FROM FORMAL TO PARTICIPATORY PLANT BREEDING: IMPROVING BARLEY PRODUCTION IN THE RAINFED AREAS OF JORDAN

CENTRE FILE: 100163

FINAL NARRATIVE REPORT

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TABLE OF CONTENTS

Synthesis 3
Research problem 4
Research findings 6
Fulfillment of objectives 8

1. *Promote participatory plant breeding and assess the potential to institutionalize the approach in the barley breeding program in Jordan* 8
2. *Improved barley varieties that fulfill the needs of poor farmers in the rainfed environments of Jordan.* 8
3. *Enhanced rate of adoption of new varieties through farmers' participation in selection and testing.* 8
4. *Identification of differences between selection criteria used by men and women farmers and by breeders.* 8
5. *Disseminate experimental results through publications, scientific articles, visits of breeders from neighboring countries and traveling workshops* 8

Project design and implementation 9
Project outputs and dissemination 13
Capacity-building 15
Project management 16
Impact 16
Overall assessment 17
Recommendations 17

Synthesis

This project used the information and the experience gained by previous projects in Syria and North Africa, supported by GTZ and IDRC, respectively, and initiated the transformation of an institutional barley breeding program into a decentralized participatory program by introducing in the research agenda of the NARS farmers' participation in early selection and testing under real farmer conditions.

The project aimed at "Improving the welfare of small resource-poor farmers by increasing and stabilizing barley and animal production in rainfed areas" and had five specific objectives:

1. Promote participatory plant breeding and assess the potential to institutionalize the approach in the barley breeding program in Jordan;
2. Improved barley varieties that fulfill the needs of poor farmers in the rainfed environments of Jordan;
3. Enhanced rate of adoption of new varieties through farmers' participation in selection and testing;
4. Identification of differences between selection criteria used by men and women farmers and by breeders, and
5. Disseminate experimental results through publications, scientific articles, visits of breeders from neighboring countries and traveling workshops.

The methodologies used ranged from a survey questionnaire used in the study conducted at the beginning of the project to assess the potential to institutionalize the participatory approach in the barley breeding program in Jordan, to meetings with the local community leaders, societies chairpersons, host farmers, Department of Agriculture representatives to select the participating farmers, to a field trials methodology based on a three years yield testing, to the development and adoption of various statistical tools to analyze field data (such as the residual maximum likelihood applied to spatial analysis, the Euclidean distance for quantitative data and the GGE biplot technique to analyze similarity of selection between various participants, and the benefits analysis flow chart to collect information about the different uses of barley by-products.

The principal findings of the project were (1) that the current Institutional structure of the NCARTT was not an obstacle to the adoption of participatory research, (2) that the methodology was very well received by the researchers as a way to develop relevant technologies in a shorter time and to respond to the desire of the researchers to do an innovative type of research, (3) that there was a positive response of farmers to participate in the selection of new barley varieties confirming what found with other projects, (4) that farmers wish to expand this type of research to all their more important crops, and (5) that there are no serious obstacles to the participation of women provided there is a strong will by the researchers to do so.

The most important result of the project has been the effective Institutionalization of participatory barley breeding in NCARTT, as demonstrated by the decision taken by the Director General of NCARTT to continue the activities beyond the duration of the project, and to extend the same type of approach to the durum wheat and bread wheat breeding programs: these two are crops of strategic importance in Jordan. The research has shown that understanding the livelihoods through PR is a critical element of the Institutionalization of

Participatory Research. This will need to involve further socio-economists in conducting this type of research.

The project has led to the identification of 9 lines which have consistently out yielded the cultivar Rum during the three years of testing, and that now will be submitted for official release, and large scale seed production and distribution, and has demonstrated that genotype x location effects are large, thus justifying the use of a decentralized breeding strategy based on selection for specific adaptation. Additional results are related to the community characterization (mapping and resources), livelihood challenges (economic activities, importance of different enterprises, health, water, schooling, migration, employment options), and the problems, solutions and aspirations of rural communities in the study area. Results show that young generations aspire more to work in non-agricultural activities. Differences between selection criteria used by farmers and breeders, and by men and women farmers were identified using the actual selection data, and were further analyzed in four locations, and an analysis of the benefits of barley by-products' use, and farmers indigenous knowledge about barley was conducted.

Research problem

Plant breeding has been much more successful in favorable than in unfavorable environments[1], and this has been associated with the relationships between the selection and the testing environments. Given that most of the breeding work, and particularly selection in the early generations, takes place in the high input conditions of the research stations [2], it is not surprising that the environments which benefited most were those more similar to the research stations. Similarly, the crops were plant breeding scored its more spectacular successes were those predominantly cultivated in those favorable environments.

Crops grown predominantly in unfavorable environments have been largely bypassed by plant breeding programs based on the paradigm of wide adaptation, and it is increasingly being recognized that plant breeding programs based on the exploitation of genotype x environment interaction, i.e. based on selection for specific adaptation, can serve more efficiently the crops and the people of marginal environments.

Selection for specific adaptation implies decentralized selection, defined as selection between and/or within early segregating populations conducted in the target environments. Decentralized selection is different from decentralized testing, which is a common feature of breeding programs and which usually takes place in the form of multilocation trials and on-farm trials, after a number of cycles of selection in one or few environments (usually research stations with high levels of inputs). The last stages of decentralized testing have been also improperly described as "participatory", only because farmers make available their land and are allowed to visit the on-farm trials and express their opinions (not necessarily taken into consideration) about the materials being tested.

Decentralization per se does not necessarily respond to the needs of resource-poor farmers in less-favored areas, if it is only a decentralization from the research station(s) of an IARC such as ICARDA to the research stations of a NARS, particularly when the research

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1 Ceccarelli, S., Grando, S. and R.H. Booth, 1996. International breeding programmes and resource-poor farmers: Crop improvement in difficult environments. In (Eyzaguirre, P. and M. Iwanaga, eds) Participatory plant breeding. Proceeding of a workshop on participatory plant breeding, 26-29 July 1995, Wageningen, The Netherlands. IPGRI, Italy pp. 99-116.
2 Simmonds, NW, 1991. Selection for local adaptation in a plant breeding programme.Theor Appl Genet, 82: 363-367

stations of the NARS do not represent, as it is often the case, the difficult environments where the crop is grown. To exploit the potential gains from specific adaptation to low-input conditions, breeding must be decentralized from research stations to farmers' fields. Although decentralization and farmer participation are unrelated concepts, decentralization to farmers' fields almost inevitably leads to the participation of farmers in the selection process. Therefore, ICARDA's barley program considers farmer participation as a type of decentralized selection to exploit GE interactions and to make use, within a formal breeding program, of the farmers' knowledge about the crop, its specific uses and its specific adaptation.

Experiments in participatory plant breeding[3] have demonstrated that (1) farmers are 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 are nearly the same as those used by the breeder, and (6) in their own fields, farmers are slightly more efficient than the breeder in identifying the highest yielding entries; the breeder is 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. Therefore, there are strong indications that there is much to gain, and nothing to lose, in implementing a decentralized participatory plant breeding program. More recently[4] it has been confirmed that selections made by the breeder and the farmers in one season rarely differed for grain yield in the following season, and when they did, breeder's selection was more effective on station, while farmers' selection was more effective in farmers' fields.

The results of these studies indicate that it is possible to organize a plant breeding program with the objective of adapting crops to a multitude of both physical and socio-economic environments: such a breeding program will, at the same time, increase productivity and stability, enhance biodiversity and produce environmentally friendly cultivars.

These, however, were only experiments in participatory plant breeding, since they did not have the cyclical nature of plant breeding. This project represents a step forward because it transferred to farmers' fields various steps of a formal breeding program (Fig. 1).

In a centralized-non participatory plant breeding program the majority of the steps take place within one or more research stations, all the decisions are taken by the breeder and by a team of other scientists (biotechnologist, stress physiologist, entomologist, pathologist, quality specialist, etc), and only at the very end of the process, the final results, in the form of a few finished varieties are tested in farmers field (in the so called "on farm trials") with the participation, often very limited of the farmers. In a decentralized- participatory plant breeding program the steps are the same as in a centralized-non participatory plant breeding program, but the majority of them take place in farmers' fields and the key decisions, such as what to promote and what to discard, are taken by the farmers. Obviously there is no more distinction between on-station and on-farm trials. One of the most important consequences of the model is

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3 Ceccarelli, S., Grando, S., Tutwiler, R.,Baha, J., Martini, A.M., 1, Salahieh, H., Goodchild, A., and Michael, M. 2000. A Methodological Study on Participatory Barley Breeding. I . Selection Phase. Euphytica 111: 91-104.

4 S. Ceccarelli, S. Grando, M. Singh, M. Michael, A. Shikho, M. Al Issa, A. Al Saleh, G. Kaleonjy, S. M. Al Ghanem, A. L. Al Hasan, H. Dalla, S. Basha, and T. Basha. 2003. A Methodological Study on Participatory Barley Breeding. II. Response to Selection. Euphytica, 133: 1-16.

that varieties are submitted for release knowing already that farmers will grow them, while in a centralized-non participatory plant breeding program, the farmers' reaction to a new variety is not known until a large investment of money and time has gone into the release and seed multiplication of the new variety. Therefore, it is expected that participatory plant breeding will ultimately have a lower cost/benefit ratio than non-participatory plant breeding. Participatory plant breeding also assumes a new role of the extension service and has additional benefits such as the maintenance or enhancement of biodiversity.

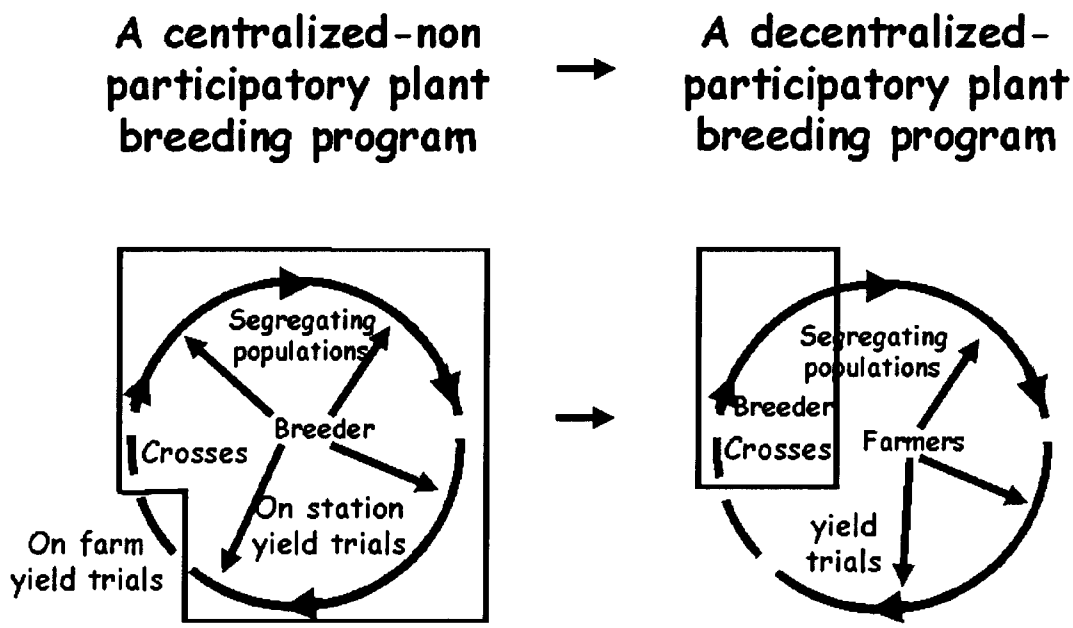

Fig. 1. The project transformed a centralized-non participatory plant breeding program (left) into a decentralized- participatory plant breeding program (right).

Research findings

The major findings of the project are:

1. Results from a study of the current institutional structure of NCARTT conducted in the first year of the project showed that the Director General of NCARTT and the Director of Extension are both willing to institutionalize the approach within their institutions, and have strongly recommended ICARDA organizing workshops and conferences for their staff to be more acquainted with the approach. They have both expressed their willingness to expand the approach to other crops.
2. Most of the scientists who were involved in the project reached a good understanding of the participatory approach. The participants from the University of Jordan introduced the participatory model in their plant breeding courses.

3. Barley is the most important rainfed crop in the areas targeted by the project. It is grown mostly because of the low and erratic precipitation.
4. Unemployment is widely regarded as the major problem faces by rural communities.
5. A total of 61 farmers in 2001, 87 (including 16 women) in 2002 and 67 (including 4 women) participated in the germplasm selection process.
6. A full cycle of selection consisting in three years of testing and selection was implemented in barley. At the end of the project the activities on barley are continuing with Initial, Advanced and Elite yield trials implemented in six farmers' field and one research station. This represents a permanent asset to NCARTT as this may be used as a model to implement a participatory breeding program in other crops.
7. Plant height was one of the more consistent selection criteria together with grain yield, biomass, spike length and kernel weight. Significant differences were found between the participants and between the environments. In general, farmers' visual selection was at least as efficient as breeder's visual selection in identifying the highest yielding breeding material. The differences between men and women in selection were greater than the differences between men farmers and men breeders. Eventually there was a strong, but not exclusive, preference for two rows, and an almost unanimous rejection of black-seeded types.
8. Two cycles of on-station purification of the selected populations were conducted, which was an additional step to fully implement a decentralized barley breeding program.
9. Genotype x Environment effects explained between 70 to 80% of the total variation of standardized data, justifying a strategy based on selection for specific adaptation. Some of the interactions were repeatable, thus allowing a more precise definition of target environments.
10. One cycle of selection in bread wheat and durum wheat was initiated in 2003 using 51 entries at three locations.
11. Nine breeding lines out yielding the widely grown cultivar Rum by between 3 and 56% were identified in the material which has completed one full cycle of selection. These lines will now be used in a crossing program specifically targeted for Jordan. Additional outstanding lines have been identified in the cycles which started in 2002 and 2003.
12. Breeding lines able to give an economic yield with 140 mm rainfall were identified in the driest of the three years. Mohay could be a more suitable dry site than Khanasri because it has a higher heritability and its association with Khanasri is sufficiently good to identify common winners.
13. Jordanian scientists and farmers visited the participatory barley breeding program in Syria while ICARDA scientists and Syrian farmers visited the trials in Jordan.
14. The Director General of NCARTT included Participatory Research in the new strategic Document of NCARTT.
15. Three NCARTT scientists are now fully capable of conducting the trials, analyze the results, and organize farmers' selection.

Fulfillment of objectives

The project had the following five specific objectives:

1. ***PROMOTE PARTICIPATORY PLANT BREEDING AND ASSESS THE POTENTIAL TO INSTITUTIONALIZE THE APPROACH IN THE BARLEY BREEDING PROGRAM IN JORDAN.***

This objective was fully fulfilled, since participatory plant breeding is now much more widely known in Jordan that before the project, and it has found its way also in the teaching at the University of Jordan. The study to assess the potential to institutionalize the approach in the barley breeding program in Jordan was completed and showed the absence of specific obstacles to institutionalize plant breeding in Jordan. In fact, during the last year of the project, the activities were extended to durum wheat and bread wheat which are two strategic crops in Jordan. Therefore, the fulfillment of this specific objective went beyond what was planned at the time the project was approved.

2. ***IMPROVED BARLEY VARIETIES THAT FULFILL THE NEEDS OF POOR FARMERS IN THE RAINFED ENVIRONMENTS OF JORDAN.***

Nine new barley varieties which out yielded the widely grown improved cultivar Rum released in 1985 by between 3% and 56% as average of three years were identified. The new varieties now need to be multiplied and submitted for official release.

3. ***ENHANCED RATE OF ADOPTION OF NEW VARIETIES THROUGH FARMERS' PARTICIPATION IN SELECTION AND TESTING.***

This objective was not fulfilled because the adoption of new varieties in Jordan is not possible without official release and large scale seed multiplication. These varieties will now be submitted to the newly formed variety release committee for their formal release.

4. ***IDENTIFICATION OF DIFFERENCES BETWEEN SELECTION CRITERIA USED BY MEN AND WOMEN FARMERS AND BY BREEDERS.***

This objective was fully fulfilled both through questionnaires and actual selection experiments. A large body of data has been generated on this specific objective. In general the data indicate that the selection criteria depend on the environment and on the participants. Even though women selection was possible only in some villages, there were differences between women and men. This project, and the one conducted in Yemen, is the only two in North Africa and Near East that have generated this type of information.

5. ***DISSEMINATE EXPERIMENTAL RESULTS THROUGH PUBLICATIONS, SCIENTIFIC ARTICLES, VISITS OF BREEDERS FROM NEIGHBORING COUNTRIES AND TRAVELING WORKSHOPS.***

This objective has been satisfactorily achieved with six presentations at International Conferences or Meeting, four regional and international seminars, two PhD students (one completed), two training courses, one visit of five Jordanian farmers to Syria, and one visit of two Syrian farmers to Jordan. One paper was published in a Conference proceeding, and one

or two scientific papers will be prepared for submission to a referee Journal in the next few months.

Project design and implementation

During the period covered by this project, the following types of activities were conducted:

***Selection of participating* farmers:** the following methodologies were used to select, in each location, a group of farmers to perform the selection:

1. Meeting with the local community leaders such as the head of Municipality, society's chairpersons, host farmers, Department of Agriculture representative, and others.
2. Introduction and promotion of the project activities.
3. The participants were chosen among farmers and interested community members who are already cultivating their own lands, and sharecroppers and families involved in the barley production. The chosen farmers represent all the household category sizes in each community. A predominant selection criterion was the interest of the farmers to participate in the project activities. Priority was also given to the farmers who own livestock and use barley as fodder crop.
4. Special attention was given to families in which female members are involved in barley production.

Planning meetings: these were conducted annually, both between scientists involved in the project to coordinate project activities, and between scientists and farmers to assess the results of trials and to plan the trials of the following cropping season. On average, we had three meetings of each type annually.

Field trials: during the project we implemented three types of yield trials, representing different levels of yield testing. The model of plant breeding NCARTT is implementing is a bulk-pedigree system, in which the crosses are done on station, where also the F1 and the F2 are grown, while in the farmers' fields the bulks are yield test over a period of three years (Fig. 2).

The model starts with the Farmer Initial Yield Trials (FIT), which are unreplicated trials with 179 entries and two checks (the improved six-row variety Rum and the local check). In each trial Rum is repeated 11 times and the local check 10 times. The trials are planted at each of seven farmers' fields and in the research station at Ghwer. Plot size is 10 m2 (2m x 5m). In each location the plots were arranged as incomplete blocks of ten plots each, and the layout is ten rows and twenty columns.

In the first year of the project, the locations were Khanasri, West Ramtha, East Ramtha, Rabba, Ghwer, Mohay and Al-Muaqure. In Al-Muaqure in 2001, the combined effect of low rainfall and the soil characteristics (fine silty, mixed, thermic, typic calciorthid) caused very poor establishment. The trial was discontinued and the location was dropped.

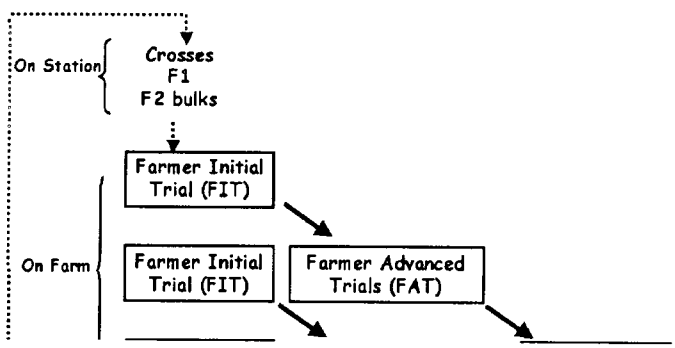

Fig. 2. The scheme of decentralized participatory barley breeding implemented in Jordan. The scheme shows only the three stages of testing and selection of bulks.

The breeding materials selected from the FIT are yield tested, starting the second year of the project, in the Farmer Advanced Yield Trials (FAT). These are replicated trials (two replications) with a number of entries and checks that varies from village to village and from year to year. The plot size in the FAT is 100 m^2 to produce enough seed on farm 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. In each village, the FAT contains the same entries with different randomizations. 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.

The entries selected from the FAT are yield tested in the third year in the Farmer Elite Yield Trials (FET). These are, like the FAT, replicated trials (two replications) and the plot size varies from 500 to 1000 m^2. No fertilizer or herbicides are applied in the trials.

In parallel, the breeders conduct pure line selection within the selected bulks (Fig 3) on station by collecting heads in the F3 bulks selected by the farmers. 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 includes new bulks as well as pure lines extracted from the best bulks of the previous cycle.

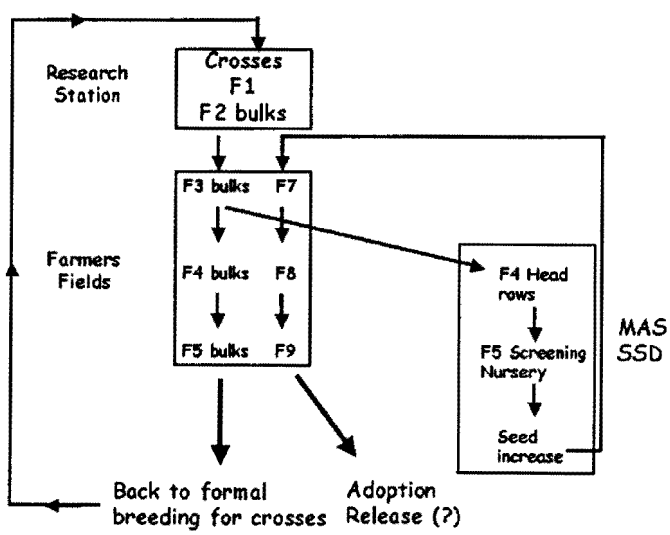

Fig. 3. The scheme of pure line selection paralleling the bulk testing in the decentralized participatory barley breeding program implemented in Jordan

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 scientist record days to heading and days to maturity. The data are subjected to different types of analysis. Firstly, the data were analyzed with a GENSTAT program for spatial analysis of un-replicated trials (FIT) or for replicated trials (FAT and FET) in which the response of the checks provides the basis for modeling the spatial variability in the field and to adjust the genotypes' performance[5]. The environmental standardized Best Lineal Unbiased Predictors (BLUPs) obtained from the GENSTAT programs are then used to analyze Genotype x Environment Interactions using the site regression (SREG) model using the GGEbiplot software[6].

Selection by participating farmers: this was one of the most critical activities of the project. In each village the objectives of the project were discussed at the beginning of the project with the farmers before conducting selection in the field. The total number of male farmers who participated in the selection in the seven locations was 61, 71 and 50 in 2001, 2002 and 2003, respectively. In addition, 16 females participated in the selection in 2002 and 4 in 2003 while in 2003, 13 farmers conducted selection in the wheat trials.

Farmers practiced the selection at two stages. When the crop was close to full maturity, and using a scoring method from 0 = discarded to 4 = the most desirable, farmers expressed their opinion on each individual entry. During selection some farmers were assisted by a researcher to record both quantitative and qualitative data.

After data analysis, a meeting was organized in each village, in which farmers were given the results of the analysis of the quantitative data, with the ranking of the entries for plant height, spike length, grain yield, biomass and kernel weight. In Rabba and Ghweer separate meetings were organized with men and women to avoid possible influences of men over women choices and vice versa. Based on a combination of the visual selection done before harvesting, and of the quantitative data, the farmers in each village decided which entries were to be promoted to the second and third year trials, respectively.

Study to identify constraints and opportunities for Participatory Plant Breeding: This study was carried out using personal interviews with 21 scientists, in addition to meetings with the Director General of NCARTT and the Director of Extension.

The purpose of this study was to determine the current institutional structure of NCARTT and to identify the constraints to and opportunities for participatory plant breeding. The following objectives were developed to guide the study:

(1) Describe the current institutional structure of NCARTT showing the new managerial organizational structure with special focus on barley researchers.
(2) Determine the main constraints facing barley researchers at NCARTT, and the opportunities to institutionalize PPB.

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5 M. Singh, R. S. Malhotra, S. Ceccarelli, A. Sarker, S. Grando & W. Erskine. 2003. Spatial variability models to improve dryland field trials. Experimental Agriculture 39: 1-10.

6 Weikai Yan, Hunt, L.A., Qinglai Sheng, and Zorka Szlavnics., 2000. Cultivar Evaluation and Mega-Environment Investigation Based on the GGE Biplot. Crop Science, 40: 597-605.

Training courses and capacity building: A training course was held in Amman in September, 2001 on the analysis of the data collected in the field trials of the PPB project using REML. The training course took place in the Computer Center of NCARTT. Nine scientists were involved in the training: two from the University of Jordan (Drs O. Kafawin and H. Saoub), one from the Jordan University of Science and Technology (Dr. M. Turk), five from the National Center for Agricultural Research and Technology Transfer (Mr. A. Kaabneh, Mr. Y. Shakatreh, Mr. A. Bawaleez, Mr. A. Khazaleh, and Mr. A. Al-Yassin) and one student from University of Jordan (Ms. A. Al-Nashash).

A training course on Participatory Plant Breeding and Agrobiodiversity Conservation was held in Amman in March, 2002. The training course was attended by 14 participants (nine from Jordan, two from Lebanon, two from Palestine and one from Syria) and covered the definition of Participatory Plant Breeding, examples of Conventional Plant Breeding Programs, a model of Participatory Plant Breeding, Science in Participatory Plant Breeding (experimental designs, data collection and statistical analysis), Participatory Plant Breeding and Diversity, and a field visit to the FIT and FAT planted in Ramtha and Khanasri.

Mr. Fekadu Fufa, spent six months at ICARDA headquarters to complete the molecular work on the populations and pure lines of the FIT evaluated in 2001. This was part of the experimental work of his PhD Study in Plant Breeding entitled "Molecular and Morphological Genetic Variation, and Grain Yield and Yield Components over Environments in Farmers' and Breeders Selections, local and Commercial Cultivars of Barley".

Mr. Yahya Shakatreh was accepted as PhD student at the University of Jordan in Amman: he was partially supported by the project.

Five Agricultural Engineers were trained on participatory breeding methodologies and handling of field trials on a on-job training by NCARTT staff.

Visit to the Participatory Breeding Project in Syria: Five scientists (Dr. M. Turk, Dr. H. Saoub, Dr. O. Kafawin, Mr. A. Bawaleez and Mr. A. Khazaleh) and five farmers (Mr. B. Majali, Mr. S. Doumor, Mr. A. Esmayrat, Mr. I. Azayzeh and Mr. F. Eraini), visited the participatory barley breeding program in Syria in May, 2001. The team participated in the selection process in three locations, Bylounan and Jurn Al-Aswad in Raqqa province, and Suran in the Hama province. Eventually the team visited ICARDA headquarters. During the visit the team of scientists and farmers participated in the discussion after the selection process in all the locations visited and were exposed to a participatory breeding program organized like the project in Jordan. Both scientists and farmers were able to discuss with the Syrian farmers who have a longer experience with participatory plant breeding.

Visit of Syrian Farmers to the Participatory Breeding Project in Jordan: Three Syrian farmers visited the participatory barley-breeding program in Jordan in 2002 and joined the Jordanian farmers during selection.

Livelihood study and community characterization (mapping and resources): In four of the six locations where participatory barley breeding program was conducted, namely Mohay, Ghwer, Rabba and Ramtha, a study was conducted to gather an understanding of the communities, identify their constraints, their livelihood challenges and strategies, as well as the degree of importance of barley production in their and their children's lives.

Several participatory tools, such as the seasonal calendar, the historical calendar, the problem analysis diagram, the livelihood matrix, the benefits analysis matrix, mapping of the social organization, village resources mapping, were used to collect information. Some of these tools have been used with men alone, some of them with women alone and some with both women and men.

Eventually, the method used for problem diagnosis was the constraints analysis tool. This tool is useful in helping the researcher in discussing with farmers the problems they face, the causes and consequences of these problems, and identify the possible entry points for eventual solutions. This tool was used with women and men separately in Ghwer, with men in Mohay, and with women in Rabba and Ramtha.

Indigenous knowledge study: An indigenous knowledge study was conducted with the following objectives:

1. To inspect the validity of the innovative capacity of users, and insight into their potential for direct participation in formal breeding programs.
2. To determine desirable characteristics, prioritized and cross-referenced to environment and utilization.
3. To provide information about indigenous theories and perceptions of the environment/genotype interactions in barley landraces.
4. Identification of women's selection criteria.

Extension of the project to bread wheat and durum wheat: During the last year of the project, the institutionalization of the participatory breeding program greatly benefited by the nomination of Dr. A. Al Yassin as Leader of the Rainfed Program at NCARTT. As responsible for the breeding activities, he has fully endorsed the methodology described below, and with the support of the Director general of NCARTT extended the participatory approach to bread wheat and durum wheat. This was largely done in response to pressing requests from farmers, particularly in Rabba.

In the fall of 2002, three trials were established with 19 cultivars of bread wheat and two checks (Jubeiha and Rabba), and 27 cultivars of durum wheat and three checks (Haurani 27, Deir-Alla 6, and ACSAD 65). Two trials were established in farmers' fields in Irbid and Rabba (two typical wheat growing areas) and one in the Maru research station that is the main station for wheat breeding in Jordan. The trial on station was also used as seed increase.

Project outputs and dissemination

The following outputs have been achieved during the three years of the project:

1. Researchers developed a positive perception of the participatory research approach. It is perceived as an approach that does not completely change the conventional research program, but improves it dramatically. As a research strategy, researchers consider PPB to be encouraging and opening new horizons to improve breeding in general. Already during the execution of the project, the Director General of NCARTT and the Director of Extension expressed their willingness to institutionalize the approach within their institutions, and strongly recommended that ICARDA organize workshops for their staff in order for them to become better acquainted with the approach. They also expressed their willingness to expand the approach to other crops.

In conclusion, the project has played an important role in starting the process of institutionalizing participatory research in the crop improvement research in Jordan.

2. The project has completed one full cycle of selection in barley which has resulted in nine lines which out yielded the check Rum by between 3 and 56% based on three years data. The three types of trials represent a model of plant breeding program being transferred from research stations to farmers' fields.

3. The project was one of the first to involve women as active participants in the process of selection indicating that the presence of female researchers is essential in a participatory project.

4. The project made a significant contribution in increasing farmers' skills. PPB is perceived by farmers as the only way through which they can express themselves. For the first time farmers felt they are partners in research and that scientists are learning from them and sharing with them their knowledge. Some researchers indicated that farmers' perceptions of the participatory research project is better than any other project in which scientists were involved because, as indicated by farmers, they get real results which they can see immediately and discuss with scientists. When farmers are exposed to lots of choices, they feel more interested to work with scientists from the beginning. It was eventually through the repeated demand of farmers that the project was extended to bread and durum wheat.

5. A new model of plant breeding, based on a different paradigm, was fully implemented in the field.

6. Differences in selection criteria between males and females were identified.

7. The capacity of the partners Institutions to conduct participatory research was greatly enhanced.

8. The project results were summarized in the following publications and conferences:
   a) Three annual Project reports to IDRC (copies attached)
   b) Dr. Kafawin attended the International Symposium on PPB held in Pokhara, Nepal from 1 5 May 2000 and presented a paper which has been published as: S. Ceccarelli, O. Kafawin, S. Dr.S., H. Saoub, S. Grando, H. Halila, M. Ababneh, Y. Shakatreh, and E. Bailey, 2000. Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of Jordan. Proceedings of the International Symposium on PPB. Pokhara, Nepal, 1-5 May 2000.
   c) In February 2001 Dr. Ceccarelli gave a seminar at JUST on farmer participation, which included a description of the activities of this project, attended by several students and some Faculty staff.
   d) In August 2001, Dr. Ceccarelli gave a presentation on "Decentralized-Participatory Plant Breeding and Diversity on Farm" in the workshop on "In-situ conservation of agrobiodiversity" (Lima, Peru).
   e) In September 2001 a training course was held in Amman with objective of training Jordanian Scientists in the analysis of the data collected in the field trials of the PPB project using REML.

f) In November 2001 Dr. Ceccarelli gave a presentation at a meeting on "Curriculum Development and Transformation in Selected African Universities in the Areas of Rural Development and Resource Management" organized by the Forum program of the Food Security Division of the Rockefeller Foundation (Bellagio, Italy), which included a description of the activities of this project, to Faculty staff of six African Universities.

g) The Director General of NCARTT has included Participatory Research in the new strategic Document of NCARTT-2002.

h) Teaching at the University of Jordan has started including elements of participatory plant breeding.

i) In March 2002, Dr. Ceccarelli gave lectures at the Training Course "Participatory Plant Breeding and Agrobiodiversity Conservation" held in Amman.

j) In April 2002, Dr. Ceccarelli gave a presentation at the Stakeholder Meeting of the PRGA Program in Bonn, where the project's results were also included.

k) In September 2002 Dr. Ceccarelli attended the Workshop "The Quality of Science in Participatory Plant Breeding" held at IPGRI Headquarters, Rome, Italy.

l) In November 2002 Mr. Yahya Shakatreh participated in Second International Agronomy Congress in New Dehli (India) where he presented a poster "Participatory Barley Breeding: Improved Barley Production in Dry Areas of Jordan".

m) On May 2003, Dr. Ceccarelli visited the Plant Stress and Water Conservation Laboratory, USDA/ARS, Lubbock, TX, where he gave a seminar on "Participatory Barley Breeding for Drought Resistance" which included the results of the project.

n) On August 7, 2003. Mr. Fekadu Fufa, obtained his PhD from the University of Jordan defending a thesis on "Molecular Genetic Variation and Yield of Barley (Hordeum vulgare L.) in one cycle of Decentralized-Participatory Breeding in Low Moisture Environments". The thesis was based on the first two years of field trials of the project and was partially supported with project's funds.

o) In September 2003, Mr. Yahya Shakatreh was accepted as PhD student at the University of Jordan in Amman: he is partially supported by the project's funds.

p) The project activities are mentioned in the IDRC book "Seeds that give. Participatory Plant Breeding" by Ronnie Vernooy published in 2003.

Capacity-building

Office expenses (mail, telephone, fax, E-mail), repair and maintenance of capital equipments (vehicles, threshers, planters and combines), one palm top, two PC, one thresher, field supplies (bags, labels, transport of seed, fuel), travel, office and computer supplies (paper, diskettes, toner for printers) for the UOJ.

Office expenses (mail, telephone, fax, E-mail), repair and maintenance of capital equipments (vehicles, threshers, planters and combines), travel, and capital Items (PC, one thresher one balance) for NCARTT.

Field supplies (bags, labels, transport of seed, fuel), office and computer supplies (paper, diskettes, toner for printers) office expenses (mail, telephone, fax, E-mail), travel, one Lap top and one balance for JUST.

Office and computer supplies (paper, diskettes, toner for printers), travel, office expenses (mail, telephone, fax, E-mail) for JOHUD.

One of the main lessons learned is that the coordination of this type of project needs to be with the Institution which is responsible for plant breeding in the country.

Project management

The administration of the project by ICARDA was reasonably smooth due to the assistance of the Regional Office in Amman.

The scientific management of the project was also satisfactory, due to the fact that most of Jordanian Institutions involved have been working closely with ICARDA long before this project. Delays in reporting due partly to lack of training by NARS in this particular activity, was one of the major problem.

Eventually, the support and administration of IDRC was fully satisfactory: initial delays in reporting were sometimes due to lack of precise guidelines at the time of reporting.

Impact

The project has developed a new philosophy and new ways to improve the use of the research products (barley varieties developed by both breeders and farmers) to promote sustainable agricultural systems. The real impact is the successful introduction of new research approaches, attitudes and ideas for farmers and breeders as well as research outputs and dissemination. Breeders gained more confidence in the local indigenous knowledge and its importance to develop successful germplasm for unfavorable zones. Farmers are now much more receptive and confident in new technologies generated with their participation in the project. Valuable local biodiversity preservation was another important impact.

The efficiency of the selection operated by breeders, male and female farmers has had a strong impact in defining the most important criteria on which farmers base their choice, and in changing the breeding strategies in selection of segregating and advanced material.

The most visible impact is perhaps the availability of new varieties: while these varieties were being developed through the farmers' selection, the Ministry of Agriculture re-established, after several years, the variety release committee, which is the body that officially approves the release of a new variety thus making its commercialization possible. Although we cannot claim that the project was the direct cause of this important decision, all the conditions are now set for a rapid diffusion of the new varieties which will mostly benefit the rural populations in the least favorable areas of the country.

The project had an impact on the GEF project on *The Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria*, coordinated by ICARDA and aiming at promoting the conservation of landraces and wild relatives of species of global importance originated from the Fertile Crescent including barley, wheat, lentils, forage legumes and seven fruit tree genera. Demonstration of low cost

technological packages and of added-value technologies, investigation of alternative sources of income, increasing public awareness and reforms of policies and legislation are major elements of the project strategy. The project is working on promoting the use of landraces through improvement of seed quality (favoring creation of nurseries and community informal seed increase) and on initiating farmer participatory evaluation and selection within landraces. 10-15 farmers participated in the evaluation of lines and landraces in all the four countries. New multi-lines of barley and wheat were evaluated in Lebanon. The Agrobiodiversity project collaborated with the barley breeding program in introducing the approach of participatory breeding and evaluation of landraces. In 2001, a joint regional one week training course was offered to 19 participants from both the agrobiodiversity project and the PPB project, mainly focusing on linking agrobiodiversity conservation with participatory plant breeding. The trainees participated to field selection with collaborating farmers. National breeders in the four countries participated in the evaluation of landraces of barley, wheat and lentil undertaken in the project sites, with collaborating farmers. Two groups of 10-12 farmers from the project sites in Syria visited the PPB trials conducted in Syria and interacted with farmers which have built good experience with ICARDA on PPB.

Overall assessment

The time, effort and funding invested in the project have resulted in a drastic change in the attitude towards research in Jordan, both in the researchers as well as in the farmers communities.

The project was instrumental in providing a precious opportunity for farmers to work side by side with scientists. This aspect cannot be emphasized enough because it was an opportunity for farmers to do visual selection over a wide array of materials. Most importantly, they were aware that their selection was taken seriously and that their criteria and their knowledge are not only being considered but they are valued and respected. We also believe that one of the strengths of the project lied in the multidisciplinary character of the work. The breeders and the sociologists have learned to work together. The local extension services have also been involved from the very beginning.

Through the project, the researchers have also understood the value of involving farmers in the process of developing, and not merely testing, new technologies, and thy become increasingly aware of the capability of farmers to conduct selection.

Participatory research is primarily concerned with processes, which are continuously evolving and changing. Participatory plant breeding requires time and continuity. Unfortunately, the duration of the project has been too short to permit the shift from line selection to seed multiplication and seed distribution systems, which represent the ultimate and concrete contributions of the project.

Recommendations

The major problem in the management of the project was the relationships between some of the Institutions in Jordan. In fact, while the local coordination of the project's activities was at

UoJ, the majority of the field work was done by NCARTT. The lesson to be drawn is that the main partner in this type of projects should be the Institution which in the given country has the Institutional responsibility for plant breeding.

It is recommended that in the continuation of this work NCARTT increases the role of locally adapted germplasm both in barley and wheat, considering that Jordan is very rich in genetic diversity.

Donors usually expect that in the case of a successful project, local Institutions will continue the most significant project activities beyond the life of the project as part of their own research agenda. In this specific project, the expectation is that NCARTT would continue its breeding programs using a participatory approach. While NCARTT is willing to do so (see the attached letter of the Director General of NCARTT), it has to be recognized that the majority of Institutions in developing countries have funds to cover the salaries of the employees, and little else. Therefore, the issue with specific reference to this project is not whether NCARTT research philosophy was changed by this project and whether it does decentralized-participatory research rather than centralized-non participatory research, but whether it does research or not. Therefore, it is recommended that IDRC considers a second phase of this project with the following objectives: 1) study the impact of the barley varieties developed in the first phase, 2) bring the participatory breeding program in wheat at the same level of barley, 3) expand the approach to food legumes, and 4) continue to train scientists in the theoretical and practical aspects of participatory plant breeding.