6 Participatory barley breeding in Syria

Policy bottlenecks and responses

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Introduction to the enhancement project

This case study is based on the development, evolution and achievements of a participatory plant-breeding project on barley that was implemented in Syria in 1996. Barley is the major rain-fed crop in Syria and is the main animal feed in the country. In the first phase of the project, which lasted 3 years, those involved in the project experimented with farmers in nine villages on a number of technical and methodological options, while in the second phase, which started in 2000, these individuals continued cultivation until the 2010–11 season. Although it had to be put on hold because of security issues in the countryside, it is hoped that a full-fledged participatory plant-breeding program will eventually be implemented.

In both phases of the project, the emphasis has been the improvement of the two main landraces grown in the country, which follows an explicit request by the farmers. In the first phase, the project was initiated by the International Centre for Agricultural Research in the Dry Areas (ICARDA) with minor involvement from the Ministry of Agriculture and Agrarian Reform (MAAR) of Syria. In the second phase, the collaboration with MAAR was more intense and allowed the expansion of the project in 24 villages covering 90 percent of the barley-growing areas. Gradually, the varieties produced by the project, which were based on crosses with or selections from landraces, started to be grown over large areas of land, and the seed being exchanged between farmers and/or sold from participating to nonparticipating farmers began to increase. At this point, the collaboration with MAAR came to an end, and in 2008, the research staff of MAAR were instructed in writing to refrain from collaborating with the project. The reason was that varieties not officially released cannot be legally cultivated and, thus, the commercialization of their seed was not legal.

Barley is a major crop in Syria and is grown over an area of between 1.0 and 1.5 million hectares annually. Its production, both as grain and straw, is used exclusively as livestock feed for small ruminants. A very small area is planted with malting barley varieties. The crop is strictly rain-fed and is predominant in parts of the country that receive at least 350 millimetres of annual rainfall. In these areas, barley is replaced by wheat only if and where farmers have access
to water for supplementary irrigation. In the drier parts of the country, it is the only possible rain-fed crop, making these farmers very vulnerable to climatic changes.

Two main landraces are cultivated: Arabi Abiad (Abiad means white in Arabic), which has white seeds and is grown in the wetter areas; and Arabi Aswad (Aswad means black in Arabic), which has black seeds and is grown in drier areas. There is very little (if any) overlapping of the two types, and farmers have a strong preference for either one or the other. Farmers in dry areas consider that the grain and straw quality of the black-seeded landrace is better that the white-seeded one. Considerable phenotypic and genotypic heterogeneity for many plant characteristics that are of agronomic importance exists among the landraces collected in different farmers’ fields (even if they are designated by the same name) as well as among individual plants within the same farmer’s field (Ceccarelli, Grando and Van Leur, 1987; Ceccarelli and Grando, 2000; Newton et al., 2010; Ceccarelli, 2012). Considerable phenotypic and genotypic heterogeneity for disease reaction also exists (Van Leur, Ceccarelli and Grando, 1989). Syrian landraces of barley are also polymorphic in both their chloroplast and nuclear genomes (Russell et al., 2003).

The project area

The project area lies in the northern part of the Fertile Crescent within Syria. It receives between 350 and 200 millimetres of average annual precipitation and stretches in a wide arc from Dara’a and Suweida provinces in the south to Hassakeh in the northeast towards the border with Iraq (see Figure 6.1). The area encompasses a range of agroecological conditions, from high to low potential environments for cereal production. Barley is the main winter cereal. It is planted in the fall, usually after the first rainfall (mid-October to mid-December), and harvested from May to June. At the wettest end of the area (with 350 millimetres of annual rainfall) and on fertile soils, farmers can obtain up to 5 tonnes per hectare of grain in a good season by using fertilizer. In contrast, at the driest end of the area (with 200 millimetres of annual rainfall), soils are generally poor, input levels are low, and grain yields vary from nothing to around 1.5 tonnes per hectare.

The first phase

A number of preparatory meetings with farmers set the scene for the first phase of the project, with the majority of the farmers expressing interest in being able to compare other types of barley with their own landraces. The experiment, which was designed in consultation with farmers in regard to plot size, number of lines, agronomic management systems and so on, included 200 barley lines and populations: 50 fixed lines that were unrelated to Syrian landraces; 50 segregating populations (F3 bulks) from crosses between fixed lines that were unrelated to Syrian landraces; 50 lines derived from Syrian landraces; and
50 segregating populations (F3 bulks) from crosses in which at least one parent was a Syrian landrace. In addition, there were eight farmers’ cultivars (from seed purchased from eight of the nine host farmers, as one of them was growing an improved cultivar already included in the trial) (Ceccarelli et al., 2000). The 208 entries were deliberately chosen to test farmers’ and breeders’ preferences for different attributes and/or characteristics. The entries could be classified according to four distinctions:

1. modern germplasm (100) versus landraces (108)
2. fixed lines (100) versus segregating populations (108)
3. two rows (158) versus six rows (50)
4. white seed (161) versus black seed (28) or segregating (mixed) seed colour (19).

All of the material was grown under rain-fed conditions.

Each farmer was given a field book in which he recorded daily precipitation (measured through a rain gauge) and observations of the evaluative plot. The quantitative scoring method that most farmers preferred was a
numeric scale (highest = best, lowest = worst). Some farmers used qualitative scoring such as ticking or classifying the plots as ‘bad,’ ‘medium,’ ‘good,’ ‘very good’ and ‘excellent.’ Eventually, farmers used a mixture of quantitative scores for some traits and qualitative descriptors for others. Farmers used the earlier observations at the time of the final selection to assign the final score.

There were large differences in average grain yield, biomass, harvest index and plant height between the nine farmers’ fields and the two research stations (see Table 6.1). The highest yield was nearly 3.7 t ha\(^{-1}\) of grain and over 7.7 t ha\(^{-1}\) of total biomass. The two most stressed sites were farmers’ fields in drier

<table>
<thead>
<tr>
<th>Location (code)</th>
<th>Rainfall (mm)</th>
<th>Grain yield (kg/ha)</th>
<th>Biomass (kg/ha)</th>
<th>Harvest index</th>
<th>Plant height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibbin (1)</td>
<td>Mean 436</td>
<td>3,248</td>
<td>8,600</td>
<td>0.37</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>standard error 81</td>
<td>147</td>
<td>0.005</td>
<td>0.6</td>
<td></td>
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<tr>
<td>Ebla (2)</td>
<td>Mean 460</td>
<td>2,857</td>
<td>8,000</td>
<td>0.36</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>standard error 58</td>
<td>113</td>
<td>0.005</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Tel Brak (3)</td>
<td>Mean 278</td>
<td>3,685</td>
<td>7,661</td>
<td>0.48</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>standard error 69</td>
<td>101</td>
<td>0.006</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Jurn El-Aswad (4)</td>
<td>Mean 284</td>
<td>1,415</td>
<td>7,259</td>
<td>0.20</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>standard error 51</td>
<td>228</td>
<td>0.005</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Baylonan (5)</td>
<td>Mean 193</td>
<td>280</td>
<td>2,599</td>
<td>0.11</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>standard error 13</td>
<td>60</td>
<td>0.004</td>
<td>0.7</td>
<td></td>
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<tr>
<td>Al Bab (6)</td>
<td>Mean 350</td>
<td>376</td>
<td>1,514</td>
<td>0.24</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>standard error 15</td>
<td>39</td>
<td>0.009</td>
<td>0.5</td>
<td></td>
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<tr>
<td>Melabya (7)</td>
<td>Mean 241</td>
<td>713</td>
<td>2,733</td>
<td>0.26</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>standard error 29</td>
<td>103</td>
<td>0.005</td>
<td>–</td>
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<tr>
<td>Bari Sharki (8)</td>
<td>Mean 248</td>
<td>1,017</td>
<td>4,534</td>
<td>0.22</td>
<td>52</td>
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<tr>
<td></td>
<td>standard error 36</td>
<td>163</td>
<td>0.006</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Sauran (9)</td>
<td>Mean 303</td>
<td>2,515</td>
<td>7,117</td>
<td>0.36</td>
<td>69</td>
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<tr>
<td></td>
<td>standard error 46</td>
<td>101</td>
<td>0.006</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Breda (BR)</td>
<td>Mean 233</td>
<td>811</td>
<td>2,689</td>
<td>0.31</td>
<td>44</td>
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<tr>
<td></td>
<td>standard error 18</td>
<td>51</td>
<td>0.005</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Tel Hadya (TH)</td>
<td>Mean 434</td>
<td>4,495</td>
<td>12,336</td>
<td>0.36</td>
<td>96</td>
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<tr>
<td></td>
<td>standard error 63</td>
<td>110</td>
<td>0.003</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ceccarelli et al. (2000).

* Melabya was not sampled.
areas, with less than 0.5 t ha\(^{-1}\) of grain, a very short crop and a very low harvest index.

Three of the most interesting conclusions to be drawn from this first phase of work were as follows. First, for some broad categories – in this case, modern germplasm versus landraces – the farmers’ selection was mostly influenced by the environment, with a large preference for landraces in drier locations. Second, the entries selected by the farmers, regardless of whether they were landraces or not, yielded as much, and in one case significantly more, than those selected by the breeder. Third, farmers can handle a large number of lines (often scientists believe that farmers can only handle a small number of lines, implying that it is only possible to do participatory variety selection \cite{Ceccarelli, 2009}, and this finding makes it possible to transfer a plant breeding program from research stations to farmers’ fields). One additional output was the increased interest of farmers towards their landraces, since it was the first opportunity for most of them to systematically compare their own varieties with exotic germplasm under local conditions.

**Second phase: the participatory plant-breeding program**

Based on the experience of the first phase and the enhanced skills of the farmers, a proper cyclical participatory plant-breeding (PPB) program was started in 2000. One of the specific requests of the farmers was that the material used in the second phase should be predominantly based on landraces. The methodology used in this second phase is described in detail by Ceccarelli, Grando and Baum (2007), Ceccarelli and Grando (2007) and Ceccarelli (2009). Like any breeding program, it consists of four stages of evaluation and selection, with entries selected from stage 1 being tested for a second year in stage 2, those selected in stage 2 being tested for a third year in stage 3, and those selected in stage 3 being tested for a fourth year in stage 4. All of the trials involved row and column designs, partially replicated in stage 1 and fully replicated (two replications) in stages 2, 3 and 4. In all of the trials, the researchers collected data on agronomic traits and grain yield, and the farmers expressed their opinion on every single plot in a numerical form. All of the data were subjected to spatial analysis, and the results were tabulated in Arabic and used by the farmers to decide which entries to discard and which to promote to the next stage.

In the second phase, as PPB was gaining popularity in Syria, the number of villages increased from nine to eleven. In 2003, following a workshop in which the then minister of agriculture expressed his personal support for PPB, the number increased to 24 villages. This increase was made possible by the collaboration of the MAAR, which had research stations in every province, and of the extension service, which had staff located in most villages.

Both phases of the project were expected to lead to an institutionalization of PPB in Syria. In fact, the MAAR in Syria is in charge of plant breeding (there is no private breeding) through the General Commission for Scientific Agricultural Research (GCSAR). The General Organization for Seed Multiplication
(GOSM) is in charge of seed production, multiplication and the supply of strategically important crops, which includes wheat and barley. However, the amount of seed produced annually is well below what is needed (about 10 percent of barley and 40 percent of wheat). The GCSAR is also the organization responsible for the evaluation of the variety for release. These lines are tested in on-farm field trials for 3 years before the respective breeder proposes one or more for release to the national Variety Release Committee (Bishaw, 2004). To fully understand the institutional issues described later in this section, it is important to mention that the on-farm trials used in Syria suffered all of the problems identified by Robert Tripp and his colleagues (1997) in the system of variety testing in relation to variety release. With particular reference to the Syrian situation, these problems included:

• inappropriate site selection – in some cases, the sites were actually within research stations and not in farmers’ fields;
• unrepresentative trial management – the level of inputs, particularly of fertilizers, were higher than those used by the majority of the farmers, and the same applied to crop rotation, which, in the best of cases, was only one of the rotations used by the farmers;
• trial analysis was biased against poor environments – usually sites with low or variable yields and those with entries failing to give a measurable yield were discarded from the analysis;
• use of suboptimal experimental designs and statistical analysis – for example, little or no use of spatial analysis and use of unweighted means across sites, which because of the scale effect leads to the selection of the highest yielding entries in the highest yielding sites – the GCSAR has used the same experimental designs and statistical analysis during the last 35 years;
• lack of farmer participation and lack of attention to farmer-preferred variety traits – farmers are only involved in providing the land for the trials.

The period from 2003 to 2007 was very fruitful. The GCSAR and the extension staff collaborated fully in running the trials, in note-taking, in interacting with farmers and in analyzing data. Farmers, after each full cycle of breeding (four cropping seasons), started identifying and naming superior lines (by 2007, more than 30 new varieties and populations were been named by farmers in this period). It was hoped that because the PPB trials did not suffer from any of the problems listed earlier, the data generated by the PPB trials – conducted, as mentioned earlier, for 4 years across a number of locations as row and column design and analyzed with spatial analysis in GenStat with the estimation of best linear unbiased predictors – could be accepted by the GCSAR as the best PPB entries for release.

The first policy-related tensions arose with respect to the project’s promotion of two pure lines – selected from Arabi Aswad, Tadmor and Zanbaka – that were developed before the PPB program was developed and that had been rejected by the national variety release committee. These lines were introduced
into the PPB program and almost immediately adopted by farmers. In their peak period of adoption, Tadmor and Zanbaka were estimated to be grown on 5,000 and 20,000 hectares of land after they were tested in the PPB trials at the beginning of the second phase. When the results of the on-farm trials were compared with those of the PPB trials, a considerable discrepancy was found in the case of both Tadmor (Figure 6.2) and Zanbaka (Figure 6.3).

In the on-farm trials, Tadmor and Zanbaka outyielded Arabi Aswad by 3.6 percent and 1.5 percent, respectively (on average, in 26 trials in 4 years). At the end of the 4 years of testing, they were withdrawn without being submitted for release because the GCSAR breeder did not consider these varieties to demonstrate a significant yield improvement. When tested in the PPB trials, Tadmor and Zanbaka outyielded Arabi Aswad by nearly 20 percent and 17 percent, respectively (on average, in 55 trials in 3 years).

Zanbaka, and to a lesser degree Tadmor, have also been successfully tested in the Gezira region of Iraq, an area where farmers have a strong preference for black-seeded barley, much like the Raqqa and Hassakeh provinces in Syria. The reasons for the different results between the on-farm trials and the PPB trials are not clear. They could actually be caused by a combined effect of the locations of the on-farm trials (which were usually planted on the best fields in the area and were often in natural depressions that favoured water harvesting), their

![Figure 6.2](image-url)  
*Figure 6.2* Grain yield of Tadmor and Arabi Aswad in the on-farm trials conducted between 1986 and 1989 and in the PPB trials conducted between 2001 and 2003.
management (optimum rotation and agronomic practices) and the statistical analysis, which did not take into account the spatial variability.

The results shown in Figures 6.2 and 6.3 were shared with the staff of the GCSAR, including the director general of the time, in order to stimulate discussion on the possible revision of the variety release process. It was decided that changes in experimental design and statistical analysis as well as the opinion of the farmers in the initial adoption, which usually takes place in a PPB program, should play a key role in the process. If successful, it was hoped that these changes would help to facilitate the release of numerous PPB varieties, which have been being continuously produced (at the moment of writing, the number of entries named by farmers has reached more than 70).

However, this approach did not lead to the expected outcome. Despite providing the GCSAR with the software and the training needed to modernize the trial’s design and analysis, the on-farm trials continued to be conducted in the usual way, and the data from the PPB trials that took place between 2003 and 2008, which were collected by the same GCSAR staff, were not even considered for a possible release. The closest attempt to integrate PPB into the National Breeding Program was when the GCSAR proposed that, after 4 years of testing in farmers’ fields and after consolidating the farmers’ opinions, the selected lines, which were named and adopted by the farmers, should be tested.
again in on-farm trials for three cropping seasons and that only the data from these 3 years should be used for eventually recommending one or more of these lines for release. This enormous delay was a result of a law that had to be respected. This proposal was discussed with the farmers, and it was agreed that it was entirely unacceptable as it would cause unnecessary delay the entire process by at least four years (three years for the trials and one for writing the report), during which time the additional information collected on the breeding material would be of dubious scientific value. An effort was also made to adjust the law that was always being quoted in these discussions but without success.

**Are policies and laws relevant?**

As more and more varieties were identified and selected by farmers, it became clear that availability of seed was a major bottleneck in adopting these varieties, and on the effectiveness of PPB projects in the longer term (Moustafa, Grando and Ceccarelli, 2006). Since there had been no progress in the stalemate with the GCSAR concerning the release of these varieties — releases that could have been implemented using the GOSM facilities to produce and distribute seed — farmers were provided with locally made equipment to clean and treat the seed from PPB varieties. This seed began to be commercialized, and several farmers started seeing results, despite the limitation of the informal seed systems, either from the higher yield of the varieties or from both the higher yield and profits from the sale of the seed (Moustafa et al., 2006).

Most of the work described earlier was supported by the International Development Research Centre through various projects. One of these projects ended in 2007 with a workshop held in Jordan (the project included Syria and Jordan) with the participation of about 200 farmers and high officials of the two Ministries of Agriculture (the Jordanian minister opened the workshop). During the workshop, several farmers shared their experiences with PPB and with its outcome and exchanged experiences on the issue of seed multiplication and distribution.

In the closing ceremony, the highest representative of the Syrian Ministry of Agriculture accused the farmers, and indirectly ICARDA, of engaging in illegal activities since the cultivation of varieties has not been officially released and the commercialization of seed from these projects is prohibited by law. A few weeks later, the minister of agriculture sent a letter to the director general of ICARDA complaining that these activities were a threat to the national food security. The letter was followed by instructions to all of the staff of the GCSAR to refrain from collaborating in PPB trials. Some of the GCSAR researchers actually continued to collaborate on the projects on weekends. As of today and despite several requests, no copy of the law has been received.

At the time of writing, we are not aware that there is a national seed law that restricts the exchange of seed — the only existing law is a ministerial decree from 1975 stating that there are no restrictions about the movement of seed. A law was drafted in 2002 with the Food and Agriculture
Organization (FAO) to regulate the exchange of plant genetic resources based on the International Treaty on Plant Genetic Resources for Food and Agriculture in conformity with the treaty’s provisions. In this draft law, national sovereignty remains the basic principle regulating access to Syrian genetic resources. The draft law further recognizes the right of farmers and local communities to participate in national decision making about conservation and the use of plant genetic resources and related benefit sharing. Farmers and local communities are also to be consulted before access is granted for collecting in situ plant genetic resources. No further progress has been made, and the draft law remains in limbo (personal communication with an FAO representative, 2009).

The gender dimension

One distinctive aspect of the PPB program in Syria is the lack of female participation, which has not been a problem in other countries where PPB programs have been implemented with the same methodology. One of these countries was Jordan, and due to the relatively short distance between Jordan and Syria, it was decided at the time of field selection to invite a group of 10 Jordanian women farmers to visit three PPB villages in Syria (two in the South and one in the centre of the country). This decision had the expected effect of bringing Syrian women out of their houses and into the field. It was thereby discovered that women farmers in Syria are interested in PPB, but they are not being informed about the possibility of collaborating or they are assuming that they cannot participate. Since that experience, a female researcher has been supporting the integration of Syrian women farmers into the PPB efforts by combining gender analysis with action research. This work has revealed gender-based differences in agronomic management, crop preferences and project needs (Galié et al., 2009).

Conclusions

The PPB Syrian experience has shown that it is entirely possible to organize a plant-breeding program with the full participation of farmers while maintaining the science of plant breeding. Thus, there is no scientific justification for avoiding the use of PPB. The Syrian experience has also shown that PPB can make a contribution to three of the most frequently debated global problems (i.e. biodiversity, climate change and world famine). The continuous decline of biodiversity has been widely documented (World Conservation Monitoring Centre, 1992; Butchart, Walpole and Collen, 2010; Frison, Cherfas and Hodgkin, 2011) as well as the entity and the effects of climate change. In addition, famine, as well as hidden hunger among various groups of people, is still widespread. A recent report to the United Nations establishes a relationship between agrobiodiversity, seed systems, hunger and participatory plant breeding. It underlines the fact that hunger is not only a problem of production but
also a problem of accession and availability, and it recommends that donors and international institutions, including the Consultative Group on International Agricultural Research and the FAO, should fund, among other initiatives, breeding projects on a large diversity of crops. These crops should include orphan crops and varieties for complex agro-environments, such as dry regions and breadbasket regions, in order to address the needs of the most vulnerable groups and put farmers at the centre of research through participatory research schemes such as participatory plant breeding. Eventually, participatory plant breeding will be able to combine the maintenance and enhancement of agrobiodiversity with the need to feed everyone by making more food available and accessible and being able to cope with a continuous and gradual change in climatic conditions.

Note


References


Participatory barley breeding in Syria


