New Directions in Participatory Plant Breeding for Eco-Efficient Agriculture

Farmers across the globe are facing unprecedented changes in their environment. Climate change is affecting the natural environment in often catastrophic and unpredictable ways. The global economic 'bubble' that provided cheap credit to many people has burst. The individual and combined effects of these two events are driving the poor into even greater poverty. Resource-poor farmers need strategies to be able to adapt to the changing conditions, over and above their ongoing efforts to raise themselves to a higher state of well-being—out of poverty.

As the effects of climate change are increasingly felt world-wide—especially in the humid and semi-arid tropics, 'dry areas' and other regions with 'extreme' climates—there is an increasing need for crop breeding and variety development to become more adapted to changing weather events while making production more efficient. In this case, 'efficiency' is not measured simply as the ability to churn out new varieties of staple crops, but for the work to be responsive to farmers' (rapidly) changing needs and in specific circumstances. To this end, the Program on Participatory Research and Gender Analysis (PRGA Program) is experimenting with, promoting, and advocating new directions in participatory plant breeding (PPB) to equip both small-scale farmers and researchers for the challenges ahead.

Evolutionary-participatory plant breeding

With funding from the PRGA Program, the barley and durum wheat breeding programs of the International Center for Agricultural Research in the Dry Areas (ICARDA) are developing a dynamic and inexpensive strategy to provide (often women) small-scale farmers in 'marginal' areas with genetic resources to address their farming constraints both today and into the future. The research involves combining four elements:

- diverse and locally adapted genetic resources (landraces);
- farmers' knowledge and participation;
- integration of plant breeding and crop management (agronomy, soil management, disease and pest management); and
- respect of farmers' rights.

The overall goal is to increase farmers' resilience to current and future climate change.

A major underlying premise of the work is that seeds removed from the field and kept in a gene bank are also effectively frozen in their evolution. If these seeds were to be brought out of storage in, say, a hundred years, they might well not be adapted to the prevailing climate and atmospheric conditions (e.g., increased carbon dioxide level). However, if plant populations that contain a high level of genetic diversity are left to grow year-on-year in the field, they will 'adapt' to the changing conditions—in particular, increased temperatures and increased carbon dioxide levels.

Plant populations containing high levels of genetic diversity can be composed in a number of ways. In terms of gene bank and existing varieties and breeding materials, breeders are identifying plants with traits that are not only required now, but are also expected to be increasingly required in the future (e.g., adaptation to high temperature, drought tolerance,

short growth cycle). In one option, breeders use the identified lines as parents in crosses to generate wide variability. Farmers have been given large populations of such highly variable material (e.g., second-generation, F_2, progenies of barley). In a second option, farmers are given access to both lines and data about their characteristics. In this case, the farmers select lines that the breeders then multiply to provide sufficient seed to start the evolutionary breeding population. A third type of population can be generated by mixing landraces. Yet another option is to combine any (or all) of these three sources of diversity. Evolutionary breeding populations are grown in bulk by the farmers (i.e., in the target environment), and so will continue to evolve under the prevailing (and changing) weather conditions. There is evidence that outcrossing rates lower than 5% are adequate to supply the variability required for natural selection of adaptation to stressed environments (Morran et al., 2009). Outcrossing rates of 7% have been reported for barley (Marshall and Allard, 1970; Allard et al., 1972; Abdel-Ghani et al., 2004) and 3.5% for wheat (Lawrie et al., 2006). (Of course, F_2 progenies are themselves still heterozygous.)

Productivity gains from such an evolutionary plant breeding method were demonstrated, in barley, over 50 years ago (Suneson, 1956). Now that we are aware of rapid human-induced climate change, the (potential) value of this technique has been re-recognized.

While the bulk plant population is evolving under natural conditions, farmers are encouraged to select those plants most suited to their current ecological and farm management situations. These can then be tested and promoted through a typical PPB system. One of the advantages of the evolutionary-participatory plant breeding system is that a number of farmers can make their own selections from the population each year—a bonus when men and women are looking for different traits in their rice varieties.

Meanwhile, the researchers are documenting farmers' (indigenous) knowledge about the germplasm for posterity (future use). Researchers will also help farmers establish their own seed production systems for the varieties they select, and empower them with an understanding of intellectual property rights with respect to plant material.

Gender-sensitive PPB

Although farmer participation has become 'the norm' for many crop breeding programs, not all of these programs have included a gender-sensitive perspective in the ongoing research work. In particular, in cultures where men play a dominant role in society, men have tended to dominate PPB programs, even where women are heavily involved in crop production. By not involving women in PPB, we are missing a significant proportion of the farming population, as research elsewhere clearly demonstrates that men and women have different priorities in their farming and crop variety choices, regarding selection and specific preferences. The importance of including women farmers in participatory varietal selection (PVS, one of the precursors of full PPB) was highlighted as early as the late 1990s by the Africa Rice Center (e.g., WARDA, 1999), among others.

PPB and gender

Conventional plant breeding has been more useful to large and rich farmers than to marginalized and poor farmers. Women have been largely neglected by conventional plant breeding. Participatory plant breeding brings the benefits of plant breeding to all farmers regardless of gender, wealth, status, literacy, etc., through an innovative way of organizing agricultural research in which farmers and scientists fully share the decisions concerning the development of new varieties.

It is important for PPB work to include a gender dimension, since both men and women share the agricultural work. In participatory research (which is by definition inclusive), women should have the priority, because (a) they often have a deep knowledge of production processes; (b) they have a specific interest in food security; and (c) in developing countries they are the poorest of the poor with least access to education and communication.

In the majority of countries where PPB is conducted, women are already active participants: in Jordan, where Christian and Muslim women come together to do selection in the field, particularly in the south (villages of Rabba, Ghweer and Mohay); in Eritrea; in Ethiopia; in Yemen; in Syria, where—in the southern village of Laheta—Druses women have now developed their own selections and manage their own trials; and in Iran, where in Garmsar village (80 km east of Tehran) women not only participate in the selection, but also in data collection and data computerization for statistical analysis.

Salvatore Ceccerelli, Barley Breeding Consultant, ICARDA

This work is supported by PRGA through a series of small research grants. A little funding goes a long way when there is a strong focus and a decision to allocate the resources for the betterment of the community, such as the enhancement of food security, adaptation of landraces to climate change, besides other immediate needs farmers can control.

In 2007–2009, ICARDA ran a program (with PRGA Program funding) to include women in PPB for the first time in Syria (which has a 10-year history of PPB work). The first-hand involvement of six women farmers in PPB was considered a major achievement in a mostly male-dominated agricultural practice, although a far cry from gender-equal participation. The experimental approach highlighted a number of factors that support women's involvement in PPB, including the following:

- Having a female facilitator on the research team.
- Holding meetings for women only (to overcome the cultural barrier of women not speaking in the presence of men).
- Collaboration with other women's networks and organizations.
- Enabling (especially younger) women farmers to participate in workshops and conferences, by providing a (female) companion to go with them.
- Organizing events (e.g., a conference) specifically open to women farmers, to enable wider sharing of experiences beyond the participants' own communities.

In addition to improving their farming through better crop varieties, women-focused PPB empowers women by boosting their self-confidence: they appreciate their own role as farmers, have knowledge and understanding of methods and technologies that can help improve their well-being, and

they are not reliant on their menfolk to filter such information for them. This is particularly important for women who are the heads of their households.

Elsewhere, the PRGA Program is working with the International Food Policy Research Institute (IFPRI) and the Confederación Colombiana del Algodón (CONALGODON) to determine women's role in the choice of cotton varieties —in this case, genetically modified (Bt) or normal—either individually or as members of regional cotton associations. It is important to note that, until recently, cotton associations effectively controlled access to Bt cotton, giving little or no participation to individual farmers or farmer-led associations. Furthermore, this research is exploring the effects (if any) of adoption of Bt cotton on gender-based activities (on- and off-farm), and men's and women's—differing?—attitudes to Bt cotton and what factors influence their decision to adopt it.

When might the sexes agree?

It has been well documented that men's and women's preferences for varieties tend to differ in many contexts, and plant breeding programs have therefore been encouraged to be gender-sensitive. However, researchers of the Pan-Africa Bean Research Alliance (PABRA)—a joint program between the International Center for Tropical Agriculture (CIAT), the Eastern and Central Africa Bean Research Network (ECABREN), and the Southern Africa Bean Research Network (SABRN)—think there will be situations where men's and women's variety preferences will be the same. In fact, it is probably long overdue that breeding programs understand when there may (or may not) be gender-differentiated preferences among the farmers they serve. With funding from a PRGA Program small grant, PABRA is looking at three scenarios—farmers in stress-dominated environments (drought and crop-failure prone, few market opportunities) who grow beans primarily for home consumption; farmers at the other end of the spectrum, with good production potential and good access to markets; and farmers in stressed environments, but where there is market demand for their crops (so part of the production will be marketed). The hypothesis is that variety preferences will converge in the two 'extreme' scenarios, while those in the 'intermediate' scenario will diverge. The results of this modest work should help shape PPB actions on the ground. The work is being conducted in three areas—central Kenya, eastern Rwanda–northern Burundi, and Malawi—and is a 'test case' for whether variety-preference convergence can be predicted.

References

Abdel-Ghani, A.H.; Parzies, H.K.; Omary, A.; Geiger, H.H. 2004. Estimating the outcrossing rate of barley landraces and wild barley populations collected from ecologically different regions of Jordan. Theoretical and Applied Genetics 109:588-595.

Allard, R.W.; Babbel, G.R.; Clegg, M.T.; Kahler, A.L. 1972. Evidence for coadaptation in *Avena barbata*. Proceedings of the National Academy of Sciences of the United States of America 69(10):3043-3048.

Lawrie, R.G.; Matus-Cádiz, M.A.; Hucl, P. 2006. Estimating out-crossing rates in spring wheat cultivars using the contact method. Crop Science 46:247-249.

Marshall, D.R.; Allard, R.W. 1970. Maintenance of isozyme polymorphisms in natural populations of *Avena barbata*. Genetics 66(2):393-399.

Morran, L.T.; Parmenter, M.D.; Phillips, P.C. 2009. Mutation load and rapid adaptation favour outcrossing over self-fertilization. (Letter) Nature 462:350-352.

Suneson, C.A. 1956. An evolutionary plant breeding method. Agronomy Journal 48:188-191.

WARDA (West Africa Rice Development Association). 1999. Participatory varietal selection: The spark that lit a flame. Bouaké, Côte d'Ivoire. 32 p.

Contact:

Patricia Biermayr-Jenzano, Ph.D.
PRGA Program Coordinator
p.biermayr@cgiar.org
www.prgaprogram.org

PRGA