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Review on Participatory Bread Wheat Breeding Program in Kermanshah, Iran under Rainfed Condition: Importance, Opportunities and Challenges

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ABSTRACT

Farmers and researchers have been isolated from each other for decades. But, now both groups realize the limits of conventional varietal selection in research stations, the quality of products grown, and their adaptability to target areas and to agricultural systems. Conventional plant breeding has mostly benefited farmers in high potential environments and those who can afford inputs such as fertilizers and pesticides and have access to water. The poorest farmers who cannot afford to change their fields through the application of additional inputs get left behind. As a consequence, low yields, crop failures, malnutrition, poverty, and eventually famine are still affecting a large proportion of humanity. Working in partnership with farmers to develop varieties adapted to the conditions they face in participatory plant breeding (PPB) programs can help to overcome these problems. This paper describes the main aspects of a PPB program, the related aspects of variety release, variety adoption and seed production, and the results obtained with a PPB program applied to rainfed bread wheat in Kermanshah province, Iran.

Keyword: participatory plant breeding

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INTRODUCTION

Despite its declining importance as a contributor to the gross domestic product (GDP), agriculture still represents an important input to the national economy and to rural livelihoods in Iran. Iran has traditionally emphasized a model of self-sufficiency in agricultural production, but this goal is very hard to attain given a national population of about 70 million people, growing at about 1.5% per year (Stads *et al.* 2008). Agricultural research and development (R&D) plays an important role in increasing food production, which makes it a priority for the Iranian government. Roughly 32 million ha are potentially arable (18% of Iran's total surface area), but only 19 million ha are actually used for agricultural production under rainfed or irrigated conditions. The remaining land has not been brought under cultivation due to harsh climatic conditions or lack of water resources for irrigation. Since 1979, commercial farming has gradually replaced subsistence farming as the dominant mode of agricultural production in Iran. However, small farmers with less than 5 ha of land constitute almost 73% of the country's agricultural producers. In 2006, only 5% of farmers owned more than 20 ha of land (Stads *et al.* 2008). The Dryland Agricultural Research Institute (DARI) is responsible for agricultural development in dry lands and low input farming systems of Iran. The rainfed cereal breeding program is one of the main research programs in DARI which were mainly focused on the improvement of yield potential under rainfed conditions, following a wide-adaptation strategy that tended to neglect areas with lower potential for crop production. In this program varieties were mostly selected under the favorable conditions of the research stations and then introduced with technological packages to farmers in the target environments. However,

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since the 2004-2005 cropping season, DARI, along with this strategy, in collaboration with the International Center for Agricultural Research (ICARDA) and the Centre for Sustainable Development (CENESTA) initiated a strategy based on breeding for specific adaptation and diversified less favorable environments for increasing crop yield. The need for adopting a new strategy came with the severe drought of 2008 when Iran went from being an exporter of wheat to become an importer of 6 million metric tons.

The majority of rainfed wheat farms are in the cold and moderately cold regions of Iran where the most commonly grown variety is Sardari and the newly released variety Azar-2, derived from Sardari as maternal parent (Khazaei *et al*. 2009). Sardari is a widely adapted wheat landrace originated from Western Iran that was released more than 30 years ago. Formal seed multiplication supports the existence and the predominance of Sardari and caused the displacement of other old local varieties. Sardari is cultivated in both favorable and less favorable conditions, because there are no other options for farmers. Since 30 years ago, climatic conditions have greatly changed and global warming causes water scarcity and together with drought stresses has a negative impact on rainfed wheat production. Within these 30 years, through a conventional rainfed wheat breeding program, we could not identify better varieties than Sardari. Even Azar-2, released 10 years ago, with more specific adaptation than Sardari, has not been adopted extensively by farmers. Thus, a conventional plant breeding program, which leads to the monoculture of a widely adapted cultivar, would not be an efficient strategy to cope with the impact of climate change which will increase the heterogeneity of the growing environment. In a conventional breeding program, heterogeneous environments make it difficult to apply consistent selection pressure because often it is difficult to identify a single or a few superior genotypes across all sets of conditions (Dawson *et al.* 2008). Therefore, when the target environment is characterized by heterogeneity of environmental stress, varieties developed in high-yielding conditions may fail to satisfy farmers' needs. To tackle the negative effect of heterogeneous environments, farmers in less favorable areas must be provided with different varieties with specific adaptation for specific environments and with a heterogeneous genetic background. The existing genetic diversity in these varieties buffers their performance when exposed to new environmental conditions (Riley 2003).

The unpredictable nature of climate change challenges the long-term viability of many of our established agricultural strategies. The concept of food security and yield stability must be addressed with regards to all possible agronomic solutions to future climatic instability. Usually, farmers from different areas with specific growing conditions have rational reasons for selecting a wide range of highly diverse materials with specific adaptation, to cope with unpredictable and variable ecological and economical conditions that they encounter (Weltzien *et al.* 2000), such as drought stress, which is one of the most important environmental stresses in the low rainfall areas of Iran. Many farmers are also interested in minimizing the amount of yield variation they observe over years. In other words, they prefer yield stability over time rather than high potential yield in favorable years. Therefore, to meet the social and economic needs of farmers in difficult environments, breeding for stable varieties which minimizes the risk of crop failure is probably the most important breeding objective (Ceccarelli 1994).

In Iran farmers in marginal and less favorable environments have a very important role in agricultural production. They are in the frontier of the challenge posed by climate change and they can offer their valuable knowledge and experience on how to live with harsh environment and protect themselves. But they need the support of researchers in this serious challenge. They deserve to benefit from the final outcome of agricultural research, especially from the varieties released from breeding programs, which genetically buffer their performance when exposed to unpredictable conditions in their field conditions that are completely different from the conditions of the research stations. The farmer and researcher may be lost soul mates, but reuniting them may not be an easy task. Having been separated and isolated for decades, they now speak different languages and have contrasting worldviews. But there is an urgent need to bring the farmer back into the research arena (Paysannes 2004) to participate with researchers in development of agriculture in less favorable area.

PARTICIPATORY PLANT BREEDING

Approaches that lead to close farmer-researcher collaboration in plant genetic improvement are known as Participatory Plant Breeding (PPB). Usually, but not always, PPB is initiated by the formal agricultural research sector. PPB consists of identifying breeding objectives, generating genetic variability, selecting within variable populations to develop experimental varieties, evaluating varieties, variety release, adoption by farmers, and seed production. Farmers can participate in breeding programs at many different points in this continuum of processes (Weltzien *et al.* 2000).

Local participation in the design of resource management improvements ensures that the outcomes will meet farmers' needs, priorities and local expertise. Participatory approaches enable local people to contribute their valuable practical knowledge in regional agricultural development. In a number of cases, PPB has promoted the formal release of greater numbers of varieties as breeders seek to make more choices available to farmers. In many of the examined cases of PPB, farmers test a larger number of varieties than is traditionally done during the adaptive or on-farm yield trials of formal research. In a number of cases, PPB has promoted the formal release of greater numbers of varieties as breeders seek to make more choices available to farmers. By emphasizing the development of varieties specifically adapted to a multitude of target environments defined according to the repeatability of genotype × locations interactions (Annicchiarico 2002; Annicchiarico *et al.* 2005; Singh *et al.* 2006), PPB is the method able to cope with the negative impact of drought stresses. This is drastically different from conventional breeding that addresses reliable environments by breeding for broad adaptation. By emphasizing specific adaptation, PPB is also expected to be more capable than conventional plant breeding in addressing some of the specific problems which are common to many conventional breeding programs in developing countries (Ceccarelli *et al.* 2007). A usual outcome of PPB programs is that different farmers in different communities select different varieties, and thus PPB in most cases has made a contribution to increased varietal diversity (Weltzien *et al.* 2000). Although the varieties developed through PPB are specifically adapted to certain environmental conditions, they may also perform well in farmers' fields located in similar climates and soil types. It is unlikely that they will spread as much as the varieties specifically targeted to have wide adaptation in higher input systems (Morris and Bellon 2004), but it is possible that they will benefit many farmers in neighboring areas.

VARIETY RELEASE AND SEED PRODUCTION SYSTEM IN PPB

In Iran variety release procedures are enforced by the Agricultural Research, Education and Extension Organization (AREEO). The needs of specific regions, especially in marginal areas, and the needs of specific consumers or users are not easily considered in such procedures. PPB is able to accommodate such a variety of needs, as well as needs for biodiversity. Consequently, recommendations on how to change the existing release procedures are often a direct result of working more closely with farmers. Participatory research also contributes to make farmers more aware about these procedures and to convince the variety release decision makers to modify the current variety release laws by understanding the real needs of farmers in marginal areas and by realizing the importance of specific adaptation. A PPB program in India is working to encourage formal committees to give greater official weight to farmer evaluations. The program argues that data synthesized from farmer varietal evaluations should be used as a base for varietal release decisions. In many cases, such data may be more predictive of future adoption than the standard yield measurements that form the core of most variety release decisions (Weltzien *et al.* 2000).

BREEDERS AND FARMERS: A STRONGER TEAM

In Iran, like in many other developing countries, farmers are hardly aware of the role and benefits of the agricultural research sector in their life even though farmers are considered as the main clients of these research systems. However, in practice they usually have little influence on the objectives, priorities, activities, and the final outcomes of the research systems. In PPB led by the formal research sector, there is an active interaction between farmers and researchers in the target environments where trials and varietal evaluations are conducted under the management of farmers. Consequently these programs spread knowledge and awareness about the role of formal agricultural research sector among the participating farmers and on the other hand, the formal breeders are able to identify the real farmers' needs by receiving essential information from the farmers. One of the important benefits of farmers' participation in plant breeding is that the variety development process is conducted directly in the target area on farmers' fields with the participation of farmers. Therefore, there is no lag between learning about a new variety and its initial adoption (Weltzien *et al.* 2000). This is true for the farmers who directly participate in the breeding project, but for other farmers in the same village or other villages this may not be true. However, in a number of PPB programs there is evidence that farmer-to-farmer exchange of seed actually works as an efficient distribution mechanism which allows the rapid spread of varieties far beyond the initial participants. An Iranian example of the lag which exists between the variety release process through conventional breeding and adoption by farmers is Sararood-1. This barley variety was released by DARI in 1998 and was recommended for moderately cold areas (with average temperature range between 7 and 25°C) of Iran; despite its good performance on farmers' fields, still a large portion of the farming community are not even aware of this variety and based on the statistics from the Ministry of Agriculture by the year 2004 it covered only 11.2% of total area of rainfed barley in Iran. Azar-2, a bread wheat variety released in 1998 for cold and moderately cold areas of Iran, has covered less than 5% of the rainfed wheat fields in Kermanshah province, which represents the area for which the variety was recommended.

TEAM WORK RESEARCH

In Iran the traditional linear sequence of research → extension → farmers is the established way of transferring the research outcomes to farmers' fields. However, as in most developing countries, this sequence is not effective. To be more efficient in transferring new technology and research outcomes, this sequence must be replaced by team work, which not only consists of these three partners but also includes other disciplines like the formal seed sector, people from technical implementation sectors, NGO's, etc. All partners must be involved and participate in conducting research, including variety development in target environments, identification of varieties with specific adaptation, multiplication and maintenance of the locally produced seed and field management. The exploitation of location-specific adaptation and more heterogeneous varieties require a different organizational framework compared to that of the established formal plant breeding institutions (Berg 1995).

LOCAL SEED SYSTEM IN PPB

The potential advantages of PPB, such as the speed with which new varieties reach the farmers, the increased adoption rate and the increased biodiversity within the crop due to the selection of different varieties in different areas, will not be achieved if the seed of the new varieties does not become available in sufficient amounts to all the farmer community (Ceccarelli and Grando 2007). In many countries this depends on the official recognition of new varieties. In Iran releasing varieties is the responsibility of the variety release committee, which makes decisions based on a scientific report on the performance, agronomic characteristics, reaction to pests and disease, and quality characteristics of the new variety. The farmers' opinion is not requested because the underlying assumption of the process is that scientists know what farmers need. Unfortunately this assumption is very seldom challenged even though there are several cases of varieties not released but grown by farmers such as Cross Alborz, a superior wheat variety suitable for supplemental irrigation in moderate cold regions of Iran which has been adopted by farmers but has not been released so far. By contrast, there are several cases of released varieties never grown by any farmer. Similar cases are common in other developing countries. In these cases the considerable investment made a public Institution in developing the new variety and in producing its seed has no benefits to the society in general and to the farmers in particular. PPB can considerably improve the efficiency of the delivery phase by considering farmers' acceptance as one of the main criteria to release a new variety. In this system, a variety is released as a result of a selection process conducted with the participation of farmers and therefore the investment on seed multiplication can be made on varieties that farmers already know and trust because they participated in their selection. This also implies a shift from a supply-driven to a demand-driven research program.

One of the main obstacles faced by the PPB project in Iran, like in other countries that deal with PPB, is a limited understanding of how the local seed system works, what rules it applies, and what channels and barriers exist for the flow of information and the seed. To cope with this problem, breeders who are initiating PPB, more often seek the integration of PPB into the formal, national systems for variety release, seed production, and distribution. Breeders working within the formal research sector are familiar with the national rules and regulations for varieties release and seeds certification, and thus foresee more clearly the opportunities or problems for achieving meaningful integration of the PPB efforts into these rules and regulations. Each seed system (formal, farmer, or something in between) has different strengths and weaknesses, and a PPB program should understand the advantages and limitations in each, rather than just adopt one of these strategies (Weltzien *et al.* 2000). In Kermanshah province, where we started a participatory rainfed wheat breeding program, during the 2008-2009 cropping season, the amount of rainfed wheat seed produced by the formal seed sectors is about 49% of the total amount of seeds required by farmers (Kermanshah Jihad-e Agriculture 2008). In other crops and countries the situation is even more critical: in Syria the formal seed sector produces less than 10% of the total amount of barley seed (the major rainfed crop) required by farmers. It is clear evidence that the formal seed system does not produce all required seed for all rainfed wheat farms and that 51% of the seed are farmers' seed. Accordingly, a local seed system governed by farmers is active in Kermanshah and should make it rather easy to initiate PPB in this province. The local seed system fulfills a range of functions, such as providing information about seed availability and about new varieties. In many regions with marginal conditions for crop production and with high ecosystem diversity, the local seed system is the only system that provides seed to farmers, especially to poor farmers (Weltzien *et al.* 2000). Farmers from low-input rainfed wheat production system in Kermanshah complain about their poor knowledge of newly developed varieties and their limited access to certified seeds and therefore they prefer to plant their own seeds. There are basic assumptions among breeders about the functioning of local seed systems: that most farmers produce their own seed, that they do exchange seeds and farmers who have seeds of better varieties will share them with others. The local seed system is often regarded as the key supplier of new varieties that were identified through a participatory project.

FORMAL SEED SYSTEM AND PPB

Formal seed systems have developed as a result of progressive successes of plant breeding efforts. These usually are designed to achieve some form of quality control for farmers and a basis for quantifying royalties that might be due to the breeder of a specific variety in countries where the private sector is actively involved in the seed system. If the varieties bred and/or tested by farmers are not released, their integration into the formal seed system needs to occur through variety testing and release. India has a provision for allowing the production and distribution of non-certified seeds on a large scale (Weltzien *et al.* 2000). To achieve the release of a variety, it has to pass through a series of standard trials designed for this purpose. Breeders as part of the formal seed system usually have access to these trials, and know how to enter new varieties into this testing scheme. Thus, also varieties bred with the participation of farmers could follow this route, as it has been done in India and Nepal.

Fortunately, so far 10 seed production private companies have been established in different regions of Kermanshah province. Their main mandates are to purchase, clean and treat certified seeds of released varieties. These companies, which work under supervision of governmental formal seed control and certification institutes, can play an important role in integrating PPB, informal and formal seed production sectors.

INITIATION OF WHEAT PPB IN IRAN

In 2006, we started a PPB in two villages, Zamanabad and Nojoub in Sarfiriozabad, Kermanshah province, Iran. The trials conducted in the 2006-2007 cropping season were the results of consultations with farmers of the two communities conducted during 2006. The consultations were organized by the staff of the Dryland Agriculture Research Sub-Institute (DARSI), CENESTA, ICARDA and the Provincial Jihad Agriculture Organization in Kermanshah. In the 2007-2008 cropping season, we continued this program in Sarfirozabad region but due to severe drought we were faced with crop failure and obtained no results. In the 2008-2009 cropping season, two more regions in Kermanshah province were added to this program and farmers along with breeders selected better genotypes compared to checks. These superior genotypes are going to be planted in bigger plots in the next cropping season along with the new genotypes. Farmers from other regions of Kermanshah province who were aware of this program have requested to join the PPB program for the 2009-2010 cropping season. For this cropping season we are going to use local bread wheat genotypes from different locations of Iran, which are available in ICARDA gene banks. Their seed have been multiplied in 2008-2009 in Sararood station, Kermanshah, Iran.

CONCLUSION

There is a great interest among breeders and farmers in Kermanshah province, Iran to collaborate in PPB, and agricultural organization in this province is supportive. Through PPB farmers will be aware of the process of varietal development program and they adopt the out put of it much more easily. Moreover, researchers would be in closer relation with farmers and they will be well aware of their needs. With PPB, a breeding program will be conducted much more efficient than before. In PPB methods, farmers' selection working with natural selection on a genetically diverse population will allow maximum adaptation to environments with specific stresses and also maximum resilience against climate change. By realizing the negative impact of global warming and climatic change on cereal production mainly in rainfed conditions in Iran, to stand against it by beneficial genetic diversity, we have started cereal participatory and evolutionary plant breeding in Iran.

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