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

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FINAL TECHNICAL REPORT

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CONTENTS

I. INTRODUCTION

In the last few years two projects, supported by IDRC and by BMZ/GTZ, Germany, have experimented with a novel breeding approach for barley improvement in the low potential, marginal rainfall environments of Morocco, Syria and Tunisia. The current project, located in Jordan, used the information and the experience gained in those two earlier projects and transformed an institutional barley breeding program into a decentralized participatory program by introducing farmers' participation in the research agenda of NCARTT.

The main output was the assessment of the potential for institutionalizing the participatory research approach into a national barley breeding program. Additional outputs were the development of methodologies needed to institutionalize participatory plant breeding, measuring the effect of decentralized participatory breeding on biodiversity, the identification of farmers' selection criteria including women's selection criteria, a more effective targeting of barley varieties to the needs of all possible users, the dissemination of the information generated by the project, an increased adoption of new varieties in low-input agriculture, and higher and more stable barley yields.

The project was approved in January 2000 and commenced on 1 April 2000. This report covers the activities from 1 April 2000 to October 20, 2003.

II. PROJECT STAFF

The project involves four formal institutions (the University of Jordan, the National Center for Agricultural Research and Transfer of Technology (NCARTT), Jordan University of Science and Technology (JUST), ICARDA) and one NGO (the Jordanian Hashemite Fund for Human Development).

ICARDA:
Dr. S. Ceccarelli (Barley Breeder and Project Coordinator)
Dr. A. Aw-Hassan (Agricultural Economist)
Dr. S. Grando (Barley Breeder)
Dr. M. Martini (Gender Analysis)
Dr. A. Amri, acting Coordinator of the West Asia Regional Program (WARP)

University of Jordan:
Dr. O. Kafawin (Barley Breeder) (National Coordinator)
Dr. H. Saoub(Forage Crops Specialist)
Dr. A. Baq'ain(Agriculture Extension Specialist)

National Center for Agricultural Research and Transfer of Technology NCARTT:
Dr. A. Al Yassin (Barley Breeder)
Mr. Yahya Shakatreh (Barley Researcher and Focal Point)
Mr. A. Oassem Khazaleh (Barley Researcher)
Mr. Abdel Raheem Bawaleez (Forage Researcher)
Dr. Amer El-Nsour (Socio-Economist)
Ms. Maissa Haddaden (Extension Specialist)
Ms. Ennas Gharaibeh (Extension Specialist)
Mr. Y. Hijazeen (Agronomist)
Mrs. Afaf Madadhah (Agronomist)
Mr. Iyad Mosalam (Agronomist)

Jordan University of Science and Technology (JUST)
Dr. Layth Rousan (Socio economist and technology transfer expert)
Dr. Moneer Al-Turk

The Jordanian Hashemite Fund for Human Development (JOHUD)
Eng. Fatma Mahmoud Abou Kaf (Agricultural Engineer)
Dr. Jamil Mohammad

III. ACTIVITIES PROGRAMMED AND EXECUTED

A. RESEARCH

The goal of the project is to improved welfare of small resource-poor farmers by increasing and stabilizing barley and animal production in rainfed areas.

The activities conducted in the period under report, the methodologies and the results obtained will be described according to the specific objectives of the project, namely:

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.
5. Disseminate experimental results through publications, scientific articles, visits of breeders from neighboring countries and traveling workshops.

During the period covered by this report, the following types of activities were executed:

Planning meetings
Establishment of field trials
Study to identify constraints and opportunities for Participatory Plant breeding
Selection of participating farmers
Three cycles of selection by participating farmers and breeders
Note taking and harvest of the year trials
Training course on data analysis
Data analysis
Visit to the Participatory Breeding Project in Syria
Establishment of the field trials
Study to identify constraints and opportunities for Participatory Plant Breeding
Livelihood study and community characterization (mapping and resources)
Indigenous knowledge study
Visit of Syrian Farmers to the Participatory Breeding Project in Jordan
Extension of the project to bread wheat and durum wheat

1) RESEARCH METHODOLOGIES

1.1 Promote participatory plant breeding and assess the potential to institutionalize the approach in the barley breeding program in Jordan.

Current institutional structure of NCARTT and identification of constraints and opportunities for participatory plant breeding

This study was conducted by Dr. Layth Rousan (JUST) and by Eng. Ennas Gharaibeh (NCARTT) and was intended to be the initial step to achieve this specific objective.
The purpose of this study was to determine the current institutional structure of NCARTT and to identify the constraints and opportunities for participatory plant breeding. The following objectives were developed to guide the study:

- describe the current institutional structure of NCARTT showing the new managerial organizational structure with special focus on barley researchers.
- determine the main constraints facing barley researchers at NCARTT.

NCARTT was established in 1985 as an organization responsible for implementing the Jordanian National Project for agricultural development in Jordan. Barley is the main field crop that NCARTT focus on to improve its productivity and production in the marginal land and rangeland of Jordan. The main broad research activities include the development of new promising cultivars, crop quality, and crop management and utilization. However, and according to the barley researchers' point of view, barley research still focuses on and is limited mainly to selecting cultivars suitable to the local environment in Jordan. Expanding the barley research to include farmers' selections is a necessity.

A descriptive design was used in this study. The population of the study consisted of a total of ten NCARTT barley researchers,.

The research instrument, which was created by the research team, was a survey questionnaire that consisted of three sections. The first part of the questionnaire consisted of four questions regarding demographic data, including educational level, years of experience, type of work, and modes of cooperation. The second part consisted of five questions related to managerial constraints. The third part of the questionnaire consisted of fifteen question statements regarding the research work at NCARTT. Space was also provided for the researchers to write additional comments about their suggested solutions for each constraint that they identified.

A panel of four experts specialized in different fields, including socio-economists and barley breeders, established content validity of the instrument. The following points were examined by the panellists: item content and clarity, wording, length of the instrument, format and overall appearance. In addition, the instrument was tested by three cereal researchers currently working at NCARTT) and who were not included in the study.

All barley researchers were invited to Ramtha research centre on 15 November 2000. A brief introduction to the study was given, and the researchers completed the questionnaire. Descriptive statistics were used to analyse the data including means, standard deviations, percentages, and frequencies. Data were analysed using the Statistical Package for Social Sciences (SPSS/Windows 10).

Livelihood analysis and community characterization

In four of the six locations where participatory barley breeding program was conducted, namely Mohay, Ghweer, 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.

The livelihood of people in these areas depends on different types of farming and a range of other activities. They succeed in some of their initiatives and fail in others, according to their access to resources, work opportunities and other life related items. The daily struggle of rural communities needs to be well understood in order for researchers and development practitioners to intervene according to the real obstacles these people face.

Farming is considered as key to rural economy and an important source of employment, but other sources of income are also of great importance because many rural people are unable to gain adequate and secure livelihoods from farming only due to different reasons.

Understanding the livelihoods is a critical element of the Institutionalization of Participatory Research (PR). Without having a "livelihoods approach" as the mean to understand more about rural communities' constraints and opportunities, PR cannot be fully institutionalized. Furthermore, PR is currently used predominantly in biophysical research and less so in social science research, and such capacity is lacking at NCARTT. The aim of this investigation was, therefore, partly to have a more complete picture of the livelihoods aspects of the villages where PBB is being conducted and partly to train and build the awareness of NCARTT staff on this aspect of the research. To achieve the last objective, national researchers from JOHUD, NCARTT and UOJ participated actively in the investigation.

In order to combat poverty through technology or other development interventions, there is a need to understand the overall livelihood system of the communities we deal with. In this respect, and as part of a larger study in the region, information was collected from four research sites (Mohay, Ghweer, Rabba and Ramtha) with both women and men using participatory tools. The research objectives of this study were to assess the livelihoods of the rural people and to understand their constraints and to understand the importance of barley production in their daily lives.

Several participatory tools, such as the seasonal calendar, the historical calendar, the problem analysis diagram, the livelihood matrix, the benefits analysis matrix (for barley products only), 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 Ghweer, with men in Mohay, and with women in Rabba and Ramtha.

Indigenous Knowledge

Jordan is a country with limited land and water resources. The per capita share of cultivated land is less than 0.1 ha The internal renewable and usable water resources are less than 175 cubic meters per parson/ year. Only 9% of the country (875.000 hectares of arable land) receives more than 200 mm annual average rainfall. Only 383.000 hectares (44%) of arable land are cultivated. About 84% (or 322.2 thousand hectares) of the cultivated area is rainfed, and the rest is irrigated (MOA, 2000).

Although agriculture is a relatively minor component of the economy, its impact is broad since input servicing and output marketing contribute to value added of the service and industrial sectors. Throughout the past decade, agriculture continued to provide 6 to 7% of the nominal Gross Domestic Product (GDP) and employed corresponding proportion of the Jordanian labor force.

The production and area planted with barley fluctuate from year to year, and depend on the rainfall pattern. One obstacle to increase the production of barley and other crops is the lack of good seed as a component of a package of improved inputs (Engelhardt, 1984). Other factors accounting for the low yield potential of field crops are environmental conditions, soil conditions, cultural practice (field preparation, fertilizer, pest control, harvesting, etc), genetic potential of varieties, and seed quality (Agrawal, 1986). Barley is grown mainly under rainfed conditions and covers approximately 54.000 hectares (about 35%) of the total field crops area planted, as average for the period 1990-1998.

The main barley production constraints in Jordan are the low yield of local varieties, the insufficient amount of seed of improved varieties available to farmers, the limited use of new technology, inadequate resources and the shortage and the erratic distribution of rainfall.

Despite the importance of barley as a main feed source for livestock in Jordan, enquiries into household objectives and reasons for producing barley has received little attention. Consequently farmer perception of the difficulties they experience in reaching these objectives, household economic security and risk considerations in the context of production objectives and genotype evaluation are not well known. There is a need to study the indigenous knowledge to provide the information about adaptation to specific environments and end-uses.

The overall objective of the indigenous knowledge component is to interpret and evaluate the results of farmers, selection, as compared with breeders' selection. The specific objectives of this component are:

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

1.2 Improved barley varieties that fulfill the needs of poor farmers in the rainfed environments of Jordan.

Field trials

Field trials were established in the first year at the following seven locations: Khanasri, West Ramtha, East Ramtha, Rabba, Ghwer, Mohay and Al-Muaqure and at the research station in Ghwer.

The characteristics of the locations are the following:

Mohay	60 km south east of Karak and about 130 km south of Amman, with an average annual rainfall of about 130 150 mm.
Al-Muaqure	50 km south east of Amman, in the arid areas, with an average annual rainfall of 150 mm.
Ramtha	100 km north of Amman, with an average annual rainfall of 225 mm.
Khanasri	135 km northeast of Amman, with an average annual rainfall of 180mm.
Rabba	140 km south of Amman, with an average annual rainfall of 340mm.
Ghwer	120 km south of Amman, with an average annual rainfall of 280mm.

The model of plant breeding NCARTT has implemented 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. 1).

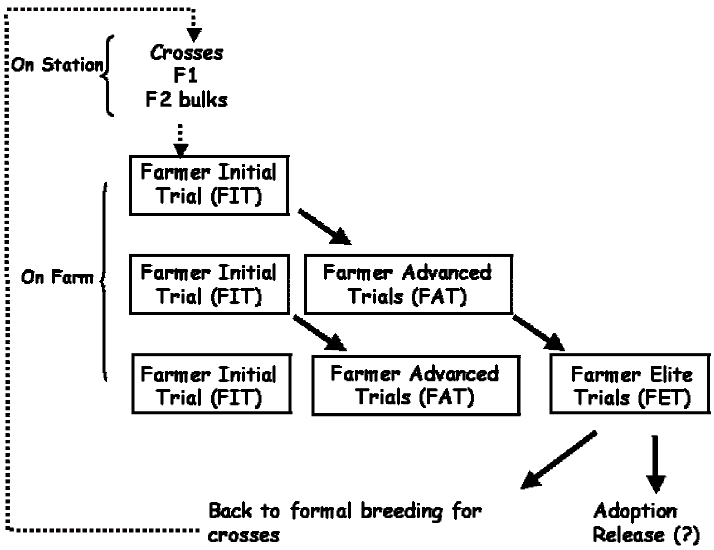

Fig. 1. The scheme of decentralized participatory barley breeding implemented in Jordan. The scheme shows only the three stages of testing and selection of bulks.

In parallel, pure line selection within the selected bulks (Fig 2) is conducted on station by collecting heads on the selected F3 bulks. 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.

The activities in farmers' fields begin with the yield testing of bulks (three years after making a cross), in trials called Farmers Initial Trials (FIT), which are unreplicated trials with 179 entries and 21 checks repeated every ten plots including the first and the last. This allows the evaluation of 179 new breeding materials every year in plots of 12 m2.

The breeding materials selected from the FIT are yield tested for a second year in the Farmer Advanced Trials (FAT) which 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 m2 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. 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. During selection farmers exchange information about the agronomic management of the trials, and rely greatly on this information before deciding which lines to select. Therefore, one of the advantages of this model is that the lines start to be characterized for their responses to environmental or agronomic factors at an early stage of the selection process.

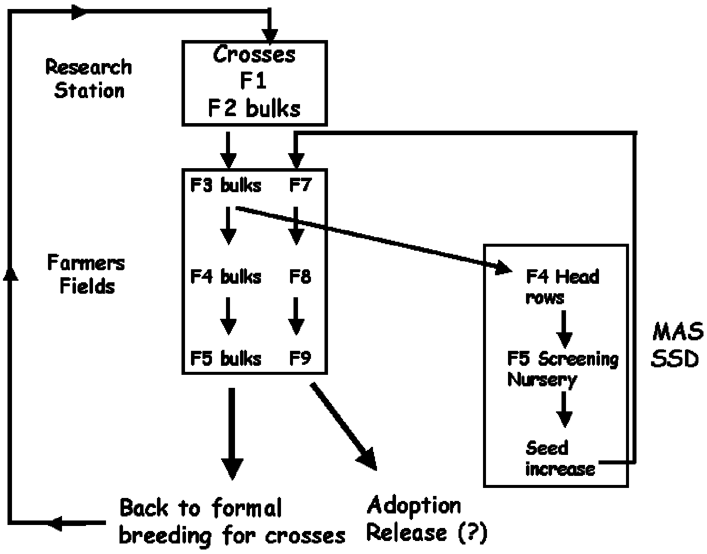

Fig. 2. The scheme of pure line selection paralleling the bulk testing in the decentralized participatory barley breeding implemented in Jordan.

The entries selected from the FAT are planted by the farmers on an area, which is determined by the amount of seed available. The third level of testing is called Farmer Elite Trials (FET), even though they are in most cases a simple comparison between one new potential cultivar and the farmer's cultivar (either improved or the local landraces): the plot size of the FET varies from 500 m2 to 2 ha. The FET are entirely managed by the farmers.

In each trial, the scientists recorded the following data: plant height (ph) in cm, spike length (sp) in cm, grain yield (gy), total biomass (by) and straw yield (sy), all in kg/ha, harvest index (hi) as ratio gy/by, and 1000 kernel weight (kw) in g. The data were subjected to different types of analysis. Firstly, the data were analyzed with a GENSTAT program for spatial analysis of un-replicated trials in which the response of the checks provides the basis for modeling the spatial variability in the field and to adjust the genotypes' performance (Singh et al., 2003). The efficiency of the various spatial models is compared against the completely randomized design. For each variable, nine models are fitted (Table 1); the selection of the best model is based on comparing Akaike Information Criterion (AIC) values in terms of deviance of the model. The model selection is done assuming the genotype effects as fixed. In this case, we compute the BLUEs of the genotype effects. For the selected model, the genotypes are then assumed as random effects, and the BLUPs and heritability are computed. In Table 1, AR stands for first order auto-regressive error in column number (i.e. along rows) and ARAR for first order auto-regressive errors in column number and in row number; L stand for the fixed linear trend fitted in column number. The Wald test was used to test statistical significance of the linear trend in column number. Where linear trend was not significant at 5% level, the best of the models 1-3 was selected; otherwise, the best of models 4-9 was selected.

Table 1. The spatial models used for the analysis of the quantitative data from the field trials.

No.	Random terms and Spatial errors(*)	Fixed linear trend	Abbreviation
1	No spatial errors (Id)	-	CrdId
2	AR	-	CrdAR
3	ARAR	-	CrdARAR
4	Id	Linear in column num. (L)	CrdLId
5	AR	Linear in column num. (L)	CrdAR
6	ARAR	Linear in column num. (L)	CrdARAR
7	Id, CS	Linear in column num. (L)	CrdLCSId
8	AR, CS)	Linear in column num. (L)	CrdLCSAR
9	ARAR, CS	Linear in column num. (L)	CrdLCSARAR

(*) Id = Independent errors; CS= random cubic spline in column number

The BLUPs, which are the genotypic values to be used for selection, were then used to calculate the correlation coefficients (r) between traits at the same location, as well as between grain yield across different locations. Because a different randomization was used at each location, the r's are actually estimates of genetic correlation coefficients. Eventually, the BLUPs for grain yield were uses to calculate genotype by environments interaction using a combination of clustering and ordination procedures (Cooper and DeLacy, 1994) that consists in clustering both genotypes and environments into groups, two-way analysis of variance, the calculation of the percentage of between genotype group × between environment group sums of squares retained for different grouping levels, and eventually using biplots to represent the information contained in G × E tables in a two or three dimensional graph. The interpretation of the biplot is given by Kroonenberg (1995). This analysis was done using the software package GEBEI (Watson et al., 1996) on the environment-standardized BLUPs.

The amount of rainfall received at the different locations during the three years is shown in Fig. 3. As expected, Rabba was the wettest site, followed by Ramtha, while Khanasri and Mohay were the two driest sites.

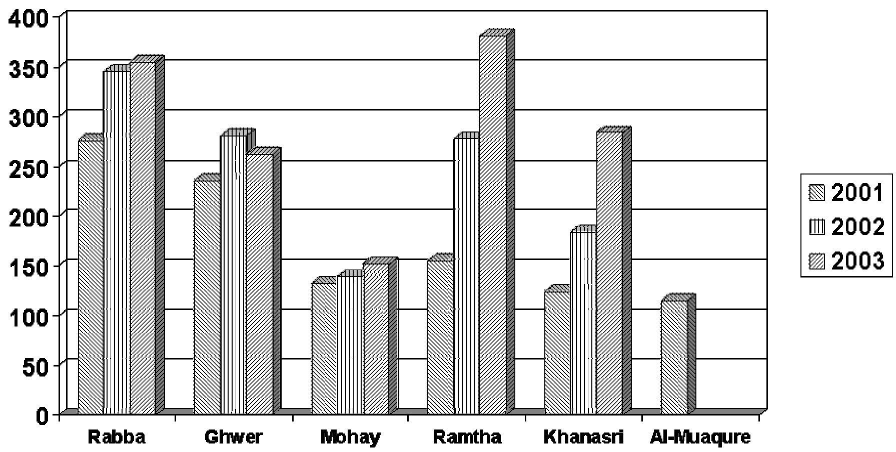

Fig. 3. Total annual rainfall in the locations used in the PPB project in Jordan (Al-Muaqure was only used in 2001).

1.3 Enhanced rate of adoption of new varieties through farmers' participation in selection and testing.

Selection of the participating farmers

The following methodologies were used to select, in each location, a group of farmers to perform the selections:

1. Meeting with the local community leaders such as the head of Municipality, societies chairmen, 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.

The process of selecting farmers consisted of (1) field visits (twice per site), (2) community meetings (20 farmers per meeting), and (3) direct contact by NCARTT and the Agriculture Directorate in the areas with a JOHUD representative. In each village the objectives of the project were discussed with the farmers before conducting selection in the field.

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. 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 year trials.

1.4 Identification of differences between selection criteria used by men and women farmers and by breeders.

The selection criteria between farmers and breeders were compared by calculating the correlations coefficients between the average score given by the farmers and by the breeders and the genotypic values (BLUPs) of the various characters measured at each location.

The similarity between the selections made by the farmers and the breeder in the research stations and the farmers field were also compared with the Euclidean distance for quantitative data. The advantage of the Euclidean distance over the Dice coefficient (used in the past to analysis similar data set) is the possibility of using the actual scores given by the farmers and the breeders without reducing them to an arbitrary 1 (selected) and 0 (discarded) matrix. The dendrograms of the various combinations of environments of selection and selectors were obtained by the unweighted pair group method with arithmetic average (UPGMA) cluster analysis. The dendrograms of the various combinations of environments of selection and selectors were obtained by the unweighted pair group method with arithmetic average (UPGMA) cluster analysis. These analyses were done using the program NTSYS-PC version 2.0 (Numerical Taxonomy System, Applied Biostatistics, N.Y.).

In addition to the Euclidean distance, a new methodology was introduced during the last two years of the project to analyze farmers' preferences. This is based on an application of the GGE biplot technique, in which the environments are replaced by the traits (Weikai Yan and I. Rajcan, 2002, Biplot Analysis of Test Sites and Trait Relations of Soybean in Ontario, Crop Science 42: 11-20).

The information on desirable barley characteristics as well as the benefits from growing barley was collected during group discussions with women in three sites, Ghweer, Rabba and Ramtha, using the participatory tools described under 1.1.1. During the discussions, they expressed their opinions about the best entries they would like to see in their respective areas. The information about the different uses of barley by-products was collected using the "Benefits Analysis Flow Chart (Buenavista and Flora, 1993)". The discussion with women started by asking them about the best characteristics of barley, and then, in the two sites where women actually did the selection, this information was related to the best 20 varieties visually selected by them before the harvest of 2002. The understanding of their choices was also linked to their ownership of livestock and to the market, which differed from one location to the other.

1.5 Disseminate experimental results through publications, scientific articles, visits of breeders from neighboring countries and traveling workshops.

The project activities were disseminated through the following publications, scientific articles, visits of breeders from neighboring countries and traveling workshops:

- Three Annual Project Reports to IDRC (copies attached)
- 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.
- 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.
- 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).
- 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.

- 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.
- The Director General of NCARTT has included Participatory Research in the new strategic Document of NCARTT-2002.
- Teaching at the University of Jordan has started including elements of participatory plant breeding.
- In March 2002, Dr. Ceccarelli gave lectures at the Training Course “Participatory Plant Breeding and Agrobiodiversity Conservation” held in Amman.
- 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.
- In September 2002 Dr. Ceccarelli attended the Workshop “The Quality of Science in Participatory Plant Breeding” held at IPGRI Headquarters, Rome, Italy.
- 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”.
- 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.
- 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.
- 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.
- The project activities are mentioned in the IDRC book “Seeds that give. Participatory Plant Breeding” by Ronnie Vernooy published in 2003.

2) RESEARCH RESULTS

2.1 Promote participatory plant breeding and assess the potential to institutionalize the approach in the barley breeding program in Jordan.

Results from the study of the current institutional structure of NCARTT

The study showed that the main constraint perceived by the barley researchers is that managers are not responding appropriately to the necessary research needs and demands. Therefore, managers at NCARTT should address this issue by responding to identified research needs and requirements. The study showed that the “annual employee work evaluation report”, the “management routine”, the “working hours”, and the “financial limitations” are not perceived as constraints on research.

Regarding the constraints related to the research operations at NCARTT, the study showed that the availability of workers, availability of computers, and the availability of laboratory analysis are not perceived as constraints on research. However, 50% of the participants consider climatic factors and lack of training as constraints for research, while only 10% of the participants identified the “clearance of strategic research plans” as a constraint for research at NCARTT. Only 10% of the participants consider “lack of knowledge of the new agricultural technology and “participating in data analysis” as a constraint for research.

Only 20% of the participants considered “knowledge and participating of the extension agent in the research activity” as research constraints, while 30% of the participants see “ the relationship with farmers” as a constraint for research. These perceived constraints could be of particular relevance to the problem of institutionalizing a participatory plant breeding approach in NCARTT, in addition to the major perceived constraint that managers are not responding adequately to the research needs and requirements.

The study revealed that the majority of research have a Masters degree and most have between six and fifteen years experience. Two-thirds of the scientists spend between 25 and 50% of their time working on-station (laboratory and office work), while one third spend 25-50% of their total working time working in on-farm trials. About half of the scientists spend some time working on PPB, while the other half work only on classical on-farm trials.

All the work done on PPB was initiated and introduced to NCARTT by ICARDA scientists. This approach is relatively new to many of the researchers interviewed; only 57% are aware of the approach. Researchers' definitions of the participatory breeding approach were diverse. The level of understanding of the approach was mixed, but it seems that by and large there is a good basis for further development. Some have understood the approach very well while others still need to be acquainted with more knowledge.

Most researchers considered that the approach offered good opportunities and that less time and effort are needed to produce varieties suitable to different environments with the participation of the concerned farmers. Also, researchers perceive that through farmer participation, research will reach the farmers' goals and the adoption potential would be higher. They anticipate many benefits from the approach although it is too early to assess real changes due to the short time of the project in Jordan.

It is important to note that most researchers who were involved in the PPB project have a satisfactory understanding of the participatory approach. However, some of them still need further training or exposure to the literature. Moreover, their understanding is limited to the use of participatory research methods breeding, and they were not aware that this approach is used in other fields such as research on natural resource management.

There was no formal training course on the PPB approach given to NCARTT researchers, they have learned by participating in the project. However, five have attended a training course on PPB given by Dr. S. Ceccarelli within a regional project on the conservation and use of agro-biodiversity.

There are certainly difficulties with such a multi-institution project and it was clear from this survey that clear mechanisms for cooperation between different institutions, such as Universities and NCARTT, should be part of the institutional framework that would make PPB work easier for collaborating scientists. This project has highlighted the difficulties that arise when multiple institutions are involved in one project. If Jordan is to use its research resources efficiently mechanisms and norms for inter-institution collaboration must be established

The researchers listed many problems that they face which are commonly found where national budgets and infrastructure facilities are limited. These difficulties included research facilities that are available at the headquarters are lacking in the other research stations, research inputs that are not provided at the right time except for special projects, etc. However, the main difficulties in implementing PPB perceived by researchers were:

- Lack of scientific information on PPB, indicated by 35% of the respondents, as only a few scientists had been exposed to the literature. Their participation in conferences and workshops on participatory research in order to improve the capacity of researchers is strongly recommended. It would be essential to invite a specialist in the field to organize brainstorming sessions and self-evaluation of NCARTT and University staff on the impact of research and ways that it can be improved through participatory research. Another recommendation would be inclusion of participatory research methods as part of the curriculum at the Universities. This will certainly increase the flow of knowledge on participatory research into agricultural research and development.
- Lack of cooperation between scientists and extension agents, indicated by 78% of the respondents. Extension agents are present only during field days organized by NCARTT. Scientists find themselves working both as scientists and extensionists at the same time, a situation that may be due to the separated directorates of research and extension. This requires much greater involvement of extension staff in participatory research if it has to be truly institutionalized.

Researchers have a positive perception of farmers' acceptance of the participatory research approach. It is perceived as an approach that has not completely changed the conventional research program, but has improved it dramatically. As a research strategy, researchers consider PPB to be encouraging and opening new horizons to improve breeding in general. Also, researchers reported that when involved in the research farmers feel more concerned about the results. PPB is perceived by farmers as the only way through which they can express themselves. For the first time farmers feel 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 concerned to work with scientists from the beginning. Furthermore, the fact that more farmers attend the meetings and activities of the PPB project shows that they are more interested in being involved. Farmers' acceptance of this approach depends on the level of exposure of these farmers to the whole exercise. Finally, in interviews with the Director General of NCARTT and the Director of Extension about the PPB project, both expressed their willingness to institutionalize the approach within their institutions, and have strongly recommended that ICARDA organize workshops for their staff in order for them to become better acquainted with the approach. They have 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.

The first indication that a process of institutionalization of participatory plant breeding is underway in Jordan was the decision by NCARTT to extend to wheat a program similar to the one currently implemented in barley. 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 will also be used as seed increase.

Livelihood analysis and community characterization

The information collected shows the major constraints affecting rural people and an understanding of the major concerns and livelihood strategies of people in those areas.

Barley and olives trees are grown in Mohay, with barley being more important than olives. Olive trees are irrigated (supplemental irrigation) during July and August. Olive picking takes place in November, and is followed by pruning, weeding and fertilizing during the month of December. In Rabba, in addition to cereals, legumes and olive trees are grown. Olive trees were also found in the other four locations. In three of the four locations (Mohay, Ghweer and Ramtha), barley is the most important crop (Table 2). In Rabba, wheat is more important than barley.

Table 2. Crops in an ascending order by degree of importance in the four villages

Mohay	**Ghweer**	**Rabba**	**Ramtha**
Barley	Barley	Wheat	Barley
Olive trees	Wheat	Barley	Wheat
	Olive trees	Lentil	Olive trees
		Chickpea	
		Olive trees	

Farmers in Mohay are also large livestock producers. They mainly rely on feeding the animals all year in addition to some periods of grazing that extend from March to June. During the same period, women perform all activities of milking, making ghee, *jamid*, cheese, and *laban*. Men shear animals during the month of May.

The main concern of the local communities is the unemployment of the young generation of both women and men. The young generation is educated and not willing to work in agriculture anymore. Therefore, the new technologies that are introduced in the village are meant mainly for the actual farmers and in the future imay remain in the hands of women if all educated men find a non-agricultural work. This raises the question of whether more emphasis should be given to women participation in the selection of new varieties than to men in the future participatory breeding work, and other participatory technology development.

Problems, solutions and aspirations, how communities sees them

In Ghweer, the problem diagnosis (by women) indicated that the main problem of rural people in Ghweer is associated with unemployment. The causes of unemployment in Ghweer are the scarcity of projects held by the Government, the scarcity of employment opportunities in the whole area, the scarcity of institutions that provide credits, *thaqafat el-'aib* which means that young people especially when educated refuse to work in some professions such as carpenter or ironsmith or agriculture. As a consequence, young people suffer from psychological problems, they look older than their real age, the age of marriage is delayed for both women and men because they cannot establish an independent household without a reliable income, the family cannot respond to some household needs such as education, the standard of living of the family decreases because the dependency ratio increases as a result of a larger number of consumers than of producers.

The solutions suggested by the local people are to provide essential needs at reasonable prices such as gas, kerosene and fuel oil, as well as sugar and other essential goods, and to provide work opportunities and health insurance to people in rural areas.

The mapping of the village resource by men in Ghweer shows that people rely mainly on governmental employment. Only one farmer living in the village has livestock, the others are Bedouins living outside the village.

The main problem stated by men in Ghweer is the lack of water for livestock producers, the lack of a secondary school for boys, and the lack of an Imam for the mosque. The causes of these problems according to men are the decline in rainfall during the last few years, the only well that provides water for animal producers is far from the areas of their flocks, the boys secondary school is located in Thania which is 5 km away from Ghweer. The effects of these problems are that the production costs are very high due to the high prices of water which reduces the profit from production, the high costs of education which leads to students sneaking away (out) of school, and selling part of the livestock due to the lack of sufficient amount of water.

The solutions suggested by the local people are building pipelines from the main well of the village to the area where most livestock producers are grouped, decrease the water prices from 0.5 JD to 30 cents, and consider upgrading the existing primary school in Ghweer to a secondary school.

In Mohay, the problem diagnosis conducted with men revealed that the main constraints are unemployment, lack of a health center and drought. Local people associated the lack of employment opportunities with the fact that their area is not well represented in governmental institutions. The lack of health center was also strongly stressed. The effects of the lack of health center are that there are more health problems in the area; reaching the closest health center (about 40 km away) requires additional time and money.In those case in which some work opportunities were created, the distance to the job was far and the income was only 70 JD, of which 30 JD are spent for transportation.

The solutions to these problems suggested by the local community are: to allocate an investor in the area to create work opportunities, to improve the small health center that already exists in the village, and to improve the water harvesting techniques through more investments.

In Rabba, the problem diagnosis (by women) indicated that unemployment followed by drought and the weaknesses of agricultural extension services are the main problems. The causes of these problems according to women are the lack of factories in the area, lack of vacancies for employment, lack of good connections at the governmental level and the absenteeism of the extension agents.

The unemployment causes difficulties for young people, both women and men, in getting married even when their have high education degrees because they have no job, migration of men outside the area - one PhD holder is employed in a Veterinarian cabinet and is paid 100 JD/month), psychological problems to men and women – a university degree holders works in the village as hairdresser to get additional income, but still *thaqafat el-Aib* is important.

The solutions suggested by the local people are to provide credits for activities generating small income, to open projects to create work opportunities, and to make credits available to people.

In Ramtha, the problem diagnosis conducted with women revealed that the main constraints farmers suffer from are unemployment of both women and men. This is the result of lack of projects in the area, and of drought (*mahl* in local language), and therefore most people rely on the salaries of their children in the Jordanian army. The irrigation of olive trees was also stated as one of the main problems in the area. Other problems include low productivity caused by drought (land produces every 10 years and is called '*ashrawiyeh*'); farmers are about to leave trees without irrigation because of water prices (from 400-600 JD every 3 months, which means that 50 trees cost 1000 JD/year); lack of projects in the area because the government wants to protect the environment (there was a factory producing soap that has been closed).

In conclusion, the project identified the major constraints and a clear understanding of the major concerns and livelihood strategies of people in those areas. Scientists should have a clearer understanding of the approach particularly for natural resource management.

Characteristics of sample farms

A pilot study was conducted in Irbid, Mafraq and Karak and was based on the interviewes of 51 farmers (Table 3). At the same time, 10 villages in the three provinces were surveyed. Irbid province is in the north of Jordan with an annual rainfall of 250-350 mm rapidly decreasing to less than 250 mm towards the east and increasing to more than 350 mm towards the south. Mafraq province is in the east of the country with an annual rainfall of less than 200 mm. Karak province is in the south of the country with an annual rainfall 300-350 mm rapidly decreasing towards the east.

Table 3. Distribution of sample by province.

Province	Frequency	Per cent
Irbid	15	29.4
Mafraq	8	15.7
Karak	28	54.9
Total	51	100

The majority of barley farmers (74.5%) are more than 50 years old, 15.7% are less than 40 years old, and the rest (9.8%) is 41-50 years old.

More than two-third (68.6%) of the farmers have less than secondary certificate as an educational level. This result is expected, because of their age (Table 4). Only 5% of the farmers completed their high education (diploma and university). Illiteracy amounts to 23.5%.

Table 4. Farmer educational level.

Educational level	Frequency	Per cent
Illiterate	12	23.5
Primary	16	31.4
Preparatory	7	13.7
Secondary	11	21.6
Diploma – University	5	9.8
Total	51	100

The average family is composed of 9 members (5 males and 4 females). About 27.5% of the households have more than 10 members. Only 10% of farmers are married with 2 wives according to Islam legislations (Table 5).

Table 5. Farmer family members and number of wives.

Item	Declaration
Average no. of male	5
Average no. of female	4
Average family size	9
% of farmers with one wife	90
% of farmers with two wives	10

The producers’ experience in agriculture ranged from 6 to more than 20 years, and their experience in barley cultivation ranged from 1 to more than 20 years (Table 6). The majority of farmers (56.9%) had more than 20 years agricultural experience, and 60.8% of them had more than 20 years experience in barley cultivation.

Table 6. Farmer experience in agriculture and barley cultivation.

Experience	In agriculture		In barley cultivation	
	Frequency	Per cent	Frequency	Per cent
1-5 years	0	0	2	3.9
6-10 years	6	11.8	7	13.7
11-15 years	6	11.8	6	11.8
16-20 years	10	19.6	5	9.8
More 20 years	29	56.9	31	60.8
Total	51	100	51	100

About 63% of the farmers are full-time operators, and the rest (37%) are part-time producers (Table 7). Only 2% of the farmers depend completely on animal production in their farming systems. An equal proportion of farmers (49%) implement either plant production activities, or both plant and animal production activities.

Table 7. Farmer job in agriculture and type of agricultural production.

Item	Frequency	Per cent
Farmer job		
Full time	32	62.7
Part time	19	37.3
Total	51	100
Type of agricultural Production		
Plant production	25	49
Animal production	1	2
Both	25	49
Total	51	100

Farm size ranged from 2 to 150 hectares with an average of 21 hectares. The average herd composition consisted of 93% sheep and 7% goat.

Private ownership is the predominant type of land tenure in the sample farms (65%), while rented or sharecropped land ownership represents 19% and 15%, respectively.

46.8% of farmers who cultivate their own land, grow barley in less than 5 ha, 21.4% in 6-10 ha, 17% in 11-20 ha, and the rest in more than 20 ha (Table 8). By contrast, the majority of farmers who rent land (71.6%) cultivate barley in more than 10 ha. Sharecropping cultivation is implemented by 11 farmers, half of them planted barley in less than 5 ha.

Table 8. Barley cultivated area according to land ownership.

Cultivated Area	Private ownership		Rented		Sharecropping	
	Frequency	%	Frequency	%	Frequency	%
≤ 5 ha	22	46.8	2	14.2	5	45.5
6-10 ha	10	21.4	2	14.2	1	9.1
11-20 ha	8	17.0	5	35.8	2	18.2
> 20 ha	7	14.8	5	35.8	3	27.3
Total	47	100	14	100	11	100

Objectives and reasons for producing barley

For the majority of farmers the low annual average rainfall is the main reason for producing barley (Table 9). They also believe that the areas receiving low quantities of rainfall with an erratic distribution are supposed to be planted with barley. About 23% of farmers indicated in the topography of the land the reason for planting barley, and a similar percent indicated that livestock production is the reason for producing barley. Other reasons are represented by soil type and traditions.

The majority of farmers (56%) are producing barley for trade, and only about one-third for feed production, and this is expected since they are involved in livestock production. Only 9% of farmers produce barley for seed, and 2% specifically to improve the income.

Table 9. Objectives and reasons for producing barley.

Item	Per cent
Reasons:	
Topography of land	23
Annual average of rainfall	43
Nature of agricultural activity (livestock)	22
Soil type	12
Objectives:	
Trade	42
Improving income	2
Feed production	24
Seed production	7

Family participation in producing barley

Family members participate in all phases of barley cultivation and production. The farmer participates in more than 50% of the activities needed in each phase of barley production. The males' family member participate in more than 70% of the activities. Females' participation ranged from 6 to 29% of the agricultural activities for producing barley. Females' participation is higher in sowing, weeding, harvesting, *tiben* and collection and storage of seed, and lower in marketing and land preparation.

45% of farmers stated that the family members participate in producing barley. This participation varied from one household to another; 24% of farmers referred that their wives participate in producing barley, while 12% and 41% of the farmers referred that their daughters and their sons participate in barley production, respectively.

Table 10 summarizes the information about family participation in producing barley. The percentages are listed according to the share of each family member in each phase of barley production.

Table 10. Family participation in producing barley.

Phase	Per cent (n-51)				
	Farmer	wife	daughters	sons	Total
Land preparation	66	5	5	24	100
Sowing	61	9	7	23	100
Weed control	55	19	10	16	100
Harvesting	49	16	11	24	100
Threshing	56	12	10	22	100
Tiben collection	56	13	10	21	100
Seed collection	53	11	8	28	100
Storage	51	12	7	30	100
Marketing	71	3	3	23	100

Households' perceptions of the difficulties they experience in producing barley

The majority of farmers (82.4%) associate the difficulties in barley cultivation with the rainfall fluctuations which determines wide fluctuations in production and area planted to barley (Table 11). About 60.8% of farmers complain about the low price of barley grains. The third difficulty in order of priority (49%) is the low productivity, followed by high prices of barley seeds (39.2), and difficulties in getting new technologies (agricultural machines) (19.6%).

Other difficulties were the low seed quality, the availability of improved and suitable seeds for local environments, lack of extension, and diseases.

Table 11. The difficulties the households experience in producing barley listed in order of priority.

Priorities of the difficulties	% of farmers respondents (n=51)
Fluctuations in rainfall	82.4
Low selling price of barley grains	60.8
Low productivity	49.0
High prices of barley seed	39.2
Difficulty in getting new technologies (machine)	19.6
Low seed quality	13.7
Availability of improved and suitable seeds for local environment	11.8
Lack of extension	9.8
Diseases	3.9

Knowledge of the source of barley seeds

The cooperative associations are the best know source for seeds distribution for 49.1% of farmers (Table 12). Local markets are a seed source for 21.6% of farmers, while neighboring farmers are a seed source for 19.6% of producers. NCARTT and the Ministry of Agriculture (MOA) are a source for

8% of farmers, and only one farmer (2%) uses his own barley seeds saved from the previous seasons.

Table 12. Knowledge sources of barley seed distribution.

Knowledge source	Frequency	Per cent
Cooperative association	25	49.1
Local markets	11	21.6
Neighboring farmers	10	19.6
NCARTT	2	3.9
MOA	2	3.9
Own-saved seed	1	2.0

MOA through the NCARTT undertakes variety maintenance, introduction of seed laws, seed quality control, and production of basic seed. The Jordan Cooperative Organization (JCO) organizes on-farm production, collection, processing, storage and marketing of certified seeds, while the University of Jordan has a seed technology unit within the Faculty of Agriculture to conduct seed technology research.

In the case of seed of improved varieties, neighboring farmers are the main source for other producers (62.7%) (Table 13). 54.9% of farmers obtained improved seed from the cooperative associations while field days, extension agents, and mass media are the sources of improved seed for 52, 50, 11.8% of the farmers, respectively.

Table 13. Knowledge sources of improved barley seeds.

Knowledge source	Per cent
Neighboring farmers	62.7
Cooperative associations	54.9
Field days	52.0
Extension agents	50.0
Mass media	11.8

Desirable characteristics in barley cultivars

High-quality seed is one of the cheapest production inputs in a crop-production system; the price of seed usually represents a small percent of the total input package needed to produce a good crop. If high quality seed of improved high-yielding varieties is used, farmers can expect, depending on the environmental conditions and crop management, a uniform crop which will produce a good yield.

The majority of farmers (81.7%) still prefer the traditional varieties A'rqadi, Arabi (Baladi) and Black (Table 14). The traditional varieties are cultivated in the three provinces (the targeted area) and they are the varieties most frequently grown by the farmers. Among the local varieites, the white seeded Arabi (Baladi) was preferred by 77.5% of barley farmers. Only 18.3% of producers preferred the improved varieties: 16.3 % Rum and 2% Acsad 176, respectively. About 75% of the farmers who preferred Arabi (Baladi) stated that their preference was due to its high productivity in grain and straw. On the other hand, drought resistance was the most frequently quoted reason for preferring the improved varieties (Rum and Acsad 176).

Table 14. The preferred varieties and criteria within the populations of barley cultivars.

Variety	% of farmers preferring the variety	The preferred criteria		
		Productivity	Straw quantity	Drought resistance
A'rqadi	2	5	12	7
Arabi (Baladi)	77.5	75	75	16
Black	2	4	8	20
Rum	16.3	12	3	27
Acsad 176	2	4	2	30
Total	100	100	100	100

The criteria used to distinguish between one variety and another are summarized in Table 15. One-fifth of the farmers stated that seed size is the main criterion for distinguishing among barley varieties, while row-type, plant height and grain color were indicated by 18, 15, and 14% of the farmers, respectively. About 12 and 11% of farmers used smothness of awns and spike length as criteria.

Table 15. Distinguishing criteria within the population of barley cultivars.

Criteria	% of farmers respondents (n=51)
Spike length	11
Grain color	14
Seed size	20
Softness of stem and leaf	5
Plant height	15
Number of rows	18
Softness of awn	12
Tillering	5
Total	100

Three characteristics are the most desirable in barley cultivars (Table 16). For the majority of farmers (78%) increasing plant height and the number of rows (from 2-row to 6-row) are the most desirable ways to improve barley. Those characteristics are desirable because they can cause an increase in the quantity of straw, and the higher return generated from the by-product will compensate the low return of grains. The improvement of seed size was ranked as second priority; about 12% of producers indicated the desirability to improve this characteristic to improve the productivity. Only for 10% of farmers an improvement in spike length is desirable.

Table 16. Desirable characteristics in barley cultivars.

Characteristics	Frequency	Per cent
Plant height and number of rows	40	78
Seed size	6	12
Spike length	5	10
Total	51	100

Activities of household applying agricultural practices in barley fields

The main agricultural practices applied in barley fields are shown in Table 17. The majority of farmers has mechanized the land preparation, and only 2 farmers in the sample used traditional land preparation methods. Chisel and disc ploughs are the predominant ploughs used in tillage. About 53% of farmers used manual methods in barley cultivation, 41% used mechanical methods, and the rest used both.

The majority of farmers used the strategy of early (dry) planting (86%) and used a crop rotation (69%) which was either a fallow-barley (49%) or a continuous barley (41%). About 55% of producers indicated that they did not change the pattern of barley cultivation. Reasons for not changing are tradition (43%), rainfall shortage (32%), not-adoption of new technologies (18%), and no land ownership (7%).

Among the farmers who did change, adoption of new technologies and rainfall pattern were the reasons for 87 and 13% of farmers, respectively. Only 29% of farmers added an average of 72 kg/ha of chemical fertilizer before planting. None of them added organic fertilizer or manure.

One-fifth of farmers sprayed herbicides, and none of them use pesticides or fungicides. Among the 51 sample farms, 25 producers use mechanical harvesting, 10 producers use manual harvesting, 8 producers use both, and the rest left their field for grazing. About 84% of farmers marketed their production to governmental stores, 4% to merchants, and 12% keep the production for their livestock. About 61% of farmers stored an average of 28.2% of their production.

Table 17. The main activities of household applying agricultural practices in barley fields.

Agricultural practices		Frequency	Per cent
Land preparation			
	- Tradition	2	4
	- Mechanical	49	96
	* Chisel plough	25	51
	* Disc plough	21	43
	* Both	3	6
Planting method			
	- Manual	27	53
	- Mechanical	21	41
	- Both	3	6
Date of cultivation			
	- Before rainfall	44	86
	- After rainfall	7	14
Crop rotation			
	- % of use	35	69
	* Fallow / barley	18	51
	* Continuous barley	15	43
	* Fallow / legume / barley	2	6
Pattern of cultivation			
	- Change	23	45
	- Not change	28	55
	* *Reasons for change*		
	- Pattern of rainfall	3	13
	- Adopting new technologies	20	87
	* *Reasons for unchanged*		
	- Shortage of rainfall	9	32
	- Land not owned	2	7
	- Not adopting new technologies	5	18
	- Tradition	12	43
Fertilizer			
	- *Farmers added fertilizer*	15	29
	* Organic fertilizer	-	0
	* Chemical fertilizer	15	100
	* Average use of chemical fertilizer	72 kg/ha	
	- *Time of addition*		
	* Before planting	14	100
	* After planting	-	0
Pesticides			
	- *Farmers sprayed pesticides*	10	20
	* Herbicides	10	100
	* Pesticides	-	0
	* Fungicides	-	0
Harvesting			
	- Manual	10	20
	- Mechanical	25	40
	- Both	8	16
	- Grazing	8	16
Marketing			
	- Governmental stores	43	84
	- Merchants	2	4
	- Keep for livestock	6	12
Storage			
	- Farmers store the production	31	61
	- Average		28.2%

End-uses of barley product and by-product

Table 18 summarizes the end-uses of barley grain and barley by-products (tiben, straw and grazing). About 47% of farmers sell the barley grain, 39% of them use it for feed and the rest (14%) use part for sale and part for feed. Tiben and straw were sold by 46% of the farmers. The same percent of farmers used tiben and straw for feed, and 8% of them use part for sale and part for feed. The majority of farmers (57%) rented their fields after harvesting and bailing (*A'qeer*), and 43% of them left their fields for grazing by owned herd. About 49% of farmers utilized the by-product (tiben and straw) by direct grazing. Among the 51 farmers sampled, 5 producers use barley grain for medicinal purposes, 1 use barley straw in hand industries, and 3 use barley grain as food.

Table 18. End –use of barley product and by-product.

Item	% of farmers respondents	% of use from product or by-product
Grain		
- Selling	47	77
- Feed	39	33
- Both	14	-
Tiben and straw		
- Selling	46	63
- Feed	46	37
- Both	8	-
Grazing after harvesting and balling (A'qeer)		
- Ranted	57	74
- Grazed by owned herd	43	-
Direct grazing	49	-

Role of women in barley cultivation

The data used to analyze the role of women in barley cultivation were obtained by personal interviews to 24 female farmers in the targeted areas. The majority of women (70.8) are more than 50 years old, and none of them is less than 45 years old (Table 19).

Table 19. Age of women farmers.

Age interval	Frequency	%
40 – 50 years	7	29.2
51 – 60 years	11	45.8
61 and move	6	25.0
Total	24	100

Women more than 40 years old were mostly illiterate, while the younger generation of girls is expected to enjoy better access to education. The majority of women in the sample (62.5%) were illiterate, one-third of them have elementary certificate, and the rest (4.2%) have preparatory certificate (Table 20). None of the women have secondary or higher education.

Table 20. Women educational level.

Educational level	Frequency	Percent
Illiterate	15	62.5
Elementary	8	33.3
Preparatory	1	4.2
Total	24	100

Women participate in all phases of barley cultivation and production. The degree of participation varied from one activity to another. Among the 24 women interviewed, 6 participate in seed treatment, 10 in hand planting, 2 in fertilizer apllication, 23 in harvesting, 6 in marketing activities, and 13 in threshing.

The two activities with the larger women participation were seed treatment (averaged of 58.3%, ranging from 30 to 100%), followed by planting, fertilizer application, harvesting, marketing, and threshing with 54%, 50%, 35%, 58%, 42%, respectively (Table 21).

Table 21. Women participation in producing barley.

Phase	Percent of participation
Seed treatment	58
Seed sowing	54
Fertilization	50
Harvesting	35
Marketing	58
Threshing	42

The barley cultivars best-known to women are baladi, arabi, a'rqadi, Rum and Acsad 176. Relatives and neighboring farmers are the main knowledge source of barley cultivars (45.8%) (Table 22). About 37.5% of women learned about varieties by themselves, and only 4.2% of them indicated that they learned about varieties from their husbands.

Table 22. Knowledge source of barley cultivars.

Knowledge source	Frequency	Percent
Relatives & neighbors	11	45.8
Self experience	9	37.5
The husband	1	4.2
Extentionists	1	4.2
Mass media	2	8.3
Total	24	100

All women preferred traditional varieties as the men did. The local variety arabi was preferred by half of women, while 45.8 and 4.2% preferred baladi and kanari cultivars, respectively (Table 23). The most preferred cultivars were cultivated by 58.3% of the women, while the rest (41.7%) were not in the position to decide which variety to cultivate. About 66% of women preferred the local variety arabi because of its high productivity, while 59% preferred baladi variety due to quantity of straw.

Table 23. The preferred varieties and criteria within the populations of barley cultivars.

Variety	% of women preferring the variety	The preferred criteria	
		Productivity	Straw quantity
Arabi	50	66	31
Baladi	45.8	24	59
Kanari	4.2	10	10
Total	100	100	100

The main criteria to distinguish among barley varieites were spike length (33%), seed size (19%), and awn smoothness (19%). Other criteria were grain color, softness of stem and leaf, and row-type (Table 24).

Table 24. Distinguishing criteria within the population of barley cultivars.

Criteria	% of women respondents
Spike length	33
Seed size	19
Awn smoothness	19
Grain color	12
Softness of stem and leaf	10
Number of rows	7
Total	100

To 58.3% of women productivity of grain and straw are the most desirable characteristics to improve, while 16.7% of them prefer cultivars that are easy to harvest (Table 25). Spike length, seed size, softness of stem and leaf, awn softness are the other desirable characteristics.

Table 25. Desirable characteristics within the populations of barley cultivars.

Characteristics	Frequency	Percent
High productivity of grain & straw	14	58.3
Easy for harvesting	4	16.7
Seed size	2	8.3
Awn smoothness	2	8.3
Spike length	1	4.2
Softness of stem & leaf	1	4.2

About 21% of women sold the barley grain, 54% of them use it as feed, and the rest use the grain both for sale and for feed (Table 26). The tiben and straw were utilized by 30% of women for sale, by 45% of women for feed, and by 25% of them for both. The majority of women (92%) rented barley fields after harvesting and bailing (*A'qee*r), Half of women utilized tiben and straw through direct grazing.

Table 26. End-use of barley product and by-product.

Item	% of farmers respondents (n=24)
Grain	
- Selling	21
- Feed	45
- Both	25
Tiben and Straw	
- Selling	30
- Feed	45
- Both	25
Direct grazing	50
Grazing after harvesting & bailing (A'qeer)	
- Rented	92
- Grazed by own herd	8

The participation of 62.5% of women in field days related to barley cultivation, confirmed the importance of the socio-economic role of women in barley production. These activities were mainly organized by local institutions (governmental and private). One woman participated in field days organized by a regional organization. Among the 24 women, 20.8% considered shortage of rainfall and its erratic distribution an obstacle in barley cultivation. They also indicated that this obstacle could be ovecome by early planting. 58.3% of women indicated that lack of agricultural machine is the main obstacle, while for 17 and 4.2% of women the main obstacles are the insufficient quantities available of improved seed, and the high price of inputs (Table 27).

Table 27. Obstacles facing women in producing barley.

Obstacle	Frequency	% of farmers
Shortage of rainfall	5	20.8
Lack of agricultural machines	14	58.3
Insufficient quantities of improved seed	4	17
High price of inputs	1	3.9
Total	24	100

2.2 Improved barley varieties that fulfill the needs of poor farmers in the rainfed environments of Jordan.

Although different material was grown each year in the Farmer Initial Trials, the average yield of this trials, assuming the breeding lines as a random sample, can be used as a good indication of the overall performance of barley in relation to the amount of rainfall and rainfall distribution which together with temperature and input levels are the main factors limiting yield levels. The biological yield, the grain yield and the harvest index (Table 28) show that 2003, the year with the highest rainfall in almost all locations (except Ghwer) was also the year with the largest biomass and grain yield (except Ghwer). The locations with consistently higher yields were Rabba and Ramtha, while those with the lowest yield were Mohay and Khanasri. With the exceptions of Ramtha 2003, all locations were characterized by a very low harvest index. This suggests that one common problem in Jordan is terminal stress, probably a combination of drought and temperature stress, that does not allow to translate the large investment in dry matter into grain yield.

Table 28. Mean biomass (kh/ha), mean grain yield (kg/ha) and harvest index (hi) of 181 breeding lines grown in seven locations and three years (the lines are different each year).

	2001			2002			2003		
Location	Biomass	Grain yield	hi	Biomass	Grain yield	hi	Biomass	Grain yield	Hi
Gweer F	3500	644	0.19	3851	884	0.20	2968	663	0.24
Gweer_S	2959	680	0.26	3569	736	0.18	3589	333	0.09
Khanasri	287	-	-	1697	353	0.20	5891	1405	0.24
Al-Mohay	928	140	0.15	900	189	0.21	1676	161	0.09
Rabba	3651	913	0.28	5841	973	0.16	3591	2766	0.23
RamthaE	1287	69	0.06	4473	1237	0.28	6201	2943	0.47
RamthaW	3272	521	0.16	4541	1654	0.36	5476	2722	0.50

There were large genotype x environment interactions effects which ranged from more than 70% in 2002, to more than 80% in 2001 and 2003 (Table 29). As a consequence genotype effects were about a quarter of the total variance of standardized data, or less.

Table 29. Two-way analysis of variance of the standardized grain yields in the FIT grown in 2001, 2002 and 2003.

Source		2001		2002		2003	
	DF	MSQ	(%)	MSQ	(%)	MSQ	(%)
Genotypes	180	1.160	19.34	1.897	27.10	1.339	19.13
Environments	6 (*)	0.000	0.00	0.000	0.00	0.000	0.00
G x E interaction	1080 (*)	0.968	80.66	0.850	72.90	0.943	80.87

* in 2001 the df were 5 (genotypes) and 900 (g x e interaction)

The biplots (Fig. 4) show that some of relationships between locations contributing to the Genotype x Environments effects were repeatable across years. For example, Ramtha East (RA_E) and Ramtha West (RA_W) were weakly correlated in 2001 and nearly independent in both 2002 and 2003. Also Rabba (RAB) and Mohay (MO), although very different in biomass yield and grain yield, from the point of view of discriminating amongst genotypes, appear closely correlated in all three cropping seasons. Khanasser (KH) seems to be more unpredictable: in 2002 it was different from all the other locations, in 2001 it was correlated with Mohay, the farmer field at Ghwer (GW_F) and Ramtha East, while in 2003 it was correlated with the research station at Ghwer (GW_S) and Ramtha East. Therefore the interaction between Mohay and Ramtha East shows some degree of repeatability. The relationship between the research station and the farmer field at Ghwer was very close in 2001, but a much looser one in both 2002 and 2003, even though it was possible to identify some common winners.

This type of analysis can reveal similarities between target environments from the biological point of view, but while in a conventional non-participatory breeding program, locations which show a high degree of repeatable lack of interaction can be deleted based on the results of this type of analysis, in a participatory breeding program this information needs to be combined with farmers' preferences.

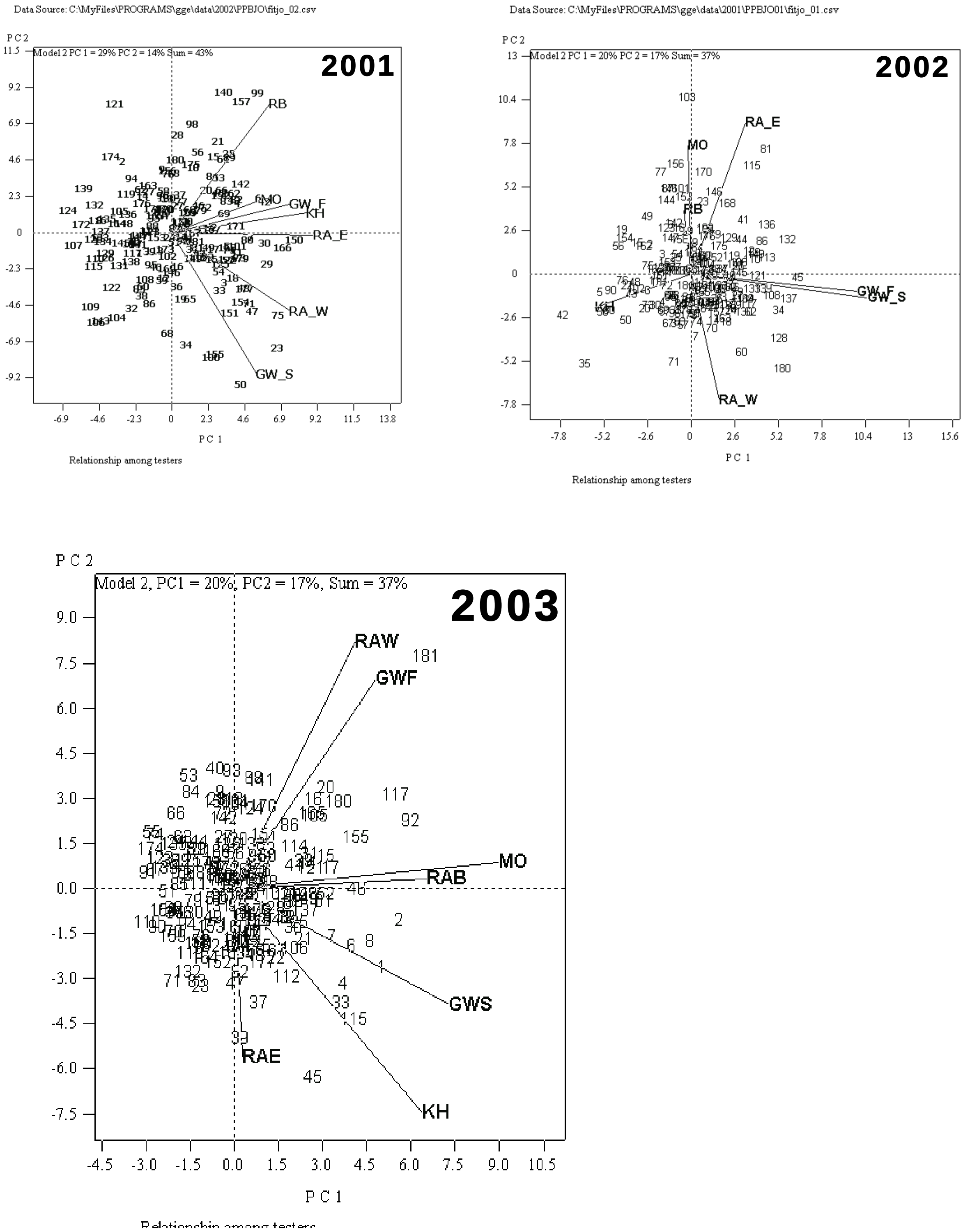

Fig. 4. Biplot of grain yield of 179 entries and two checks grown in the initial yield trials (FIT) in seven locations in Jordan (Gw_F = Gweer, farmer; Gw_S = Gweer, research station; Mo = Mohay; Kh = Khanasser; Ra_E = Ramtha East; Ra_W = Ramtha West; Rb = Rabba.) in 2001, 2002, and 2003.

There were several lines out yielding the best check at nearly all locations in each of the three years (Table 30, 31 and 32). In 2001 the number of lines out yielding the local check, which out yielded Rum in five of the seven locations, ranged from 41 to 180. Only in Ghwer and Ramtha West out yielding the checks proved to be difficult. In 2002, the local check out yielded Rum in five of the seven location, and the number of lines out yielding either the local or the best check was much larger than in 2001, ranging from 21 in Ghwer to 98 in Rabba. Eventually, in 2003, Rum out yielded the local check everywhere except Rabba, and no lines were found that out yielded Rum in Ghwer and Ramtha West and only one was found in Rabba. This fits with the general pattern by which local varieties do better that modern varieties in dry years and/or dry locations, while the opposite is true in wet years and wet locations.

It is interesting that in locations considered to be very difficult for plant breeding, such as Khanasri and Mohay, with each cycle of breeding material a large number of lines out yielded both the local and the best check.

Table 30. Grain yield of the highest yielding entry in each location, number of entries yielding more than the best check and the local check, heritability, and mean yields of the local check and the improved released cultivar Rum in 2001.

Entries	**Ghwer**	**GhwerSt**	**Khanasri***	**Mohay**	**Rabba**	**RamthaE**	**RamthaW**
best line	784	1179	299	290	1289	435	665
Lines > best check	1	41	149	106	41	105	3
Lines > local check	1	41	149	167	41	180	3
Heritability	0.3	0.54	0.05	0.51	0.54	0.89	0.06
Checks							
Local check	781	810	283	83	989	5	647
Rum	610	735	274	126	755	27	480

***** biomass yield

Table 31. Grain yield of the highest yielding entry in each location, number of entries yielding more than the best check and the local check, heritability, and mean yields of the local check and the improved released cultivar Rum in 2002.

Entries	**Ghwer**	**GhwerSt**	**Khanasri**	**Mohay**	**Rabba**	**RamthaE**	**RamthaW**
best line	2090	1196	941	335	1418	1615	2513
Mean	884	736	353	189	973	1237	1654
Lines > best check	21	57	80	36	28	22	95
Lines > local check	21	57	80	36	98	97	95
heritability	0.04	0.32	0	0.38	0.26	0.36	0.69
Checks							
Local check	1225	803	360	212	957	1223	1628
Rum	835	540	295	153	1073	1398	1399

Table 32. Grain yield of the highest yielding entry in each location, number of entries yielding more than the best check and the local check, heritability, and mean yields of the local check and the improved released cultivar Rum in 2003.

Entries	**Ghwer**	**GhwerSt**	**Khanasri**	**Mohay**	**Rabba**	**RamthaE**	**RamthaW**
best line	742	935	2764	405	1131	4886	3389
Mean	663	333	1405	161	832	3057	2722
Lines > best check	0	59	74	44	1	70	0
Lines > local check	0	59	118	51	1	79	0
Heritability	0.057	0	0.493	0.481	0.274	0.595	0.219
Checks							
Local check	630	371	1220	178	1119	2990	3379
Rum	742	395	1464	184	993	3057	3389

The heritability values were variable, ranging from very low (very low or zero estimates were found in Khanasri and Ramtha West in 2001, in Ghwer (farmer field) and Khanasri in 2002, and in Ghwer (farmer field and research station) in 2003. There was no obvious relationship between the magnitude of heritability and the yield level. Mohay, which was consistently one of the lowest yielding locations, had heritability ranging from 0.38 to 0.51. This confirms earlier finding from an experiment conducted in Syria and Jordan (Al Yassin et al., submitted). The heritability values of the two lowest yielding sites

(Khanasser and Mohay) together with the information provided by the GGE analysis (Fig. 4), suggest that Mohay could be a better selection site for drought tolerance because is reasonably correlated with Khanasser, but with consistently higher heritability estimates.

The most significant output of the project were nine lines (Fig. 5) which out yielded Rum as average of the three years of testing between 6 and 56%. The name and pedigree of the lines with the overall yield advantage over Rum is shown in Table 33.

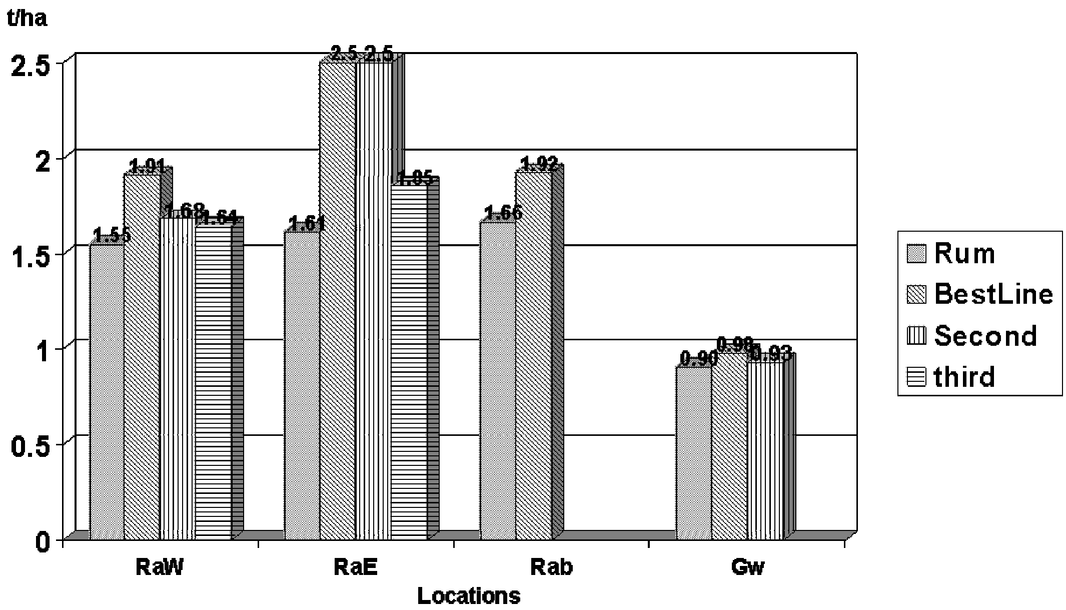

Fig. 5. Nine lines which out yielded Rum as average of 2001, 2002 and 2003 (names are in table 33.

Table 33. Names of the lines which outyielded Rum across the three years of testing.

Location	Name	Yield advantage
Ramtha W	Moroc9-75/ArabiAswad//WI2291/WI2269	6.4
	Mo.B1337/WI2291//Moroc9-75	8.9
	Clipper/Volla/3/Arr/Esp//Alger/Ceres362-1-1/4/Hml	23.6
Ramtha E	Shyri-3/4/Rhn-08/3/DeirAlla106//DL71/Strain205	56.0
	Mo.B1337/WI2291//Moroc9-75	55.6
	Sara	15.5
Rabba	Felicie/4/WI2269/3/Roho//Alger/Ceres362-1-1	15.7
Ghwer	Harmal	8.5
	SLB05-96/Arta	3.3

These nine lines will be tested in large scale for one additional cropping season and the best two submitted for official release.

2.3 Enhanced rate of adoption of new varieties through farmers' participation in selection and testing.

During the first year of the project, 61 farmers participated in the germplasm selection process. The characteristics of the selected farmers in each site were reported in the Annual Report 2000.

In each village, between 6 and 11 farmers conducted the selection when the crop was close to full maturity, using a scoring method from 0 = discarded to 4 = the most desirable. During selection some farmers were assisted by a researcher to record both quantitative and qualitative data.

In total, 56 farmers in 2001, 87 in 2002 and 67 in 2003 participated in the selection process (Fig. 4). The number of women who participated in the selection was 16 in 2002 and 4 in 2003, while 16 farmers participated in the selection in the wheat trials in 2003.

Two or three barley breeders conducted the selection at the same time of the farmers' selection, but independently from them, or shortly after.

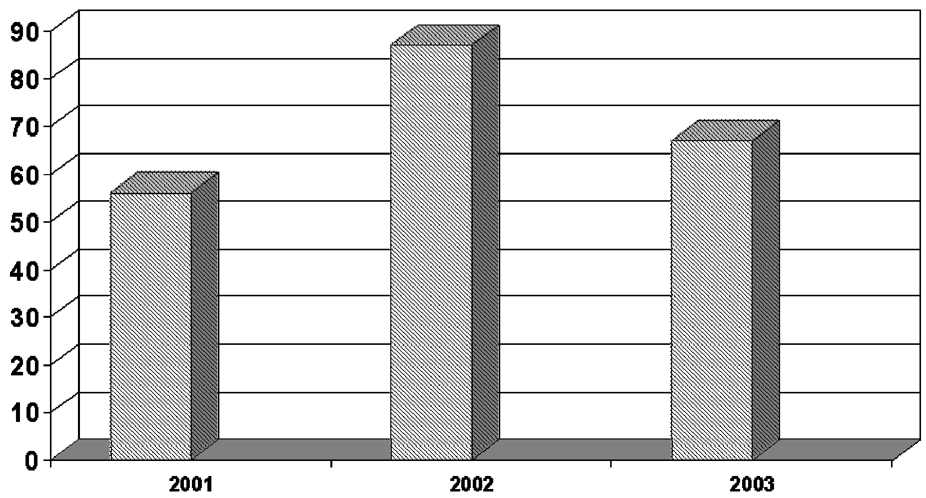

Fig. 4. Total number of farmers (males and females) who participated in the selection in the three years of the project.

As a result of farmers' selection (both visual and based on quantitative data, 42 of the 179 entries tested in the initial yield trials (FIT) of 2001 were selected. Of these, only 7 were selected in two locations, while all the others were selected in only one location. The selection criteria of the 42 entries are summarized in Table 12. More than 65% of the entries were visually selected by the farmers; of these, about 25% were also selected for either grain yield, or biomass yield or plant height. Eventually 33% of the entries were selected only on the basis of the quantitative data provided to the farmers at the time of the final selection.

Table 34. Selection criteria used in the selection of the entries promoted to the 2002 trials.

Selection criterion	Number of entries	%
Farmers' Visual Selection	17	40.48
Grain Yield	13	30.95
Grain Yield + Visual Selection	9	21.43
Biomass	1	2.38
Biomass + Visual Selection	1	2.38
Plant height + Visual Selection	1	2.38

The selected entries were arranged in five Advanced Yield Trials (FAT) planted at Rabba (11 entries), Mohay (9 entries), Khanasri (8 entries), Ramtha (10 entries) and Ghwer (11 entries). In each location the improved cultivar Rum was added as a common check. The trials were replicated (2 reps) and had large plots (8 rows at 25 cm distance and 50 m long). In total there are 12 Advanced Yield Trials, two in Rabba, two in Mohay, one in Khanasri, four in Ramtha, and three in Ghwer. In addition to the advanced yield trials, one additional trial per location was planted with all the entries selected in the other locations. This trial will allow farmers to evaluate the entries selected in other locations, and the scientists to assess the spectrum of adaptation of the selected entries.

A new set of FIT (each with 179 entries and 21 checks) were planted in the same locations as last year (Ramtha East, Ramtha West, Rabba, Ghwer, Khanasri, Mohay) and in one research station (Ghwer). These trials are conducted as in 2001, namely unreplicated with a different randomization in each location. A major change was the exclusion of entries with black seed, which do not meet the interest of the farmers.

As a result of farmers' selection (both visual and based on quantitative data) in the FAT, 18 genetically different entries were selected for testing in the FET in 2003 (Table 36). Only one line was selected in two locations (Ramtha East and Ramtha West). Of the selected lines, only one had black seed, and only 3 were six-row, indicating a strong farmers' preference for two-row white-seeded types. 10 Farmers will grow the FET in 2003.

From the FIT 2002, 53 genetically different entries were selected (Table 37). Of these, only 6 were selected in two locations, while all the others were selected in only one location. The majority of the selections were two-row while, as mentioned earlier, there was no variation for seed color since all the entries in the FIT 2002 were white seeded.

Table 35. Number, row type and seed color of the FAT lines selected by the farmers for testing in the FET in 2003.

Location	Number of entries	Farmers	Row type		Seed color	
			Two	Six	White	Black
Gweer	4	2	4	0	4	0
Khanasri	3	1	3	0	3	0
Mohay	4	1	3	1	3	1
Rabba	3	2	2	1	3	0
Ramtha East	3	2	2	1	3	0
Ramtha West	3	2	3	0	3	0

Table 36. Number, row type and seed color of the FIT lines selected by the farmers for testing in the FAT in 2003.

Location	Number of entries	Farmers	Row type	
			Two	Six
Gweer	10	2	10	0
Khanasri	8	2	7	1
Mohay	8	2	7	1
Rabba	13	2	13	0
Ramtha East	11	2	11	0

2.4. Identification of differences between selection criteria used by men and women farmers and by breeders.

Most of the information on the differences between selection criteria used by men and women farmers and by breeders were derived by the correlation coefficients between the scores given by the three types of participants and the blups of the various traits which were measured in the field. We also examined the correlation coefficients between the score given by the three participants (Tables 37 and 38).

There were several positive and significant correlation coefficients between participants' score and plant height at all locations (Table 38), indicating that in the majority of the cases the participants selected for taller plants. However, there were two interesting exceptions: in the farmer's field in Ghwer in 2002 the women selected for shorter plants, while in Rabba in 2001 the breeder selected for taller plants while the farmers selected for shorter plants. the research station in Gweerand Ramtha East in the case of grain yield.

The correlation coefficients between participants' scores and grain yield were significant in about half of the cases. Usually but not always, when the correlation coefficients between participants' scores and grain yield was significant, also the correlation coefficients between participants' scores and biomass yield was significant. There were 15 comparisons between farmers and breeders: in nine comparisons the farmers' scores were more closely associated with grain yield than breedrs' scores, and even if the differences were significant in only two cases (farmers field and research station at Ghwer in 2001) this indicates that the visual selction of the farmers is not less effective in identifying the highest yielding breeding material than the visual selection of the breeder.

Table 38. Correlation coefficients between farmers scores (fs), breeder score (bs) and women score (ws) and plant height (ph) grain yield (gy) and biological yield in 2001, 2002 and 2003 (in bold are those significant at P < 0.01, in italics those significant at P < 0.05).

Location		**Ph**			**gy**			**by**		
		2001	**2002**	**2003**	**2001**	**2002**	**2003**			
Ghwer F	Fs	0.135	**0.235**	**0.378**	**0.340**	0.100	*0.174*	**0.255**	0.134	**0.249**
	bs	0.134		**0.394**	0.004		**0.251**	0.057		*0.168*
	ws		**-0.193**			**0.222**			0.079	
Ghwer_S	Fs	**0.692**	**0.283**	**0.543**	**0.391**	*-0.154*	**0.496**	**0.390**	0.027	*0.170*
	bs	**0.633**		**0.519**	*0.157*		**0.493**	0.106		*0.163*
	ws		0.108		-	-0.047			0.026	
Khanasri	Fs	**0.628**	**0.598**	*0.175*		**0.289**	**0.460**	**0.392**	**0.367**	**0.293**
	bs	**0.592**	**0.576**	0.054		**0.303**	**0.393**	**0.320**	**0.368**	*0.159*
	ws			0.018			0.104			*0.156*
Mohai	Fs	**0.558**	0.128	**0.498**	**0.415**	**0.294**	**0.386**	*0.166*	**0.278**	**0.302**
	bs	**0.628**		**0.417**	**0.285**		**0.365**	0.035		*0.186*
Rabba	Fs	**-0.538**	**0.484**	**0.386**	*0.170*	**0.405**	0.017	-0.061	**0.420**	0.061
	bs	**0.535**	**0.513**		*0.149*	**0.317**		*0.164*	**0.362**	
	ws		**0.482**			**0.354**			**0.404**	
RamthaE	Fs	**0.497**	**0.299**	**0.231**	**0.721**	0.052	**0.211**	**0.552**	0.080	**0.254**
	bs	**0.471**	0.064	0.128	**0.646**	0.013	**0.191**	**0.558**	0.046	*0.199*
	ws	-	-	*0.178*			0.064			0.099
RamthaW	Fs	**0.479**	**0.448**	-0.017	**0.230**	0.010	0.065	**0.275**	0.059	0.069
	bs	**-**	**0.585**	0.076		-0.045	0.032		0.023	0.060
	ws	-	-	0.090			0.132			*0.167*

level of significance: r = ± .146 (P<0.05) ; r = ± .191 (P<0.01)

In the case of the other two traits, spike length and kernel weight (Table 39), the number of significant correlation was less than in the case of plant height, grain yield and biomass. In the case of spike length, all the significant correlation coefficients were also postitve indicating a preference (expected) for breeding material with a long spike because this is associated with an expected higher number of kernels per unit area. In most case there was uniformity amongst participants, even though in some cases (Khanasri 2003, Ramtha East 2002, and Ramtha West 2002) there were differences in the strenght of the association between spike length and the score given by the farmers or the breeder. In the case of kernel weight, only few correlation coefficients were significant, but they indicated strong differences between the participants. For example, in the farmer' field in Ghwer and in Rabba in 2001, only the farmers' score was significantly correlated with kernel weight, while in the research station in Ghwer in 2001 and 2003, only the breeders' score was significantly, but negatively in 2001 and positively in 2003, correlated with kernel weight, in Ramtha West in 2003 only the farmers' score was significantly and negatively correlated with kernel weight. Eventually, in 2002 in the farmer field in Ghwer, only women selection was significantly correlated with kerlen weigth.

In general there was a positive and significant correlation between farmers' scores and breeders' scores as well as between men and women. However, out of six correlation coeffieicnts between men and women, two were not significant (Ramtha East and West 2003), three were significant but were much lower than the correlation coefficients between farmers and breeders Ghwer farmer's field and research station 2002, and Khanasri 2003), and only one (Rabba 2002) was of the same magnitude as those between farmers and breeders.

Table 39. Correlation coefficients between farmers scores (fs), breeder score (bs) and women score (ws) and spike lenght (sp), and kernel weight (kw) in 2001, 2002 and 2003 (in bold are those significant at P < 0.01, in italics those significant at P < 0.05).

		Sp			Kw			Fs		
		2001	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
	Fs	0.136	-0.009	0.083	*0.159*	0.136	*0.184*			
	Bs	0.017		0.012	-0.089		*0.182*	0.011		**0.625**
	Ws		0.069			**0.298**			**0.354**	
Ghwer_S	Fs	*0.162*	-0.14	**0.491**	-0.090	-0.130	*0.163*			
	Bs	0.069		**0.490**	**-0.259**		**0.193**	**0.674**		**0.846**
	Ws		0.15			*0.151*			**0.376**	
Khanasri	Fs	-	**0.323**	*0.172*	-	-0.064	-			
	Bs	-	**0.261**	**0.246**	-	-0.019	-	**0.796**	**0.744**	**0.630**
	Ws			0.053			-			**0.193**
Mohai	Fs	**0.350**	**0.258**	0.117	**0.353**	0.059	-			
	Bs	**0.371**		0.023	**0.250**		-	**0.703**		**0.576**
Rabba	Fs	0.038	0.077	0.220	**0.515**	0.145	-0.040			
	Bs	0.016	0.03		-0.182	0.085		0.039	**0.796**	
	ws		0.034			0.131			**0.784**	
RamthaE	Fs	-	**0.302**	-0.065	**0.613**	0.036	-			
	bs	-	*0.183*	-0.055	**0.464**	-0.022	-	**0.746**	**0.829**	**0.213**
	ws			-0.015			-			0.105
RamthaW	Fs	**0.424**	*0.168*	0.015	**0.418**	**-0.256**	-			
	bs		**0.281**	-0.086		-0.133	-		**0.768**	**0.362**
	ws			-0.031			-			0.009

level of significance: r = ± .146 (P<0.05) ; r = ± .191 (P<0.01)

IV. OUTPUTS

Outputs in 2000

- Results from a study of the current institutional structure of NCARTT.
- A total of 61 farmers selected to participate in the germplasm selection process and their characteristics recorded.
- Two hundred lines planted in trials in each of seven farmers' fields and in the research station.
- 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.
- 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.

Outputs in 2001

- The Director General of NCARTT, and the Director of Extension have been interviewed about Participatory Barley Breeding Project. They 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. Results from a study of the current institutional structure of NCARTT.
- Most scientists who were involved in the project have a satisfactory understanding of the participatory approach. However, some of them still need either to read about the approach or be more involved into training courses related to participatory research. Also, their understanding is

limited to its use in breeding, and do not know that this approach is used in other fields such as the management of natural resources.

- A total of 56 farmers participated in the germplasm selection process and their selection criteria recorded.
- Five scientists and five farmers visited the participatory barley breeding program in Syria in May 2001.
- Breeding lines able to give an economic yield with 140 mm rainfall were identified.
- Two types of trials were implemented, one (FIT) with two hundred lines planted in each of seven farmers' fields and in the research station, representing the initial breeding material, and one (FAT) with the selection of the previous FIT and planted in 12 fields.
- 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).
- 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.

Outputs in 2003

- A total of 95 farmers (including 17 women) participated in the germplasm selection process and their selection criteria recorded.
- Three types of trials were implemented, one (FIT) with two hundred lines planted in each of seven farmers' fields and in the research station, representing the initial breeding material, and one (FAT) with the selection of the previous FIT and planted in 11 fields, and a third one with the lines promoted from FAT to Elite Farmer Trials (FET).
- On station activities have started to back up the work in farmers' fields. This consists in the collection of spikes from the entries selected in the FIT. These spikes are planted in Ramtha station to reach the homogeneity. This will enhance the seed increase process when any genotype will be released in the future.
- The wheat breeding program (bread and durum) in NCARTT started in 2002 participatory plant breeding using 51 entries (FIT), at three locations.
- The Director General of NCARTT included Participatory Research in the new strategic Document of NCARTT.
- Teaching at the University of Jordan has started including elements of participatory plant breeding.
- Three Syrian farmers visited the participatory barley-breeding program in Jordan and joined the Jordanian farmers during selection.
- Several breeding lines out yielding the local and the improved check were identified.
- The full set of trials has been implemented, namely the initial trials (FIT) with two hundred lines planted in each of seven farmers' fields and in the research station, the advanced yield trials (FAT) with the selection of the previous FIT and planted in 12 fields, and eventually the elite yield trials (FET) with the selections from FAT grown in the previous year.
- In April 2002, Dr. Ceccarelli gave a presentation at the Stakeholder Meeting of the PRGA Program in Bonn
- In September 2002 Dr. Ceccarelli attended the Workshop "The Quality of Science in Participatory Plant Breeding" held at IPGRI Headquarters, Rome, Italy.

V. BUDGET

Please refer to the Financial Report submitted separately.