An Example of Participatory Plant Breeding: Barley at ICARDA

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Abstract

The paper describes a model of participatory plant breeding in which genetic variability is generated by professional breeders, selection is conducted jointly by breeders, extension specialists and farmers in a number of target environments, and the best selections are used by breeders in further cycles of recombination. Farmers handle the first phases of seed multiplication of promising breeding material in village based seed production systems. The model has the following advantages: varieties reach the release phase earlier than in conventional breeding, the release and seed multiplication concentrate on varieties known to be acceptable by farmers, increases biodiversity because different varieties are selected in different locations, fits varieties to the agronomic management that farmers are familiar with and can afford and therefore can be beneficial to poor farmers. These advantages are particularly relevant to developing countries where large investments in plant breeding have not resulted in production increases, especially in marginal environments.

Introduction

Adoption rate of improved varieties in marginal environments is lower than in higher-producing zones. While the reasons for these lower adoption rates are many (e.g. non adapted varieties, seed supply) we believe the principal cause is related to risk. Resource poor farmers in marginal environments have few options in crop production, and therefore the adoption of new technologies is perceived by farmers as risky. This is likely to be the causal factor in farmer preference in continuing to grow unimproved, but well known, varieties.

Participation of farmers in the very initial stages of breeding, when the large genetic variability created by the breeders is virtually untapped, offers farmers the possibility to familiarize with new options without exposing the household to any risk. Participatory plant breeding also exploits the potential gains of breeding for specific adaptation through decentralized selection, defined as selection in the target environment, and is the ultimate conceptual consequence of a positive interpretation of genotype x environment interactions (Ceccarelli, 1996).

The gradual change to decentralized-participatory barley breeding was implemented in Syria between 1997 and 2003 in three phases, and the model and concepts developed during its implementation were gradually applied in Tunisia, Morocco, Eritrea, Yemen, Jordan and Egypt.

Exploratory phase

The first phase was mostly exploratory, the main objectives being to build human relationships (building the team), understanding farmers' preferences, measuring farmers' selection efficiency, developing scoring methodology, and enhancing farmers' skills. The exploratory work included the selection of farmers and sites, and the establishment of one experiment common to all participants. The experiment, described in detail by Ceccarelli et al. (2000, 2003), included 208 plots and was grown in two research stations and nine villages. All possible combinations of selection were conducted, namely centralized-non participatory (breeders on station), centralized-participatory (farmers on station), decentralized non-participatory (breeders on farm) and decentralized-participatory (farmers on farm). The results indicated that (1) farmers were able to handle large populations of entries, to take a number of observations during the cropping season, and to develop their own scoring methods, (2) farmers select for specific adaptation, (3) for some broad attributes, such as modern germplasm versus landraces, selection is mostly driven by

environmental effects, (4) there is more diversity among farmers' selections in their own fields than among farmers' selections on research stations, and among breeder's selections, irrespective of where the selection was conducted, (5) the selection criteria used by the farmers were often similar to those used by the breeder, and (6) in their own fields, farmers were slightly more efficient than the breeder in identifying the highest yielding entries. Breeders were more efficient than the farmers in selecting in the research station in a high rainfall area, but less efficient than the farmers in research stations located in a low rainfall area. Therefore, the first phase indicated that there is much to gain in implementing a decentralized, participatory, plant breeding program.

Fine tuning the model and the methodologies

The second step was mostly about methodologies and consisted in the implementation of the breeding plan, in the choice and testing of appropriate experimental designs and statistical analysis, in the refinement of farmers' selection methodology refined, and eventually in initiating village-based seed production activities.

From a breeding point of view, the major features of the second phase were (1) a different role of the two research stations (one was not used in the new phase, while the second, located in an area with more reliable rainfall, was only used for seed multiplication), (2) the increase in the number of farmers directly involved in the project, and (3) the initiation of village-based seed production. The details of the second phase, such as number of lines, plot size, type of germplasm, selection criteria, and seed production issues, were discussed in meetings with farmers held in villages. The host farmers and a number of neighbors (from 4 to 12) attended these meetings organized by the host farmers. The model of plant breeding in Syria is a bulk-pedigree system, in which crosses are done on station, where also the F_1 and the F_2 are grown, while in the farmers' fields the bulks are yield-tested over a period of three years (Fig. 1) starting from the F_3. The F_3 bulks are yield tested in trials called Farmers Initial Trials (FIT), which are unreplicated trials with 170 entries and 30 check plots (with one or two check cultivars) in plots of 12 m^2.

In parallel, on station, we collect heads on the F_3 bulks selected by the farmers. The F_4 head rows are promoted to the F_5 screening nursery only if farmers select the corresponding F_4 bulks. The process is repeated in the F_5 and the resulting families, after one generation of increase, return as F_7 in the yield-testing phase. Therefore when the model is fully implemented, the breeding material, which is yield tested, includes new bulks as well as pure lines extracted from the best bulks of the previous cycle.

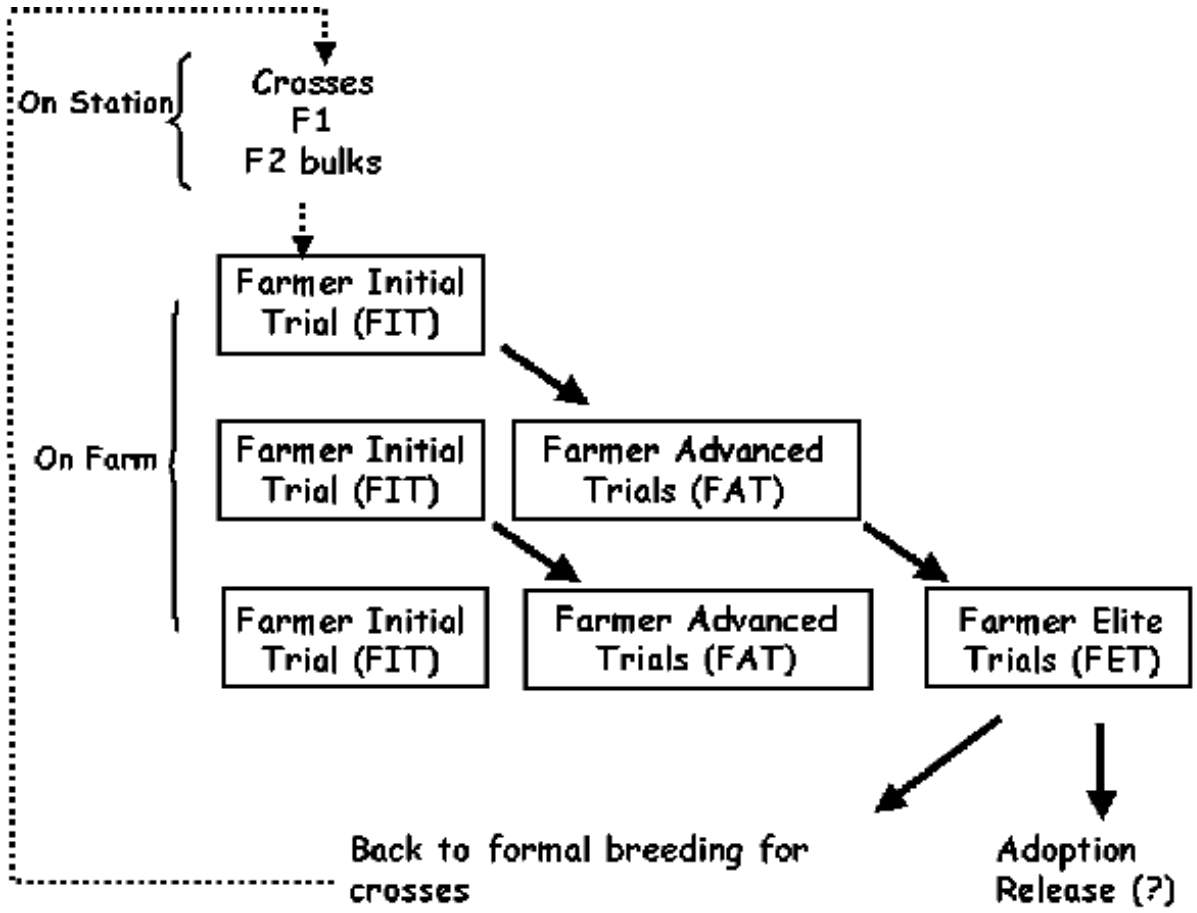

Fig. 1. Schematic representation of decentralized participatory barley breeding, as implemented in Syria

The breeding materials selected from the FIT are yield tested for a second year in the Farmer Advanced Trials (FAT) which are replicated trials grown by 4 to 8 farmers in each village. While within a village the FAT contain the same entries, the type and the number of entries and checks varies from village to village. The plot size in the FAT is 36 m^2 and is meant to produce enough seed to plant the selected entries on larger plots in the third stage. The number of FAT in each village depends on how many farmers are willing to grow this type of trial. Each farmer decides the rotation, the seed rate, the soil type, the amount and the time of application of fertilizer. Therefore, the FAT are planted in a variety of conditions and managements. During selection farmers exchange information about the agronomic management of the trials, and rely greatly on this information before deciding which lines to select. Therefore, one of the advantages of the program is that the lines start to be characterized for their responses to environmental or agronomic factors at an early stage of the selection process.

The entries selected from the FAT are yield tested for a third year in the Farmer Elite Trials (FET), which are replicated trials with plot size of 144 m^2 grown by 4 to 8 farmers in each village. These entries are also used on station as parents in the crossing program. The three types of trials are planted by scientists using plot drills but are entirely managed by farmers.

During selection some farmers are assisted by a researcher to record both quantitative and qualitative data. Some farmers practice the selection at various stages but the majority do selection when the crop is close to full maturity, and using a scoring method from 0 = discarded to 4 = the most desirable.

In each trial, the scientists record the following data: plant height, spike length, grain yield, total biomass and straw yield, harvest index, and 1000 kernel weight. On station scientists record days to heading and days to maturity. The data are subjected to spatial analysis of un-replicated or replicated trials (Singh et al. 2003). The Best Lineal Unbiased Predictors (BLUPs) obtained from the GENSTAT programs are then used to analyze Genotype x Environment Interactions using the GGEbiplot software (Yan et al. 2000).

One farmer's concern was the seed multiplication of the selected lines. In particular farmers requested a full control of this operation to avoid mechanical mixtures. To respond to this concern, we established, in four of the eight villages, small seed units which clean and treat the seed with fungicides against seed-born diseases. The unit has a limited capacity (about 400 kg/h) but allows farmers full control of the seed quality of their selections in the various stages of the breeding program. This is the first step towards the creation of village-based seed production activities.

Institutionalization and scaling up

We soon recognized that the work described above, being conducted by the farmers and ICARDA scientists, even with only occasional participation of researchers of the Ministry of Agriculture, and staff from the Extension Service, will not be able to reach a large number of villages and farmers and hence have an impact at national level. Therefore, in the third phase the emphasis was on institutionalization of participatory plant breeding and scaling up.

The first step in this direction was the organization of a workshop, with the participation of the farmers from the villages where the PPB program has been implemented, a large number of researchers, including heads of research stations of Agricultural Offices from most provinces, research policy-makers, the seed organization, extension service and the Minister of Agriculture. The workshop was a useful forum to discuss the relationships between PPB, seed production, and variety release, and to start planning for scaling-up participatory barley improvement with the objective of having an impact on barley production at the national level.

The mechanism agreed upon for scaling-up PPB was a gradual transfer of responsibilities from ICARDA scientists to local scientists and staff of the Extension Service so that at the end of the process each province will implement all the various PPB activities within its boundaries, with the overall coordination shared between ICARDA and the Ministry of Agriculture. Therefore one important component of the initial steps of scaling-up was an extensive training program of the researchers and extension staff on all the aspects of PPB.

As a result of the workshop the PPB program was extended to seven provinces and to 25 villages making 27 research sites because in two villages the trials are planted under different managements (Fig. 2). The research and extension staff in each province will work with the farmers of between five and seven villages and between 15 and 30 farmers per village. Such a large network of farmers will greatly enhance the access of non-participating farmers to the products of PPB, and therefore to large scale adoption. For this to be possible, village-based seed production will play a key role.

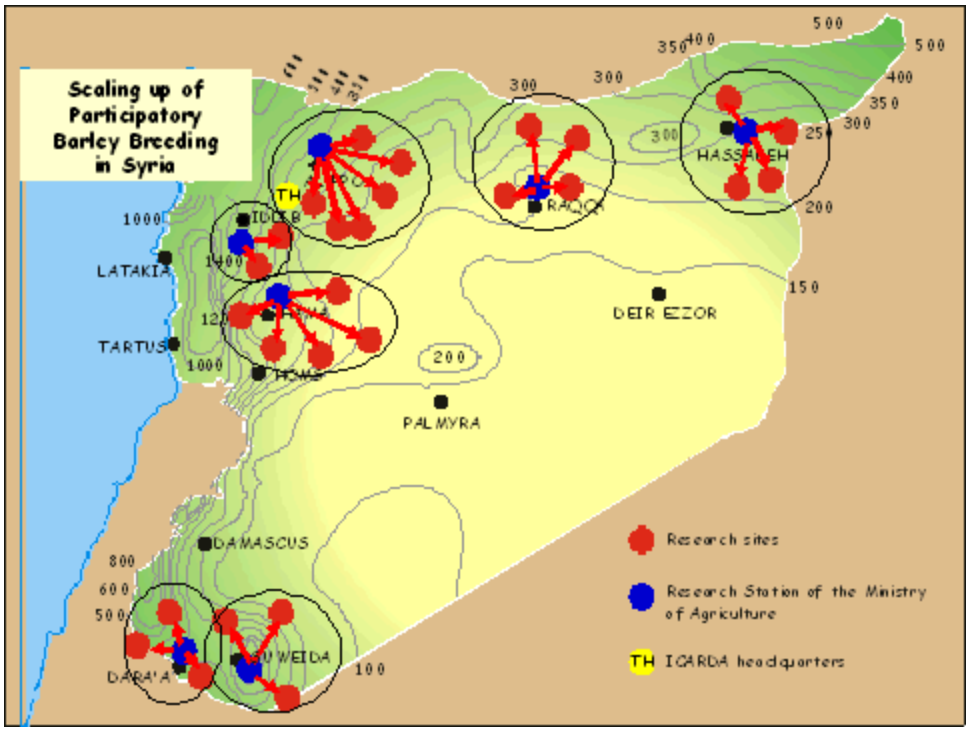

Fig. 2. Participatory barley breeding in Syria (7 provinces, 27 research sites in 25 villages)

Zanbaka, a variety that about 10 years ago went through the conventional system and was rejected from being released, offers one of the best examples of the success of the PPB project. When it entered the PPB program it began to be slowly adopted, until the drought in year 2000 forced the farmers to use all the available seed to feed their sheep. We then distributed 5 t of seed, which were planted on about 50 ha. Within two years the variety has reached 3500 ha in an area receiving 150-250 mm rainfall and where conventional breeding never had any impact. Similar initial successes have been observed in Egypt where new barley varieties out yielding the local by between 30% and over 100% are multiplied in four villages; in Jordan where the first two varieties derived from a PPB program will be proposed for released in 2004, four years after the program started; in Yemen where two varieties of barley and two of lentil have been adopted by farmers.

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