common bean in the Southern region of Ethiopia

Asrat Asfaw

The Ethiopian common bean breeding programme has developed many productive varieties with the potential to increase yield per unit area. However, there has been very limited uptake of improved bean varieties by smallholder farmers in the South Nations, Nationalities and Peoples' Regional (SNNPR) state. This limited adoption can be partly attributed to the restricted effectiveness of the breeding programme addressing the farmers' biophysical production environments. In conventional bean breeding, selection and testing environments are often fertilized, well weeded, flat, fertile and uniform land, and trials are grown in sole crop stands. This is in contrast to farmers' bean production environments: These landscapes are usually unfertilized (depending on the wealth of the farmer), sloping, less fertile and heterogeneous. They vary between and within farms and villages, and crops are mostly grown in inter or relay cropping systems. Breeders' selection or testing environments do not reflect the full range of farmers' myriad production environments. A second reason for low adoption is the limited effectiveness in addressing users' and clients' needs, i.e. limited involvement of the farmers and other actors in variety development. As a result, most of the bean varieties released through conventional breeding programmes have less acceptable characteristics such as none-attractive seed colour, seed size, cooking time and taste. They are often not diverse enough to meet the preferences of local bean farmers and consumers.

The conventional bean breeding approach lacks contextual thinking in addressing the issues of for whom and in what context the new genetic technology (variety) will work. Matching selection and testing environments with target farmers' production environments (i.e., by decentralization of selection and testing environments) and having farmers and other end users participate in the breeding process would apparently enhance the efficiency and effectiveness of bean breeding.^{97,108} Having farmers participate in the breeding process helps to fit the crop to the specific needs and uses of farmers' communities¹⁰⁹ and improves cultivar adoption.¹¹⁰ Participatory variety evaluation (PVS) and participatory plant breeding (PPB) are techniques for integrating clients' or end-users' needs and including actual production environments in the crop improvement process. This section outlines the process and lessons of integration of participatory techniques in bean breeding in the southern region of Ethiopia.

Local bean production and seed system in context

The crop, *Phaseolus vulgaris* L., was domesticated in Andean South and Middle America about 7000 to 8000 years ago and probably introduced to Africa in the past four centuries.¹¹¹ It is thought to have been introduced into Ethiopia by the Portuguese in the 16th century. Since then, farmers have developed bean cultivation practices adapted to the local conditions by maintaining the bean's adaptive and productive potential, and the present genetic diversity of beans in farmers' fields is the result of continued human-plant-environment interaction, i.e. the preservation and exploitation of useful alleles. The crop is not traditional in Ethiopia and hence does not show high genetic diversity in comparison with other 'centres of diversity' like Central America or the Andean region, or even with other African countries like the Great Lakes region. However, the population genetic structure of Southern Ethiopian farmers' bean varieties is not well known despite the believed narrow genetic base.

Beans are grown under diverse farming systems and agro-climatic conditions; either as a mono-crop or inter-cropped with maize, sorghum, coffee, etc. Farmers cultivate beans twice a year: first during the short '*Belg*' rainy season from February to April and then in the long '*Meber*' rainy season that starts in June and usually ends in September. In the *Belg* season, beans are usually intercropped with maize, sorghum and coffee while in the *Meber*, they are often planted as sole crops or relay cropped with maize or sorghum. The *Belg* planting takes the lion share of bean production of the region.

SNNPR is one of the major bean production belts of Ethiopia. The crop is principally cultivated for home consumption by smallholder farmers but in recent years it has been rapidly evolving into a cash crop. Both the small seeded Mesoamerican and the large-seeded Andean bean type are grown and consumed, although the preference for each type differs across regions. Small white beans of the Mesoamerican gene pool are the principal export class for Ethiopia. Smallholder farmers predominantly grow the small whites in the central rift valley. Small red-seeded beans are the most popular bean class in southern Ethiopia, although the preference in some areas is for Andeans. In the drier areas like Konso and Derashe, black beans are predominant. In Gedio coffee-based agro-forestry system, farmers grow climbers. In different production niches, farmers grow different bean seed classes. Adaptation to local climatic and agronomic conditions as well as the post harvest domestic sphere and market preference (local and/or export) might dictate the dominance of certain ideotypes in certain localities.

Farmers obtain bean seeds for planting from different sources. About 1.5% of bean farmers in SNNPR used improved seeds in the 2003/04 *Meber* season planting,¹¹² presumably obtained or purchased from formal seed sector institutions. The remaining farmers planted seed they obtained from other informal sources. The Ethiopian Seed Enterprise is the only formal seed sector institution that produces certified bean seed. Under the current commercialization of bean production, research institutes, universities, NGOs, farmer cooperative unions and offices of the Bureaus for Agriculture and Rural Development are engaged in bean seed production and supply to farmers. The seeds from these sources are usually some form of quality declared or truthfully labelled seeds. The supply from formal seed sources has never

met the farmers' actual seed needs. However, it is not clear how the different bean seed supply and demand mechanisms interact in the region. In general, both formal and informal seed systems are operating for bean production in the region, although their degree of dominance differs greatly.

Design of participatory research in bean breeding

Participatory techniques were used at different stages of bean breeding. Farmers were involved in selection of fixed as well as segregating populations.

Selection of fixed variations

The research design made use of participatory on-station selection and follow up of on-farm selection, and performance evaluation and diffusion of selected materials. Three participatory approaches were used: (i) decentralized participatory individual selection, (ii) decentralized participatory group selection and (iii) participatory group evaluation by neighbouring non-selector farmers. The selection process was conducted from 1999 to 2003 at two sites, Remeda and Korangoge, in Sidama zone of the SNNPR.

In decentralized participatory individual selection, farmers were invited to evaluate a wide range of germplasm (147 diverse fixed lines including 8 climbers, 36 large-seeded and 103 small- to medium-seeded beans). The collection was planted on-station and managed by a breeder at Remeda during the 1999 *Belg* season. Forty-four individual farmer-selectors (10 women and 34 men) participated in the selection process. Individual farmers selected lines they considered interesting, based on their own criteria without any outsider interference. Subsequently, individual farmer-selectors planted their selections in their own field ("individual plot trial") according to their individual preferences, and attempted selection for three consecutive *Meber* seasons (1999, 2001 and 2002).

In decentralized participatory group selection, all farmer-selectors (participants in decentralized individual selection) from the two sites were invited to visually assess and select all individual farmer selections pooled and each planted at "communal plot trials" at respective sites in 2001 and 2002. For attempting group selection, the participating individual farmer-selectors from the two sites were further divided into sub-groups: a group of all women selectors, one of all men selectors, and a non-gender desegregate group from the two sites. The groups were asked to select materials from amongst those selected at their respective individual selection that they thought would be useful to them as a group and to other farmers in the community. The communal plot trials were researchers managed at Remeda and farmers managed at Korangoge.

In decentralized participatory group evaluation, the participants were 10 neighbouring non-selector farmers (5 men and 5 women) representing the bean farming communities from the two sites. Evaluators were farmers who made the final assessment of selected lines but did not directly participate in the previous selection. The farmer-evaluators rated the individual farmers' selections planted at respective years and sites on a 1 to 5 'appreciation scale' (1 = worst and 5 = best) for selection traits (agronomic and market). The selection traits were further elicited using open-

ended and verification interviews and through informal interaction with each selector and evaluator farmer.

Selection in segregating variations

Based on the participatory varietal evaluation exercise, attempts were made to cross the farmers' preferred lines to generate more preferred variability for further participatory selection. A breeder produced 26 single-cross populations and advanced them to F₄ populations using the single pod descent method. The 26 F₄ populations were planted at Kokate in the 2004 *Belg* season for single plant selection by farmers. Four farmers attempted single plant selection. The farmers' single plant selections were planted in progeny rows at Amaro in the 2004 main season to screen the lines for low soil moisture stress. The promising lines at Amaro were advanced to F₆ at Awassa in 2005 main season for breeders' evaluation. The promising F₇ lines selected were planted at Kokate in the 2006 *Belg* season for farmer evaluation. Twenty farmers (including those who attempted single plant selection) participated in evaluating the lines. The participatory approach used was decentralized group on-station selection and evaluation.

Both the selections and the evaluations were conducted when the crop was close to physiological maturity and after threshing. The grains of each line from the previous year's harvest were presented in transparent plastic bags at the time of selection and evaluation at physiological maturity, so as to give the farmers options for selection and evaluation for seed characteristics. Farmers used their own judgment, based on their own selection criteria, to retain or reject the materials without any interference from the researchers.

Results of the participatory breeding programme

Farmer selection of fixed variations

The number of lines selected by a farmer ranged from five to 51 and on average, a farmer selected 15 lines in the first selection cycle in the *Belg* season of 1999. During the final selection cycle in 2002, the number of lines selected by a farmer ranged from one to four and on average, a farmer retained two preferred lines for production. At the final selection, the participating farmers at the two sites retained in total 17 large-seeded and 17 small- to medium-seeded beans i.e., 34 lines out of the diversity of 147 lines they were exposed to in 1999. Exposing farmers to diversity elicited farmers' implicit demands for bean varieties which were not made explicit during participatory rural appraisals and group discussions. Farmers need diversity for quite different purposes: varieties producing well under no or low fertilizer input conditions, varieties responsive to fertilizer application, beans preferred in local markets, beans mainly for home consumption (women), beans for home consumption and local markets, beans suitable for sole cropping, and beans suitable for intercropping. Farmers participating in the breeding process created access for the communities to improved bean germplasm (new genes) and increased intra-varietal diversity at farm level at the sites where there was a low level of bean diversity before.

Farmers applied diverse selection criteria to maintaining bean varieties on their own field. The diversity in selection criteria is an indication of the complexity of users' needs and production conditions. The more diverse the selection criteria, the better the chance of maintaining large diversity on-farm since all positive traits are seldom available in a single variety. However, the selection process and subsequent interviews with farmers revealed that seed colour and seed yield were decisive criteria in retaining or rejecting a variety. Yet, other characteristics are considered descriptors for the selection of a good line: e.g. large seed size, tall plant height, early maturity, high pod load, long pod, high number of seeds per pod (> 5 seeds/pod), strong stem (non-lodging), upright growth habit, pod clearance from the ground, good taste and fast cooking. Red and red mottled are the preferred seed colours.

During group selection, farmer-selectors identified bean lines preferable in their community by majority votes. However, low consistency in selection was observed among groups over years and locations. In all the selection events, greater proportions of larger seeded bean lines were retained as compared to the small and medium seed sized lines. A similar selection preference was observed during individual selection.

Table 4.6 Mean grain yield and farmer preference of bean lines evaluated at communal and individual plot trials in 2001 and 2002 at two locations

<i>Variety</i>	<i>Mean grain yield (kg/ha)*</i>		<i>Mean preference rating#</i>
	<i>Communal plot trial</i>	<i>Individual plot trial</i>	
CAL-170	999.4	727.7	3.9
AFR-697	948.9	1086.3	2.9
OBA-4	1112.6	1340.8	3.2
AFR-708	1069.7	809.4	3.1
DICTA-109	1565.6	1529.8	2.6
Roba-1	1414.9	1143.9	3.6
RAB-585	1200.9	1245.1	3.8
AFR-702	1323.7	1659.5	3.5
Red wolayta (local variety)	1117.2	838.6	2.9

Notes: * Average of two years and two locations;

Preference rating where a variety rated 5 is the most preferred and 1 the least preferred.

Of the new farmers' selections which were evaluated in diverse management conditions in 2001 and 2002, *DICTA-109* in the communal plot trial and *AFR-702* in the individual plot trial recorded the highest yields of 1565.6 and 1659.5 kg/ha respectively (Table 4.6). The results revealed that some of the highly preferred varieties like *CAL-170*, with a mean preference rating of 3.9 in participatory group evaluation, gave lower yields than the high yielding variety *DICTA-109*, rated with a mean preference of 2.6. This indicated that, for adoption of a new bean variety, it is not only grain yield but also farmers' qualitative criteria and assessments that are vital. The overall selection and evaluation process with farmers in participatory methods revealed that farmers are capable of selecting and evaluating varieties that give superior yields in their own field. This result is in line with Ceccarelli and colleagues¹⁰⁹ who stated that farmers can handle selection choices from among a large number of

lines, and that it is possible to transfer the responsibility for selection to farmers in their field.

Farmers' selection in segregating variations

The farmers who developed fixed lines performed remarkably. The participating farmers selected 26 populations from 500 single plants. Out of the 500 single plant selections by farmers evaluated at Amaro in the 2004 *Meber* season, the top ten gave on average a 19% and 55% yield advantage over standard and local checks, respectively (data not shown). The best 76 lines were then advanced to a preliminary yield trial at Awassa in 2005 for breeder evaluation. The promising 74 lines were then planted at Kokate along with four checks in the 2006 short *Belg* season for farmer evaluation and selection. The farmers attempted group selection and retained the best-preferred 11 lines for further evaluation. The grain yield of the farmer single plant selection in 2006 ranged from 1859.4 kg/ha (*ETAW-02-2-7*) to 6537.5 kg/ha (*ETAW-02-4-9*). Thirty five lines performed better than the best check (*DOR-554*).

Impact of participation on diversity and plant breeding efficiency

Exposing farmers to bean diversity, with fixed as well as segregating materials, resulted in the identification of new variation and the re-introduction of lost diversity attractive to farmers. The new as well as the re-introduced bean varieties provided farmers with more reliable seed yields under marginal environments. The newly selected lines offered yield advantages over existing farmers' varieties. Because of these and other good seed characteristics, they are highly appreciated by other farmers and consumers. Farmers' cultivation of new bean types and the subsequent supply to local markets created new demand niches for red kidney, red speckled and large seeded beans. Especially the red kidney varieties sell extremely fast in the local markets, and farmers complain that they cannot get seed. The creation of new niche markets for new beans in the region is an encouraging factor for the communities who developed the varieties. Because of good prices in the local market, some farmers started multiplying the new beans in larger areas. The introduced red mottled varieties create a new market for export to northern Kenya.

The integration of participatory techniques in common bean breeding resulted in increased farmer-held diversity. Farmers' skills in breeding were enhanced. Their selection criteria and preferences were adopted in the breeding programme and positive interactions between farmers and researchers increased the efficiency of the breeding programme. Consequently, participatory approaches also reduced research costs in relation to impact gained. Research was enabled to effectively target user needs, acceptable varieties were identified faster, and there were fewer research dead ends.

4.4 Participatory varietal selection of barley in the highlands of Tigray in Northern Ethiopia

Fetien Abay and Asmund Bjørnstad

Barley (*Hordeum vulgare* L.) is a major crop in the Tigray region of Northern Ethiopia, and its importance has been increasing as more areas have become drought prone over the past years. On average, barley covers 34%, 23% and 12% of cultivated land in eastern, southern and central zones within the Tigray region.¹¹³ Its production is rain dependent and its productivity is low. Increasing the productivity is therefore a priority for improving the food security of the poor farmers. Development of varieties for drought-prone areas has had less priority in Ethiopia; instead breeders targeted early maturing varieties. The national barley breeding programme initiated utilisation of local varieties since 1990 and some hulled barley varieties were released for large-scale production. During the past three decades 32 barley varieties have been released; six of these varieties have been widely distributed because the Ethiopian Seed Enterprise (ESE) produces their seed. Inadequate adoption and dissemination of the released varieties is also the result of limited seed production by the formal seed sector, local unavailability of seeds, and farmers' lack of awareness about improved varieties. The main reason for low adoption is the fact that the needs of low input barley growing areas of northern Ethiopia have not been adequately addressed in breeding, and the released varieties show a high degree of genotype x environment interaction in the farmers' fields.

In striving to transform its economy, Ethiopia is pursuing agricultural development-led industrialization for poverty reduction and food sufficiency. To achieve this objective, seed is considered an important component of the high input extension package. The participatory, demonstration, extension and training approach of extension agents emphasizes high input extension packages and provides seed of improved varieties and fertilizer on credit. The officially recommended improved varieties, i.e. *HB-42* and *Shege*, have not been adopted by farmers, however. Farmers in northern Ethiopia rely on their own knowledge and selection strategies in variety choice. To develop high yielding varieties specifically adapted to the variable rainfed environments found in Tigray, researchers and farmers have to join forces in experimentation and innovation. The potential of such participatory crop improvement (PCI) programmes for identifying preferred varieties, improving adoption of varieties, and enhancing productivity level, has been well documented.* This section describes the result of a participatory varietal selection (PVS) trial in Tigray, using the 'mother and baby' design, a systematic approach to participatory evaluation.¹¹⁴ The research was a joint effort by farmers, development agents, university students and researchers.

* Walter de Boef and Juliana Bernardi Oglari provide a more detailed description of definitions and approaches to participatory crop improvement in Section 4.1.

Steps in barley varietal selection

Diversity fairs

At the planning stage, village-level diversity fairs were organized. Each farmer was asked to display the varieties of barley that he or she was growing. The fair allowed farmers and researchers to exchange knowledge and identify constraints on adoption and dissemination of varieties. Knowledge exchange was important for identifying the relevant characteristics of farmers' varieties, selecting experimental varieties that will meet farmers' requirements, and learning about farmers' reasons for rejecting the released barley varieties. During the fair, farmers indicated their intention to include rare and endangered varieties in future testing. This led to a modification of the experimental design that the researchers initially proposed; both farmers' and researchers' suggested varieties were now included.

Identification of varieties to be included in the trials

Suitable varieties for the trials were identified, based on farmers' criteria; other varieties were deliberately included because of their limited adoption. The trials included four released or modern varieties, two farmers' developed varieties and three rare and endangered farmers' varieties (Table 4.7). *Dimtu* and *Misrach* are respectively released by Holleta and Debrebrhan research stations for both early and late sowings and high-and low-external input conditions. *HB-42* and *Shege* are released by Holleta for high input areas, but deliberately included because of their official recommendation for cultivation in Tigray. '*Himblil*' and '*Dembay*' are farmer developed, locally preferred varieties.

Table 4.7 Characteristics of the test varieties used in the experiment

<i>Variety</i>	<i>Source and method of Improvement</i>	<i>Row Type</i>	<i>Caryopsis type</i>	<i>Year of release/status</i>
<i>HB-42</i>	Exotic x indigenous cross IAR/H/81/compound 29// compound 1420/coast	Six	Covered	1984
<i>Shege</i>	Pure line selection from accession 1622-05	Six	Covered	1996
<i>Misrach</i>	Pure-line selection from <i>Kulmsa 1/88</i>	Six	Covered	1998
<i>Dimtu</i>	Pure-line selection from accession 3369-19	Irregular	Covered	2001
<i>Himblil</i>	Farmers' developed variety through pure line selection	Six	Covered	Preferred locally since 2000
<i>Dembay</i>	Farmers' developed variety through pure line selection	Six	Naked	Preferred locally since 2000
<i>Rie</i>	Farmers' variety	Six	Covered	Rare variety
<i>Sibumay</i>	Farmers' variety	Six	Covered	Rare variety
<i>Atona</i>	Farmers' variety	Irregular	Covered	Rare variety

Note: all varieties are of the late maturity type.

Identification of trial sites

Seven major barley growing highland districts in Tigray were identified jointly by the researcher and the agronomy section of the Regional Bureau of Agriculture. Highland districts with ≥ 2400 masl were deliberately selected because of the late maturing nature of the test varieties. On the basis of these criteria, seven districts were selected; two from central Tigray, i.e. Dogua Tembien (location Melfa) and Tahtay Maychew district (location Adinefas); two from eastern Tigray, i.e. Atsbi (locations Habes FTC and Habes on-farm) and Gantafesham district (locations Buket and Mugulat); and three from southern Tigray, i.e. Enderta (location Mekele), Endamekhoni (locations Bolenta, Mekhan and Neksege) and Olfa district (locations Menkere and Fala); see Figure 4.1. Holleta and Debrebrhan (Mush) were included since the modern varieties, *HB42*, *Shege* and *Dimtu* were released from Holleta and *Misrach* from Debrebrhan. At the selected sites, barley is grown in both the main and the short (*Belg*) seasons. The short season rainfall starts in January and extends to the end of April while the main season rainfall is from early June to the end of September. Off-season cultivation on the residual moisture (September to December) is also practised.

Figure 4.1 Map of Tigray and location of test sites



Identification of farmer experimenters

During village meetings, experimenting farmers were identified on the basis of their interest and the constraints that needed to be addressed. Known seed selectors were deliberately included. Farmers helped in the identification of interested farmers. In Tigray nearly 30% of the households are female headed. These households were encouraged to participate in the experimentation process; on average 20% (range of 8.3% - 25%) of the experimenter farmers were women. During the planning and implementation process, lack of oxen and ploughing skills of female-headed

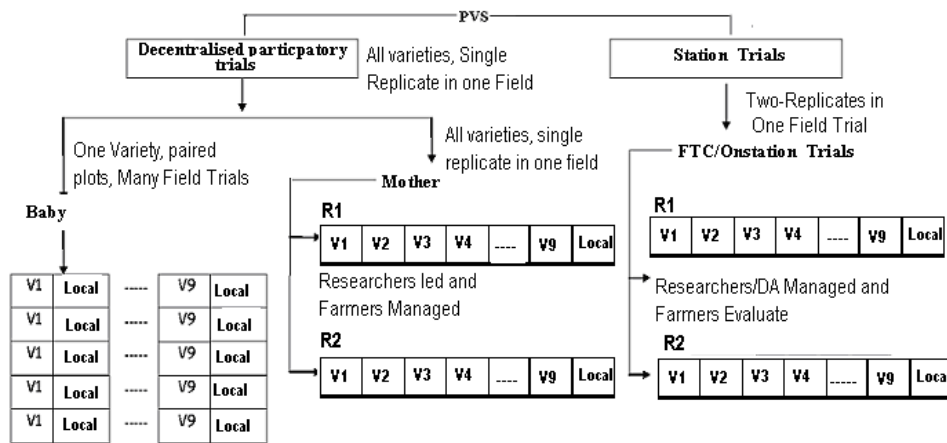
households were raised as major constraints for participation. This expected challenge was managed through flexible solutions raised by farmers, such as sharing of labour with ploughing skills, and using neighbours and relatives' skills.

Experimentation: mother and baby trials

The PVS used a “mother and baby trials” system.¹¹⁴ Farmers’ knowledge and preferences were considered in decisions made on the varieties to be tested. At each site, farmers participated in providing farmers’ developed varieties and farmers’ endangered varieties. Farmers define ‘endangered’ varieties as those grown either in mixed cultures or by only a few households in neighbouring villages. Farmers helped in the identification of experimental fields.

See in Figure 4.2 an outline of the experimental design. A total of 21 mother trials were conducted: nine at the FTCs, three on the research stations (Mekelle, Holleta and Debrebrhan) and nine in farmers’ fields. The FTC and on-farm trials were conducted for two years (2004-05 and 2005-06) but the on-station trials were conducted for one year only (2005-06). Farmers’ fields served as replications in the on-farm trials. They were conducted in a randomized complete design with two replications at the FTCs and research stations. A plot size of 3 m² (1.2 x 2.5 m) was used for all trials.

Figure 4.2 Experimental design of the mother and baby trials



Baby trials consisted of paired plots of each test variety with a local check. One kg of seed of each test variety was randomly given to five farmers to grow it alongside their local variety on their farms under their own management conditions. A total of 180 farmers were involved in the baby trials; 45 farmers in each village. The objective of these trials was to test varieties under various environmental conditions and farmer management practices.

Cross visits within villages were organized for participatory evaluation at three stages of crop growth, i.e. at the vegetative, flowering and grain filling stage. During the flowering stage, evaluating farmers were asked to bring representative spikes of

five test and local varieties. Specific traits like spike length and number of grains per spike were recorded. Exposure visits across districts were performed to share the experiences of recognized seed selectors, mainly from Bolenta and Habes, and from Mugulat and Buket.

Data collection and analysis

The quantitative data from the trials were recorded by research assistants, development agents, and students of Mekelle University through the practical attachment programme, and supervised by the researcher from the University. Each farmer experimenter was given a logbook to record observations and quantitative traits such as days to heading, maturity, and plant height. Schoolchildren in the household were briefed so they could assist in recording of data. Three members from the village experimenters were elected to facilitate field monitoring and to provide the researchers with feedback.

For the harvest, the central four rows (2 m²) were hand harvested and hand threshed. In this way the grain yield (in grams and later converted into kg/ha) could be recorded. Household preferences were assessed on the basis of variety matrix ranking. The reasons for preference of a given variety were recorded and considered as criteria for ranking. The criteria and varieties were listed in a matrix to understand the choices between the varieties and traits and the constraints.¹¹⁵

Analysis of variance, using Proc GLM of SAS version 9.1, was computed for grain yield of year/location combinations (environments) and two year-location combination trials. The qualitative data collected from household questionnaires were subjected to Chi-square tests¹¹⁶ where the numbers of farmers responding better and not better in relation to the local variety were arranged in a two-way table.

Results from the mother and baby trials

The results from the mother baby trials are shown in Table 4.8. The coefficient of variation (CV) ranged from 6 to 16%, indicating the consistency of the experiments over the two years and locations. The overall mean yield of two years' trials indicated highly significant differences among the genotypes. The farmer-developed variety *Himblil* was the best: it was significantly different from other varieties, not only at the high yielding environments of Bolenta and Habes, but also at the driest site, i.e. Neksege, and in the waterlogged soils of Menkere. *Misrach* was superior to the two row local checks of Buket, Habes and Mugulat, but not at Neksege. It did not differ significantly from the six row local checks at Bolenta and Mekan and it was inferior to the local check at Menkere. In the relatively fertile soils of Bolenta and under waterlogged locations at Menkere, the yield advantage of *Himblil* over *Misrach* was 370, and 378 kg/ha, respectively. The superior performance of *Himblil* in waterlogged soils indicates a potential and genotypic variability for waterlogging tolerance, which is being further investigated. Its waterlogging tolerance was also observed in other trials. Except at Mugulat, where *Dimtu* was the best performing variety, *Dimtu* was either inferior or not different from the local varieties tested at different locations. The recommended varieties, *HB-42* and *Shege*, were consistently the lowest yielding varieties at all sites (Table 4.8).

Table 4.8 Mean grain yield of barley varieties grown at seven locations over 2004-05 and 2005-06

Variety	Mean grain yield in location (kg/ha)							Mean yield (kg/ha)
	Bolenta	Habes	Mugulat	Buket	Menkere	Mekhan	Neksese	
<i>HB-42</i>	455 ^g	105 ^f	156 ^f	203 ^e	219 ^h	297 ^g	100 ^h	219 ^f
<i>Shege</i>	819 ^f	706 ^d	800 ^d	558 ^d	820 ^d	681 ^f	483 ^f	695 ^h
<i>Misrach</i>	1250 ^c	1042 ^b	1056 ^b	1182 ^a	861 ^c	916 ^b	948 ^b	1036 ^b
<i>Dimtu</i>	1149 ^d	939 ^e	1330 ^a	917 ^b	728 ^f	828 ^c	764 ^c	950 ^d
<i>Himblil</i>	1620 ^a	1283 ^a	1089 ^b	1161 ^a	1239 ^a	952 ^a	1010 ^a	1193 ^a
<i>Dembay</i>	1195 ^{cd}	880 ^d	782 ^d	778 ^c	738 ^f	781 ^d	656 ^d	815 ^e
<i>Rie</i>	1180 ^{cd}	889 ^e	726 ^d	725 ^c	852 ^e	789 ^d	282 ^g	778 ^f
<i>Sibumay</i>	1413 ^b	875 ^d	612 ^e	523 ^d	490 ^g	658 ^f	386 ^g	708 ^h
<i>Atona</i>	960 ^e	648 ^e	782 ^d	723 ^c	787 ^e	732 ^e	522 ^e	729 ^g
<i>Local</i>	1262 ^c	970 ^e	950 ^e	951 ^b	958 ^b	933 ^{ab}	900 ^b	989 ^e
Location								
mean	1130	834	828	772	769	757	605	811
s.e.d.	78	57	44	63	31	30	19	16
CV	10	14	11	16	8	8	6	11

Note: Genotypes with different letters are significantly different; those with the same letters are not significantly different from each other.

Farmer's preferences and perceptions

A chi-square test analysis was performed for the matrix ranking of all experimental entries including local varieties.¹¹⁶ The overall farmers' preferences across the seven sites are presented in Figure 4.3. *HB-42* was rejected by 98% of experimenter farmers. *Dimtu* was preferred by farmers in Mugulat because they observed its 'stay green' trait during late season drought. However, it was not preferred at Bolenta because of its less compact, thin spike. The released varieties *Rie* and *Sibumay* were not preferred since their extended vegetative period made them prone to drought at the end of the season. The preference for high grain yield was only significant for *Himblil*. Overall, the preference was only significant for *Himblil* and *Misrach*, the latter not for yield but for its overall performance, indicating the multiple criteria and flexibility of farmers in maintaining varieties. The experiments also allowed information exchange among farmers and increased the familiarity with new varieties of barley. As shown in Figure 4.4, the area expansion of varieties indicates the acceptance by farmers, with a clear variation between villages for area allocation of each variety. At Bolenta, *Himblil*, *Misrach* and rare farmers' varieties are the most preferred ones. The latter were preferred because of their high yield in a relatively long growing season. *Dimtu* was favoured at Mugulat and *Misrach* at Buket. *HB-42* was not preferred and not planted in the second year, except at Buket and Mugulat by one and two farmers, respectively (Figure 4.4). In other words, the PVS already showed tangible results in its second year.

Figure 4.3 Overall preference ranking of barley varieties in three districts of Tigray

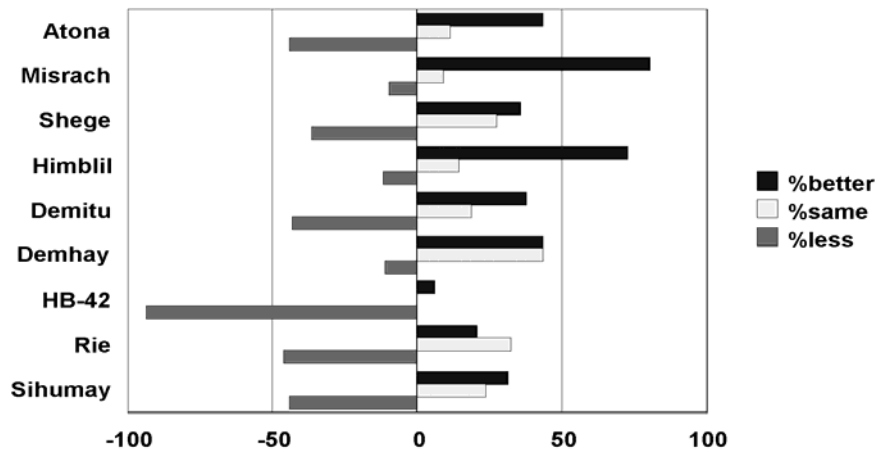
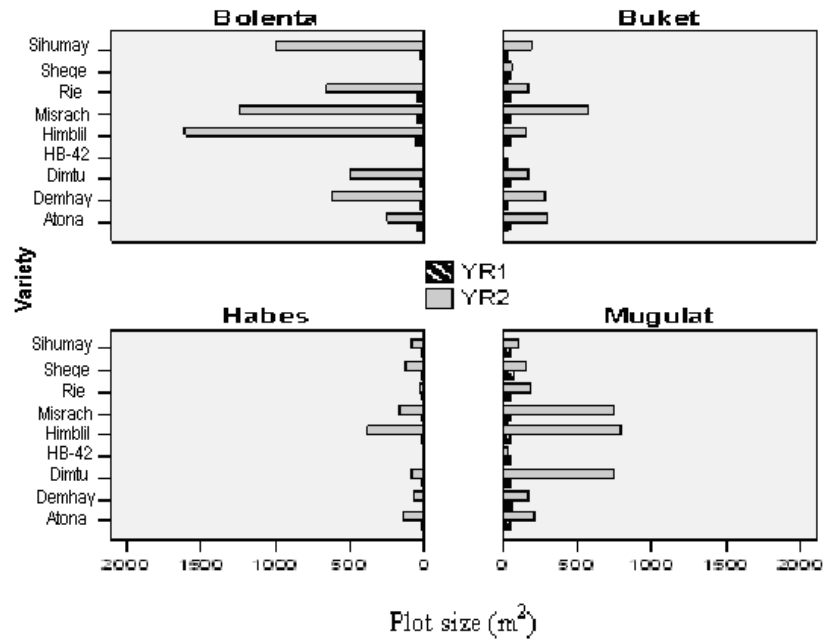


Figure 4.4 Area expansion in two years of preferred varieties by location



Lessons learnt from PVS in barley breeding in Tigray region

The merits of PVS for barley improvement in Tigray

The experiments have shown that PVS is a viable method for identifying preferences, constraints and the potential of varieties. The results of the PRA methods corresponded well with the data from the mother and baby trials, and the analysis showed that the level of accuracy was acceptable. The preliminary experiences of variety dissemination are also promising. For further work, strong collaborative networks have been established between the farming communities and regional extension workers. A group of farmers experimenting with introduced and local varieties spontaneously organized themselves in an “Association for Barley”, established to share information, ideas and seeds which they found to be more productive than other introduced and local varieties. This study confirms the practical use of a methodology for breeders and agricultural experts to perform varietal selection. The combined efforts of farmers, breeders and development agents may lead to more preferred varieties being tested, to the benefit of the farmers.

Choice of breeding strategies and genetic diversity

The results of varietal testing on-farm, at FTCs and on-station showed the importance of conducting selection in the target environment. The correlations between variety performance under stress and under favourable growing conditions were poor, indicating high genotype x environment interactions. This is similar to the data of Ceccarelli,^{117,118} who observed that the largest gains for barley improvement for drought stress can be expected from direct selection under stress conditions. In our studies, we found that the farmer-developed variety *Himblil* out-yielded recommended varieties. This confirms the relevance of targeting specific adaptation and the use of local varieties in breeding for stress-prone environments.

The expected yield advantages of the modern varieties *Misrach* and *Dimtu* were not realized. Only when grown under high input conditions did the two varieties perform better than the local varieties. The performance of the local varieties was much better than the performance of *Shege* and *HB-42*, the other two modern varieties tested. *Misrach* originates from a local variety in Arsi and has been promoted in Debrebrhan because of its superior waterlogging tolerance. However, *Himblil*, selected by a farmer in Bolenta, performed similar to or better than *Misrach*.

Local varieties are an important source of drought resistance.¹¹⁹ *Himblil* can be considered as a good source of abiotic stress tolerance, both to drought and waterlogging stresses. It is more stable than the improved varieties under the low input and low rainfall conditions of Tigray. The superior performance of *Himblil* in contrasting seasons and low input conditions confirms the importance of specific adaptation, as negative results were obtained when the variety was tested under high input conditions.

In current barley breeding in Ethiopia, increasing use is being made of more adapted germplasm and more relevant testing methods.¹²⁰ The performance of this new germplasm in the highlands of Tigray region approximates that of *Himblil*. If a

wider genetic diversity is used in crop improvement programmes, including local germplasm from Tigray region, even better cultivars may be developed in the future.

Variety recommendation

When looking at the various testing environments, the differences between high and low input conditions were more important than the differences between farmers' fields. The differential response of varieties to the environment indicated the relevance of conducting variety selection in the target environment. It can be concluded that there are good reasons for farmers not to adopt the recommended varieties *HB-42* and *Shege* which were released long time ago. The recommendation of inappropriate improved varieties makes farmers lose confidence in future released varieties. It is therefore important that EIAR and TARI revise their approach for variety testing and recommendation. Farmer-developed varieties should also be formally recognized and promoted in the target environment.* *Himblil* can be a potential candidate for formal release. The results of our studies indicate that it is possible to improve grain yields of crops in low input abiotic-stressed target environments.

Key conclusions from the study are that the improved varieties are not better than the local varieties, that joint evaluation of varieties helps in rapid dissemination of varieties and information, and that farmers are reliable partners in research and plant breeding.

* In Section 7.5 Walter de Boef and Anthony van Gastel share the recommendations as formulated by a significant group of policy makers during the policy workshop of the Tailor Made Training Programme on Informal Seed Supply in Ethiopia.

4.5 Working with farmer research committees in participatory bean breeding in Honduras^{*,†}

*Sally Humphries, Omar Gallardo, José Jiménez, Fredy Sierra
and the Association of CIALS of Yorito, Victoria and Sulaco*

Introduction: setting the scene

Origin of the initiative

The participatory bean breeding initiative in Yorito, Honduras, grew out of collaboration between la Fundación para la Investigación Participativa con Agricultores de Honduras, or FIPAH, a Honduran non-governmental research and development organization, local agricultural research committees known by the Spanish acronym, CIALs, and plant breeders at the Pan-American Agricultural School (Escuela Agrícola Panamericana, EAP), referred to here as EAP-Zamorano. The CIAL programme in Honduras developed from a pilot project set up by the International Centre for Tropical Agriculture (CIAT) in 1993. Following training by CIAT in participatory research methods in 1996, FIPAH agronomists facilitated the establishment of CIALs in three locations in Honduras, including one in the department of Yoro. Today there are 24 CIALs for adults and nine CIALs for youth located in the municipalities of Yorito, Sulaco and Victoria in Yoro.

From the outset, the CIALs searched for crop management alternatives that would improve on their existing practices. This involved simple split plot trials in which new varieties or techniques were evaluated against current practice. EAP-Zamorano provided the new germplasm for these trials. After more than three years of experiments conducted by the CIALs at multiple locations, it became clear to FIPAH and CIAL members that communities at higher elevations were not seeing many benefits from the newer technologies. In most cases, their own local landraces outperformed breeders' materials. This gave rise to the recognition of the potential for improving local bean germplasm through participatory plant breeding (PPB).

Problem addressed and local conditions

Beans in Honduras, as elsewhere in Central America, provide the poorest people with most of the protein in their diets. Farmers' bean varieties are mainly small in size and

* This section is adapted from a chapter with the same title by these authors in Almekinders, C. and J. Hardon (Eds). *Bringing farmers back into breeding. Experiences with participatory plant breeding and challenges for institutionalization. Agromisa Special 5*. Wageningen, Agromisa: pp. 47-57.

† The Honduras project is part of the Meso American Programme on Participatory Plant Breeding (Programa FP-MA, Fitomejoramiento Participativo Meso Americano): <http://www.programa-fpma.org/> FIPAH has been funded since October 2000 by USC-Canada, an NGO supported by the Government of Canada through the Canadian International Development Agency (CIDA).

red in colour. Black beans are also consumed in smaller amounts in rural communities but they have little commercial value. Breeders' varieties have tended to be darker in colour than farmers' red varieties and have frequently been rejected by farmers because of the low prices that they receive for these on the market. This, combined with the unreliable and frequently inferior yields of improved materials, particularly at higher altitudes, meant that poorer farmers, living in remote upland locations, had little interest in adopting newer varieties.

In spite of the disincentives for poor farmers to adopt breeder varieties, farmers readily admit that their own varieties are far from ideal. Through a visioning exercise, focus groups of Yorito farmers (17 women and 20 men) at higher altitudes came up with a wish list of traits for their ideal bean, presented in Table 4.9. Early maturity is an additional appreciated characteristic because it allows for food and income to be generated earlier in the season, which is particularly important in Yorito where the hungry period is lengthy and pronounced. However, there is a trade-off here against yield, and overall yield was considered by farmers to be the more important characteristic.

Table 4.9 List of ideal bean traits for Yorito farmers at higher altitudes in Honduras

<i>Agronomic characteristics</i>	<i>Pod and bean characteristics</i>	<i>Taste and cooking qualities</i>
<ul style="list-style-type: none"> • (Non-trailing) bush beans, 35-40 cm in height • Yields of 25-40 pods/plant • Disease resistant • Even ripening • Thick stem • Resistant to heavy rain and drought 	<ul style="list-style-type: none"> • Thickish pod to prevent the beans from sprouting during wet weather • 7-8 beans/pod • Longish, thick, heavy bean • Dark reddish colour, shiny • Easy to shell • Firm bean skin to prevent pest infestation in storage 	<ul style="list-style-type: none"> • Produces a thick soup when cooked and doesn't need lard • Expands in the pot • Soft, good tasting bean • Cooks quickly without much fuel

Note: the list of traits was developed during a visioning exercise by a focus group of 17 women and 20 men.

Local crop production and the seed system

The Honduran Government is responsible for seed regulation. In the past, it also played a key role in research but cutbacks in the early 1990s saw much of the research function passing to EAP-Zamorano, which conducts seed research both publicly and privately. Since the inception of the CIAL project in Honduras, FIPAH and the CIALs have been partners with Zamorano, testing out new germplasm as members of a network conducting regional adaptive trials. This has permitted EAP-Zamorano to acquire feedback on its materials from much less favourable resource areas than was previously possible.

As in many other parts of Honduras, Yorito has a six-month dry season from approximately November through to May. Farmers plant beans twice annually: once in May/June, when the rainy season begins, for harvest in July/August and again in October, near the end of the rainy season, for harvest in December. Beans are

produced both for consumption and for sale. Maize is generally sown once per year: planted in June and harvested in September or October. Most hillside farmers only produce maize for consumption purposes; on the whole, they do not own enough land to grow it commercially. Seed, traditionally selected by women at home, is mainly saved from one cycle to the next. Other crops include coffee, grown at higher elevations, and small quantities of vegetables and fruits for home consumption. Soybean has recently been introduced through the CIALs.

Like other poor farmers in the region, CIAL members report that climatic conditions have become more extreme over the past decade. Drought and torrential rains appear to be more common than anyone can remember in the past. Given the marked effect that the hungry season (*los juniros*) has on people's lives, any perturbation in weather patterns that delays the start of the rainy season or lowers grain yield during the growing season is a cause of major concern to local people: hunger is never far away. The decline in coffee prices in the early years of this decade added to this concern and contributed to increased out-migration.

Women's responsibilities in Honduras typically include managing small livestock, chickens and pigs, close to home. Responsibility for maize and beans, often grown on hillsides far from the house or village, is generally left to men. When women do participate in agricultural tasks away from the house, it is limited to certain activities, such as the coffee harvest or pulling up beans. Usually their involvement in these activities is a sign of poverty, as local mores dictate that women's rightful place is in the home.

The inclusion of many women within the CIALs has bucked this trend. In Yorito, women make up around 40% of all CIAL members. This can partly be explained by poverty, but also partly by the indigenous backgrounds of many of the women. In addition, the facilitation skills of FIPAH staff and farmer facilitators, who have provided a welcoming environment for women, have contributed to this.

Organizational and institutional structures

The Yorito CIALs are the largest organization of CIALs in Honduras: there are 105 men and 102 women members in 24 local (adult) CIALs. Nationally there are 80 CIALs with a total of 710 members. Information exchange between CIALs is common and farmers meet annually or biannually to present research findings to one another in national meetings. Thus the results of PPB are readily disseminated through the country's CIAL network to hundreds of other farmers who are equipped to test out new materials against their own local varieties.

In Yorito, four CIALs carried out PPB in beans on behalf of other high altitude communities in the area. The socio-economic characteristics of CIAL members vary somewhat between communities. In Mina Honda and La Patastera, they are extremely poor, as are most people in these two upland communities, and many are indigenous Tolupan. While most families have access to a small amount of land (less than 1.5 ha), this is generally of very poor quality. In the other two communities, there is more variation amongst CIAL members: a couple of the members own approximately 3.5 has. In Santa Cruz, two CIAL members are also farmer facilitators working with FIPAH and have considerable knowledge of experimentation, and are acknowledged

leaders in the regional Association of CIALs. The inclusion of three farmer facilitators in two of the CIALs conducting PPB undoubtedly helped accelerate the generation of knowledge by PPB. As a participatory research methodology, PPB is congruous with the CIAL methodology. CIAL members are familiar with conducting controlled experiments and are generally regarded by others in their communities as leaders in innovation and research.

PPB methodology and farmer participatory (breeding) practices

The research project presented in this section aimed to compare the results of three processes: (i) PPB with farmers (on-farm), (ii) conventional plant breeding (on-station) and (iii) distributing all materials generated on-station to farmers for selection in the 6th generation through single seed descent.

Genetic material used and locations for conducting trials

At the outset of the project, EAP-Zamorano provided segregating materials from F₄ generations to participating CIALs to accustom members to the challenge of working with unstable materials. Most previous CIAL experiments had involved PVS with F₆- and more advanced materials. Farmers had to learn how to manage such instability. Meanwhile the breeder crossed the most frequently utilized farmers' bean variety, *Concha Rosada*, with various breeders' materials. A population of 120 F₃ families, in which *Concha Rosada* was the maternal parent, was sent to CIAL members in Yorito for the early planting in 2000.

The original plan was to keep all the materials together in one 'collective selection site' in the community of Mina Honda until the F₆ generation with the four different CIALs conducting field and post harvest evaluations with the F₃-F₆ materials at this site. Land was provided by a community member in exchange for maize provided by the CIAL. However, almost immediately the CIALs voted to decentralize the trials and the selections that they made in the F₃-trials were taken back to their own communities at the end of that cycle. They felt this would permit greater genetic adaptation of the materials to emerge at an earlier stage in response to local environmental variations. The communities were located at a range of altitudes from 1550 metres above sea level (La Patastera) to 1260 metres (Santa Cruz), with Mina Honda (1350 metres) and Chaguitio (1460 metres) at intermediate altitudes.

Evaluation

Prior to the field evaluations, a workshop was organized in Mina Honda for participants from the four communities. The workshop explained to participants the background of the project, its objectives, and why they had been invited to attend. After the workshop, participants carried out an evaluation involving the identification of disease and other characteristics in the PPB (F₃) beans. The groups were broken down along gender lines to gauge differences in selection criteria between men and women. Each individual participant toured the experimental plot, seeking out materials that met his/her expectations. Individual selections were marked by coloured tags and the information was subsequently collated by the secretary of each CIAL. A trained team member noted down the criteria utilized by each participant in

selecting or rejecting materials. In this way, a picture was obtained of the most widely used selection criteria within the communities, broken down along gender lines. This process involved the use of open questions allowing interviewers to get a clear picture of the guiding selection criteria employed by participants.

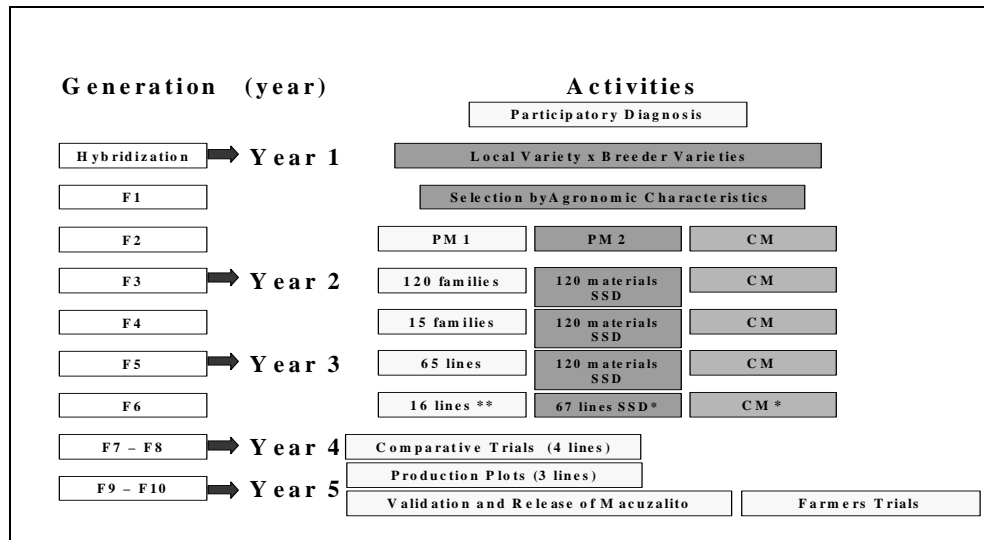
Workshops on criteria of post-harvest selection and grain quality were carried out by FIPAH with the members of each CIAL team. Seed from each of the materials selected in the field was taken to each participating community. In each community, a table and benches were set up on which to display the materials. The seed from each plant family was then placed on a plastic plate with a label displaying its code or name. Five men and five women from the team or from the community were invited to observe the materials and comment on them. The other evaluators were kept at a distance so that they remained unaware of each other's choices. The preferred materials were marked and recorded by the secretary of each CIAL. The evaluators were also interviewed to find out the criteria for their decisions to select or reject a given material. The information gathered from these questions was then displayed on a flip chart to derive a scoring for each family. At the end, this information was analysed and consolidated to determine which selection criteria were the most important in that community. In subsequent analysis, the families that had the highest frequency in field and grain selection were selected to continue with the F₄-planting.

A very diverse range of selection criteria were identified but the most frequent were: resistance to rust, Anthracnose and powdery mildew; bush architecture (with a preferred height of 30-40 cm); uniform maturity; and a good yield (20-30 pods/plant). Farmers preferred a thick and heavy, longish bean. At this stage of selection, grain colour was excluded from consideration. Gender differences in selection criteria were not significant. It was noticeable that, although men had more experience in the field, the women found it easier to evaluate and select, rapidly seeing differences between traits in the different materials. Their evaluations and selections were often more discriminating than those of the men.

The field and grain evaluations continued in the four communities until the F₆ stage, as described in Figure 4.5. At that stage, ten materials selected by the communities and five materials selected on-station at EAP-Zamorano were put into comparative trials, along with a local control, *Concha Rosada*. The participating communities selected quite different materials to put in the comparative trials. This was partly due to different selection intensities and partly to different cultural preferences between the different communities. Other factors, such as environmental conditions, also played a role. For example, La Patastera CIAL made the broadest initial selections, with members retaining more than 50% (63) of the original F₃ materials. In F₄ they selected 23 materials but then subsequently lost all their selections in F₅ due to poor weather conditions. Two of the other communities, Mina Honda and Santa Cruz, over-selected at the outset (retaining less than 13%) which probably limited the genetic variability and hence the possibilities for making the best selections in F₄. The fourth community, Chaguitio, retained 19%. In short, selection in this first attempt at PPB occurred by trial and error with both farmers and the NGO learning along the way. In the following table, only the selections made between F₃ and F₅ in Mina Honda (the original collective site) are recorded. The complete list of

materials put into F₆ trials resulting from selections made by the three communities, as well as by the breeder, is given in the legend below Figure 4.5.

Figure 4.5 Outline of the participatory bean breeding programme in Honduras



Legend:

PM1 Participatory Management 1: PPB conducted by farmers from F₃ in the community of Mina Honda.

PM2 Participatory Management 2: Single Seed Descent. At F₆, 67* materials were provided to CIALs by EAP-Zamorano for participatory selection in separate trials. None were eventually selected by farmers.

CM Conventional Management: Materials selected on-station at EAP-Zamorano.

* 5 best bet materials were provided to farmers for inclusion in PM1 F₆ trials.

** F₆ trials contained materials selected as follows: Zamorano: PPBY-5, -9, -11, -13, -15; Mina Honda: PPBY-1, -4, -6, -10, -12; Santa Cruz: PPBY-3, -8; Chaguitio: PPBY-2, -14, -7 + plus the local control (Concha Rosada). La Patastera lost its F₅ materials due to excessive rain and cold weather. The F₆ trials were conducted in the 4 communities: Mina Honda, Sta. Cruz, La Patastera, Chaguitio.

Results of the participatory trials

Farmers selected four lines for advancement from the F₆ trials; all four of these selected materials came from the local PPB trials, none of the breeder's selections were advanced beyond the F₆ level. The results of the F₇ trials are given in Table 4.10.

One of the lines (*PPBY-1*) was discarded in the F₈ trials owing to unfavourable agronomic traits. Three lines (*PPBY-2*, *PPBY-14*, *PPBY-8*) were advanced for production and subsequent validation. Macuzalito (*PPBY-8*) was later released as a new variety in August 2004 in the municipality of Yorito. As shown in Table 4.11, this variety was considered by farmers to show the best overall traits; the other two varieties had good individual traits but contained at least one drawback. Nevertheless,

these varieties were kept for local use because of their useful characteristics, such as earliness in the case of *PPBY14* (an important trait as it helps to shorten the hungry season) and high yield in the case *PPBY2*, which was beneficial for food security.

Table 4.10 Average yields in comparative trials in three Yoro communities, Spring 2002¹²¹

No.	Line*	Communities			Total yield (kg/ha)	Average yield (kg/ha)
		Santa Cruz	Mina Honda	La Patastera		
1	PPBY-8	1823	1686	2727	6236	2079
2	PPBY-14	1648	1629	2822	6098	2033
3	PPBY-2	1686	2008	2292	5985	1995
4	PPBY-1	1515	1610	2405	5530	1843
5	C. Rosada**	1515	1175	2386	5076	1692
6	Tío Canela***	1563	1023	1705	4290	1430

Notes: * Lines selected from F₆ trials: Mina Honda: PPBY-1; Chaguitio: PPB-2, -14; Sta Cruz: PPBY -8; ** Local Control; *** Universal Control.

Table 4.11 Farmers' evaluations of PPB varieties¹²¹

Attributes	PPBY-8 (<i>Macuzalito</i>)	PPBY-14	PPBY-2
Maturity	Moderate	Early	Late
Uniformity of maturation and colour	Uniform with attractive red colour	Uniform but a lighter red colour	Uniform but with white pods*
Disease tolerance	Medium	Medium-low*	Medium-high
Architecture	Excellent, medium height with well distributed pods	Good, low height* with well distributed pods	Good, medium height with well distributed pods
Yield	Good yield	Regular yield	Excellent yield
Commercial value	Good	Good	Poor*

Note: * Traits considered unfavourable by farmers.

Reflection on experiences

Empowerment

As mentioned above, PPB is a special case of participatory research with CIALs, and one that has greatly empowered farmers. Through PPB, farmers have not only acquired new knowledge (working with segregating materials, etc.) but they have also succeeded in creating a new variety from their own local material. This is a source of great pride as it signifies the importance of the conservation of local varieties by communities: the farmers are very aware that the successful outcome of the programme was due to their having conserved this material locally. This has provided a real impetus for the conservation of agrobiodiversity, and seed banks have been set up in six communities to continue this.

CIAL members are cognisant of the time and energy that they have invested in this process, in other words, of the opportunity cost of their labour, but they still think that it has been worth it overall. They feel they have invested in their future. Women feel particularly empowered as they have acquired new knowledge in an area formerly largely controlled by men. The recognition that CIAL members have received from other institutions has also been a powerful motivator for them, along with getting to know new people, networking, etc. Other benefits are less closely associated with PPB per se, but rather have come to them from their CIAL membership (e.g. loans, tools, and information) and from community infrastructure (e.g. meeting rooms).

Participants also mentioned difficulties encountered; the length of the process and the poor weather which caused setbacks and made the process even longer than anticipated. Some CIAL members had a hard time understanding PPB and had to be carried along by others in the group. Illiteracy was felt by some to be a real handicap that prevented people from fully grasping the process.

In a reflection on the process, three of the CIALs engaged in the project came up with the following definitions of PPB:

- “It is to improve a variety, get rid of the bad things that it has through crossing it with improved varieties and so obtain a better harvest. And it is participatory, involving the participation of men, women, technicians and organizations” (CIAL Mina Honda).
- “It is a process in which we make changes in the varieties, exchanging ideas with different actors: technicians, farmers and scientists” (CIAL Santa Cruz).
- “It is to change a variety: its appearance, its form, yield, etc. taking into account the criteria and experiences of all of the group or the community” (CIAL La Patastera).

Genetic selection and diversity

One of the side benefits of PPB has been to substantially increase genetic diversity in the participating communities. For example, in Mina Honda, the community has gone from relying almost solely on *Concha Rosada* to utilizing a number of new PPB varieties: apart from *Macuzalito*, Mina Honda residents have also adopted *Liberal* (PPBY-10), *Domínguez* (PPBY-2) and *Santa Marta* (PPBY-14) - varieties derived from the 15 lines evaluated during F₆ comparative trials that were multiplied and retained for local use. In addition, members selected a variety known as *Marvelino* from one of the early segregating materials that the breeder gave them to practice with at the very outset. One CIAL member from Mina Honda also retained a few lines from F₅ trials, took them back to her plot and together with her husband advanced these independently, eventually selecting one variety known locally as *La Esperanza*. Other earlier PPB materials discarded by the CIALs are undoubtedly present in the four participating communities and in local use. In addition, farmers have become reacquainted with a host of landraces, such as *Pedreño*, *Careto Negro and Rojo*, *Bocado*, *Carmelito* and others. Thus PPB has played an important role in highlighting the importance of conserving landraces. In these respects, PPB has contributed substantially to increased local agrobiodiversity.

Other findings and lessons

At the end of the PPB activities, a workshop was conducted in each participating community to gauge the reaction of CIAL members to the overall process. A great majority of participants said they would prefer to work with early generations (F₃) in the future, and some would prefer to carry out the crosses themselves. As people said, “in this way we learn more about how to improve seed” and “it is like raising a child and seeing it grow, knowing the part you played in it”. A few said they had invested too much time in PPB and would prefer to start at F₆; fewer still said they would prefer to restrict themselves to validating new materials.

The preference for continuing with PPB expressed by the majority of CIAL members is not surprising. In spite of the fact that advanced breeder materials have been, and continue to be, evaluated by the CIALs, they have not produced the anticipated results. While a few of the materials, e.g. *Amadeus-77*, are being used by farmers in low-lying areas, none of these materials have been adopted by farmers at higher elevations.

Institutionalisation of PPB

Macuzalito was ‘released’ in August 2004 and has since been tested and multiplied in 30 locations. Members’ associations in the national CIAL network are leading this process and results are being shared between the members. While the 2004 release took place at the municipal level, CIAL members still dream of having *Macuzalito* released at the national level once the extent of its adaptability has been assessed.

Macuzalito is being further improved by scientists at EAP-Zamorano through the inclusion of genes for resistance to Angular Leaf Spot Disease. To this end, 22 lines of *Macuzalito* have already been evaluated in Mina Honda, leading to the selection of five lines that are more resistant to the disease than the parent. These five lines were being evaluated at the time of writing. The same 22 lines are also being tested out by another CIAL in a different region of the country. Thus the improvement of *Macuzalito* is already under way, as are trials to test its adaptation in other regions. Whether PPB will be institutionalized through scaling out the farmer improved variety generated by the CIALs, or by seeking to introduce PPB into other communities where a CIAL does not exist, remains to be seen. However, given the skills involved, and the time and resources needed to support their development, it may be worthwhile to focus on the CIAL federation, rather than trying to replicate this process in communities where such skills and organizational forms are lacking.

Ownership of the PPB products

In August 2004, a special act of the Municipal Government of Yorito recognized the Yorito, Victoria and Sulaco regional CIAL Association as the rightful owners of *Macuzalito*; and prohibited commercial use of the seed. But can this be enforced? CIAL members have the advantage of knowing how to manage PPB but are generally not in a good position to profit from it commercially. They have small properties that are inadequate for commercial production. This means that others may become the beneficiaries of their investment and labour. And this is proving to be the case. Following the release of *Macuzalito*, several CIAL members involved in the PPB

process sold seed to wealthier farmers with access to irrigation. Supported by a large international NGO these farmers have multiplied *Macuzalito* in order to sell it back to the NGO for distribution. Similarly, FIPAH has purchased seed from the participating CIAs to take to other CIAs for testing in their regions. While this is certainly beneficial from the perspective of upscaling, there is little payback for CIA members other than the personal satisfaction of knowing their variety is helping other poor farmers. It is hard to imagine that such altruism will stand the test of time and it is likely that some form of monetary incentive will be required in the future.

Outlook on the future

If PPB is to endure as an alternative to conventional breeding it may be necessary to provide appropriate incentives for participants. Since there is no readily available mechanism for providing protection for varieties created by farmer breeders (and farmers do not appear interested in seeking protection), breeding contracts should be sought to subsidize the difference between the external (social) benefits from PPB and private returns accruing to farmer-breeders. NGOs which support PPB will need similar financial assistance. PPB cannot follow the pattern of so many other activities that have been introduced into communities without available funds to support them. While PPB is an exciting new activity, it does, like all research, involve costs and these will have to be factored into future planning.

4.6 Farmer field schools supporting farmer-led participatory plant breeding: some Asian experiences

Hans Smolders, Arma Bertuso and Bert Visser

To ensure increased food security, national and international plant breeding schemes have worked on the development of favourable production systems, and have been fairly successful in releasing new high-yielding varieties. However, they have also found it impossible to cater for all farming systems, crops, household preferences and market conditions existing in farming environments. Participatory Plant Breeding (PPB) programmes* can offer advantages to farming communities in many different agro-ecosystems. Their success is not limited to marginal, heterogeneous or low-input farming systems that are often characterized by limited public and private breeding services; PPB can also succeed in favourable high-production environments that are already covered by national plant breeding schemes.

* Walter de Boef and Juliana Bernardi Ogliaresi (Section 4.1) provide more details on definitions of Participatory Crop Improvement (PCI), Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB). The authors of the current section follow a different categorization, using PPB as an overall term and distinguishing between breeder- and farmer-led PPB.

In PPB, farmers participate in breeding and selection programmes to various degrees. Their participation is not limited to the evaluation of end products; more and more farmers are involved in the setting of selection criteria, evaluation of early and advanced lines, and even in the selection process itself. In contrast to formal-led approaches, where farmers participate in institutional PPB programmes, farmer-led approaches allow farmers to decide on their own crop selection criteria and breeding methodologies. Research linkages in this new and innovative PPB approach are established in a collaborative atmosphere.⁸⁴ A number of PPB programmes in Asia have conceptualized this farmer-led PPB approach for a Farmer Field School (FFS) context.

In this section, we present experiences from two regional NGO-managed PPB programmes in Asia: the Biodiversity Use and Conservation in Asia Programme (BUCAP) and the Participatory Enhancement of Diversity of Genetic Resources in Asia Programme (PEDIGREA). Carried out by various institutions and in several countries, the programmes have much in common. Both are spin-offs of the Community Biodiversity Development and Conservation Programme (CBDC), a global on-farm biodiversity programme established in 1994. They focus on rice, Asia's farmers' staple crop. Both BUCAP and PEDIGREA have adopted the FFS approach as the key pedagogical and institutional approach to technology transfer, facilitating farmers' learning, and upscaling. It should be noted that the FFS approach can cater equally well for formal-led and farmer-led approaches to PPB.

Scope of the programmes

The BUCAP programme started in 2000 and is carried out in North and Central Vietnam, Laos PDR and Bhutan. BUCAP is implemented by the Southeast Asian Regional Initiatives for Community Empowerment (SEARICE), a Philippines-based NGO, and funded by a number of international donors. The objective of BUCAP is to use PPB to strengthen on-farm management and use of plant genetic resources. The start of the BUCAP programme marked two major changes in approach. Firstly, from the outset, BUCAP involved not only farming communities, but also government research and extension institutions. The idea behind this was that support and acceptance by breeding institutions would be important to anchor PPB approaches in national development strategies. Secondly, BUCAP adopted PPB as a way not only to conserve traditional varieties, but also to utilize them to develop varieties better adapted to local production environments. The countries in BUCAP represent a diverse selection of rice cultivation environments and conditions, ranging from subsistence farming (Bhutan) to irrigated lowland production, with a strong orientation towards commercial markets (Vietnam).

The PEDIGREA programme was established in 2002 and is carried out in Indonesia, Cambodia and the Philippines. PEDIGREA aims to develop novel sustainable farmer-led approaches in PPB. There is close collaboration with research institutions and scientists to provide complementary services and guarantee maximum input. Unlike BUCAP, PEDIGREA has adopted a farming system approach, addressing diversity in a farming community by focusing not only on the staple crop, rice, but also on other crops such as vegetables, and on livestock such as goats and

pigs. PEDIGREA activities are carried out in farming communities with intensive rice production, characterized by cultivation of large acreages of modern varieties and a low degree of diversity, yet with limited cultivation of some highly appreciated traditional varieties. Apart from rice, its main focus is on local indigenous vegetables, often the main source of farmers' income and a source of enrichment of the community's diet. National breeding programmes for these marginal crops are either lacking or are considered very weak. The uniqueness of PEDIGREA is that market research has been integrated into PPB.

PEDIGREA is carried out in partnership between three local NGOs that coordinate the respective country programmes: Farmers' Initiatives for Ecological Livelihoods and Democracy (FIELD) in Indonesia, SRER KHMER ('Field of Cambodia') in Cambodia, and People, Plants Research and Development Inc. (PPRDI) in the Philippines. Backstopping is provided by three partners: the Centre for Genetic Resources, the Netherlands, the Agricultural Economics Research Institute of Wageningen University and Research Centre, and Bioversity International, Asia and Pacific Office in Malaysia. The overall management lies with the PEDIGREA foundation based in Manila, the Philippines.

The Farmer Field School framework

The common ground between BUCAP and PEDIGREA is that both have adopted the FFS concept as the key approach. The FFS provides farmers with a structured way of learning, problem solving and decision making; it facilitates structured co-operation between research/extension and farmers. Pioneered in the 1980s by the FAO in Indonesia, the FFS approach was embraced by state and local governments in Asia as an effective tool for agricultural extension on integrated pest management (IPM). In developing the curriculum for PPB, both programmes benefited from this history, as the concept was well known among NGOs, government and rural communities. PPB could be built within FFS with experienced local trainers.

In an FFS, farmers get together in weekly or bi-weekly meetings for the duration of one full cropping season to study particular topics in the curriculum. Basic topics in the curriculum on PPB include understanding genetic diversity and crop improvement, baseline assessments, participatory variety selection, and variety rehabilitation. When possible, crop hybridization and selection in segregating populations are included. After the first season, small groups of interested farmers are formed who continue with variety selection and breeding per crop under the guidance of an experienced farmer, extensionist or NGO trainer. In PEDIGREA, a sequential approach is used, targeting the same farming community. In the first season, an FFS on rice is conducted, usually followed by an FFS on vegetables in the next season, and where possible with an FFS on vegetable marketing or working with farm animals.

Field guides on PPB implementation in FFS have been published by BUCAP¹²² and PEDIGREA.¹²³ The latter also included an FFS curriculum on PPB for vegetables. Simultaneously, PEDIGREA published a booklet with framework information on the development of FFS programmes in participatory plant breeding, including the concepts underlying FFS, preparatory activities, FFS implementation, and guidelines on how to upscale and monitor.¹²⁴

In the six countries, farming communities responded enthusiastically. The involvement of national research and extension institutes varies among the countries and regions. The BUCAP projects are relatively well structured while the PEDIGREA projects operate more informally. We will present a selection of cases of the activities with relevance to rice and vegetables.

Case studies on participatory plant breeding in rice and vegetables

BUCAP country experiences in breeding rice¹²⁵

Agriculture in Bhutan is characterized by subsistence farming. In Bhutan, BUCAP is coordinated by the National Biodiversity Centre of the Ministry of Agriculture, responsible for *ex situ* conservation and policy formulation, in partnership with the agricultural research institutions and the agricultural extension agencies. The FFS approach was introduced by BUCAP in this country in 2002; it involved farmers directly in participatory varietal selection (PVS), and focused on the selection of rice blast resistant varieties. This focus was inserted into the PVS activities following a severe outbreak of rice blast at high altitude (1800-2700m) production environments in 1995. The materials used were crosses between local and improved varieties made by researchers in the research centre. Parents were selected on the basis of the farmers' feedback. The early generation materials were evaluated on-station by researchers and farmers on the basis of the plant type, maturity, and disease resistance. After a number of generations, fairly uniform and disease-free lines were bulked. From F₅ onwards, promising lines were selected and included in the PVS trials in farmers' fields, facilitated by a host farmer, together with other variety introductions and local checks. Assessment of the materials was performed using ranking tools, including matrix ranking, based on preferred criteria such as yield, kernel colour (red), disease resistance, maturity, taste, height, easiness of threshing, grain type, and straw yield. However, a majority of farmers considered yield and yield stability as the main criteria. The collaborative programme works with farming communities in different valleys of Bhutan. The programme has thus far succeeded in increasing the diversity of blast resistant varieties in farmers' fields, and has released two improved local blast resistant rice varieties, namely *Yusirep Maap* and *Yusireay Kaap*.

In Laos PDR, BUCAP is coordinated by the Plant Protection Centre of the Ministry of Agriculture and Forestry. It is carried out in four provinces and involves a number of partners, including provincial secondary schools, agricultural extension, and for backup technical support and material, the Nappok Agricultural Research Centre. This research centre is responsible for rice breeding in the country. It has supplied the provincial BUCAP programmes with modern and traditional varieties for PVS, and breeding populations in the F₃-F₆ generations for further selection in farmers' fields within an FFS context. The impact of BUCAP in Laos PDR is uneven. Progress is notably hampered by regular adverse weather conditions and by low farmer participation in the FFS. Participation by women is especially limited. Nevertheless, farmers evidently have improved their skills through BUCAP and the programme has strengthened varietal diffusion and contributed to an increased awareness of genetic diversity among farmers.

The BUCAP Vietnam Programme is an example of an extended farmer-led PPB approach, characterized by collaboration with formal institutions. Between 2000 and 2002, PPB projects were started in five provinces. Its successes led to the programme being expanded to include five other provinces. The programme is being implemented in a wide range of environments, including both rain-fed and irrigated rice production systems. As in Laos, Indonesia, Cambodia and the Philippines, the BUCAP programme in Vietnam is linked to the extensive and successful FFS-IPM efforts in rice. The high level of organization of farmers in communes and their familiarity with FFS were important contributing factors facilitating the success of the programme in Vietnam. In addition, both state and local government gave key support to FFS activities and local seed multiplication. For example, the government exempted farmers from land taxes if they were engaged in seed production, and compensated farmers who used land for BUCAP experiments.

Varieties and segregating materials supplied to farmers for PVS and PPB originate from various breeding institutions. FFS activities included PVS, variety rehabilitation, PPB and seed multiplication. Farmers themselves also made many crosses between local and high yielding varieties, with the objective of increasing yield while retaining local adaptedness and preferred culinary traits. Government plant breeders provided advice on breeding methods and training in crossing, but the farmers maintained a high level of autonomy through their communes. Until now, hundreds of FFS have been organized in villages. Remarkable results were obtained in rehabilitating local varieties through mass selection, and yield increases of more than 20% have been reported. In the Northern Hoa Bin province alone, the BUCAP programme has contributed to the restoration (purification) and seed multiplication of 17 traditional varieties, and the selection of 8 stable lines from farmers' and breeders' crosses. Early successes include the varieties *MD1*, *MD2* (originating from Mo Da Village) and *TX1*, *TX2* (from Tam Xuam village), which are now being multiplied and planted by farmers in the region.¹²⁶

*PEDIGREA country experiences in breeding rice*¹²⁷

The PEDIGREA country projects are entirely farmer-led. The programme is designed such that farmers, and not researchers or NGOs, are responsible for the decisions on breeding objectives and approaches. Experienced farmer-breeders cum trainers coordinate FFS programmes through local farmer forums. By 2005, some 30 farming communities in the PEDIGREA countries were participating in rice FFS, involving 1437 farmers, both men and women. Good collaboration has been established with local authorities, providing support to FFS, and allowing extension staff to participate in the FFS as trainers. The projects are supervised by the local partner NGOs, who support the FFS activities through liaison and lobbying with national and local authorities and research institutes, and internationally with other PEDIGREA partners. NGOs and partners, including government rice breeders, provide backstopping in terms of curriculum development, participation in Training of Trainers workshops and in regional seminars.

As in BUCAP, the FFS on rice involves setting of breeding objectives through participatory baseline surveys, PVS, variety rehabilitation, parental crosses, and

selection within segregating material. Initial breeding materials for the FFS included early and advanced lines, supplied by government rice research stations. Most material was taken from surplus stock of the institutions' breeding programmes. Farmers report that selection within these materials is promising but not very effective. In the Philippines, restrictions on diffusion of farmer selected varieties apply as the rice research institute uses a material transfer agreement to claim breeder's rights of farmer-made selections from their materials. Farmers currently produce most of their crosses themselves, using improved and traditional varieties as well as promising advanced lines in their crosses.

Bottlenecks encountered in the selection programmes are land scarcity, storage facilities for seed selections, and the relatively small size of the breeding populations. Interestingly, there are few problems with sustaining the interest of farmers for the duration of the breeding cycle. Habits of sharing of tasks and land in the community breeding programmes gradually develop, enabling farmers to deal with the above-mentioned problems. Three categories of farmers can be generally identified within the participating communities. A few individual farmers who are skilled breeders and run their own rice breeding programmes, select parents and perform crosses. A second category of farmers grow out and evaluate segregating selections, supported by the farmers in the first category. The third category of farmers is not actively engaged but interested in further testing and growing the products of farmer-led PPB. This would appear to provide some evidence that a few skilled farmer-breeders can be sufficient to support others and serve as a source of farmer-bred material for the rest of the community and neighbouring areas, thus sustaining the farmer-led PPB programme in the longer term.

PEDIGREA has proven to be a genuinely low-cost effort. Small allowances have been provided to national researchers, farmer-trainers and extension staff participating in the Trainings of Trainers workshops. Major costs are covered by the farmers themselves. In some cases, small grants and land were provided free of charge by the municipality. Support from local governments was often instrumental in public relations (e.g. advertising).

Until 2005, farmers have made over 200 crosses in rice. In the Philippines, crosses were made primarily with tungro virus-resistant rice varieties and in Indonesia with brown plant hopper (BPH)-resistant lines. Farmers used modified pedigree selection as the main selection method, involving mass selection during the F₂-F₄ followed by ear-to-row selection in the F₅ for selection on yield and taste. Results are promising. In the three countries, farmers have thus far evaluated 218 varieties through PVS, and are currently managing 26 promising advanced lines in the framework of PPB. In the Philippines, one high-yielding, good-tasting farmer-bred variety (*Pagasa 97*) and one with tungro virus resistance (*Jemar 6*) are being tested on a larger scale by farmers in the municipality.

PEDIGREA: methodologies in breeding local vegetables

The PPB programmes on local vegetables in PEDIGREA take a different approach to the rice programmes, focusing on two or three crops simultaneously and linking PPB with the local markets by integrating market research into the FFS programme. Since

the start in 2003, cucurbits comprised the major share in Indonesia and Cambodia. Other crops included are wax gourd and pumpkin in Cambodia, pumpkin, loofah and bitter melon in Indonesia, and eggplant, pumpkin and yard-long bean in the Philippines. Farmers are directly engaged in comparing varieties through PVS, using trials of between 5-15 varieties with a single replicated design. Varieties tested had been collected by the farmers from neighbouring villages, distant markets, districts and provinces, and included exotic varieties introduced by the PEDIGREA team. Useful starting materials were provided by vegetable breeding programmes in the region. By 2005, a total of 125 varieties of these vegetables had been evaluated.

Once the FFS programme continued, farmers learned to perform crosses. They showed great enthusiasm, which quickly resulted in a large number of crosses being made. They focused particularly on cucurbit crops, which are relatively easy to hybridize because of their monocious flowering habit. Between 2003 and 2005, farmers made a total of 134 crosses and managed to produce 6 advanced lines of vegetables. After storage, seeds were replanted in relatively small plots of maximum 200 plants. Farmers used mass selection methods or a modified version of mass selection, involving extensive manual crossings of selected siblings in the early generations to avoid unwanted offspring. Farmers also started to experiment with back-crosses. During the baseline survey, selection criteria were set; farmers observed the materials in the field, and analysed them using matrix or other ranking tools comparing the varieties for agronomic characteristics, taste, texture, appearance, cooking and storage quality.

Market studies were undertaken with farmers and traders in nearby city markets to identify consumer preferences.¹²⁸ Such market studies received considerable interest from farmers as they could better understand the market mechanism, and identify niche markets for non-mainstream vegetable products. Results were fed back into the PPB programme, which in Indonesia led to the start of a cross breeding programme involving a smaller type of bitter melon. In Cambodia, crosses involved local slender wax gourd types and introduced round types; the latter showed high tolerance to wet production conditions. To date, the vegetable PPB programme remains a pilot programme that is closely monitored by PEDIGREA partners.

Reflection and outlook on the future

From the BUCAP and PEDIGREA experiences in Asia, two immediate lessons can be learned. Firstly, PPB has an empowering effect on farmers, which motivates them to continue with development, selection and breeding activities. An important aspect of farmer empowerment through PPB and FFS training is that it tends to change the relationship between research and extension services, changing farmers from recipients of top-down knowledge to participants in a more equal partnership. A number of plant breeders have clearly had difficulty in accepting the rather distinct concepts and objectives of the proposed farmer-based PPB, in which breeders play only a supporting role and seem to receive little identifiable credit. Whereas in BUCAP this problem has been addressed from the start by a collaborative structure, PEDIGREA has chosen to strengthen and empower farmer communities first, in order to ensure farmer-led PPB approaches from the start. In most cases, closer

interactions between breeders and farmers proved rewarding for both; farmers got access to germplasm and were trained in selection techniques, and breeders found additional testing grounds for their breeding materials.

Secondly, the FFS concept has proven to be an effective institutional approach for addressing the needs of the farmers, while at the same time facilitating the process of upscaling. The structured approach of FFS and the familiarity of local governments and research institutes with the concept has allowed for early adoption into government programmes in Bhutan, Laos PDR and Vietnam. In turn, this facilitates upscaling and addressing policy related issues, as well as acceptance of farmer-led PPB and farmers' varieties by the formal sector, a process which has to be followed up and still has to be addressed in the PEDIGREA projects in Indonesia, Cambodia and the Philippines. The slightly different approaches taken by BUCAP and PEDIGREA respectively have resulted in dissimilar and complementary lessons.

Postscript

After training events in Mali (2003) and Sierra Leone (2005) in the context of the Community Biodiversity Development and Conservation Programme and FAO, a PEDIGREA-like FFS programme was started in Ethiopia in 2007 under the name PEDIGREAF, in which the AF stands for Africa. This FFS-based farmer-led PPB programme is the initiative of the local NGO Ethio-Organic Seed Action Project (EOSA) and the Centre for Genetic Resources, the Netherlands.

