

# Decentralized Participatory Plant Breeding: A Case from Syria



Conventional modern plant breeding has been recognized to be more beneficial to farmers in high potential environments or those who could profitably modify their environment to suit new cultivars, than to the poorest farmers who could not afford to make the necessary modifications. As a consequence, low yields, crop failures, malnutrition and poverty affect a large proportion of humanity.

The reason for the relative low degree of success of plant breeding in marginal environments has to be largely attributed to the widespread use of research stations for the selection, and often for the testing work (centralized non-participatory breeding). Therefore, several cycles of selection, during which the breeder decides what to select and what to discard, are conducted in a relatively uniform environment and controlled condition. This has little in common with the target environments characterized by heterogeneous conditions and complex interplay of factors. Centralized breeding becomes “participatory” when, for example, farmers are invited to the research station(s) to express their opinion about the breeding material.

Several data indicate that when the differences between selection environment and target environment are large, genotype x environment (GXE) interaction effects are generated. Thus, the lines performing well in the selection environment perform poorly in the target environment, and vice versa (Ceccarelli, 1989). Apparently, an obvious solution to this problem is to conduct selection in the target environment, a strategy defined as decentralized breeding (Ceccarelli *et al.*, 1994, 1996).

### Steps in an International Breeding Program

Produce early segregating populations from crosses targeted to specific environments



Send them to National Agricultural Research System (NARS)



Allow national program scientists to select both between and within populations

The best selections are eventually used in further cycles of recombination and selection. At the national level, selection and testing are conducted by breeders directly in a number of target environments (decentralized non-participatory breeding). According to Cooper (1999), target environments are identified on the basis of repeatable genotype x location interactions (i.e., two locations represent two different target environments when they consistently discriminate differently among breeding lines over time). By contrast, locations which cause unpredictable and not repeatable genotype x location interactions are considered to belong to the same target environment.

Decentralized breeding does not necessarily respond to the needs of the farmers for two reasons:

- ❑ International breeding programs are often merely involved in the transfer of selection from one research station to another.
- ❑ In national breeding programs, the definition of the target environment does not include farmers' (men and women) preferences and needs.

In the latter case, farmers in areas which are classified as one target environment on the basis of GXE interactions may actually prefer different types of germplasm.

This may increase the number of "effective" target environments to a number which is beyond the capabilities of most national programs in developing countries.



The participation of farmers in the very early stages of selection offers a solution to the problem of fitting the crop to a multitude of both target environments and users' preferences (Ceccarelli *et al.*, 1996, 2000). Although farmer participation is often advocated on the basis of equity, there is a sound scientific and practical reason for farmer involvement to increase the efficiency and the effectiveness of the breeding program. It is also expected that decentralized participatory plant breeding could be particularly effective in situations where seed is supplied by the informal seed system.

# From Centralized Non-Participatory to Decentralized-Participatory Plant Breeding

At the International Center for Agricultural Research in Dry Areas (ICARDA), the gradual change from centralized non-participatory to decentralized participatory plant breeding was implemented in Syria between 1997 and 2003. This was done in three steps and was gradually applied in Tunisia, Morocco, Eritrea, Yemen, Jordan and Egypt.

**Table 1. Steps and Features of Decentralized Participatory Plant Breeding**

Steps	Features
1. Exploratory Step	<ul style="list-style-type: none"> <li><input type="checkbox"/> builds human relationships (building the team)</li> <li><input type="checkbox"/> understands farmers' preferences</li> <li><input type="checkbox"/> measures farmers' selection efficiency</li> <li><input type="checkbox"/> develops scoring methodology</li> <li><input type="checkbox"/> enhances farmers' skills</li> </ul>
2. Methodological Step	<ul style="list-style-type: none"> <li><input type="checkbox"/> implements breeding plan</li> <li><input type="checkbox"/> chooses and tests appropriate experimental designs and statistical analysis</li> <li><input type="checkbox"/> refines farmers' selection methodology</li> <li><input type="checkbox"/> initiates village-based seed production</li> </ul>
3. Institutionalization and Scaling-up	<ul style="list-style-type: none"> <li><input type="checkbox"/> organization of workshops</li> <li><input type="checkbox"/> conduct of extensive training programs</li> </ul>

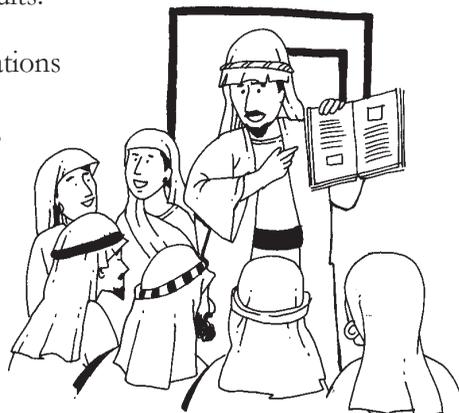
## Exploratory Step

This includes the selection of farmers and sites, and the establishment of one common experiment for all the 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:

- centralized-non participatory (breeders on station)
- centralized-participatory (farmers on station)
- decentralized non-participatory (breeders on farm)
- decentralized-participatory (farmers on farm)

The exploratory step generated the following results:

- 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.
- Farmers selected for specific adaptation.
- For some broad attributes, such as modern germplasm versus landraces, selection was mostly driven by environmental effects.



- ❑ There was more diversity among farmers' selections in their own fields than among farmers' selections on research stations, and among breeders' selections, irrespective of where the selection was conducted.
- ❑ The selection criteria used by the farmers were nearly the same as those used by the breeder.
- ❑ Farmers were slightly more efficient than the breeder in identifying the highest yielding entries in their own fields.
- ❑ The breeder was more efficient than the farmers in selecting in the research station located in a high rainfall area, but less efficient than the farmers in research stations located in a low rainfall area.

There is much to gain, and nothing to lose in implementing a decentralized participatory plant breeding (PPB) program.

## Methodological Step

The model of plant breeding used in Syria and in a number of other countries is a bulk-pedigree system. The crosses are done on station, where F1 and the F2 are grown. On the other hand, yield testing of bulks is done in the farmers' fields (Figure 1).

The activities in farmers' fields begin with the yield testing of bulks (three years after making a cross), in trials called Farmers Initial Trials (FIT). These are unreplicated trials with 170 entries and 30 checks randomly distributed. Plot size is 12 sq.m.

As in the first phase, in two of the eight locations, the farmers requested two sets of the same FIT to expose the genetic material to different environments or practices within the same village (two different rotations and two soil depth).

In parallel, pure line selection is conducted on station within the bulks selected by the farmers in their fields by collecting individual heads. The F4 head rows are promoted to the F5 screening nursery only if farmers select the corresponding F4 bulks. The process is repeated in the F5 and the resulting families, after one generation of increase, return as F7 in the yield-testing phase. Therefore, when the model is fully implemented, the breeding material which is yield-tested included new bulks as well as pure lines extracted from the best bulks of the previous cycle.

The breeding materials selected from the FIT are yield tested for a second year in the Farmer Advanced Trials (FAT). These are replicated trials grown by between four to eight farmers in each village. All the FAT grown within a village contain the same entries, while the type and the number of entries and checks varies from village to village and from year to year.



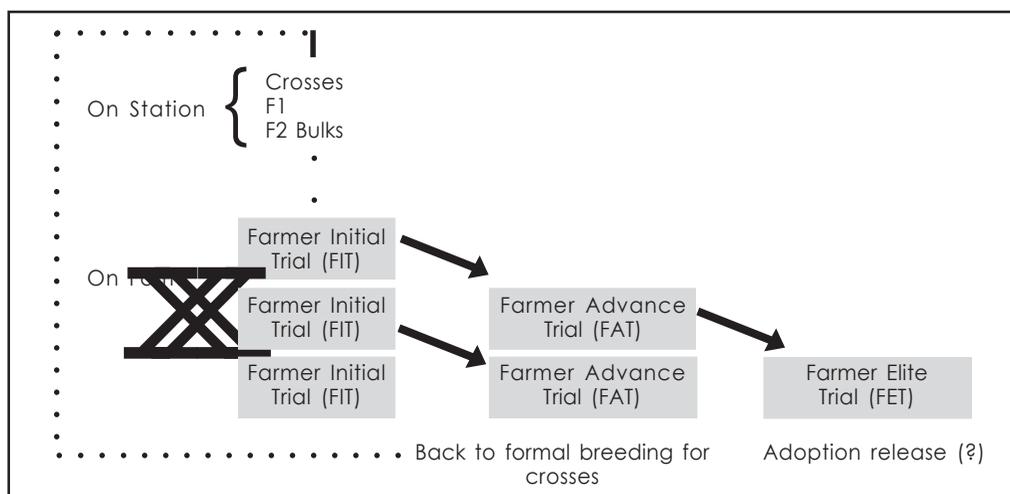
The number of FAT in each village depends on how many farmers are willing to grow this type of trial. Each farmer decides the rotation, the seed rate, the soil type, the amount and the time of application of fertilizer. Therefore, the FATs are planted in a variety of conditions and management. During selection, farmers exchange information about the agronomic management of the trials, and rely greatly on this information before deciding which lines to select.

The entries selected from the FAT are planted in the third level of testing, called Farmer Elite Trials (FET), with plot size of 144 sq. m. These entries are also used on station as parents in the crossing program. The three types of trials are entirely managed by the farmers.

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

In each trial, 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 the days the heading and days to maturity. The data is subjected to different types of analysis (Singh *et al.*, 2003; Yan *et al.*, 2000).

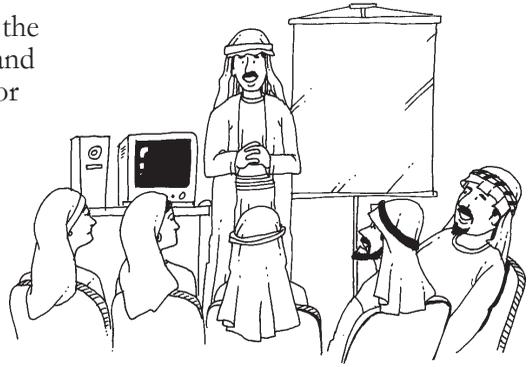
**Figure 1. The Scheme of Decentralized Participatory Barley Breeding Implemented in Syria.**  
The scheme shows only the three stages of testing and selection of bulks.



## Institutionalization and Scaling-Up

In 2003, the process of institutionalization and scaling-up in Syria started. The first step in this direction was the organization of a workshop participated in by about 20 farmers from the villages. A large number of researchers (including heads of research stations of agricultural offices from most provinces, the main research policymakers, the seed organization, the extension service and the Minister of Agriculture) participated as well.

The workshop was a useful forum to discuss the relationships between PPB, seed production and variety release. The mechanism agreed upon for scaling-up PPB was a gradual transfer of responsibilities from ICARDA scientists to scientists of the General Commission for Scientific and Agricultural Research (GCSAR) and the staff of the Extension Service. At the end of the process, each province implemented all the various PPB activities within its boundaries, with the overall coordination shared between ICARDA and GCSAR. Thus, one important component of the initial steps of scaling-up was an extensive training program of the GCSAR scientists and of the extension staff on all the aspects of PPB, partly supported by the International Development Research Center (IDRC).



### Success Story

One of the best examples of success that the PPB project has is the variety Zanbaka. About 10 years ago, it went through the conventional system and was rejected from being released. When it entered the PPB program, it began to be slowly adopted, until the drought in 2000 forced the farmers to use all the available seeds to feed their sheep. Afterwards, seeds were distributed and planted on a 50ha plot. Within two years, the variety has reached 3,500ha 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 two barely varieties are being released, and in Yemen where two varieties of barley and two of lentill have been adopted by farmers.

## Lessons Learned

Lessons learned were derived not only from participatory barley breeding conducted in Syria, but also from Jordan, Yemen, Egypt, Tunisia, Morocco and Eritrea.

- ❑ The cost to the institutions and to the farmers of decentralized participatory plant breeding is not necessarily higher.
- ❑ Farmers' selection is effective, and this allows addressing a larger number of target environments than in decentralized non-participatory breeding.
- ❑ New varieties are spreading in areas where centralized non-participatory breeding had no impact.
- ❑ Participatory plant breeding has a large positive effect on diversity because different breeding lines are selected in different locations.
- ❑ The methodology is continuously evolving, also as a consequence of farmers' improved skills.

- ❑ Participatory plant breeding methods can be very different, even with the same crops, depending on current farmers' practices.
- ❑ Participatory plant breeding projects have to be developed primarily with the institutions responsible for plant breeding in order to successfully scale-up.
- ❑ Participatory plant breeding projects have a large effect on farmer empowerment even if this is not explicit in the design of the projects. When the model described above was fully implemented, the farmers controlled all the crucial steps of the breeding program including the crossing program, even if the crosses were technically executed by the breeders on-station.

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