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Decentralised Participatory Plant Breeding

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A fundamental problem in plant breeding is the relationship between selection environment and target environment. Direct selection in the target environment is always the most efficient. Selection efficiency is likely to decrease as the difference between the selection environment and the target environment increases.

Therefore, it is not surprising that plant breeding has been much more successful in environments with a great similarity to those where most selection usually takes place: the research stations where breeding material is customarily grown in near-optimum conditions. Plant breeders have considerable success in favourable environments, but they often address the problems of poor farmers living in unfavourable environments by simply extending the same methodologies and philosophies to favourable, high-potential environments. In doing so, they do not consider limitations associated with the presence of large interactions between Genotype and Environment (GE). Plant breeders regard these GE interactions to be among the main factors limiting response to selection and, in general, the efficiency of breeding programmes. When the selection environment is very different from the target environment, GE interactions usually become more important.

Plant breeders distinguish between two types of interactions: the first type changes the ranking of genotypes in the same location over time causing large *temporal* variability. The second type consistently changes the ranking of genotypes between different target environments causing large *spatial* (or geographical) variability. Farmers are mostly interested in avoiding or reducing temporal variability, while the majority of plant breeders (and the seed companies) are mostly interested in avoiding geographical variability.

In the case of temporal variability, the objective should be to avoid GE interactions by stabilising crop yields. One way in which this can be achieved is by breeding heterogeneous populations (genetically similar to the old landraces) rather than uniform cultivars, such as pure lines or hybrids, or by growing different varieties at the same location.

Decentralised selection

In the case of geographical variability, the objective should be to exploit GE interactions by breeding for specific adaptation within target environments. This can be achieved by selecting directly in the target environments: *decentralised selection*. In such cases, the breeding programme has a number of selection sites, with each site representing a different type of target environment. Decentralised selection becomes selection for specific adaptation when it is based on the performance within each target environment rather than on the average performance across all sites and all years.

This strategy has two important consequences. First, crops and cultivars are adapted to the biophysical and socioeconomic environment. Second, the importance of landraces in plant breeding is reassessed: these old cultivars usually do not perform well under the high-input conditions of the research stations, but are very difficult to beat in low-input, marginal conditions (Ceccarelli 1994).

Although decentralised selection is a powerful methodology to fit crops to the physical environment, crop breeding based on decentralised selection can still miss its objectives if it does not consider farmers' preferences and knowledge of the crops and the environment. Unless it becomes participatory, such crop breeding may fail to fit crops to the specific needs and uses of farming communities.

In the initial stages of breeding, breeders create a large genetic variability. Subsequently, farmers' perceptions of their own needs and their knowledge of the crop must be brought in. In this way it is possible to fully exploit potential gains from breeding for specific adaptation through decentralised selection. Farmers' participation 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; Kornegay et al. 1996).

The acceptance of decentralised selection as a breeding strategy almost inevitably leads to the acceptance of farmers' participation as a tactical necessity. There are sound reasons for farmer participation to increase the efficiency and the effectiveness of a breeding programme, even though farmer participation is often advocated mainly on the basis of equity.

Barley variety selection project

The objective of this PPB project conducted in Syria is to test an alternative way of producing improved varieties of crops, such as barley, for marginal environments. The project operates in 9 villages chosen to represent variations in annual rainfall (from 200-250 mm), soil types, management practices, farm sizes, types of livestock ownership, and the formal education level of the farmers.

The area shows a range of agroecological conditions varying from high to low-potential cereal production environment. Barley is the main winter cereal. It is the principal feed crop for sheep in Syria. It is planted in autumn, usually after the first rain (mid-October to mid-December) and harvested in May-June. It covers over 2 million hectares with little use of modern or improved varieties. At the wettest end of the spectrum and on fertile soils, farmers can obtain up to 5 tons/ha of grain in a good season by using fertiliser. In very dry conditions where soils are generally poor and input levels low, grain yields only reach 1.5 tons/ha. Syria's national average barley grain yields are stagnant at a low of 0.65 tons/ha.

Landraces are predominant in Syria (99% of the area). They are exclusively two-row types, and known as either *Arabi Abiad* (white-seeded), common in slightly better environments (250 to 350 mm of rain) or *Arabi Aswad* (black-seeded), common in harsher environments (< 250 mm). Considerable phenotypic and genotypic heterogeneity exists both among landraces collected in different farmers' fields (even if designated by the same name) and among individual plants within the same farmer's field. Farmers in dry areas consider the grain and straw quality of the black-seeded landrace is best.

Methodology

In 1997, 208 barley lines were planted in the field of one farmer in each village. The lines were a random sample of those representing the early stages of the breeding process (normally planted only at the research station). The lines represented different types of germplasm such as two-row and six-row, modern and landraces, uniform lines and segregating (heterogeneous) populations, and black and white seed colour. The lines were also planted at 2 research stations, representing a favourable and an unfavourable environment, respectively.

The host farmers carried out the selection together with a breeder from the Syrian Directorate of Agriculture and Scientific Research. Each farmer and the breeder also selected at the 2 research stations. In 5 of the 9 villages, group selection sessions took place in which about 9 farmers scored each plot and indicated reasons for selecting or discarding them. In this way the project compared the following four strategies of selection:

- By farmers in their own fields (decentralised participatory selection),
- By farmers on the research station (centralised participatory selection),
- By the breeder in farmers fields (decentralised non-participatory selection),
- By the breeder in the research station (centralised non-participatory selection).

In the second year (1998), each of the 9 participating farmers planted the lines selected under the 4 strategies, and a second cycle of selection was conducted following the 1997 procedures. This is being repeated in 1999.

Results

The most important findings are the following (Ceccarelli et al., in press):

- In the first year farmers selected, in their own fields, about one-tenth of the number of entries selected by the breeder. On-station, the farmers selected, on average, about half the number of lines selected by the breeder. Farmers' selection was based only on the performance of the lines in their respective fields: they did not use their on-station observations. Breeder's selection was based on the performance of the lines in all 11 environments. Eventually, 2 groups of entries were selected, one for high-rainfall and one for low-rainfall areas.
- Landraces were selected more often in the dry sites and the modern cultivars more often in the wet sites.
- There was more diversity among farmers' selections in their own fields than among farmers' selections on research stations.
- Kernel size, grain yield, and total biomass were the most frequently selected characteristics by breeder and farmers.
- In their own fields, most farmers were slightly more efficient than the breeder in identifying the highest yielding entries.
- There were significant changes in selection preferences (both by farmers and breeders) under two different rotations, indicating an important (yet unplanned) advantage of decentralised breeding, namely the possibility of adapting the breeding material to changes occurring in the farming systems and agronomic practices of the target environments.

Impact

Farmers acquired the ability to conduct the trials without supervision, and were able to formulate suggestions about potential parents for crosses. They were able to explain the project to other farmers. Farmers began to realise that there could be many different types of barley. We showed farmers how crosses were made, and the different types of barley generated by a single cross. In one of the villages, a farmer's wife suddenly started sitting in the same room with us 'foreigners' and began participating in the discussion. Such a change obviously makes it much easier to find out the preferences of women which would otherwise be 'filtered' through the men. These reactions may seem small, but they indicate that this approach can have a major impact on variety adoption, skill building, increased female participation, and the capacity of farmers to redirect plant breeding and shape agricultural research to their needs.

Upscaling

National scientists visiting ICARDA were interested in developing similar activities in their own countries. As a result, there are now participatory barley breeding projects in Tunisia, Morocco, Yemen, Ethiopia and Eritrea and are being developed in Jordan and Egypt.

Conclusion

Plant breeding programmes can be organised so farmers become major actors in selection, testing and multiplication of new cultivars. PPB recognises that it is the farmers who ultimately decide whether or not to adopt a new variety and it reduces the chances of developing cultivars that are unacceptable to farmers. PPB may be the only possible type of breeding for crops grown in remote regions, for crops requiring a high level of diversity within the same farm, or for those considered as minor crops and therefore neglected in formal breeding.

There are a number of considerations, however. First, an important obstacle to PPB seems to be the reluctance of breeders to share with others the paternity of new varieties. Second, a critical step in participatory research seems to be the first contact with farmers during which scientists should be able to establish a relationship in which both partners have equal status. Third, PPB improves over time as scientists and farmers come to understand each other's skills, interests, motivations, problems, and limitations. Increased awareness of what plant breeding can do for them, will inevitably lead to more demands by farmers to formal breeding programmes. ■

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