GERMPLASM PROGRAM

Annual Report for 1999

ICARDA

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the Central and West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

CGIAR

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from a wide variety of country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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Annual Report for 1999

International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within the Central and West Asia and North Africa (CWANA) region, with whom ICARDA has close collaboration. Owing to the tight production deadlines, editing of the report was kept to a minimum.

From 1986 to 1993 this report was published under the title "Cereal Improvement Program Annual Report." Starting with the 1994 and until the 1999 issue, it changed its title to "Germplasm Program: Cereals Annual Report." Its companion volume for legumes during the same period (1994 to 1998) was published under the title "Germplasm Program: Legumes Annual Report."

Starting with this issue for 1999, this report combines the "Germplasm Program: Cereals Annual Report" and "Germplasm Program: Legumes Annual Report," and takes a new title "Germplasm Program Annual Report."

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1. GENERAL INTRODUCTION

Crop improvement research on cereals and legumes at the International Center for Agricultural Research in the Dry Areas (ICARDA) is conducted within the Germplasm Program. Among the cereals, it covers barley, durum wheat and bread wheat, while amongst the legumes it covers lentil, chickpea, faba bean and forage legumes. ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and a regional mandate for the improvement of durum wheat, bread wheat, chickpea and forage legumes. The improvement of durum and bread wheat is done jointly with the International Maize and Wheat Improvement Center (CIMMYT), Mexico, which has a global mandate for wheat improvement. Similarly, chickpea improvement is done jointly with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), India, which has a global chickpea mandate. Integrated Pest Management research at ICARDA is also within the Germplasm Program.

To fulfill the global mandate for the improvement of barley, ICARDA has posted a barley breeder in CIMMYT-Mexico to address the needs of barley improvement for Latin America. CIMMYT has placed a durum breeder and a spring bread wheat breeder at ICARDA with a regional responsibility for West Asia and North Africa (WANA). Winter and facultative bread wheat breeding is based in Ankara (Turkey), where ICARDA has posted a breeder in 1997, with backup at headquarters.

The overall objective of the Germplasm Program is to increase the productivity and sustainability of the farming systems which include barley, lentil, faba bean, durum wheat, bread wheat, chickpea, grasspea, pea and forage legumes in partnership with NARS, NGO and farmers.

This objective is being pursued through methodologies emphasizing specific adaptation through decentralized breeding, gender-sensitive participatory approaches, use of biotechnology, use of inputs compatible with the preservation and improvement of the resource base, maintenance and enhancement of agricultural biodiversity, and ultimately alleviation of poverty.

The base for most of the research work is at Tel Hadya, where ICARDA's headquarters are located and where additional environments are created by different planting dates and plastic houses. However, research is also conducted in other sites in Syria (Breda, Bouider, Latakia and farmers' fields) and Lebanon (Terbol and Kfardan). All these sites are directly managed by ICARDA. High elevation sites of the national programs of Syria, Turkey, Central Asia and Caucasus, Iran and Maghreb countries are used, in a collaborative mode, for developing improved winter and facultative barley, bread and durum wheat, lentil, chickpea and forage legumes adapted to cold environments. The research sites and facilities of the national programs of about 50 countries in the five continents, are used jointly for developing breeding material with specific resistance to some key biotic and abiotic stress factors because of the presence of ideal screening conditions and/or expertise there. The process of decentralization of breeding work is being continued and extended with the help of national programs.

The weather conditions during the 1998/99 season are shown in Figure 1.1 for two dry sites (Bouider and Breda), and in Figure 1.2 for relatively wetter sites (Tel Hadya and Terbol). The total precipitation during the season was lower than the long term average in all locations but at Bouider. On average, temperatures were above the long term average (about 1-2°C).

At Bouider, the total precipitation matched the long term average (222 mm versus 226 mm). The highest monthly precipitation deviations from the long term average during cropping season occurred in January (-23 mm)and March (+24 mm). The temperature during the 1998/99 cropping season was 1°C above the long term average maximum temperature, and 2°C above the average minimum temperature. The monthly mean maximum temperature during the cropping season ranged from 11 to 35°C, and the minimum from 4 to 18°C.

At Breda, the total precipitation was 22% below the long term average (198 mm versus 253 mm). The highest monthly precipitation deviations from the average occurred in January (-30 mm) and in March (+40 mm). The temperature during the 1998/99 cropping season was 2°C above the long term average maximum temperature, and 1°C above the average minimum temperature. The monthly mean maximum temperature during the cropping season ranged from 12 to 34°C, and the minimum from 3 to 17°C.

At Tel Hadya, the total precipitation was 8% below the long term average (307 mm versus 334 mm). The highest monthly precipitation deviations from the average occurred in December (+37 mm) and in January (-25 mm). No precipitation occurred at the end of the season—May and June—and overall precipitation in spring was about 20 mm below average. The average maximum and minimum temperature during the 1998/99 cropping season was 1°C above the long term average. The monthly mean maximum temperature during the cropping season ranged from 13 to 34°C, and the minimum from 3 to 19°C.

At Terbol, the total precipitation was 45% below the long term average (292 mm versus 524 mm). The highest monthly precipitation deviations from the average occurred in January (-21 mm), February (-46 mm) and March (-47 mm). The average maximum temperature during the 1998/99 cropping season was 1°C above the long term average, while the minimum temperature was 2°C below the average during spring. The monthly mean maximum temperature during the cropping season ranged from 13 to 31°C, and the minimum from 0 to 8°C.

During the year the following changes in senior staff occurred:

a. Dr Chrys Akem, Legume Pathologist left the Program towards the end of 1999.
b. Dr Victor Shevtsov relocated as Barley Breeder to Tashkent, Uzbekistan.
c. Mr Bruno Rudolf Schill joined the Program as a Post Doctoral Fellow-Faba Bean Breeder.
d. Dr Imad Eujayl joined the Program as a Post Doctoral Fellow-Biotechnology.
e. Dr Wafa Choumane joined the Program as a Consultant-Biotechnology.
f. Mrs Bianca van Dorrestein relocated as Research Fellow to Cairo, Egypt.

More than 70 scientists from 20 different countries spent between few days and few months in the Germplasm Improvement Program. Their activities varied from discussions with staff members to research projects in collaboration with specific scientists. Their contributions to the achievements of the Program are reported in details in the specific sections.

The following special projects were operational during 1999:

1. **Use of DNA-markers in selection for disease resistance genes in barley**, supported by BMZ and in collaboration with Technische Universität München, Lehrstuhl für Pflanzenbau und Pflanzenzüchtung, Munich, Germany (scientist in charge: M. Baum)
2. **DNA-Marker assisted breeding and genetic engineering of ICARDA mandated crops,** supported by BMZ and in collaboration with University of Hannover, Prof. Dr.H.J. Jacobsen and University of Frankfurt, Prof. Dr. G. Kahl (scientist in charge: M. Baum)
3. **Improving yield and yield stability of barley in stress environments,** supported by the Government of Italy (scientist in charge: S. Grando)
4. **Farmer participation and use of local knowledge in breeding barley for specific adaptation**, supported by BMZ and in collaboration with University of Hohenheim (scientist in charge: S. Ceccarelli)
5. **Increasing the relevance of breeding to small farmers: Farmer participation and local knowledge in breeding barley for specific adaptation to dry areas of North**

Africa, supported by IDRC and in collaboration with IRESA (Tunisia) and INRA (Morocco) (scientist in charge: S. Ceccarelli)

6. **Resistance to nematodes in lentil and chickpea** in collaboration with the Institute of Nematology of Bari (scientist in charge: R.S. Malhotra)
7. **Development of chickpea resistant to biotic and abiotic stresses using interspecific hybridization and genetic transformation**, supported by the Government of Italy and in collaboration with ENEA, University of Napoli and the University of Tuscia in Viterbo (scientist in charge: R.S. Malhotra)
8. **Fusarium wilt in chickpea**, supported by the Government of Spain and in collaboration with INIA, Spain (scientist in charge: R.S. Malhotra)
9. **International durum wheat improvement**, supported by GRDC, Australia in collaboration with the New South Wales Department of Agriculture (scientist in charge: M. Nachit)
10. **Coordinated improvement program for Australian lentils,** supported by GRDC, Australia (scientist in charge: A. Sarker)
11. **Improvement of drought and disease resistance in lentils**, in Nepal, Pakistan and Australia supported by ACIAR, Australia (scientist in charge: A. Sarker)
12. **Central and West Asia rusts network-enhanced regional food security through the development of wheat varieties with durable resistance to yellow rust,** (scientist in charge: H.T. Rahme)
13. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN),** supported by IFAD, Italy (scientist in charge: M. Machit)
14. **Faba bean in China,** supported by the ACIAR, Australia and in collaboration with the Genetic Resources Unit (scientist in charge: L. Robertson)
15. **Integrated management of pests and diseases**, supported by BMZ, Germany (scientist in charge: K. Makkouk)
16. **Durum wheat improvement** supported by ACIAR, Australia (scientist in charge: M. Nachit)
17. **Kabuli chickpea**, supported by ACIAR, Australia (scientist in charge: R.S. Malhotra)
18. **Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants**, supported by ACIAR, Australia (scientist in charge: S. Ceccarelli)
19. **Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality,** supported by Agricultural Technology,

Utilization and Transfer Project-ATUT) (scientist in charge: M. Nachit).

20. **Development of high yielding, long spike bread wheat cultivars possessing high tiller, number, rust resistance and heat tolerance facilitated by microsatellite DNA-markers**, supported by Agricultural Technology, Utilization and Transfer Project-ATUT (scientist in charge: O. Abdalla)
21. **Genetic transformation of barley for improved stress resistance**, supported by CGIAR (scientist in charge: M. Baum).
22. **Adaptation of barley to drought and temperature stress using molecular markers**, supported by USDA, Texas Tech University, U.S.A. (scientist in charge: S. Ceccarelli)
23. **Inheritance and linkage of winter hardiness in lentil,** supported by USDA, Washington State University, U.S.A. (scientist in charge: A. Sarker)
24. **Use of entomopathogenic fungi for the control of Sunn pest**, supported by USDA, University of Vermont, U.S.A. (scientist in charge: M. El-Bouhssini)
25. **Legume resistance to Luteoviruses supported by GRDC, Australia**, *(scientist in charge: K. Makkouk) (started* in October 1998)
26. **Development of biotechnological research in the Arab States**, supported by Arab Fund for Economic Social Development (AFESD) (scientist in charge: M. Baum)
27. **Improvement of lentil and grasspea in Bangladesh,** supported by ACIAR (scientist in charge: A. Sarker)
28. **Pulse transformation technology transfer**, supported by ACIAR, Australia (scientist in charge: M. Baum)
29. **Decentralized barley breeding with farmers' participation in North Africa**, supported by OPEC *(scientist in charge: S. Grando)*
30. **Village-based participatory breeding in the terraced mountain slopes of Yemen**, supported by SWP PRGA (scientist in charge: S. Ceccarelli)
31. **International Collaboration in barley research between ICARDA and Waite Campus Institutions,** supported by GRDC, Australia (scientist in charge: S. Ceccarelli)
32. **Improving the yield Potential and Quality of Grasspea (lathyrus sativus L),** suported by DFID, U.K (scientist in charge: Ali M. Abd El-Moneim)

In addition the program is actively involved in the activities of the six Regional Programs and in the following special projects:

- Mashreq and Maghreb (M&M) Project
- Mediterranean Highland Project

- Barley Improvement Project in Ethiopia
- Problem-solving Regional Network Project in Egypt Ethiopia, Sudan and Yemen
- Matrouh Resource Management Project in Egypt

This report is published in seven sections, as per the projects described in ICARDA's Medium Term Plan.

Most of the results reported in the seven sections were obtained during the 1998-99 season, although work done in earlier years is also reported when considered important. The training and network activities, the scientific publications of the program's staff and an updated list of varieties released by national programs are also reported.

As mentioned earlier, much of the work reported here has been done in collaboration with our colleagues in the national programs in WANA and other developing countries and in some institutions in the industrialized countries. Space limitations prevent to mention all our collaborators individually, but to all of them goes our most sincere appreciation. Eventually, the program is greatly indebted to the support staff at the headquarters as well as in various substations: without their hard work, competence and dedication none of the work reported here would have been possible.

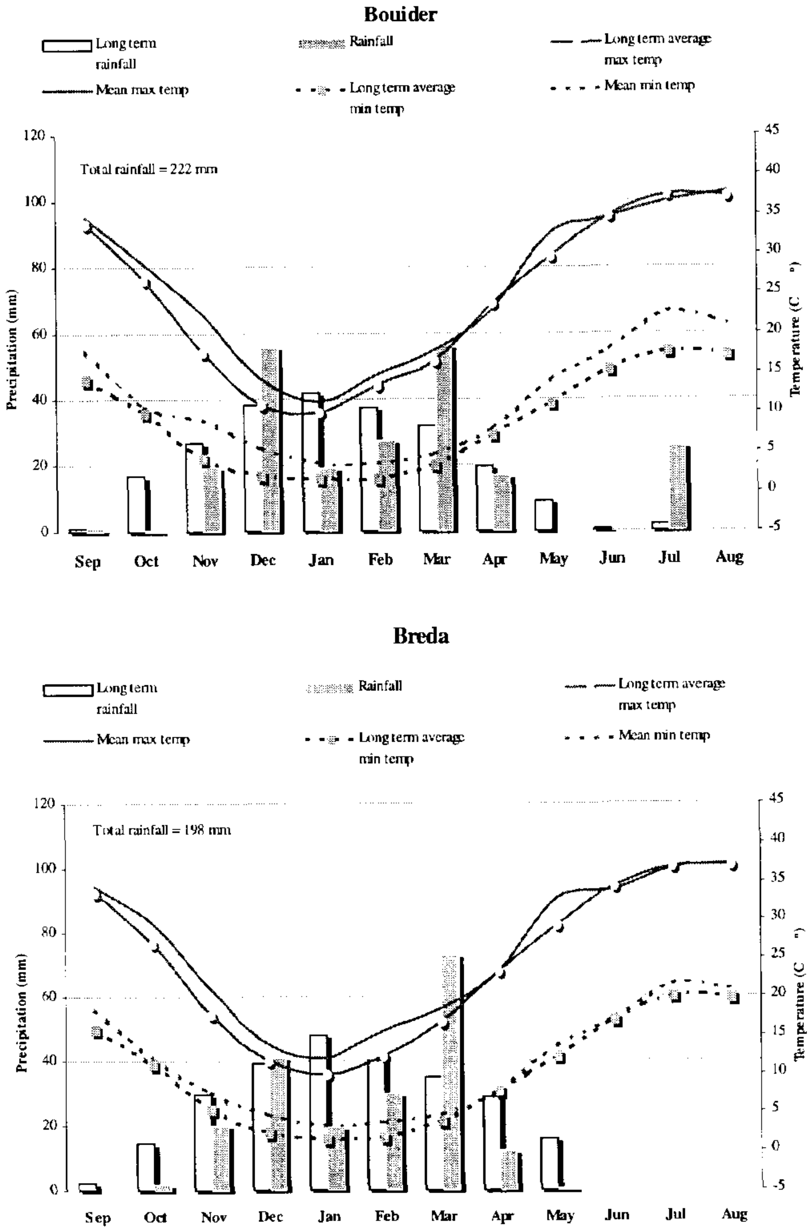
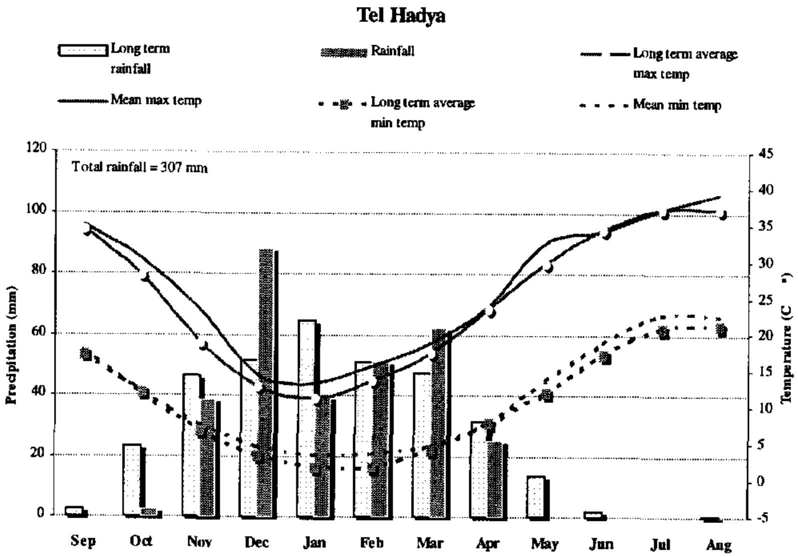


Figure 1.1. Weather conditions at Bouider and Breda during 1998-99



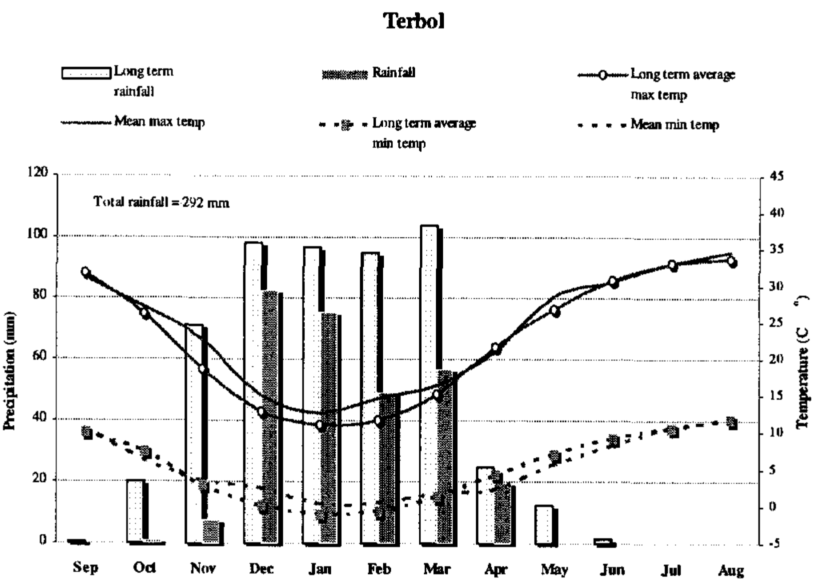


Figure 1.2. Weather conditions at T. Hadya and Terbol during 1998-99

2. BARLEY IMPROVEMENT

2.1. Introduction

The long term objective of the barley improvement project at ICARDA is a sustainable increase in barley productivity by adapting the crop to the different farming systems and uses in developing countries with special emphasis in those areas where the crop is grown by resource-poor farmers, thus contributing to alleviation of poverty. This objective is pursued with different strategies depending on the research capacity of the various national programs, and ranges from the development of finished varieties to the development of breeding methodologies. Such methodologies emphasize specific adaptation and include decentralized breeding and farmers' participation, the use of sustainable levels of inputs, and the maintenance and enhancement of the crop's biodiversity.

Barley improvement at ICARDA has a global perspective and addresses the problems that limit the production of the crop in all developing countries. The target areas of the project have been divided in six geographic regions, which are dealt with by six sub-projects. They are:

1. Near East and West Asia;
2. North Africa;
3. East Africa and Yemen;
4. Central Asia and Caucasus;
5. Far East
6. Central and Latin America

The development of germplasm pools is the responsibility of four barley breeders as follows (Figure 2.1):

1. Breeder for Latin America
   Responsible for Mexico, Ecuador, Peru, Colombia, Bolivia and Chile
2. Breeder for CAS
   Responsible for CAS, Russia, Turkey, Iran
3. Breeder for Africa and Yemen
   Responsible for Mauritania, Morocco, Algeria, Tunisia, Libya Egypt, Ethiopia, Eritrea and Yemen;
4. Breeder for Near East and West Asia
   responsible for Syria, Jordan, Iraq, Afghanistan and Pakistan

At the moment the breeder for Near East and West Asia is also responsible for India, Nepal, Bangladesh, China, Korea, Vietnam and Thailand. The work of the four breeders is supported by six specialists who spend in the project between 35% and 8% of their time.

The total barley area in the six regions exceeds 42 million hectares. In these regions barley is grown for animal feed, human food and malt, and in many different types of environment. However, most barley is grown in marginal environments, often on the fringes of deserts and steppes or at high elevations in the tropics, and receives modest or no inputs.

The project deals with a wide range of germplasm, from spring to winter, and from the wild progenitor, *Hordeum spontaneum*, to landraces and modern cultivars. To cope with the diversity of environments in which barley is grown, and with the diversity of uses, the project has adopted the strategy of breeding for specific adaptation in partnership with the barley breeders of the various countries. In this partnership the role of ICARDA's barley breeders is to generate useful genetic variability through targeted crosses, to distribute segregating populations, and to coordinate the analysis of data, while the role of the national barley breeders is to identify parental material (for example sources of resistance), to design suitable crosses, and to perform selection in the target environments.

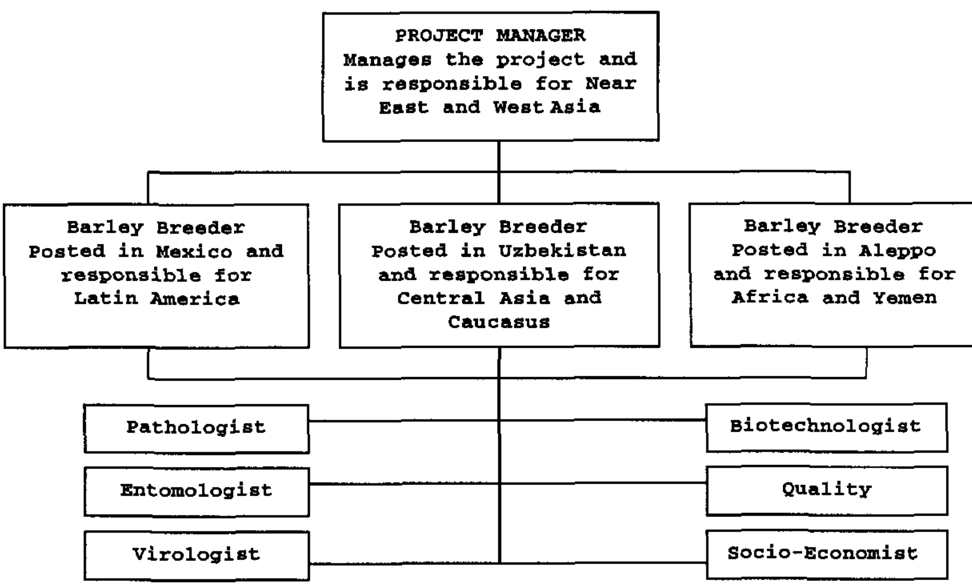


Figure 2.1. The structure of the barley project at ICARDA

2.2. Major Achievements in 1999

2.2.1 A Workshop on Farmer Participatory Research

A Workshop on Farmer Participatory Research (FPR) was held at ICARDA Headquarters from May 6 to May 11, 1999.

The Workshop was co-sponsored by the Islamic Development Bank, FAO, the System Wide Program on Participatory Research and Gender Analysis (SWP PRGA) and ICARDA.

Prof. Dr. Adel El-Beltagy, Director General of ICARDA, officially opened the Workshop. He underlined the significance of having such a workshop in the area where agriculture began several thousand years ago. He pointed out that there are numerous research activities conducted at ICARDA in collaboration with different national programs that directly involve farmers. Farmer participatory research has become one of the strategic pillars of the ICARDA's present and future research approach. He indicated the wide range of variation in degrees, types, and objectives of farmer participation. Several participatory plant breeding projects are currently implemented by ICARDA. However many scientists in the region are not aware of the research approach. Similarly, several Natural Resources Management Projects use farmer participatory approaches but there have been few opportunities for interaction among the researchers. Many believe that farmer participation holds the key to research success, particularly, in the dry environments where the environmental variation and associated risk in agriculture requires greater adaptation of the technologies than in more favored ecosystems. Since, farmer-participatory research is based on the involvement of people (men and women) with different interests and stakes in which type of technology is designed, those who have espoused farmer-participatory research are becoming increasingly aware of the need to bring different types of stakeholders in the research process.

The objectives of the Workshop were to generate interest towards FPR and to promote its use as a new research strategy by providing researchers from a number of countries with a forum to discuss and exchange ideas about farmer participation. The output of the workshop was the recommendations listed below. To reach its objective the Workshop was structured in four components:

1. Formal presentations
2. Participation in farmer selection both in a farmer's field representing the dry areas of Syria and in a research station
3. Discussions with farmers

4. Perspectives for participatory research in various countries

In addition to formal presentations, the participants traveled to Bylounan, a village in the Raqqa province that in the last cropping season received only 162 mm rainfall. A large group of farmers welcomed the participants who visited one of the trials conducted in the framework of a participatory barley breeding project supported by GTZ while the farmers did the selection.

The farmers were also invited at Tel Hadya (the ICARDA's headquarters) to do selections in trials planted in the research station and to participate in a discussion with the scientists attending the Workshop.

Scientists of Turkey, Mauritania, Algeria, Libya, Egypt, Pakistan, Jordan, Iraq, Iran, India, China, and Eritrea presented the perspectives for participatory research in various countries in the form of country reports.

Eventually the Workshop formulated the following recommendations:

1. Methodology in Participatory Research should take into account diversity and must be adaptable to specific conditions.
2. Farmers should be exposed to a large range of options.
3. The sustainability of the process requires the community participation by stakeholders groups, considering external stakeholders and addressing cost sharing as one of many aspects.
4. Explore ways of reinforcing existing local systems of seed production and distribution, while encouraging and supporting farmer-producers to emerge as alternative suppliers of quality seed, who have links with sources of new material and maintain close and trustworthy relationship with the seed-using community.
5. Attempts to introduce certification should be based on real need and standards that are realistic and achievable and within the capacity of the farmers to manage and sustain.
6. Where applicable, the legal issues of variety release and property rights should be made flexible so as to enhance rather than impede farmers' access and use of improved seed.
7. From the beginning of Participatory Research, social, physical and biological disciplines and concepts should be involved, in order to adequately reflect the complexity of the system.
8. Indigenous knowledge and traditional rights should be considered and engaged as the core of any partnership

between researchers and farmers on equal basis.

9. The socioeconomic and technological impact of both the technologies and the processes developed through Farmers Participatory Research must be assessed.
10. A Network on Participatory Research should be established at regional level including farmers, researchers, extension workers and trainers. The Network should focus on: sharing experiences, education and training, elaboration of a newsletter, elaborate a program for information to policy makers, organize an international workshop on Participatory Research attended predominately by farmers.

The Workshop was attended by 34 scientists of National Programs of Algeria, China, Ecuador, Egypt, Eritrea, Jordan, India, Iran, Iraq, Libya, Mauritania, Morocco, Pakistan, Tunisia, Turkey, Yemen, by representatives of the Islamic Development Bank, Instituto Agronomico per l'Oltremare, Firenze (Italy), FAO, (Rome, Italy), DANIDA (Denmark), GTZ, (Germany), CIAT (Colombia), and by IPGRI (Italy) and ICARDA scientists.

2.2.2. Participatory Barley Breeding in Eritrea

Barley is one of the most important crops in Eritrea. It is grown in the Central Highland zone on about 40,000 hectares with an average yield of about 500 kg/ha. Barley production represents 20% of the total agricultural production.

The most important areas for barley are the provinces of Hamassien (nearly 17,000 ha), Akele Guzai (11,000 ha), Seraye (7,800 ha), Sahel (2,500 ha) and Senhit (2,500 ha).

Barley is one of the staple crops in the highlands of Eritrea where is widely used as human food in a number of recipes such as injera (pancake), kitcha (roasted bread), geat (porridge), siwa (a local beer). In addition, straw is an important source of animal feed, highly valued because of the high digestibility.

During 1999 a new project was started with the long term objective of increasing barley production in the country and with the short term objective of assessing the possibility of using a participatory approach in the development of new cultivars.

After consultation with farmers, three villages were identified, one in the south of the country near Senafe, one north east of Asmara, near Embaderho, and one close to the research station of Halale, at Tea Amine.

In each village we introduced 100 pure lines derived from the local landraces collected in November 1997 (see Annual Report of the Germplasm Improvement Program for 1997) and 37 populations representing the landraces of the 37 collection sites visited during the 1997 collection.

The pure lines were divided in two trials, each containing 50 pure lines and the local check (from seed purchased from the farmer) repeated 5 times. The two trials were few hundred meters apart in Senafe and Embaderho, and three kilometers apart in Tea Amine. Two different farmers in the village hosted them. The bulks were evaluated in a different trial together with three improved cultivars, namely Beka, Halker and HB-32. This trial was planted close to one of the two trials with the pure lines. Therefore in each village 137 different types of barley were evaluated.

Close to maturity the host farmer and a group of neighbors, ranging from 9 to 12, scored each individual plot either alone or assisted by a researcher when they need assistance in recording the scores. Farmers were interested in performing the selection, in giving reasons for selecting or discarding and in ranking what they considered to be the best entries.

There was a large variation in yield between the different locations: the highest total biomass (about 7 t/ha) was obtained in the research station and in Embaderho, while the lowest (about 3.5 t/ha) was obtained in Tea Amine. Grain yield varied from about 1 t/ha (Tea Amine) to nearly 3 t/ha (Embaderho). The yield advantage of the best entries over the local check ranged from 60% in Senafe to 100% in Embaderho for total biomass, and from 30% in Senafe to 100% in Embaderho for grain yields.

There were also large genotype x environment interactions with different lines and bulks being the highest yielding in different locations. In particular, the data suggested that the Research Station at Halale is not a good selection site for the target environments explored in this work. In fact, in the case of the grain yield, the 10 best lines on station included only one of the 10 best lines in Tea Amine and none of the 10 best lines in the other locations. What was even more interesting was that the ten lines with the lowest grain yield in the Research Station included four of the highest yielding lines in Embaderho, and two of the highest yielding lines in Senafe. Similarly, in the case of total biomass yield, the 10 best lines on station included only one of the 10 best lines in Tea Amine and none of the 10 best lines in Embaderho, and two of the ten best lines in Senafe. The ten lines with the lowest biomass yield in the Research Station included three of the highest yielding lines in Senafe and one each of the highest yielding lines in Tea Amine and Embaderho.

From discussions during and after selection it emerged that grain filling is one of the major selection criteria (entries with marked different phenology were given an equally good score because they showed a good grain filling), followed by spike length and in some case plant height. Although the presence of diseases (particularly scald and net blotch) was widespread and very serious (in the majority of the plots the flag leaf had no green tissue left), farmers did not think that this would cause a yield reduction.

In one location, two farmers collected few heads (3-4) from the plots that they ranked highest: they will plant them in their garden to multiply the seed and eventually plant them in their field.

2.2.3. Osmotic Adjustment (in collaboration with Texas Tech, USA)

Osmotic adjustment (OA) is recognized in several crops as an effective component of drought resistance. OA results from the active accumulation of solutes within cells, which lowers the osmotic potential (OP) beyond the level dictated by mere "concentration effect" of tissue water loss on OP. OA helps maintain turgor of both shoots and roots as plants experience water deficit. This allows turgor-driven processes such as stomatal opening, cell enlargement and expansion growth to continue, though at reduced rates, to progressively lower leaf water potentials (LWP). It has been shown that growth and yield under water-limited conditions can be improved by selecting lines with higher levels of OA in wheat, sorghum and barley. We have limited information on the extent of genetic variation for osmotic adjustment in barley.

The objective of this research was to determine the magnitude of osmotic adjustment (OA) capacity in barley genotypes and to see if there is any difference in OA among the genotypes. The information will be used to select parents to develop mapping populations for tagging QTLs/genes associated with osmotic adjustment and drought tolerance in barley.

The seed of 12 barley genotypes was sown in a temperature-controlled greenhouse at Texas Tech University on March 10, 1999, using a randomized block design and three replications. After germination, seedlings were thinned to 2 per pot (30-cm diameter at the top, 26-cm diameter at the base, 31-cm height). Plants were well fertilized and irrigated until April 22, 1999. Then watering was stopped. To assess the intensity of the stress, plants were monitored visually and also by measuring relative water content (RWC). When RWC reached a value around 70% and wilting occurred in most plants, plants were rehydrated at night to restore full turgor. The most recently fully expanded leaves were sampled in the early morning from well-watered plants (before the stress) and rehydrated plants (after rehydration) and then kept at -80^{0}C in a freezer. Osmotic potential of leaf samples was measured with a vapor pressure osmometer (Model 5520, Wescor, Inc., Logan, UT) using extracted sap. Osmotic adjustment capacity was calculated as the difference in osmotic potential between well-watered and rehydrated plants.

Variation in OA capacity for these genotypes ranged from 0.27 MPa to 1.06 MPa, with Athenais having the highest and Sara having the smallest capacity (Figure 2.2). Although few genotypes were evaluated in this experiment, the magnitude of OA in this study was larger than that found in previous studies (-0.17 to 0.46 MPa), suggesting that these genotypes are very diverse in OA capacity.

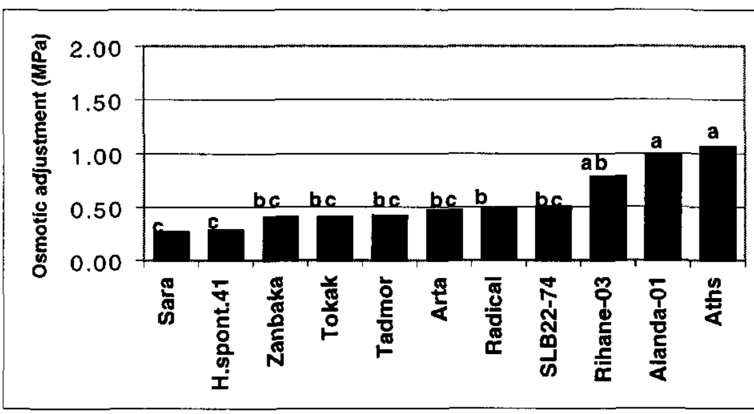


Figure 2.2. Osmotic adjustment in eleven barley genotypes evaluated in the spring of 1999 at Texas Tech University. The black bars with common letters are not different at the probability level of 5% (LSD at 5%=0.39 MPa).

2.2.4. Drought Tolerance

During 1999 the total rainfall in Breda was below 200 mm rainfall (197 mm) and well below the long term average (258 mm). Total rainfall does not give the full picture of the moisture stress that affected the crop. In fact, rainfall started late, in the middle of November, and by the end of December it was only 63 mm (about 30 mm less than long term average). Eventually, the crop suffered a period of drought that lasted nearly forty days from beginning of February to mid-March. During this period the amount of rainfall is usually about 50 mm, while in the same period in this cropping season the crop received only 4 mm. At this time, with only 113 mm of rainfall a number of barley lines were already heading, did not show any symptom of drought stress, such as wilting, leaf rolling or leaf senescence.

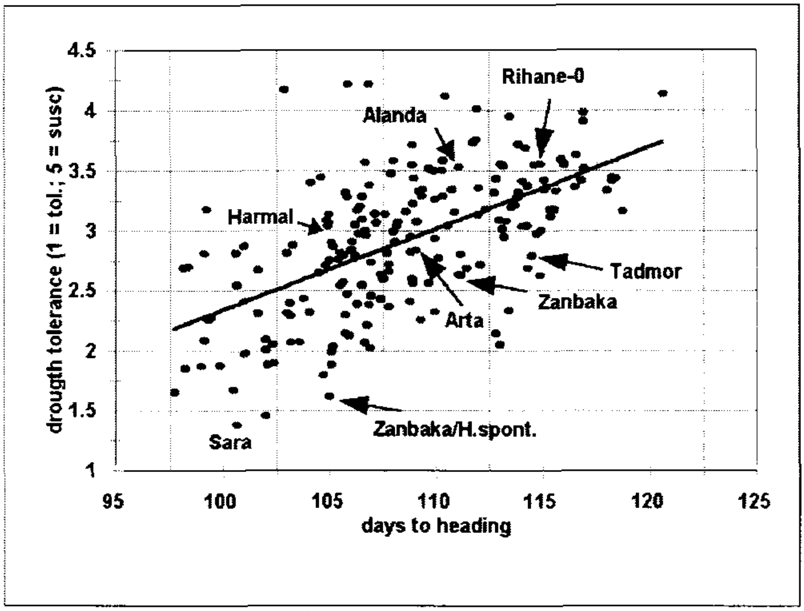


Figure 2.3. Relationship between the score for drought tolerance and earliness (expressed as days to heading) in nearly 200 barley lines. The most drought tolerant lines are also the earliest (bottom left quadrant) but that not all the early lines are drought tolerant (left upper quadrant)

Drought tolerance was scored visually from 1 (tolerant) to 5 (susceptible), and, as it shown in (Figure 2.3), most of the highly tolerant lines were early, but not all the early lines were drought tolerant. This indicates that lines such as Sara and Zanbaka/*H. spontaneum* may have a combination of escape and resistance mechanisms. The graph also shows the score and the heading date of some of the most known barley varieties.

Many of the lines which performed well at the time the crop received 113 mm rainfall, did not take full advantage of the subsequent rains: the most notable exception was a line derived from the cross between Zanbaka and *Hordeum spontaneum* that was the top yielding at Breda with nearly 1.5 t/ha of grain and an yield advantage of between 9% (over Arta) to about 40% (over Sara, Zanbaka and Tadmor) to 50% and above (over modern cultivars such as Harmal and WI2291). In (Figure 2.4) the yield of this line is shown together with the kernel weight measured in Breda, which is comparable with that of some of the most drought tolerant material developed in the past.

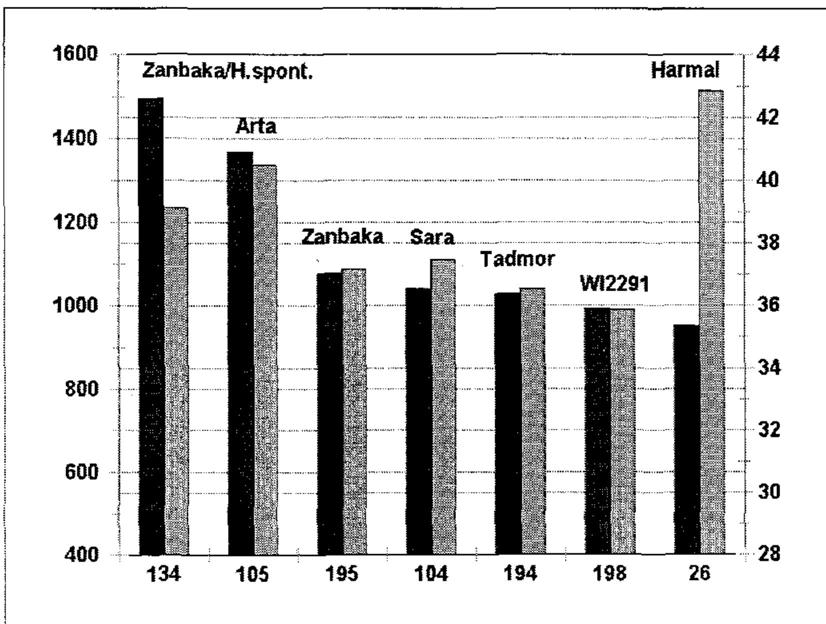


Figure 2.4. Grain yield (kg/ha in the left axis) and 1000 kernel weight (g in the right axis) of a new very drought tolerant line (Zanbaka/*Hordeum spontaneum*) compared with the best barley lines developed so far for the dry continental areas of the Near East

The progresses made in drought tolerance were confirmed by the results obtained with 117 lines tested in a farmer field in the province of Raqqa that received only 187 mm rainfall with a distribution similar to the one described for Breda. In this location the crop was at the limits of survival with an average grain yield of 365 kg/ha and an average biomass yield of 1536 kg/ha and 17 lines that failed to produce any grain. In this location the maximum grain yield was obtained with three lines (WI 2291/Tadmor, Sara, and Zanbaka/*H. spontaneum* 41-1) with grain yields between 670 and 750 kg/ha (an increase of between 20 and 35% over Zanbaka-a barley lines adopted by some farmers, and an increase of between 26 and 23% over Arta).

The yield advantages obtained in the extreme conditions of 1999 confirmed that the use of locally adapted landraces in breeding for stress environments could substantially increase yield under severe moisture conditions, and hence yield stability.

2.2.5. Diversity in Barley Landraces

The Near East is recognized as a center of genetic diversity, and one of the three nuclear centers of agricultural origin. This area corresponds geographically to a region that extends from Palestine through Syria, southern Turkey into Iraq and western Iran.

The early plant gatherers found that the local plants constitute a convenient source of concentrated energy and protein, which could be easily carried and stored. Archaeological evidence indicates that wheat, barley and, to lesser extent, lentil, pea and other food legumes played an essential role in the rise of the great Near East civilizations. Contemporary geographical distribution of their wild progenitors corroborates the archaeological evidence. Wheat and barley were the two staples on which food production in the Near East started. These two crops together with the domesticated sheep and goats were the basis of a farming system that evolved in the Fertile Crescent about 7000 BC and which spread as a Neolithic agricultural package quickly from the nuclear region to other parts of West Asia, to the Nile valley and the Balkans.

Today it is estimated that 38% of the world's food is provided by crops which originated in the semi-arid regions of the Near East. It is now widely recognized that the wild progenitors, the wild relatives and the landraces of these crops have accumulated, during their long existence, a rich reservoir of genes for adaptation and survival to the harsh natural environment.

The wild relatives of crops and landraces have already contributed many useful genes to the cultivated species, especially those related to biotic stress tolerance. In future, the rich genetic diversity of wild relatives and landraces may be indispensable in breeding crops adapted to climatic changes. In spite of the recent advances in biotechnology making gene transfer between unrelated organisms possible, wild progenitors and landraces are still, and will remain for the next few decades, the most immediate source of useful genes for conventional breeding programs, provided they still exist.

ICARDA maintains a large collection of about 6000 pure lines derived from Syrian and Jordanian barley landraces.

To describe the population structure of theses landraces from a morphological, agronomical and molecular stand point, we conducted a study on 480 lines derived from landraces collected in four to five sites in each of five geographic regions.

The details of the study are reported in (section 6.2.1.2). Here we only anticipate that a large variation was detected between regions, as well as between sites within regions, and between lines within sites, for most of the characters.

2.2.6. QTL for Disease Resistance and Agronomic Traits

The success of breeding for yield stability in stressful environments has been limited due to the high variability in the timing, duration and severity of a number of climatic stresses. In Northwest Syria, the most important abiotic stresses affecting rainfed crops, such as barley, are low temperatures in winter, and terminal drought and heat in spring. In addition, a number of biotic stresses such as the foliar and root diseases limit yields. Among the foliar diseases two of the most common are powdery mildew and scald.

The complexity of combining in the same cultivar a number of desirable traits can be considerably reduced by using DNA molecular-marker techniques that are now sufficiently developed to be exploited in breeding programs to improve resistance/tolerance to biotic and abiotic stresses.

A population of 245 recombinant inbred lines (F6) from the cross Tadmor and Sel160 was mapped with restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD) and microsatellite markers. An 882 cm linkage map was constructed consisting of 15 individual linkage groups. With this linkage map, quantitative trait loci (QTL) analysis was performed for a number of agronomical and physiological traits as well as disease resistance genes and straw parameter traits.

One major QTL (RF-1) for scald was identified and localized on chromosome 4Hc, explaining about half of the phenotypic variation, and a second QTL (RL-2) was found on 4Hd, explaining 3.4% of the phenotypic variation. In the case of powdery mildew, one QTL (P1-1) was identified and localized on chromosome 1Ha, explaining 22.6% of the phenotypic variation. Both alleles from 'Sel160' resulted in 26% less powdery mildew infection than the lines with the two alleles from 'Tadmor'. This QTL also was found in the analysis of the data of the second powdery mildew scoring (P2-1) which explained 18.1% of the phenotypic variation. For this second scoring, another QTL was localized on 2Hb (P2-2) explaining 4.6% of the phenotypic variation; both QTLs explained 18.4% of the phenotypic variation. In this case the lines with the 'Tadmor' allele were more resistant.

A number of QTLs related to yield under stress conditions clustered on chromosome 5H such as QTLs for days to heading (DH-1 on chromosome 5Ha, which explained 4.5% of the phenotypic variation), cold damage (CD-1 on chromosome 5Ha and CD-2 on chromosome 5Hb explaining together 32.5% of the phenotypic variation and 37.5% of the genetic variation), growth habit (GH-1 localized on chromosome 5Hb and explaining 6.8% of the phenotypic variation), and early growth vigor (GV-1 on chromosome 2Hb, GV-2 on chromosome 3Hb, and GV-3 on chromosome 5Hb, explaining together 12.4% of the phenotypic variation).

Interestingly enough, all three QTLs for grain yield (defined as average grain yield across locations and years) were also localized on chromosome 5H, one on 5Ha (GY-1) and two on 5Hb (GY-2 and GY-3). The three QTL's explained 23.3% of the phenotypic variation and 70.0% of the genetic variation. The group with the highest grain yield has Tadmor-alleles on GY-1 and GY-2 and Sel160-alleles on GY-3 and it out yields the best parental combination with Tadmor-alleles on all QTLs.

A QTL for plant height was located on chromosome 3Hb, probably in the vicinity of the location of the denso gene. One QTL for lodging (L1-1) was localized on 4Hd and explained 4.3% of the phenotypic variation. The QTL showed a highly significant QTL x environment effect and the lines with both alleles from 'Sel160' were more lodging resistant then the one with the 'Tadmor' alleles.

Two QTLs were detected for leaf color, one on 3Hb (LE-1) and one on 4Hd (LE-2). The effect of both QTL was similar. The 'Sel160' alleles caused darker color. LE-1 and LE-2 together explained 14 % of the phenotypic variation.

Three QTLs for awn roughness (AR-1, localized on 1Hb, AR-2 localized on 5Hb, and AR-3 localized on 7H) were localized explaining together 40% of the phenotypic variation. Only for AR-1, 'Tadmor' contributed the allele with the higher roughness while for the other two QTLs the alleles from 'Sel160' showed the higher value (higher roughness).

The clustering of QTLs related to the expression of yield in marginal environment (DH-1, GY-1 and CD-1 in the interval Op-M14a-MWG54-MWG522 on chromosome 5Ha and CD-2, GY-2 and GV-3 in the interval HVDHN7-HVDHN9 on chromosome 5Hb) was one of the most interesting findings of this study. The two QTLs for grain yield and days to heading and the QTL for cold tolerance originate from Tadmor, while only the QTL for early growth vigor originates from Sel160. A QTL for growth habit, originating from Tadmor, is also located on chromosome 5Hb in the interval MWG533-MWG569. Additionally, one of the three QTL for awn roughness (AR-2), which maps in the same region as the roughness gene R or raw1, is also localized on chromosome 5Hb. The relatively high correlation between grain yield and awn roughness (-0.28) could be due to the reduced evaporation associated with awn roughness.

All these traits that appear to be concentrated in a relatively restricted chromosomal region, are those that past studies revealed to be associated with the consistent good performance of landraces in the Syrian type of stress environments. It is also interesting to note the close association of these traits with the dehydrin genes on chromosome 5Ha.

These results could partly explain why genotypes with Tadmor as a common parent, have a higher yield under stress than the population mean (ICARDA, Cereal Improvement Program Annual Report for 1991).

The use of molecular markers associated with the three QTLs for grain yield on chromosome 5H, together with the markers for quantitative resistance to powdery mildew on chromosome 1H and to scald on chromosome 4H, can considerably improve the efficiency of selecting genotypes combining tolerance to abiotic stress with tolerance to biotic stresses.

2.2.7. Multiple Disease Resistance

Barley is grown under a wide range of climatic conditions that are conducive to the development of a wide array of fungal pathogens. In CWANA region, quite often at least three or four diseases appear simultaneously. It is common to observe good development of scald, net blotch, powdery mildew, and leaf rust in many countries in this region. Seed born diseases such as barley stripe, loose smut, and covered smut are also very common in many countries, particularly with small farmers that cannot or do not use chemical seed treatment. We conduct extensive screening for disease resistance to most prevalent pathogens in CWANA, as well as general disease surveys, virulence studies, and identification of new sources of resistance. 954 fixed barley genotypes within the advanced breeding nurseries were tested for resistance to combinations of foliar and seed-born diseases. 58 genotypes showed good level of resistance to most diseases. Over 6% of all the barley lines screened showed resistance to all the seven diseases tested compared to 11% of the lines that showed resistance to only one disease. About 326 lines (34.2%) showed good level of resistance to three diseases (Figure 2.5). Highest levels of resistance to three diseases were recorded in the PDG98 and ADG98 nurseries whereas high level of resistance to five diseases was recorded in the PDG99 nursery. Ten fixed progenies (in the ADG99 nursery) were identified as resistant to seven diseases and forty-eight progenies and fixed lines were identified as resistant to five diseases.

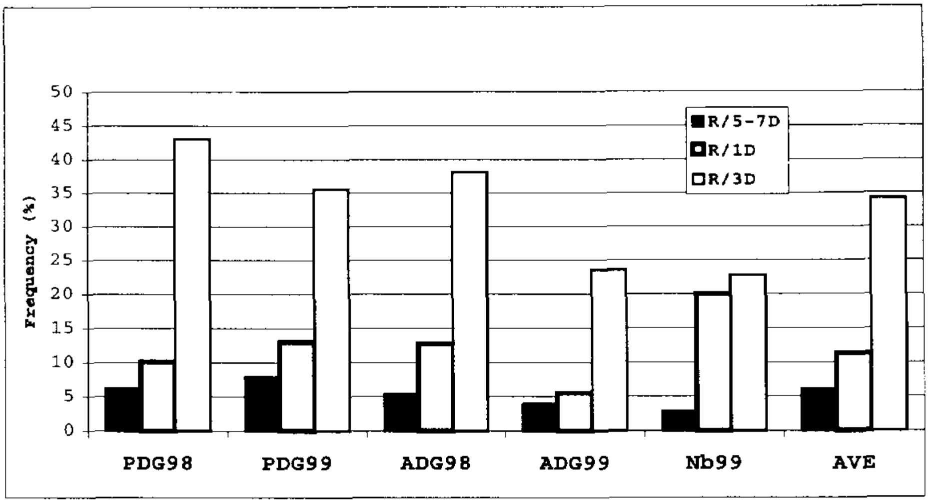


Figure 2.5. Frequency of lines with multiple disease resistance in different nurseries

2.2.8. New Barley Varieties Released or Recommended

The ICARDA line ChiCm/An57//Albert has been released in Iran with the name of Sararood-1. It has good resistance to powdery mildew, net blotch, leaf rust, and loose smut and its drought and heat tolerance is higher than the checks. The variety is suitable for harsh environments and it has a yield potential of about 7 t/ha. During the last year of severe drought this variety gave an average yield of 5 t/ha in large-scale trials in farmers fields.

The spring barley variety "Mamluk" has been recommended for release and cultivation in the foothills and mountainous zones of Armenia. It was developed under the joint program between the Research Institute of Agriculture of Krasnodar (Russia) and ICARDA. During three years testing the new variety out yielded the local check by 11 to 27 %. "Mamluk" has very fast initial growth vigor, is resistant to lodging, and has a good response to fertilizer and irrigation.

2.3. Major Events in 1999

2.3.1 Conferences and Workshops

Workshop on "Breeding for Low-Input Conditions, and Consequences for Participatory Plant Breeding" (Wageningen, 26-28 January).

Meeting on "Barley Improvement in North Africa and Egypt: Past, Present and Future" (Tunis 1-2 September)
ICARDA/Iraq Coordination Meeting (Baghdad, 18-19 October)

Workshop on "Scaling-up Successful Sustainable Agriculture and Natural Resource Management Initiatives to Benefit Small Farmers" (Washington, 23 October)

Seminar of the PRGA System wide Program on 'Participatory Plant Breeding' (Washington, 24 October)

International Workshop on "Broadening the Genetic Base of Crops" (Edinburgh, 25-27 November)

2.3.2. Visits

Visited Eritrea to Assist with the Design and the Planting of the 1999 Trials (June 20-July 16)

Visited Eritrea to Participate in Farmers-Selection, to assess the Importance of Foliar Diseases, and to assist with the Harvesting Planting of the 1999 Trials (September 20-October 28)

Selection of Barley for Resistance to Net Blotch (spot form) in Adelaide, South Australia.

Evaluation of Barley Germplasm for Resistance to Yellow Rust and Fusarium Head Scald at Toluca, Mexico

2.4. Headquarters Activities

2.4.1. The Crossing Program

The implementation of the breeding philosophy rests on a large crossing program that is the main source of new genetic variation. Parental lines include lines selected for their performance in various target environments, sources of resistance to diseases, pest and viruses identified either by ICARDA scientists or by National Program scientists, lines selected for special characteristics (seed quality attributes, lodging resistance, resistance to drought, heat, cold or salinity, etc), and cultivars produced by other breeding programs in the world. In term of diversity, the parental lines include landraces and modern varieties, six- and two-row, early and late maturing types, spring, facultative and winter types, hulless and hulled.

The overall crossing program consists of several groups of crosses, each targeted to a specific country, or to a group of countries, or to a specific objective.

The crosses made in Aleppo in 1999 are given in (Table 2.1).

Crosses with landraces and with *H. spontaneum* are not listed separately as most of the crosses for Syria, Jordan and northern Iraq have a landrace and/or *H. spontaneum* as one of the parents. Most of the crosses done in 1999 to transfer, incorporate or combine resistance to diseases, pests and BYDV and to incorporate the hull-less gene were included among those targeted for specific countries.

Some of the crosses are used to produce populations of random inbred lines by single seed descent (SSD) of for double haploid production (see under biotechnology).

Table 2.1. Number and type of crosses done in 1999 in the barley project compared with 1998

Country/Objective	1998	1999
Algeria	84	64
Egypt	88	
Iraq (irrigated areas)	74	79
Libya	105	32
Morocco	129	87
Tunisia	128	35
Cyprus	54	
Syria, Jordan and north Iraq	272	201
Vietnam	0	
China	35	
Far East	79	119
Ethiopia	94	59
Eritrea/Tigray/Yemen	86	11
Russian Wheat Aphids	56	
Earliness (Libya, Egypt, Bangladesh)	79	15
CAC, Turkey, Continental Highlands	840	
High yield potential		71
Disease and pest resistance	*	
Tunisia and Powdery Mildew	*	
Recurrent selection		189
Malting quality		
Total	2203	962

2.4.2. Base Broadening (The Comics)

We began in 1996 a specific activity directed at base broadening by developing composite populations (a new population every year) obtained by mixing an equal amount of seed from about 1000-1500 different F2's. These populations are called COMIC (Composites ICARDA) and are grown every year in two contrasting locations (one wet and one dry) in Syria under natural selection only. The parental material (about 300 parents) includes landraces from various countries, *H. spontaneum* accessions, modern cultivars, and lines derived from crosses between the previous groups. The parents represent both spring, facultative and winter types, two-rows and six-rows, hulled and hulless. The are now five of these populations, namely COMIC96, COMIC97, COMIC98, COMIC99, and COMIC00. During 1999 we also started discussing with a number of National Programs the usefulness of growing the COMIC's as a long term investment for both conservation and improvement objectives. During 1999 we developed a strategy to make available internationally these populations that contains an immense wealth of genetic variability. The strategy is as follows:

1) One or more base populations will be constructed in the Summer 2000 using about 1200 F1 produced in spring 1999 from nearly 500 parents which include landraces from the Fertile Crescent (Jordan, Syria, Turkey and Iraq), from other countries (Algeria, Bangladesh, Ethiopia, Eritrea, Yemen, Morocco and Tunisia), *H. spontaneum* accessions, modern cultivars (including malting barley), and lines derived from crosses between the previous groups, namely landraces x landraces, landraces x *H. spontaneum*, landraces x modern, and modern x *H. spontaneum*. The parents (nearly 500) represent both spring, facultative and winter types, two-rows and six-rows, hulled and hulless. While one population that includes all possible genetic resources best achieves the objective of broadening the genetic base, a number of smaller populations can be constructed where the type of genetic resources is restricted to those potentially useful. The use of this "reduced" populations will be more towards improvement than conservation.

2) One more cycle of recombination will be done by crossing F1 x F1. The F2 seed and the seed produced by the F1xF1 crosses will be mixed to generate two base populations, one with and one without locally adapted germplasm (landraces from Syria, Jordan and Iraq and *H. spontaneum*) which will be increased in the cropping season 2000/2001 and which will ready for international distribution in September 2001.

3) Initially we plan to grow the base population in the following countries: Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, Turkey, Iraq, Iran, Kazakhstan, Kyrgyzstan, Uzbekistan, Azerbaijan, Armenia, Ethiopia, Eritrea, Yemen, Nepal, India, China, Colombia, Ecuador, Peru, Bolivia and Mexico in between two and three locations in each country representing important target environments for the crop. In Syria, both populations will be grown in two research stations and in eight farmers fields where farmers will manage it. Farmers' fields will also represent a number of locations in Morocco, Tunisia, Egypt, Jordan, Yemen and Eritrea, where ICARDA has collaborative projects on participatory plant breeding.

4) The population(s) will evolve mostly under natural selection pressure (including diseases), but the breeders (and the farmers) can also practice positive selection for desirable types.

2.4.3. The Yield Trials

The most commonly used breeding method both at the headquarters and in the decentralized programs, is the bulk-pedigree that has been described in the 1997 Annual Report.

There were three major changes in the yield testing at the headquarters.

The first change is a direct consequence of the process of decentralization and consists in a gradual decrease in the number of lines which are yield-tested at the headquarters (Table 2.2), because most of the yield testing is now conducted in the target environment (or at least in the target countries), and those yield trials still conducted at the headquarters are targeted for areas with Mediterranean climate with cool winters, i.e. Syria, Jordan, Iraq, and part of Turkey and of Iran. This component of the program is now increasingly conducted in farmers' fields where selection is done by farmers, and therefore most of the yield testing is in the process of being gradually shifted to farmers' fields. Therefore, during 1999, of the three types of yield trials conducted in the past on station, namely initial, preliminary and advanced yield trials, the preliminary and the advanced yield trials were still kept on station; in 2000 only the advanced yield trials will be kept on station, and in the 2001 the yield testing will be entirely conducted in farmers' fields.

Table 2.2. The number of breeding lines in the yield trials conducted at the headquarters from 1993 to 1999

Year	Initial	Preliminary	Advanced	Total
1993	2268	702	224	3194
1994	1408	564	114	2086
1995	1532	392	132	2056
1996	858	329	137	1324
1997	858	249	89	1196
1998	478	241	79	798
1999	-	688	138	826

The second change introduced in 1999, was the separation of two-row and six-row types in two different yield trials. The trials with the six-row types (preliminary and advanced) were planted only in Tel Hadya, while the preliminary and advanced yield trials with two-row types were planted in Tel Hadya, Breda and Bouider. The yield trials are conducted without addition of fertilizer (Breda and Bouider) or with modest amount (30 kg/ha of nitrogen and 20 Kg/ha of P_2O_5) at Tel Hadya.

In the three locations rainfall was lower than normal (Table 2.3), particularly in Breda that was the driest of the three locations. There was a late start of the rainy season that delayed the emergence and shortened the growing season.

Table 2.3. Comparison between the total rainfall and rainfall distribution in 1998/99 with the long-term rainfall data in Tel Hadya, Breda and Bouider

	Tel Hadya		Breda		Bouider	
Month	1998/99	Long Term	1998/99	Long Term	1998/99	Long Term
September	0	2.9	0	3.1	0.8	1.28
October	2.3	25.4	1.8	19.9	0.4	19.5
November	39.3	50.2	20.2	31.9	19.7	34.4
December	87.8	51.5	40.8	35.7	55.8	40
January	40.3	65.7	19.6	51.2	19.2	47.2
February	50.4	51.8	30	44.8	27.6	34
March	65.9	48.2	72.8	38.3	56	36.1
April	22.8	28.9	12	20.1	17.9	19.3
May	0	12.3	0.6	13.2	0	8.5
June	0	1.6	0	1.2	0	1.9
July	0	0	0	0	25.4	2.4
August	0	0.8	0	0	0	0
Total	308.8	339.3	197.8	259.4	222.8	244.6

There was a period of drought that in Breda lasted nearly forty days from beginning of February to mid-March (Figure 2.6). During this period the amount of rainfall is usually about 50 mm, while in this cropping season the crop received only 4 mm. At this time, with only 113 mm of rainfall, the majority of the plots showed both leaf rolling and wilting.

The third change introduced in 1999 was the use of ASREML (see Annual Report 1998) as a routine analysis for the data collected in the yield trials.

The yield trials are designed as α-lattices: while the randomization was performed using ALPHANAL (AFRC Statistics, Edinburgh) as in the past, the data were analyzed with ASREML using two models. In both models, the entries were always considered as fixed effects; in the first model we used a two dimensional spatial analysis of the following type:

```
"Var. Name" ~ mu entry !f mv
1 2
x row AR 0.1
y col AR 0.1
```

where x and y are the number of rows and columns,

respectively in the field layout. In the second model we fit random row and column effects:
"Var. Name" ~ mu entry !r row col !f mv
Both analysis produce best linear unbiased estimates (BLUE) of the entries. For further analysis and selection we chose, case by case, the model that gave the smallest standard error between entries.

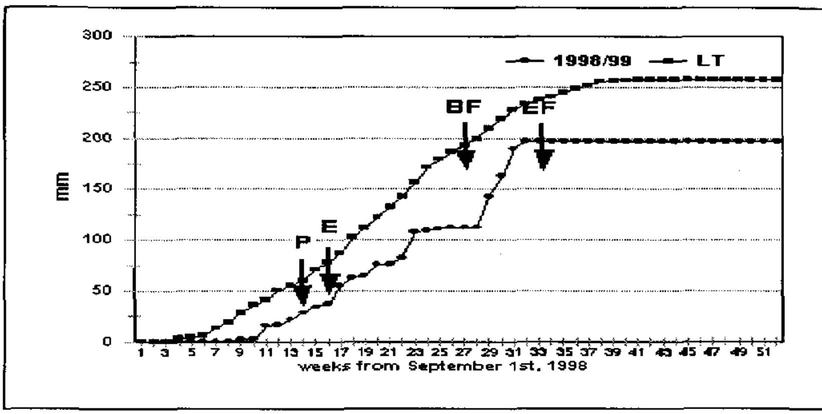


Figure 2.6. Cumulative long-term weekly rainfall (mean of 14 years) and 1998/99 weekly rainfall in Breda (P=planting date, E=emergence date, BF=beginning of flowering, EF=end of flowering).

The performance of the breeding material in the advanced yield trials is summarized in (Tables 2.4 & 2.5 for the two rows and six rows, respectively. The performance of the breeding material in the preliminary yield trials is summarized in (Tables 2.6 & 2.7) for the two rows and six rows, respectively.

In the advanced yield trials of the two-rows types (Table 2.4) the best checks were Rihane-03 in Tel Hadya, and Zanbaka in Breda and Bouider. The highest yielding entry in Tel Hadya was a pure line selection from a landrace (SLB 31-24) while the highest yielding lines in Breda and Bouider were both crosses with SLB 05-96. Two lines were consistently among the top yielding in both Breda and Bouider

(Arar/*H.spont*.19-15//Arta-entry nr. 7, and Tadmor/Zanbaka).

In the advanced yield trials of the six-rows types (Table 2.5) several lines had the same yield level of the two checks (Rihane-03 and Alanda-01) and a similar reaction to a number of diseases.

In the preliminary yield trials of the two-rows types (Table 2.4) the best checks were Rihane-03 in Tel Hadya, and Arta in Breda. As with the advanced yield trials, few lines had the same yield level of Rihane-03. On the contrary, several lines out yielded Arta even though the differences were not significant. Eventually, in the preliminary yield trials of six-row types few lines reached a yield level of 5.5 t/ha, about 500 kg/ha more than Rihane-03 and Alanda-01.

2.4.4. Cold Tolerance

For the evaluation of cold tolerance the breeding material is tested in Turkey, at Krasnodar, in collaboration with the Krasnodar Research Institute of Agriculture, and at ICARDA. At the headquarters, the evaluation of cold tolerance is done in Kottermann chambers with the modified traditional method for frost tolerance that was described in the 1998 report. With this technique the material is classified as susceptible, moderately susceptible and resistant. Among the resistant germplasm the most interesting were the hulless winter barley lines H-1, H-2 and Hymalaya. Their cold tolerance was confirmed by two years data from Krasnodar, Turkey, and ICARDA under both controlled and natural conditions. The six-row lines H-1 and Hymalaya have good agronomic characteristics and a yield potential of 6 t/ha. The two-row line H-2 combines cold tolerance with good grain quality and resistance to shattering. Results from the freezing chambers have shown that these lines are considerably more cold tolerant than the most commonly grown varieties in Turkey and Iran (Table 2.8).

The interest in barley as a food crop is increasing not only in the areas where the crop has been traditionally used as food. Breeders in Turkey and Iran, where barley production is based on winter types, are increasingly interested in hulless barley. However, most of the progress achieved in breeding hulless barley is generally limited to spring types. Therefore, the first step should be directed to improve the cold tolerance of hulless barley. In this respect the results shown in (Table 2.8) are important. Even though some agronomic characteristics of these lines still need some improvement, they represent valuable breeding material for further breeding. They were included into WBCB-CH-CW99 nursery and were sent to many collaborators in the highlands, and to CAC.

Concerning frost tolerance as the major component of winter hardiness, the achievements of American breeders are the most significant. Breeding material from the Uniform Barley Winter Hardiness Nursery (UBWHN99) such as Nebraska 92 716, Nebraska 93 760, Dictoo, and Kearney had the highest cold tolerance (Table 2.9).

One of the achievements of the last year was the considerable improvement in cold tolerance of the two-row barley types. This achievement is important for Turkey, the CAC countries, and Russia, in relation to the improvement of malting barley. ICARDA has developed valuable material as a result of the long term cooperation with Turkey, the USA and some European countries, based on the use of two-row winter and spring barley. In some nurseries promising lines were identified with acceptable level of cold tolerance and good expressions of other traits (Table 2.10).

The problem of improving the cold tolerance of two-row malting barley is also urgent for CAC countries. Uzbekistan and Kyrgyztan have joint ventures with Czech Republic and Germany to organize beer production in the two countries.

2.4.5. Depth of Crown Node

The depth of underground crown node is closely related to winter hardiness. In fact, every centimeter of soil gives 1-3°C protection against frost to the crown node.

During 1999 we tested 530 winter barley entries from advanced nurseries and crossing block and 500 lines extracted from Syrian landraces. They were planted in the field at the depth of 8 cm and the depth of underground crown node was measured as it was described in the 1998 report.

There was a wide variation in the depth of underground crown node that ranged from 2.2 cm to 7.1 cm. The majority of the lines formed the tillering node at a depth of 3.0 cm. In addition to genotypes such as Dictoo and Rostov-55 known for a deep crown node, two new lines from USA, NE 93760, NE 93 747, showed very deep crown node (6-7 cm).

Among the 500 Syrian landraces, 7 lines formed the crown node at a depth of 5-7 cm.

In the same experiment, a total of 48 plants with deep crown nodes were selected from 1200 F4 plants for further research.

Table 2.4. Drought score at Breda (DSBR), plant height at Breda (PHBR), days to heading (DH) and grain yield at Tel Hadya, Breda and Bouider (GYTH, GYBR, and GYBO) with rank in parenthesis of the best lines in the advanced yield trials (two-row types)

Entry	Name	DSBR	PHBR	DH	GYTH	(R)	GYBR	(R)	GYBO	(R)
79	WI2291/Tadmor	2.8	38	114	4626	(5)	1191	(8)	793	(16)
12	Harmal-02/Arabi Abiad/3/Api/CM67//Nacta/4/...	3.5	40	114	4632	(4)	1046	(37)	602	(62)
57	Moroc 9-75/Arta	3.6	42	117	3467	(79)	1216	(5)	782	(17)
8	Arar/*H.spont*.19-15//Arta	2.1	51	107	3812	(64)	1199	(6)	607	(60)
1	SLB 31-24	2.7	40	115	5013	(1)	1136	(21)	600	(63)
7	Arar/*H.spont*.19-15//Arta	3.3	55	115	3733	(67)	1236	(3)	890	(4)
2	SLB 32-39	4.7	35	117	4725	(2)	1064	(32)	578	(65)
39	SLB 05-96/Arta	3.3	41	117	3984	(49)	1297	(1)	836	(6)
52	Tadmor/Zanbaka	2.5	55	118	3699	(69)	1226	(4)	901	(3)
45	SLB 05-96/H.spontaneum 41-1	2.1	48	116	3091	(93)	816	(81)	913	(1)
41	SLB 05-96/Arta	2.7	35	118	3835	(61)	1147	(18)	906	(2)
	Checks									
99	Rihane-03	3.4	50	119	4699	(3)	983	(49)	562	(67)
91	Arta	3.4	38	115	4307	(21)	1159	(16)	714	(33)
93	Zanbaka	2.4	58	115	3499	(78)	1282	(2)	805	(12)
95	A. Abiad	3.8	41	119	4042	(43)	923	(13)	830	(35)
94	A. Aswad	2.9	52	108	3604	(76)	1059	(61)	752	(60)

Table 2.6. Drought score at Breda (DSBR), Plant height at Breda (PHBR), Days to heading (DH), Grain yield at Tel Hadya and Breda (GYTH, GYBR) and rank in parenthesis of the best lines in the preliminary yield trials (two-row types)

Entry	Name	DSBR	PHBR	DH	GYTH (R)	GYBR99 (R)
404	Roho/Arabi Abiad//Arta	3.1	42	116	4195 (59)	1776 (1)
63	Syrian landrace (el fan aussad)	4.5	39	119	4768 (14)	1767 (2)
47	Syrian landrace (al bab)	4.2	44	120	4689 (19)	1761 (3)
45	Syrian landrace (al bab)	4.5	37	118	4609 (23)	1757 (4)
95	H.spont.41-1/Tadmor//SLB 45-90/H.spont.41-2	2.5	56	117	2276 (406)	1748 (5)
389	SLB 18-76/Arta	3.5	46	116	4260 (53)	1746 (6)
94	Zanbaka/5/Pyo/Cam//Avt/RM1508/3/Pon/4/Mona/Ben//Cam/ 6/Arupo	3.9	38	110	5211 (3)	1589 (43)
82	Emir/Sbt//CM67/3/F8-HB-854-23/121//148-221/4/CI 08887/CI 05761/5/ER/Apm/3/Arr/Esp//Alger/Ceres 362-1-1/6/Sfa-02/3/RM1508/Por//WI2269/4/Roho/Arabi Abiad	3.0	37	115	5414 (1)	1521 (70)
129	WI2291/Hma-03/3/Roho//Alger/Ceres 362-1-1/4/Arta	3.0	45	114	5266 (2)	1391 (189)
128	Emir/Sbt//CM67/3/.../6/Arta	3.8	36	115	4950 (5)	1681 (21)
84	Tadmor//Kv/Masurka/3/Roho/Arabi Abiad	3.6	43	110	4939 (6)	1579 (48)
	Checks					
427	Rihane-03	3.7	50	120	5184 (4)	1418 (165)
419	Arta	3.4	34	115	4115 (72)	1720 (14)
421	Zanbaka	2.5	46	116	3481	1430 (152)
423	Arabi Abiad	4.1	37	119	4117 (71)	1360 (223)
422	Arabi Aswad	2.9	51	119	3756	1167 (382)

Table 2.7. Plant height at Tel Hadya (PH), Days to heading (DH), Grain yield at Tel Hadya (GY), 1000 KW and VR requirement of the best lines in the preliminary yield trials (six-row types)

Entry	Name	PH	DH	GY	KW	VR
80	IPA7/Katara	102	102	5553	43.0	1
124	Lignee 527/NK1272//Alanda/3/Alanda-01/Alanda-01	92	92	5514	32.2	1
90	Rhn-08/3/Deir Alla 106//DL71/Strain 205/4/Aw Black/Aths//Rhn-08	109	109	5513	42.8	1
215	CI-10114/Attiki//NK-1272/3/Mzq/CI-3909-2//Aths	94	94	5495	41.8	1
226	Ballan/6/Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/N-Acc4000-123-80	105	105	5481	39.1	2
109	Alanda//Lignee527/Arar/6/Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/Gas/Ore'S'	103	103	5469	42.6	1
210	Avt/Aths//Min-480/Gva/3/M-AtT73-337-1/4/Aths/3/Ore"S"//33-4/Bahtim-10	89	89	5437	41.1	1
52	Giza 126/Barbara	102	102	5347	37.5	2
260	CN100/DC23//Fun*3/3/Tra/4/10925-1/5/BcoMr/As/6/SeedSource72-Sal/7/JLB70-63	89	89	5317	36.3	1
264	Lignee 527//Lignee 527/NK1272	106	106	5314	42.3	1
116	Shyri-3/4/Rhn-08/3/Deir Alla 106//DL71/Strain 205	108	108	5293	37.1	1
	Checks					
272	Alanda-01	93	93	5161	40.8	-
271	Rihane-03	99	99	4979	40.4	-

Table 2.7. Plant height at Tel Hadya (PH), Days to heading (DH), Grain yield at Tel Hadya (GY), 1000 KW and VR requirement of the best lines in the preliminary yield trials (six-row types)

Entry	Name	PH	DH	GY	KW	VR
80	IPA7/Katara	102	102	5553	43.0	1
124	Lignee 527/NK1272//Alanda/3/Alanda-01/Alanda-01	92	92	5514	32.2	1
90	Rhn-08/3/Deir Alla 106//DL71/Strain 205/4/Aw Black/Aths//Rhn-08	109	109	5513	42.8	1
215	CI-10114/Attiki//NK-1272/3/Mzq/CI-3909-2//Aths	94	94	5495	41.8	1
226	Ballan/6/Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/N-Acc4000-123-80	105	105	5481	39.1	2
109	Alanda//Lignee527/Arar/6/Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/Gas/Ore'S'	103	103	5469	42.6	1
210	Avt/Aths//Min-480/Gva/3/M-AtT73-337-1/4/Aths/3/Ore"S"//33-4/Bahtim-10	89	89	5437	41.1	1
52	Giza 126/Barbara	102	102	5347	37.5	2
260	CN100/DC23//Fun*3/3/Tra/4/10925-1/5/BcoMr/As/6/SeedSource72-Sal/7/JLB70-63	89	89	5317	36.3	1
264	Lignee 527//Lignee 527/NK1272	106	106	5314	42.3	1
116	Shyri-3/4/Rhn-08/3/Deir Alla 106//DL71/Strain 205	108	108	5293	37.1	1
	Checks					
272	Alanda-01	93	93	5161	40.8	-
271	Rihane-03	99	99	4979	40.4	-

Table 2.8. Cold tolerance (% of survival), cold damage (CD 1=no damage, 5=severe damage), growth habit (GH 1=erect, 5=prostrate) and growth vigor (GV 1=max, 5=min) of hulless winter barley lines

Name	Cold tolerance		CD	GH	GV
	Krasnodar	Severo-Kuban			
Rihane-03	0.0	5.2	3	3	1
Tokak (Turkey)	20.6	38.7	2	5	2
Dobrynia-03	100	100	1	4	3
Radical	93.6	100	1	4	4
Hulless barley					
Hymalaya	88.4	90.5	1	4	4
H-1	86.8	86.3	1	4	3
H-2	60.2	66.2	1	5	4
LSD 0.05	9.6	10.6			

Table 2.9. Cold tolerance (% of survival), growth vigor (GV 1=max, 5=min) and growth habit (GH 1=erect, 5=prostrate) of germplasm from the Uniform Barley Winter Hardiness Nursery (UWBN 99)

Name	Cold Tolerance			GV	GH
	ICARDA	Krasnodar	Severo-Kuba		
Rihane-03-check	5.2	0.0	0.0	1	3
Tokak-check	40.2	20.6	38.7	2	5
Radical-check	80.6	88.5	90.8	2	4
Kearney	100	93.6	100	4	4
Dictoo	100	95.4	100	5	5
NE 93 760	100	100	100	4	5
NE 92716	100	100	100	4	4
PA 9550151	88.9	84.7	90.3	4	4
PA 9550155	90.4	87.8	92.4	4	4
LSD 0.05	8.7	10.2	11.5		

Table 2.10. Row type (RT), cold tolerance (CD as % survival), plant height (PH in cm), scores for disease resistance (DR) and grain yield (GY in g/plot) of winter barley lines selected from ICARDA nurseries at Krasnodar

Variety		RT	CD	PH	DR		GY
					Er.Gr.	*P.teres*	
Entry	Dobrynia-03-check	6	86.4	80.6	5	8	608
	Tokak-check	2	48.4	105.3	3	5	430
	Rihane-03	6	5.3	86.5	7	7	580
IWBIOOIN-CH-CW99							
1002	Kenya Research/Belle//Wysor	2	80.7	105.6	8	7	450
1087	Plaisant/Radical	6	65.4	100.2	6	6	610
1173	Radical/Xemus	6	87,8	90.5	5	4	715
WPYTCH-CW99							
438	3896//1-15/3/3896/28//…	2	71.6	102.3	7	7	650
442	86-5013/F3 Bulk Hiproly/4/…	2	20.6	95.4	7	7	630
537	Alpa/Cun/3/Car/RMI…	2	48.4	100.8	7	6	658
IWEBON-CH-CW99							
7	Foma 72-1144r-174 Azmir 56…	2	50.4	98.8	7	7	710
LSD 0.05			10.2				48

2.4.6. Molecular Breeding

2.4.6.1. Collection and Genetic Characterization of Powdery Mildew Isolates in Syria for Gene Postulation in Barley Breeding lines

Samples of powdery mildew were collected from different barley growing areas in Syria and were used for screening barley germplasm and for determination of virulence spectrum of the powdery mildew populations using the European differential set. Single spore colonies were developed from random populations representing different barley areas and were compared to colonies from the previous year.

Among the 1998 isolates, the TH1 isolate was the most virulent and TH3-T was the least virulent on the set of the selected resistance genes. The virulence of 1999 isolates was relatively higher than that of 1998. THM-1, from Mousiaf region in central Syria, was the most virulent isolate and showed a new virulence on Mlg and Mla7/Mlk as compared to 1998 isolates (Table 2.11). The 1999 isolates were collected over a larger area and hence showed a wider range of virulence gene. Some cultures showed two reaction types on the same resistance gene and hence should be further analyzed. Other single colonies are under investigation and will be added to this collection.

The selected resistance genes tested showed a different level of resistance to the powdery mildew isolates tested. Mla-1, Mla12, Mla13, Mla (new), and mlo showed effective resistance against all the isolates. Mla (new) showed higher level of resistance than mlo that showed an intermediate type of resistance against the virulent isolates. The behavior of Mla3, Mla9, and Mla7/Mlk should be further clarified. Mla12 and Mla13 will be recommended to the breeder as source of resistance to powdery mildew in Syria. Unknown sources of resistance found in the ICARDA barley germplasm will be characterized this coming season.

2.4.6.2. Development of Doubled Haploid Techniques in Barley

The value of doubled haploid (DH) production for breeders is the reduced time required to obtain homozygous populations. Furthermore, with the introduction of DNA-marker technology in plant breeding for gene-tagging and genome-mapping, DH lines represent the ideal plant material for the application of this technology.

Table 2.11. Testing of Syria powdery mildew isolates and European mildew tester set

	Varieties														
	Gitte	Po2	Vol	Orto	Welam	Sultan	Rupal	Wi	Bollo	Vada	HT 235	HIM	Tadmor	Sm 4142	Union
	Gen														
Isolates	Mla-1	Mla-3	Mla-6	Mla7/M 1k	Mla9	Mla12	Mla13	Mlg	Mlh	Mila	Mla,New	Mlo	-	-	Mlg
Ghab 1	0		3	1	0	-	0	3	-	3	0	0-3	-	-	3
Ghab 2	0	3	-	1	0	2	0	3	-	3	1	0	-	-	2
Ghab 3	0	2	-	2	1	2	0	2	-	-	1	0	-	-	3
Ghab 4	0	2	3	1	0	2	1	0	3	3	1	0	-	-	0
Ghab 5	0	2	3	3	1	3	1	3	3	-	2	0		-	-
TH 1	0	3	3	2-0	1-0	2	1	0	3	-	1	0	-	-	0
TH 2-HS	1	2	-	1	1	2	1	1	-	-	1	0	-	-	0
TH 3-Ta	0	2	3	2	1	1	1	0	-	-	0	0	-	-	-
TH 4	0	1	3	0	0	0	1	0-1	-	3	0	0	-	-	0
TH 5	1	1	-	0	1	1	1	1	3		0	0	-	-	0
Idleb 1	0	1-2	3	1	0	1	0	0-2	3	2	1	0	-	-	0-2
Lattakia *1	0	1-2	3	-	2	0	10	2	2	3	1	0	-	-	2
El-Bab 1	0	2	2	0-2	0	1	0-1	2	-		1	0	-	-	2
Musyaf 1	0	2	-	3	0	1	0	-	2	3	1	0	-	-	3
Musyaf 2	0	2	3	0-1	0	0	0	2	2		1	0	-	-	2
Musyaf 3	0	2	3	2	0-2	1	0	2	2	2	1	0	3	3	2
Musyaf 4	0	0	-	2	2	1	0	2	2	3	0-1	0-1	3	3	2
Musyaf 5	0	0	-	1	0	1	0	0	3	2	0	0	-	-	-

The anther culture systems was used in 1999 to produce haploid plants from both the cross of Tadmor with WI2291 and its reciprocal. Fourteen F1 plants yielded 5040 anthers that produced 3651 calli leading to 307 green plantlets on O4 induction and regeneration medium (Table 2.12). The major increase in green plant production as compared to earlier results (1995) can be attributed to a change in the medium. An average green plant production rate of 5% is lower than that observed for bread wheat. Nevertheless, it is sufficient to produce DH populations from selected crosses, if a sufficient number of F1 seed is made available.

Table 2.12. Development of doubled haploid lines in barley using anther-/isolated microspore culture

No. of F_1 Plants	Year	No. of anthers	No. of calli on			No. of green plants/% of GP per 100 anthers		
T.W			O4	FHG	BK	O4	FHG	BK
14	1999	5040	3651	3394	-	307/6.1	9	-
	1995	1890	-	-	116	-	-	11/0.63
	1995	3810	-	225	-	-	35 /0.92	-
W.T								
34	1999	11565	50330	51050	-	431/3.7	10	-
Field-grown barley								-
1 (No.36)	1999	405	276	12	-	19/4.7	0	-
1 (No.270)	1999	315	38	8	-	10/3.2	0	-
1 (No. 330)	1999	360	861	14	-	3/0.8	0	-

2.4.6.3. Genetic Mapping of the Cross Arta/*H. spontaneum* to Tag Plant Height under Drought Stress and Brittle Rachis

The wild progenitor of barley can contribute useful genes for several characters like disease resistance, earliness, biomass, grain yield, grain protein, and tolerance to salinity and drought. One of the most useful traits of *Hordeum spontaneum* in relation to stress tolerance is its plant height under drought. This is important because one of the most evident effects of drought is a reduction in plant height, making harvest by combine difficult or impossible. In addition, not only grain but also straw has a value to farmers in West Asia and North Africa (WANA). Gene introgression from *H. spontaneum* into cultivated barley is a long and difficult process despite the fact that crosses between the two are easy to make and fully fertile. This is because *H. spontaneum* has a number of undesirable traits such as brittle rachis, low kernel weight, and rough awns. An additional difficulty is that the improvement of plant height under drought often causes a reduction in tillering, and hence in both grain and straw yield.

It is evident that in order to fully exploit the potential of crosses between cultivated barley and *H. spontaneum* a large number of recombinant lines derived from each cross has to be evaluated. Using DNA-molecular marker techniques that are now sufficiently well developed to be exploited in breeding programs, can considerably reduce the complexity of combining a number of desirable traits in the same line. These techniques make it feasible to develop linkage maps for crops such as barley. Together with statistical techniques, these linkage maps are used to locate and estimate phenotypic effects of quantitative trait loci (QTLs). QTL analysis provides a powerful tool to locate genes on chromosomes. Therefore, the identification of molecular markers closely linked to QTLs of agronomic interest, or to negative traits, will allow the use of marker assisted selection and thus increase the efficiency in the exploitation of *H. spontaneum*.

The objective of this work was to identify trait-marker linkages in a population of recombinant inbred lines (RILs) of a cross between Arta and *H. spontaneum* 41-1 using the QTL approach.

A population of 494 F7 RILs derived by single seed descent from the cross Arta/*H. spontaneum* 41-1 was developed at ICARDA. Arta, a pure line selected from the Syrian white-seeded landrace Arabi Abiad, is well adapted to Syrian conditions, high yielding, but becomes very short under dry conditions. *H. spontaneum* 41-1, a pure line selected for its adaptation to severe drought stress conditions, combines earliness with acceptable cold tolerance, and its ability to maintain plant height under drought. At least six characters are expected to segregate from this cross: rachis brittleness, awn roughness, peduncle extrusion, plant height, tillering, and kernel size. The main objective of this cross was to develop lines combining the grain yield and tillering ability of Arta with the plant height and the adaptation to severe drought stress conditions of *H. spontaneum* 41-1.

The two parents and the 494 RILs were field tested in 1997 and 1998 at ICARDA's research stations located near Tel Hadya, (36°01' N; 37°20' E, elevation 300 m asl) and near Breda (35°56' N; 37°10' E, elevation 354 m asl), in Syria. The traits measured are listed in (Table 2.13).

Table 2.13. Traits evaluated in RILs of Arta x *H. spontaneum* 41-1

Trait	Description	Units	*TH 97**	*TH 98*	BR 97	BR 98
GH	Growth habit	Scale (1- 4)	Y	Y	Y	N
RS	Rachis	Brittle/tough	N	N	Y	Y
CD	Cold damage	Scale (1-5)	Y	Y	N	N
GV	Growth vigor	Scale (1-5)	Y	Y	N	Y
DH	Days from emergence to heading	Days	Y	N	Y	N
TN	Tiller number m^2	No.	Y	N	Y	Y
PH	Plant height	Cm	Y	N	Y	Y
BY	Biological yield	kg ha^{-1}	Y	Y	Y	Y
GY	Grain yield	kg ha^{-1}	Y	Y	Y	Y
KW	1000 kernel weight	G	Y	Y	Y	Y
PR	Kernel protein content	%	Y	N	Y	N

*TH=Tel Hadya, BR=Breda

One hundred and ninety-four RILs were used for map construction. Genetic mapping was carried out using Amplified Fragment Length Polymorphic (AFLP) markers and microsatellite-based markers. Linkage analysis was assessed with MAPMAKER (Lincoln et al., 1992, Version 3.0) and JOINMAP. Regression analysis was used to identify possible marker-trait linkages. Interval mapping was used to identify QTLs (qGene 2.3).

A number of microsatellite markers and AFLPs were used to cover the barley genome. Sixty-nine markers grouped in seven linkage groups (Table 2.14) were used for the analysis. The microsatellite-based markers identified the seven linkage groups. The location of the microsatellite markers agrees with known locations in other maps.

The major objective of the present work was to see whether markers could be identified for brittle rachis and plant height under drought from *H. spontaneum* 41-1and for yield. For brittle rachis the evaluation in Breda, in 1997 and 1998 showed in both cases linkage to the same marker Bmac0006 on the proximal end of chromosome 3H (Table 2.15). If brittle rachis is treated as a qualitative marker, it will, at a LOD score of 3.0, form a linkage group with marker 52. As marker 52 is located at the distal end of the linkage group with a fair distance to the next marker, the position of marker 52 on chromosome 4a is not yet secured. However, with an R^2 of 0.263 and 0.213 for 1997 and 1998 respectively one major QTL can be expected as indicated by the present analyses. Other markers with smaller effects are located on chrom1 (33P81M836 R^2=0.082) chromosome 2b (39P71M344, R^2=0.079), and linkage group 2 (15P71M8215 R^2=0.065).

Table 2.14. Linkage map of the cross of Arta with *H. spontaneum*

Chromosome 1H	
Marker	Distance
Bmag0213	0
Hvm20b	16
Hvm20c	42

Chromosome 2H	
Marker	Distance
P71/M34-12	0
P71/M34-11	8
P71/M34-7	17
P71/M34-7	38
Hvm20a	50
P71/M184-1	71
P294/M62-9	78
P81/M183-5	80
HVBKASI	84
Bmag0140	91
Bmag0378	101
HVCSG	121
Hvm54	131
P71/M34-1	134

Chromosome 3H	
Marker	Distance
Bmag0006	0
Hvm15	20
P71/M34-3	36
P294/M62-10	62
Bmag0013	73
P71/M88-5	80
P71/M88-8	91
P294/M62-5	94
Hvm62	102

Chromosome 4H	
Marker	Distance
Bmac273b	0
HVM40	0
P71/M42-1	24
HVN68	41
P71/M82-9	63
P71/M88-2	69
Hvm67	104

Chromosome 5H	
Marker	Distance
P71/M889	0
Bmag0222	18
P294/M62-4	43
P71/M82-3	67
HVM06	86
Bmag0337	110
P71/M34-6	132

Chromosome 6H	
Marker	Distance
P71/M82-14	0
P71/M184-1	4
P71/M184-2	8
P71/M184-8	27
P71/M184-9	33
P71/M82-8	41
HVGNIRE	62

Chromosome 7H	
Marker	Distance
P71/M42-3	0
P71/M82-6	5
P71/M88-3	10
Bmag206	12
HVM04	17
Hvwaxyg	21
Hvm51	40
P71/M82-12	42
P71/M42-4	45
P71/M184-4	48
Bmac273a	51
Bmac0031	53
P294/M62-7	61
P294/M62-8	64
Bmac064	76
P81/M183-1	83
Bmag0120	90
P71/M88-6	104
P294/M62-3	111
P71/M184-6	114
P71/M184-3	135
P71/M88-12	138

The same marker identifying the brittle rachis trait on chromosome 3H showed linkage to biological yield and grain yield in Tel Hadya and Breda in 1997 and 1998. For grain yield *an average of 976 kg/ha for H. spontaneum* 41-1 and 1185.87 kg/ha for Arta was recorded in Breda, whereas 3156.84 (*H. spontaneum* 41-1) and 4665.2 kg/ha (Arta) were recorded in Tel Hadya. However, due to the brittle rachis the range for the analyzed lines was from 632 and 4504 kg/ha in Tel Hadya and 573 and 1665.5 kg/ha in Breda. It appears that the brittle rachis, located at the same position, masks QTLs for yield. Marker P81M1844 detected only one other putative QTL on chromosome 7H.

Plant height under drought in Tel Hadya 1997 was 79.89 and 105.00 cm for Arta and *H. spontaneum* 41-1, respectively, and 29.43 cm for Arta and 51.9 cm for *H. spontaneum* 41-1 as average of both years in Breda. The range was 31.9 and 64.5 cm for Breda and 83.5 and 115.1 cm for Tel Hadya 1997. Two AFLP markers P71M885 and P294M6210 on the distal part of chromosome 3H show linkage. It is possible, that this chromosome region identifies the *denso* locus that is responsible for dwarfing in other barley germplasm. However, Hvm54 on chromosome 2H identified an additional location for plant height in Breda in 1998.

For days to heading, the QTL with the biggest effect was located on chromosome 3H identified by markers Bmac0013 and AFLP marker P71/M88-5 for Tel Hadya and Breda. This again is the same chromosomal region that is responsible for the plant height. For many other traits, QTLs and their locations were identified in this cross such as cold damage on chromosomes 2H and 7H, number of tillers on chromosome 7H, growth habit on chromosome 2H, and kernel weight on chromosome 2H and 3H.

Table 2.15. Identified marker-trait linkages in the cross Arta H. spontaneum

Trait	Marker	Chromosome	N	Source	F	RSq
RSBR97-98	Bmag0006	3H	194	*H.spontaneum* 41-1	55.70	0.225
GHTH97	Hvm20a	2H	194	Arta	28.19	0.128
	P71M8214	6H	178	Arta	26.85	0.132
GHTH98	Hvm20a	2H	194	Arta	29.08	0.132
CDTH97	HVBKASI	2H	191	Arta	13.24	0.065
	Bmac273a	7H	180	*H.spontaneum* 41-1	34.64	0.163
CDTH98	Hvm20a	2H	194	Arta	16.07	0.077
GVTH97	P71M347	2H	182	*H.spontaneum* 41-1	16.23	0.083
DHBR97	Bmag0013	3H	179	Arta	23.85	0.119
	Hvwaxyg	7H	189	Arta	17.51	0.086
DHTH97	Bmag0378	2H	155	*H.spontaneum* 41-1	10.32	0.063
	P71M885	3H	179	Arta	14.95	0.078
PHBR97	P71M885	3H	179	*H.spontaneum* 41-1	30.84	0.148
PHTH97	P294M6210	3H	182	*H.spontaneum* 41-1	27.53	0.133
PHBR98	Hvm54	2H	184	*H.spontaneum* 41-1	11.62	0.060
TNBR97	P294M627	7H	185	*H.spontaneum* 41-1	13.95	0.071
BYBR97	P71M1844	7H	186	Arta	13.34	0.068
BYTH97	Bmag0006	3H	194	Arta	40.96	0.176
BYTH98	Bmag0006	3H	194	Arta	29.36	0.133
GYTH97	Bmag0006	3H	194	Arta	61.23	0.242
GYTH98	Bmag0006	3H	194	Arta	51.87	0.213
GYBR98	Bmag0006	3H	194	Arta	20.38	0.096
KWTH97	Bmag0378	2H	155	Arta	11.80	0.072
	Bmag0013	3H	179	Arta	12.91	0.068
KWTH98	Bmag0013	3H	179	Arta	11.24	0.060
KWBR98	HVBKASI	2H	191	Arta	15.73	0.077
	Bmag0013	3H	179	Arta	15.52	0.081
KWTH97	Bmag0378	2H	155	Arta	11.80	0.072
	Bmag0013	3H	179	Arta	12.91	0.068
PRTH97	P294M6210	3H	182	H.spontaneum 41-1	25.15	0.123
	Bmag0337	5H	175	*H.spontaneum* 41-1	11.06	0.060
	P71M8812	7H	184	*H.spontaneum* 41-1	15.24	0.077

2.4.7. Stress Physiology and Adaptation

Part of the activities described below are the result of a strategic link between Waite Campus Institutions (Department of Plant Science of the University of Adelaide, The South Australia Department of Agriculture, South Australia) and ICARDA that increases the capability of all institutions through germplasm exchange and targeted collaborative research. The collaborative arrangement provides access to international genetic resources and the ICARDA breeding program, including significant biotechnological capability. The aim is to identify and introgress alleles for drought stress tolerance from wild barley and landraces into elite germplasm, with the ultimate goal of improving the yield and the range of cultivated barley in low rainfall environments. In most Mediterranean-type, dryland-cropping environments of the world, barley is the crop which is best adapted to the marginal fringes of cropping. In contrast, wheat is the crop best adapted to marginal areas in Australia. Landraces and wild barley identified at ICARDA are a rich source of genes for adaptation to environments where drought stress is common. A program of germplasm introduction and field evaluation provides this project with the materials necessary to improve the adaptation of Australian barley varieties to drought stress.

Biochemical and physiological screening of this germplasm in conjunction with molecular mapping techniques will yield progress towards understanding the basis of stress tolerance, and identify genes for introgression into elite germplasm.

2.4.7.1. Field Testing of RIL's from Four Mapping Populations

During 1998/99 cropping season four RIL's populations were grown in the two contrasting environments in Northern Syria described earlier, namely Tel Hadya and Breda. The first is a typical high-input favorable environment with a wide choice of crops, while the second is a typical low-input risky environment, with barley as the most common rainfed crop and with limited choice of crops and cropping systems.

The four populations (Table 2.16) were chosen among twelve mapping populations developed at ICARDA by advancing through SSD twelve crosses between parent with various combinations of adaptation to Syrian dryland conditions.
For each cross we grew 88 RIL's and the two parents using an alpha-design with two replications and sub-blocks of size 10 in both locations. Plot size was 8 rows at 20 cm distance and 2.5 m long in Breda and 6 rows at 20 cm distance and 2.5 m long in Tel Hadya.

Table 2.16. The four populations of RIL's used in 1998/99

Cross #	Name	Comb.*	Row type
3	WI2269/Line 251-11-2/3/Leb71/CBB37//Leb71/CBB29	AxNA	2
6	Gustoe/6/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272	NAxNA	6
7	Arta/3/Harmal-02//Esp/1808-4L	AxA	2
9	Zanbaka/5/Pitayo/Cam//Avt/RM1508/3/Pon/4/Mona/Ben//Cam	AxNA	2

* A= Adapted; NA = not adapted

The following traits were measured or scored: growth habit (GH) using a visual score from 1=erect to 5=prostrate, at Tel Hadya; early growth vigor (EGV) at the five leaf stage using a visual score from 1=good to 5=poor at Tel Hadya; chlorophyll content (SPAD) obtained from the mean of 5 readings from intact leaves in the field using a portable chlorophyll meter [SPAD-502, Soil-Plant Analysis Development (SPAD) Section, Minolta Camera Co., Osaka, Japan]; agronomic score in Breda (AGSCBR) after a drought spell of nearly six weeks using a visual score from 1=good to 5=poor); lodging susceptibility using a visual score from 0=no lodging to 9=100% lodging, at Tel Hadya; plant height (cm) both in Tel Hadya (PHTH) and Breda (PHBR) from ground level to the base of the spike at maturity; days to heading (DH) as number of days from emergence to awn appearance in 50% of the plants in the plot in Tel Hadya; grain yield both in Tel Hadya (GYTH) and in Breda (GYBR) in kg/ha; kernel weight both in Tel Hadya (KWTH) and in Breda (KWBR) in g.

The data were analyzed using ASREML. The following two models were fitted to the data:

y ~ mu entry !r row col !f mv

y ~ mu entry !r block block.subock !f mv

The two models gave very similar fit. Eventually the second model was chosen to obtain the blues for the entries. The variance components for each single cross were estimated using the model below:

kwbr ~ mu cross !r block block.sblock cross/line !f mv

There was a large phenotypic variability for all the traits that were measured (Table 2.17). In most of the crosses there was transgressive segregation for most of the traits with the exception of growth habit in cross #9 were the prostrate growth habit of Zanbaka represents the more extreme expression of the character, and for lodging resistance in crosses #3 and #6.

Table 2.17. Mean, range and standard error of the mean (s.e.) of a number of traits scored on 88 RIL's and the respective parents of four crosses derived from parents differing in adaptation to Syrian dryland conditions

Cross#	Name	dh	gh	gvth	agscbr	spadth	ldgth	phth	phbr	gybr	gyth	kwth	kwbr
3	(P1)	89.5	1.76	1.37	2.88	43.47	0.97	69.7	38.6	1179	3654	34.7	30.1
	(P2)	95.7	2.61	2.49	4.12	41.73	0.00	63.7	39.9	1184	3031	28.0	25.1
	Mean	94.3	1.97	2.32	3.59	43.97	0.13	73.4	40.5	1205	4058	35.4	28.9
	Min	88.8	1.27	1.13	2.70	38.95	0.00	61.9	33.1	942	3197	28.0	23.2
	Max	104.5	2.99	3.37	4.82	49.84	3.95	88.0	50.6	1470	4896	41.0	34.3
	s.e.	0.3	0.04	0.06	0.04	0.24	0.05	0.6	0.4	13	40	0.3	0.3
6	(P1)	108.6	3.28	3.69	4.30	47.57	0.00	54.4	34.7	947	2399	21.3	22.8
	(P2)	99.3	1.53	2.92	3.65	42.95	0.00	88.1	41.7	1133	4265	28.4	23.2
	Mean	103.0	2.40	2.99	3.77	46.09	0.08	79.1	46.4	981	3188	26.9	24.8
	Min	92.2	0.85	1.72	2.81	40.16	0.00	47.4	25.7	409	1832	18.8	16.0
	Max	117.8	5.04	4.91	5.02	54.26	4.00	107.4	66.8	1349	4799	37.7	39.8
	s.e.	0.6	0.14	0.08	0.06	0.31	0.05	1.8	0.9	22	63	0.5	0.4
7	(P1)	98.4	3.45	2.79	3.49	46.72	7.44	73.5	41.4	1445	4209	40.1	27.3
	(P2)	95.6	2.13	1.54	3.10	46.06	0.00	81.9	44.5	1392	4478	43.7	36.4
	Mean	95.2	2.74	2.38	3.38	43.12	1.17	73.0	40.3	1491	4905	42.0	33.5
	Min	90.8	1.48	1.56	2.59	35.01	0.00	61.1	33.2	1107	3816	32.5	26.5
	Max	101.8	3.96	3.10	4.16	49.21	8.93	87.0	50.4	1800	6142	52.0	40.9
	s.e.	0.2	0.06	0.04	0.04	0.28	0.22	0.5	0.4	16	48	0.4	0.3
9	(P1)	98.2	4.16	2.34	2.73	36.01	9.00	91.3	54.4	1647	3794	30.9	32.6
	(P2)	100.5	1.41	2.50	4.01	39.23	0.03	79.4	39.7	906	3875	29.2	24.5
	Mean	94.9	2.57	2.36	3.04	38.35	2.77	83.0	48.4	1195	3582	35.1	29.2
	Min	75.2	0.96	1.29	0.94	33.15	0.00	47.6	25.4	435	1131	26.1	20.4
	Max	105.2	4.25	3.23	4.19	44.21	8.95	104.2	66.0	1532	4979	44.5	38.5
	s.e.	0.5	0.08	0.04	0.06	0.25	0.31	0.9	0.8	21	61	0.4	0.3

* Full names are given in Table 2.16

In the case of grain yield at Breda there was also transgressive segregation in all crosses except in cross #9, derived from Zanbaka which was the highest yielding of the eight parents in Breda and the most lodging susceptible in Tel Hadya, where recombinants better than Zanbaka were not found. In this cross, however, some of the highest yielding lines were not too different from Zanbaka for grain yield in Breda, they had the same seed color (black) but were as lodging resistant as the improved parent. The highest yielding lines in Breda were all derived from the cross #7 between the adapted pure line selected from the local white-seeded landrace (Arta) and the improved line Harmal-02//Esp/1808-4L also well adapted to Syrian dryland conditions. Some of the best lines (Table 2.18) yielded more than the parents both in Breda and in Tel Hadya, but only two yielded more than, or as much as, Zanbaka in Breda. These lines were also taller or similar to Arta in Breda (Arta tends to become very short under drought), and one of them (line 266) also had large kernels both in Breda and in Tel Hadya. Since the average days to heading of cross #7 was 95.2 (ranging from 90.8 to 101.8) the yield of most of these lines is probably not due to escape mechanisms. Therefore, from the results of the first year, it appears that this work may generate some useful breeding material for the Syrian dryland conditions.

Table 2.18. Characteristics of nine RIL's derive from cross #7 with grain yield in Breda higher than Zanbaka or Arta (P1), grain yield at Tel Hadya higher than Harmal-02//Esp/1808-4L (P2) and plant height in Breda higher than Arta

Entry	Dh	agscbr	ldgth	phth	phbr	gybr	gyth	kwth	kwbr
185	95.0	3.14	4.98	81.5	45.0	1800	5490	44.9	35.3
228	92.1	3.08	0.05	73.2	43.7	1749	5040	46.2	35.8
266	95.1	3.18	0.03	87.0	49.5	1576	5275	49.3	38.0
213	93.7	3.43	1.50	77.5	42.4	1621	5268	41.3	32.1
205	96.1	3.69	0.97	71.0	42.1	1677	5153	40.2	28.6
189	94.2	3.21	3.01	79.3	41.8	1536	5594	41.0	31.3
225	99.1	3.42	6.49	83.7	44.7	1616	4634	41.0	33.3
241	96.7	3.23	0.00	74.7	43.6	1618	4758	38.7	33.4
256	98.1	3.44	0.00	73.9	42.3	1597	5031	39.4	35.8
Zanbaka	98.2	2.73	9.00	91.3	54.4	1648	3795	30.9	32.6
(P1)	98.4	3.49	7.44	73.5	41.4	1445	4209	40.1	27.3
(P2)	95.6	3.10	0.00	81.9	44.5	1329	4478	43.7	36.4

There were differences in the amount of genetic variation within the different crosses (Table 2.19). The amount of genetic variation was, not surprisingly, higher for traits such ad flowering time, growth habit, plant height (particularly in Tel Hadya) and kernel weight. It was also evident that, in general, the stress environment of Breda decreased the amount of genetic variation. However, the decrease varies with the character as well as with the genetic material. For example, in the case of grain yield, only cross #3 showed a marked decrease, while in the case of plant height, cross #9 had a similar heritability in the two environment, while all the other crosses showed a decrease.

Table 2.19. Heritability of a number of traits scored on 88 RIL's and the respective parents of four crosses derived from parents differing in adaptation to Syrian dryland conditions

CROSS	dh99	ghth	gvth
3	0.83	0.49	0.52
6	0.95	0.95	0.76
7	0.63	0.74	0.16
9	0.94	0.84	0.32
CROSS	agscbr	Spadth	ldgth
3	0.31	0.21	0.00
6	0.60	0.43	0.00
7	0.20	0.35	0.83
9	0.59	0.26	0.91
CROSS	phth	phbr	gybr
3	0.43	0.19	0.09
6	0.92	0.82	0.57
7	0.39	0.29	0.28
9	0.74	0.76	0.56
Cross	gyth	kwbr	kwth
3	0.16	0.32	0.58
6	0.56	0.68	0.79
7	0.32	0.47	0.67
9	0.51	0.53	0.73

2.4.7.2. Mapping and Validation of Stress Parameters

Seventy-one doubled haploid lines (DH) were developed from the cross Tadmor/ WI2291 by anther-/microspore culture. Of these, 51 lines were used for the molecular marker analysis using RFLP, RAPD, STMS, AFLP as well as the traits seed color and powdery mildew resistance.

Two hundred forty eight (58 probes, 5 enzymes) RFLP loci, 97 RAPDs, 147 microsatellite, 13 (primer combinations) AFLPs markers were assayed in the two parents to get polymorphic bands (Table 2.20).

One hundred forty five markers (5 RFLPs, 42 microsatellite, 11 RAPD, and 87 AFLP markers) were tested for their segregation in 51 DHs derived from the cross. The proportion of loci deviating from the expected monogenic segregation ratios in DHs population was 56 of 145 loci (39.3%). Chi-square values showed excellent fit to hypothesized ratios for 92 markers in the DHs population, and 56 markers showed significant skewness at two levels of probability (44 loci deviated at 0.05, and 12 loci deviated at 0.01) (Table 2.21).

Table 2.20. Analysis of the RFLP, RAPD, SSR, and AFLP, generated banding patterns in Tadmor and WI2291

Marker type	No. of assay units	No. of polymorphic bands	Polymorphic bands (%)	Monomorphic or not amplified
RFLPs	295(59 probes, 5 enzymes)	127	43.1%	168
RAPDs	97(primers)	48	49.5%	49
SSRs	147(primer pairs)	41	27.9%	106
AFLPs	13 (primer combinations)	87	66.9%	-
Total	552	303		323

Table 2.21. Type of markers, number of markers, which showed polymorphic segregation in DHs from the cross Tadmor/WI2291, and percentage of distortion

Type of markers	No. of markers	Distortion (DHL)			
		P<0.05*	P<0.01**	Total	%
RFLPS	5	3	1	4	80
STMS	42	4	13	17	40.5
AFLPs	87	3	25	28	32.2
RAPDs	11	3	5	8	72.7
Total	145	12	44	57	
Skewed Segregation(%)	-	8.3%	30.3%	39.3%	

(*) Significant at 0.05, (**) Significant at 0.01.

Chi square analysis of the fitness of the segregation of markers indicated that 80% of RFLPs, 40.5% SSRs, 32.2% AFLPs and 72.7% RAPDs deviated significantly from the expected Mendelian ratio.

Out of the 145 markers, 89 fit a 1:1 ratio. The rest (56 markers) showed a significantly skewed segregation (44 loci deviated at $P<0.05$, and 12 loci deviated at $P<0.01$) (Table 2.21). This frequency of distortion is higher than any distortion reported for other crops that is between 6% and 10%. According to Schulz et al, (1994), the distorted segregation ratio may be caused by gametic or zygotic selection or incorrectly scored bands in small mapping populations. According to Zamir et al, (1986) the distorted segregation ratios in the genera *lens*, *capsicum* and *lycopersicum* is higher (54%) for progeny of interspecific hybrids than for progeny of interaspecific hybrids (13%).

In a comparison of p-values and chi-square calculated for the DH and F2:F3 population, the chi-square test showed better fit to expected ratios for F2:F3 at 9 loci of STMS, with approximately half the number of samples in the DHs population, however the distortion in F2:F3 population was 11%.

For 9 markers in the F2:F3 the codominant segregation ratio of 1:2:1 was hypothesized. Both the chi-square test for data pooled over these 9 loci and the heterogeneity test were significant. Markers included in the heterogeneity test cannot be considered to fit to a 1:2:1 ratio nor can they be considered to represent a non-uniform sample.

2.4.7.3. Screening Mapping Populations

The single seed descent derived populations listed in (Table 2.16) were screened with AFLP marker for their usefulness in genetic mapping studies. For that purpose, the parents, plus 8 randomly selected lines were analyzed by AFLPs. According to the results, populations no. 3, 6 and 9 are not useful for mapping purposes. Either polymorphic fragments in the parents did not segregate in the population, or fragments segregated where there was no difference between the parents, or additional fragments not explained by the parental phenotype occurred.

However, population no. 7 seems to be suitable for mapping. DNA of 88 lines was extracted. Microsatellite markers were applied for segregation analysis. Two lines were eliminated from the analysis while 86 give a clear segregation pattern. So far, 12 microsatellite markers were analyzed (GMS1, HVM33 chrom3h, BMS30 chrom4h, BMS64 chrom7h, BMS90 chrom1h, BMS40 chrom6h, HVCSG chrom2h, HVM4 chrom7h, HVM6 chrom5h, BMAC96 chrom5h, HVBKASI chrom2h).

2.4.7.4. Screening for Drought Stress in Australia

Encouraging results have been obtained from preliminary yield trials at two low rainfall sites in Australia, Port Wakefield, (32°50',135°07') and Minnipa Agricultural Center (32°50',135°07'). The trial contained 156 lines from ICARDA low rainfall nurseries. The sites experienced severe drought stress, with the best yields less than 1 t/ha. Pt Wakefield experienced cyclical drought stress first evident at late tillering, while Minnipa was characterized by terminal drought stress. Yield analysis confirmed that a significant number of the ICARDA lines were comparable to current Australian feed varieties, despite showing significant variation in growth habit and developmental patterns (Table 2.22).

Table 2.22. Yield (t/ha) of the top six ICARDA lines at Port Wakefield in comparison to current Australian barley varieties

Origin	Variety	Yield (t/ha)
Aust.	Barque	0.83
	Schooner	0.79
	Keel	0.79
	Gairdner	0.76
	Sloop	0.74
	Mundah	0.52
ICARDA	ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1	0.81
	Arabi Abiad/WI2291//Tadmor/4/H.Spont.93-4/......	0.81
	UC566/5/M64-76/Bon//Jo/York/3/M5/Galt//.......	0.81
	Rihane-03	0.77
	Moroc 9-75/Harmal-02	0.76
	WI2291/3/CI 03309/Attiki//Hja33/4/Jerusalem...	0.75

The performance of these lines in field trials in 2000 will allow more detailed analyses, and will allow comparison with the 81 elite lines selected from the ICARDA barley breeding program. This material will also be tested in the stage 1 trials in 2000.

On the basis of the yield in the 1999 field trials at South Australian low rainfall sites the following six ICARDA breeding lines have been selected:

1. Arar//Comp.Cr.29/C63/3/Anoidium
2. JLB 70-01/5/Deir Alla 106//DL70/Pyo/3/RM1508 /4/Arizona 5908/Aths//Avt/Attika/3/Ager
3. Roho//WI2198/Hml-02

4. H.spont.41-1/Tadmor/3/Hml//Kv/Mazurka
5. WI2291/3/CI 03309/Attika//Hja33/4/Jerusalem a barbes lisses/CI 10836
6. Weeah 11//WI2291/Bgs

These lines are genetically diverse, having Australian (Weeah, WI2291, WI2198), *H. spontaneum* (H. spont.41-1), ICARDA (Roho, Harmal), and primitive landrace (Tadmor, JLB 70-01, Jerusalem a barbes lisses) parents. The varieties Barque, Mundah and Keel have been selected as recurrent parents. The progeny from these crosses will be a resource for the breeding program as well as being used in ongoing genetic analyses.

2.4.8. Pathology

2.4.8.1 General Overview

Barley productivity in the barley growing areas in Central and Western Asia and in North Africa (CWANA) is affected by many production constraints among which biotic stresses are of major importance. Foliar and seed borne-diseases are prevalent in all barley growing areas. Under moderate rainfall conditions such as in North Africa and the Nile Valley and Red Sea regions, leaf rust and net blotch can cause important yield losses. Scald is widespread in CWANA particularly in areas characterized by cool winters. High infections were observed during this season in Eritrea, Ethiopia, Turkey, Tunisia, and Morocco. Likewise, powdery mildew is a primary disease in the semi-arid regions where early infection can affect the stand establishment of the crop and hence great reduction in tiller number. Monoculture of elite barley varieties such as Rihane-03 in North Africa and in many countries in West Asia can lead to serious disease epidemics such as the case in Tunisia for powdery mildew, scald and net blotch where farmer had to apply fungicides in order to save the crop.

Newly developed pure line cultivars are often overtaken by diseases before they even reach large production areas. Hence rapid change of varieties is an important control measure to avoid epidemics. The use of landrace cultivars, barley populations, and wild relatives offers broader resistance type and will further improve the longevity of varietal cultivation particularly in low input agriculture that is predominant with small farmers in CWANA.

In barley pathology we collaborate with NARS to target the development and identification of barley genotypes that

have multiple disease resistance and encourage the proper deployment of known resistance sources. In CWANA, barley is grown under a wide range of climatic conditions that are conducive to the development of a wide array of fungal pathogens. Quite often at least two to three diseases appear simultaneously. The most important barley diseases targeted by the breeding program for the WANA region are scald, powdery mildew, net blotch, barley stripe and root rots. Priority diseases for the NVRSP region that cover Egypt, Eritrea, Ethiopia, and Yemen are leaf rust, net blotch, and seed borne diseases. For Central and Western Asia seed-borne disease, scald and powdery mildew are of major importance.
Barley nurseries are screened for disease resistance at Tel Hadya under controlled environment and field conditions, selected lines are further evaluated by collaborators in the WANA region under field conditions in hot spot areas for individual diseases or combination of diseases. Resistant entries are advanced for further selections. Fixed resistant lines are further tested for yield and/or incorporated in the crossing program. The screening at Tel Hadya is planned for single diseases then for combination of diseases. The germplasm tested at Aleppo in 1999 is shown in (Table 2.23). Screening nurseries of selected germplasm are also tested under natural conditions within CWANA and NVRS regions by NARS collaborators. Table 2.23 shows the list of barley nurseries and selection sites in the region. The screening under field condition at Tel Hadya (Aleppo) is complemented by artificial inoculation using local Syrian isolates for each particular disease. Information on virulence of isolates, methods of inoculation, and evaluation are detailed later in the IPM report. Information for the evaluation of specific diseases realized by NARS will appear in the NARS annual reports.

Breeding nurseries screened for diseases resistance (Table 2.24) represent advanced barley germplasm being tested in CWANA for yield (nurseries ending with YT), such as: LIBYT specific yield trials for Libya, MORYT for Morocco etc.; and nurseries tested for specific traits in different agroclimatic zones in the region such as EBON99 (early barley observation nursery), etc. A total of 3003 entries are screened under artificial inoculation in Syria, Lebanon, and Turkey.

Table 2.23. Number of entries in the barley nurseries screened under artificial inoculation for disease resistance in Syria (Tel Hadya, Lattakia), Lebanon (Terbol) and Turkey (Hymana)

Nursery	Scald				Powdery mildew			C. Smut	L. Smut	Bstripe		N. Blotch
Screening Sites	SYR TH-F	SYR-TH-PH	LEB-TER	TUR-YHYM	SYR TH-PH	SYR-TH-PH	SYR LAT	SYR TH-F	SYR-TH-F	SYR TH-PH	SYR THF	SYR LAT
Pathology	805	612	671	340	662	612	689	976	913	604	913	689
Breeding	2407	425	745	364	499	739	893	1463	904	425	904	893
Total	6369				4094			2139	1817	1029	1817	1582

*: Includes barley material with known resistance factors "Differentials" etc.
F-Field; PH-Plastic House

Pathology nurseries (Table 2.25) contain selected fixed barley lines from breeding nurseries that are tested for specific diseases resistance against a wide range of virulence of selected pathogens. Entries selected for resistance to single disease are used as parents in the crossing programs or are exploited in areas where a single disease is predominant, such as leaf rust in Egypt. These nurseries are also tested for multiple disease resistance under artificial inoculation. Selected lines are assembled in nurseries called germplasm pools and dispatched to NARS for field evaluation in selected hot spots for diseases. Selections from the germplasm pools could be tested for yield.

2.4.8.2. Evaluation of Barley Nurseries for Disease Resistance

2.4.8.2.1. Screening for Resistance to Individual Diseases

The level of resistance to individual barley diseases, among the barley germplasm tested, is adequate for some diseases such as barley stripe, leaf rust, covered smut, and powdery mildew, but relatively low for other diseases such as scald, net blotch, and loose smut. (Figure 2.7) shows the overall resistance level in the nineteen breeding nurseries screened in 1998-99 crop season.

Table 2.24. Barley breeding nurseries (number of entries) screened for disease resistance in Syria, Lebanon, and Turkey 1998-99

		Screening at Tel Hadya (Aleppo)								Lattakia (Syr)	Terbol (Leb)	Haymana (Tur)
		SCALD		Powdery Mildew		C.Smut	L.Smut	Barley Stripe		Blotch PM	Scald	Scald
Nursery	Nb.Entries	A19	PH.13	PH.25	PH.13	C.4	C.4	C.4	PH.13	Lattakia	Lebanon	Turkey
PARE99	314	314	-	-	314	-	314	314	-	-	-	-
BPT.2R99	430	*430	-	-	-	-	-	-	-	-	-	-
BPT. 6R99	270	*270	-	-	-	-	-	-	-	-	-	-
BAT2R99	100	*100	100	100	100	100	-	-	100	100	-	-
AT6R99	50	*50	50	50	50	50	-	-	50	50	-	-
BRYT99	75	*75	75	75	75	*75	-	-	75	75	75	-
TUNYT99	90	*90	-	-	-	*90	-	-	-	90	-	-
LIBYT99	82	*82	-	-	-	82	-	-	140	82	-	-
MORYT99	52	*52	-	-	-	52	-	-	-	*52	-	-
JORYT99	20	*20	-	-	-	*20	-	-	-	20	-	-
WCB99	140	*140	140	140	140	140	-	-	-	140	140	140
EBON99	50	*50	-	50	-	-	-	-	-	50	-	50
WBON99	150	*150	-	-	-	-	-	-	-	150	-	150
WBYT99	24	*24	-	24	-	24	-	-	-	24	-	24
NEWZ99	30	*30	30	30	30	-	-	-	30	30	30	-
F.F.VT.99	30	*30	30	30	30	30	-	-	30	30	-	-
SCRI	500	500	-	-	-	500	-	-	-	-	500	-
PARE98	300	-	-	-	-	300	300	300	-	-	-	-
WCB98	200	-	-	-	-	-	200	200	-	-	-	-
BAT98	90	-	-	-	-	-	90	90	-	-	-	-
TOTAL	3003	2407	425	499	739	1463	904	904	425	893	745	364
REQ. ENTRY	-	-	1700	499	2550	1648	904	904	850	945	745	364

* Planted in two replications; **Planted in three replications

Table 2.25. Barley nurseries screened for multiple disease resistance

	Screening sites in Syria										Lebanon	Turkey
	Entry	Scald		Powdery mildew		C.Smut	L.Smut	B.Stripe		N.Blotch-&PM	Scald	
	Field	A19	P.H.13	P.H.25	P.H.13	C.4	C.4	C.4	P.H.13	Lattakia	Terbol	Hymana
ADG99	254	*254	254	*254	254	*254	254	254	254	*254	254	254
POG99	350	*350	350	350	350	350	350	350	350	350	350	-
IBSCGP	8	*8	8	-	-	-	-	-	-	-	-	8
IBPMGP	8	*8	-	8	8	-	-	-	-	-	-	8
IBCSGP	14	-	-	-	-	14	-	-	-	-	-	-
ADG98	55	-	-	-	-	-	55	55	-	-	-	-
PDG98	254	-	-	-	-	-	254	254	-	-	-	-
TOTAL	643	620	612	612	612	618	913	913	604	604	604	270

(*): Replicated; PH: Plastic House

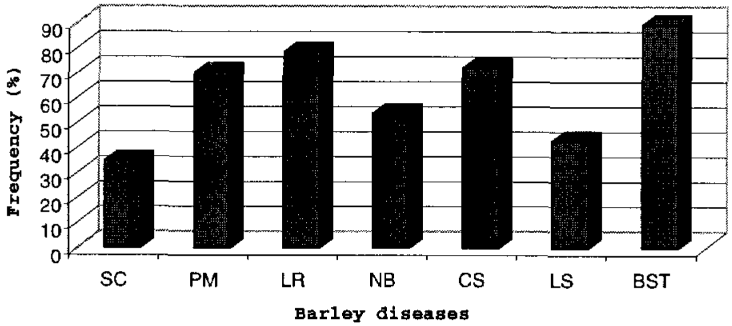


Figure 2.7. Level of resistance to individual diseases

The resistance level to the prevalent barley diseases varied among breeding nurseries. (Table 2.26) shows the relative frequency of different levels of resistance among nineteen breeding nurseries for foliar and seed borne diseases. Sources of resistance to individual diseases could be selected. Good sources of resistance to scald (*Rhyncosporium secalis*) were identified in WBYT99 (83.3%) and in SCRI99 (59.6%). However, the level of resistance to scald in the yield trials remains relatively low (Table 2.26). Resistance to powdery mildew (*Erysiphe graminis fsp.hordei*) is relatively high in most of the nurseries (BAR992R, WBYT99, MORYT99, NZEA99, etc.). An improvement could be made to enhance resistance in the germplasm targeted for Libya (LIBYT99); selections from BAT992R will be appropriate for resistance to this disease to fit Libyan conditions. Leaf rust (*Puccinia hordei*) was evaluated under natural infection in the summer nurseries planted at Terbol (Lebanon). Different levels of resistance were observed among the nurseries that were evaluated. Highly resistant genotypes were identified in the yield trial for Tunisia (TUNYT99), in the yield trial BAT992R and in the nursery IWBON. Lower resistance levels were also found in BAT996R and EBON99. Artificial inoculation will be used next season to avoid escape and more material will be screened.

All yield trials showed good level of resistance to covered smut at all testing sites. Further improvement for resistance to net blotch (*Pyrenophora teres*) is needed in the yield trials targeted for Tunisia and Libya. Selection from BAT996R and BAT992R for net blotch resistance could offer adequate resistance level in Tunisia and Libya respectively.

Loose smut (*Ustilago nuda*), covered smut (*Ustilago hordei*) and barley stripe (*Pyrenophora graminea*) are seed transmitted diseases that are very common in most area of WANA region particularly with farmers that use their own seed and do not or cannot apply seed treatment. Resistant/tolerant germplasm offers the best alternative. The barley breeding project has focused on these diseases in its varietal development program. All the parental and promising lines are systematically tested for their resistance to the seed borne diseases. All the crossing block nurseries (PARE98S, WCB98) show high level of resistance especially to barley leaf stripe (Table 2.26). Yield trial nurseries that are being tested in WANA carry high levels of resistance to cover smut.

Table 2.26. Frequency Distribution of Barley Lines Resistant to prevalent foliar and seed borne diseases identified in the observation nurseries and yield trials tested in WANA

	Total	Diseases used for artificial inoculation						
	Number of	Foliar diseases				Seed-borne diseases		
Nursery	entries	Scald	P.mildew	L.Rust	N.Blotch	C.Smut	L.Smut	B.Stripe
BAT992R	100	23.0	82.0	86.0	25.0	63.0	-	-
BAT996R	50	32.0	06.0	88.0	96.0	22.0	-	-
SCRI99	500	59.6	-	43.3	58.2	-	-	-
EBON99	50	64.0	48.0	-	-	30.0	-	-
IWBON99	150	53.3	96.0	-	-	65.3	-	-
PARE99	314	28.9	62.7	-	-	-	-	-
NZEA99	30	23.3	80.0	-	-	-	-	-
BPT992R	430	06.5	-	-	-	-	-	-
BPT996R	280	24.2	-	-	-	-	-	-
PARE98S	300	-	-	-	78.3	-	47.3	87.0
WCB99	140	54.2	-	-	52.8	-	-	-
WCB98	200	-	-	48.0	-	-	35.5	98.0
BAT98 pa	90	05.5	-	-	-	-	44.4	77.7
				Yield trials				
WBYT99	24	83.3	83.3	20.8	100	-	-	-
BRYT99	75	14.6	42.6	49.3	84.0	-	-	-
TUNYT99	90	33.3	62.2	37.3	84.4	87.7	-	-
MORYT99	52	23.0	82.6	71.1	86.5	-	-	-
LIBYT99	82	28.0	24.3	23.1	85.3	-	-	-
JOYT99	20	20.0	60.0	65.0	40.0	-	-	-
Total	2877	-34.7	(70.1)	(53.7)	(71.9)	(78.2)	(42.8)	(89.3)

(-) Nursery not tested for disease resistance

2.4.8.2.2. Multiple Disease Resistance in Advanced Barley Germplasm

Under field conditions diseases infection can often be due to different pathogens. Therefore, the ultimate objective in the search for genetic resistance to biotic stresses is to develop varieties that offer resistance to as many diseases as possible. The barley germplasm within the advanced breeding nurseries (Table 2.25) was tested for combinations of the predominant foliar and seed-borne diseases. (Table 2.27) shows the distribution of resistant lines in the barley breeding nurseries grown in WANA region. The preliminary disease germplasm (PDG), and advanced disease germplasm (ADG) represent selected lines from breeding nurseries tested for multiple disease resistance. PDG99 shows an improved level of resistance to at least three diseases in genotypes grown as yield trial nurseries in WANA. Highest levels of resistance to three diseases were recorded in PDG98 and ADG98 nurseries, whereas high level of resistance to five diseases was recorded in PDG99 (Figure 2.8). Available/usable resistance sources to specific diseases were selected in PDG99 nursery (Figure 2.9). Complete resistance to all diseases is relatively low (Figure 2.10) as compared to resistance to individual diseases (Table 2.28) particularly for leaf rust and powdery mildew. These lines will be recommended for use at hot spots for appropriate diseases.

Source of resistance to scald, powdery mildew, leaf rust, and cover smut were identified in PDG99 nursery. Lines resistant to scald (65.2%) and to cover smut (74%) were identified in ADG99 (Figure 2.8). Qualitative resistance type is also found in this nursery and could be exploited in area where the disease incidence is severe to halt the disease progress and allow the development of the durable type of resistance and the stabilization of the disease. High levels of resistance for covered smut were identified in this nursery, whereas the resistance to leaf rust and powdery mildew is relatively low.

Table 2.27. List of diseases and nurseries tested for multiple disease resistance

NURSERIES	Ent	DIS	Disease
PDG98 255	255	7	Scald, Net blotch, Powdery mildew, barley stripe, Leaf rust, Loose smut, Covered smut
PDG99 350	350	5	Scald, Powdery mildew, Barley stripe, loose smut, Covered smut
ADG98 55	55	5	Scald, Powdery mildew, Barley stripe, loose smut, Covered smut
ADG99 254	254	5	Scald, Powdery mildew, Barley stripe, loose smut, Covered smut
N.Blotch99 35	35	5	Net blotch, leaf rust, Scald, Powdery mildew, Covered smut
Total	954		

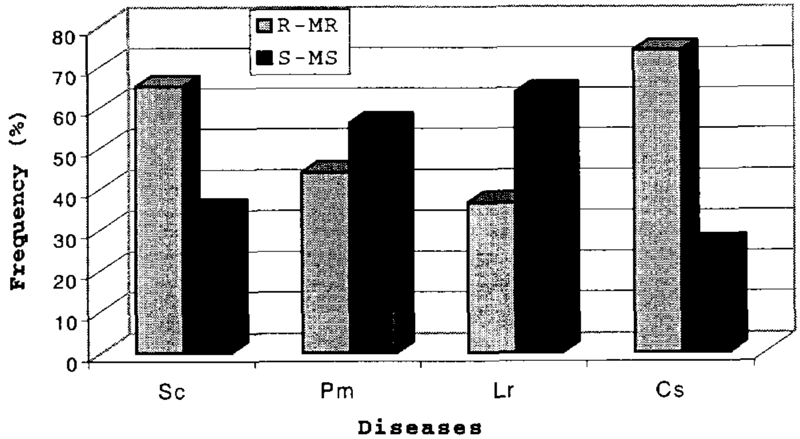


Figure 2.8. Available sources of resistance in the preliminary disease germplasm (PDG) nursery distributed in 1999

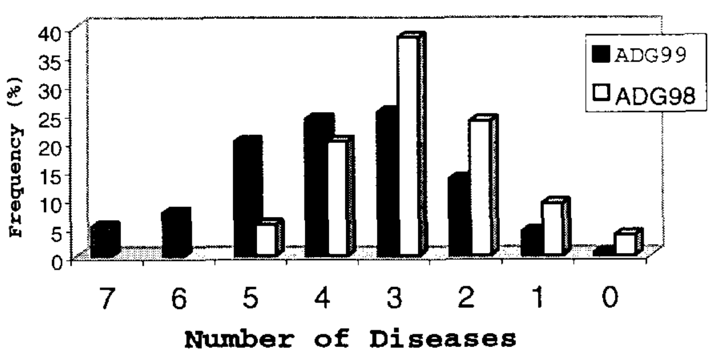


Figure 2.9. Multiple disease resistance in two barley nurseries

Table 2.28. Number of barley lines that show multiple resistance to diseases* in five Selected barley breeding nurseries

Nurseries	Nr. of diseases*	Res. to seven diseases	Res. to three diseases	Res. to one disease
PDG98	7	10	60	14
PDG99	5	3	21	7
ADG98	5	28	125	45
ADG99	5	16	110	26
N.blotch99	5	1	10	16
Total		58	326	108

*Diseases listed in Table 2.27

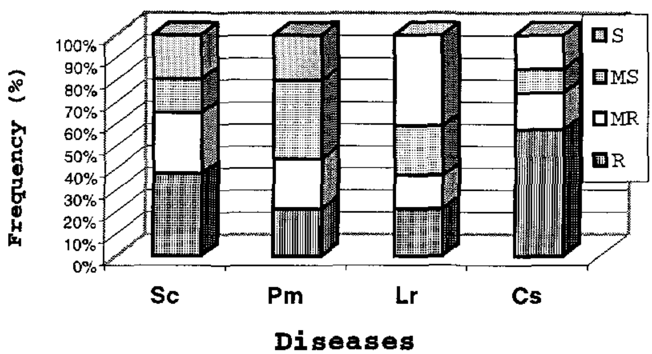


Figure 2.10. Resistance to scald (Sc), powdery mildew (Pm), and leaf rust (Lr), and cover smut (Cs) in the nursery PDG9

Among the barley germplasm tested for multiple disease resistance, fifty lines showed good disease resistance to five diseases. Seventeen lines were resistant to scald, powdery mildew, net blotch, leaf rust, and covered smut (Table 2.29). These lines could be used as sources of resistance in North Africa where these diseases are of major importance. Thirty-three lines showed good resistance to five diseases (scald, powdery mildew, covered smut, loose smut, and barley stripe) predominant in West Asia and the Middle East (Table 2.30). Thirty-five lines showed good resistance to six diseases including all the seed borne-diseases and three foliar diseases. Resistance to smuts and barley stripe could be very useful in areas where seed treatment is not practiced or is not affordable by small farmers. Twenty-six entries were resistant to scald, powdery mildew, net blotch, covered and loose smut, and barley stripe (Table 2.31). Six entries were resistant to powdery mildew, net blotch, leaf rust, and the three seed bone diseases (Table 2.32). A set of three entries showed good resistance to another combination of diseases (Table 2.33). Ten fixed progenies and four check cultivars were identified as resistant to seven diseases (Table 2.34)

Table 2.29. Barley genotypes resistant to scald, powdery mildew, net blotch, leaf rust and cover smut

Name	Pedigree	Source	SN
Carbo			
Arar/Lignee 527//Arar/Rihane-03	ICB93-0344-0AP	PDG98	52
Cln'S'/80-5138//Gloria'S'/Copal'S'/3/Matnan'S'/EH165/4/LB Iran/Una8271//Gloria'S'/Coma'S'	CMB89-0779-B-8Y-1M-1Y-0B-0AP	PDG98	65
Gloria'S'/Come'S'//Lignee 640/3/SP/4/ Valeriana'S'	CMB89A-0485-10M-2Y-1M-0Y-0AP	PDG98	67
Geranio/Matnan'S'/EH165	CMB88A-0556-4M-1Y-5M-1Y-0B-0AP	PDG98	74
Granado	CMB86-0954-L-1Y-2B-0B-1B1-1B-1M-0Y-0AP	PDG98	75
Gloria'S'/Copal'S'	CMB81-0295-30B-4Y-1M-1Y-1M-0Y-0AP	PDG98	76
Gloria'S'/Copal'S'	CMB81-0295-30B-4Y-9M-2Y-1M-0Y-0AP	PDG98	77
Gloria'S'/Copal'S'//Abn/3/Shyri	CMB87-0490-A-1Y-2B-1Y-1M-0B-1M-0Y-0AP	PDG98	84
Anca/2469//Toji'S'/3/Shyri	CMB87-0628-AL-2Y-2B-1Y-1M-0B-1M-0Y-0AP	PDG98	85
F1HJ17/Maris Otter/3/Robust//Gloria'S'/Copal'S'	CMSWB92A-0016-0AP	PDG98	88
Gerbel/Quina	CMSWB92A-0070-0AP	PDG98	92
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-6AP-0AP	PDG98	97
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-8AP-0AP	PDG98	98
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-3AP-0AP	PDG98	101
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-1AP-0AP	PDG98	102
Alpha/Durra	OR-1861165	PDG98	246

2.4.8.2.3. Evaluation of Barley Nurseries for Disease Resistance in Eritrea

The barley nurseries (1723 entries) were composed of local material, mostly land races (ER99 accessions), selection from local population (Bulk99 and Bulk00), and nurseries from the ICARDA barley-breeding program. All the material was planted at the main station (Halhale), while the landraces were also tested in the PPB trials described in section 2.2.2.

Table 2.30. Barley genotypes resistant to scald, powdery mildew, cover smut, loose smut, and barley stripe

Name	Pedigree	Source
Mimosa	-	PARE96
Arizona 5908/Aths//Lignee 640/3/ Gerbel/Harma	ICB89-0892-5AP-0AP-0AP	PARE96
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-6APH-0AP	PARE96
Express	-	PARE96
Gloria'S'/Copal'S'	CMB81-0295-30B-4Y-9M-3Y-3M-0Y	PARE96
Line 32-16 C26	IPA-Iraq	PARE96
Line 9-26 F27	IPA-Iraq	PARE96
Man/Huiz//M69-69/3/Apm/Rl//H272	ICB91-0109-1AP	PARE96
Man/Huiz//M69-69/3/Apm/Rl// H272/4/	ICB91-0209-1AP	PARE96
Rabat 013	-	PARE96
Th.Unk.7//WI2197/Cr.272-3-4	ICB90-0942-2BO-1AP-0AP	PARE96
Aths/Lignee 686/4/Chaaran-01/3/Arizona	ICB89-0210-6AP-1AP-0AP	PARE96
H.Spont.20-4/Arar 28//WI2291/Bgs	ICB87-0704-1APL-1APH-0TR-0AP-	PARE96
Salmas/Arabi Aswad	ICB85-1293-6AP-2AP-2AP-0AP-	PARE96
Rihane-03/3/Roho//Alger/Ceres.362-1-1	ICB85-0405-3AP-5AP-0TR-3AP-	PARE96
Dt/Robur	ICBH90-0012-0AP-7AP-0AP-4AP-	WBYT97
Piratl/Malta 1-4-3094-2	ICBH89-0104-6AP-0AP-5AP-0AP	WBYT97
Tsumje 2/Robur//Sonate	ICBH90-0008-0AP-4AP-0AP-1AP-	WBYT97
Dt//Triall/Hudson	ICBH90-0011-0AP-5AP-0AP-3AP-	WBYT97
ICB-100615/3/Roho//Alger/Ceres 362-1-1	ICBH89-0004-4AP-0AP-5AP-0AP	FBYT97
Lokus/Sls	ICBH89-0313-5AP-0AP-2AP-0AP	FBYT97
Ranniy/Dt	ICBH90-0073-0AP-2AP-0AP-1AP-	FBYT97

Table 2.30 (continued) Barley genotypes resistant to scald, powdery mildew, cover smut, loose smut, and barley stripe

Name	Pedigree	Name Sc PM LS CS BSTR	Plot
Chaaran-01/3/Arizona 5908/Aths//Bgs /4/Ager//Api/CM67/3/Cel/WI2269//Ore	ICB89-0799-4AP-1AP-2AP-0TR-0AP	BAT97	24
Austria SC PM CS LS BST	-1	BI98IN	25
Tunisia	-1	BI98IN	111
Manitou/Courlis	ICB94-0193-0AP	BI98IN	1169
Courlis/3/Cita#S#/Giza119//Cln#S#	ICB94-0775-0AP	BI98IN	1509
TUNISIA		BIT97	1001
Carbo		Check	0
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-9AP-0AP	BIT97	2259
Line 49-14 D30	IPA-Iraq	PAR96	104
Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/5/Satter 2/Numar	ICB85-1058-3AP-3AP-0TR-3AP-0TR-0AP-0AP-3AP-0TR-0	BAT97	26
Cyclone	-1	WCB96	50

Table 2.31. Barley genotypes resistant to scald, powdery mildew, net blotch, cover smut, loose smut, and barley stripe

Name	Pedigree	Source	SN
Gloria'S'/Celo'S'//Teran 78	CMB84A-0236-0AP-1AP-0TR-1AP-0TR-0AP	PAR96	43
Aths/Lignee 686/4/Chaaran-01/3/Arizona 5908/ Aths//Bgs	ICB89-0210-6AP-1AP-0AP	PAR96	167
ARAR/Lignee 527	ICB85-0625-6AP-0AP-17APH-0AP	SBLS97	8
Salmas	-	SBLS97	11
SLB 34-65/Arar	ICB88-0043-16AP-0AP-1AP-0AP	PAR95S	187
Api/CM67//Harma-03/4/Cq/Cm//Apm/3/RM1508/5/Attiki/6/At.s/7/SP(6H)/Apro//Cal.Mr/3/ROD586/Apm/4 Aths	ICB90-0288-0AP	PAR95S	225
Alpha/Durra//Antares/Ky63-1294	ICB90H-0042-0AP-1AP-0AP-5AP-0AP	WBYT97	21
Wysor	USA	WBYT97	2
ICB-105959/Ranniy	ICB90H-0002-0AP-2AP-0AP-5AP-0AP	WBYT97	10
Rihane/lignee 640//ICB-107766	ICBH88-0088-0AP-12AP-1AP-0AP	WCB96	8
Rihane/lignee 640//ICB-107766	ICBH88-0088-0AP-20AP-0AP-0AP	WCB96	9
YEA389.3/YEA475.4	YAA348-4A-2A-1A-0AP	WCB96	10
Salmas*2/3/Vg/Julia//Zy	ICB85-0373-0AP-1AP-1AP-2AP-0AP	WCB96	13
Salmas*2/3/Vg/Julia//Zy	ICB85-0373-0AP-1AP-4AP-3AP-0AP	WCB96	33
Lignee 131//4341 N/Ortolan	ICBHA81-2207-1AP-3AP-0AP	WCB96	43
Kitchin/Mullers Heydla//Salams	ICBH88-0148-0AP-9AP-0AP	WCB96	44
Yugodar	-	WCB96	45
Rapidan	-	WCB96	48
Taman	-	WCB96	57
Miron 87	-	WCB96	58
Plaisant/Novator	-	WCB96	60
Victoria	-	WCB96	110
Alger/Cerese,362-1-1	-	WCB96	113
Rihane/Lignee 640//ICB-102411	ICBH88-0086-3AP-1AP-0AP	WCB96	131
Rihane/Lignee 640//ICB-107766	ICBH88-0088-0AP-18AP-0AP	WCB96	132
NE 89747	-	WCB96	145

Table 2.32. Barley genotypes resistant to powdery mildew, net blotch, leaf rust, cover smut, loose smut, and barley stripe

Name	Pedigree	Source	SN
Mo.B1337/WI2291//JLB 37-74	ICB89-0168-11AP-0AP-0AP	SBLS97	33
Mo.B1337/WI2291//JLB 37-74	ICB89-0168-13AP-0AP-0AP	SBLS97	34
Hart	-	PAR95S	48
Fighter	-	PAR95S	52
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-3APH-0AP	PAR95S	74
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-6APH-0AP	PAR95S	75

Table 2.33. Barley genotypes resistant to scald, powdery mildew, leaf rust, cover smut, loose smut, and barley stripe

Name	Pedigree	Source	SN
Line 49-14 D30	IPA-Iraq	PAR96	104
FireFly	-	PAR95S	51
Manitou	-	PAR95S	53

Table 2.34. Barley genotypes resistant to scald, powdery mildew, net blotch, leaf rust, cover smut, loose smut, and barley stripe

Name	Pedigree	Source	SN
Th.Unk.7//WI2197/Cr.272-3-4	ICB90-0942-2BO-1AP-0AP	PAR96	141
24569=(80-5138/Aths)	-	PAR95S	54
Antares/Ky63-1294/3/Roho//Alger/Ceres 362-1-1	ICB90-0148-0AP-1AP-0AP-3AP-0AP	FBYT97	14
Tipper/ICB-102854	ICB90-0032-0AP-5AP-0AP-2AP-0AP	FBYT97	19
Kitchin/Mullers Heydla//Salams	ICBH88-0148-0AP-9AP-0AP	WCB96	44
Lignee 131//4341 N/Ortolan	ICBHA81-2207-1AP-3AP-0AP	WCB96	43
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-6APH-0AP	PAR95S	75
Eagle	-	PAR95S	55
Halcyon	-	PAR95S	57
Plaisaut	-	WCB96	36
Vavilon	-	WCB96	49
Cyclone	-	WCB96	50
Rapidan	-1	WCB96	48
Manitou	-	PAR95S	53

The late rains associated with relatively high temperatures favored rust, bacterial and blotch diseases development at the main station. In the farmer fields, Helminthosporium diseases were well developed, particularly barley net blotch "net and spot forms" (*Pyrenophora teres*), spot blotch (*Bipolaris sorakiniana*), and scald (*Rhyncosporium secalis*) were recorded. Bacterial leaf streak (*Xanthomonas translucens*) and septoria (*Septoria passerinii*) were observed on barley at Halhale and Embaderho, respectively.

Based on the status of disease development in the cereal growing area, pathology work has to be strengthened. Special disease nurseries will be dispatched from ICARDA base program to Eritrea. The main research station, Halhale, can be a good site for screening for resistance to net blotch "net and spot forms". The spot form of net blotch does not occur in Syria, hence screening for resistance could only be done in Eritrea provided that the National program assigns a research staff to work on cereal pathology.

2.4.9. Entomology

2.4.9.1. Barley Stem Gall Midge

2.4.9.1.1. Evaluation of the Nursery BI99IN and a Collection of Moroccan Barley Landraces for Resistance to the Barley Stem Gall Midge in Morocco

The barley stem gall midge (BSGM), *Mayetiola hordei* Keiffer, is a destructive pest of barley in the Mediterranean countries. In Morocco, both Hessian fly and the barley stem gall midge may infest barley fields; however, the latter is the most important. This insect causes severe grain yield losses averaging 35% yearly, which is equivalent to losses caused by the Hessian fly on wheat. Therefore, there is an urgent need to identify sources of resistance to this pest, and incorporate this resistance into adapted barley cultivars.

The breeding nursery BI99IN (5274 lines) was screened both in the field and the greenhouse for resistance to BSGM. A Moroccan barley land race collection (759 lines) was also screened in the greenhouse at the CRRA-Settat.

Greenhouse screening: The entries of both nurseries were seeded in standard wooden greenhouse flats containing a mixture of 1/3 peat and 2/3 soil, at a rate of one line per entry and 25 seeds per line. The susceptible cultivars 'Tamelalt' and 'Kanby' were included in each flat. When plants were at the two-leaf stage, flats were covered with cheesecloth cages, and about 100 females of BSGM were released in each flat, and allowed to oviposit on the plants for 48 hours, then removed. Three weeks after infestation, plants were pulled out of the flats, and examined under the binocular for resistance reaction. Plants that were stunted and had dark green color were considered as susceptible, those that had normal growth with a light green color are considered as resistant. Susceptibility and tolerance are confirmed by the presence of live larvae and/or pupae. Antibiosis is confirmed by the presence of dead first instars at the base of the stems. Plants that host no larvae (dead or live) are considered as escapes and are not taken into consideration. Plants are also examined for the presence or absence of galls at the bases of stems.

Field tests: The BI99IN nursery was also screened in the field. Entries were seeded in 1-meter long rows, with no replication, at the Experimental Station of Sidi El Aidi, considered as a hot spot for the BSGM in Morocco. During spring, selection was made visually in collaboration with the barley breeder. Mainly tolerances to the pest and good agronomic characters (good stands, stress tolerance, and earliness) were sought.

Results of the greenhouse screening showed that these two nurseries carry no significant levels of resistance to this pest. No antibiosis was noticed in any line; almost all plants were susceptible, stunted and hosted large numbers of live larvae. However, and as it happens often, some lines showed low levels of tolerance. Tolerant plants were not stunted and kept normal growth even though they hosted live larvae. Very distinct galls were observed on stunted as well as on tolerant plants

The field test resulted, however, in the selection of a good number of lines (174). Selection was based mainly on the field tolerance to the fly, expressed through the possession by the line of a good stand, and also on earliness, good grain filling, and drought tolerance. The numbers of the selected lines are:
41, 244, 300, 375, 383, 424, 436, 561, 563, 564, 567, 568, 572, 584, 638, 684, 716, 731, 737, 756, 782, 1000, 1063, 1068, 1071, 1080, 1082, 1084, 1091, 1099, 1101, 1107, 1117, 1119, 1120, 1138, 1140, 1145, 1146, 1148, 1153, 1156, 1157, 1158, 1164, 1170, 1174, 1176, 1209, 1213, 1215, 1230, 1269, 1271, 1289, 1290, 1292, 1296, 1298, 1307, 1309, 1329, 1336, 1339, 1388, 1432, 1447, 1449, 1456, 1458, 1460, 1461, 1500, 1542, 1544, 1552, 1625, 1662, 1689, 1690, 1702, 1840, 1848, 1851, 1854, 1937, 1947, 1954, 1955, 1960, 1961, 1962, 1968, 1970, 1973, 1975, 1978, 1979, 1980, 1982, 1983, 1987, 1988, 2012, 2015, 2016, 2018, 2024, 2025, 2026, 2065, 2069, 2175, 2177, 2179, 2184, 2217, 2218, 2227, 2318, 2338, 2340, 2346, 2418, 2419, 2455, 2611, 2512, 3423, 3538, 4214, 4269, 4272, 4343, 4350, 4392, 4524, 4525, 4534, 4542, 4543, 4552, 4553, 4584, 4586, 4595, 4597, 4632, 4637, 4791, 4800, 4816, 4817, 4820, 4862, 4936, 5008, 5054, 5062, 5070, 5072, 5091, 5093, 5110, 5111, 5122, 5124, 5131, 5141, 5158, 5159, 5160, 5167, and 5168.

Seed of these lines was harvested, and the lines will be tested again for confirmation in the field next year. These results suggest that we may be able to find some tolerance to this pest; in this case we will be focusing on this kind of resistance in the future, as antibiosis has been very hard to identify. Tolerance allows for larval survival, which slows down the development of new virulent biotypes, and increases the resistance life span.

On the other hand, the only source of antibiosis that we have identified in a wild barley earlier has now been crossed with cultivated barley, and the seed of this cross will be tested next season to see if the resistance has been transferred.

2.4.9.2. Russian Wheat Aphid

2.4.9.2.1. Evaluation of the Barley Russian Wheat Aphid Nursery in Morocco

Russian wheat aphid (RWA), *Diuraphis noxia* (Mordivilko), a pest of wheat and barley, is native to Russia and its neighboring countries, but has now spread to most of the cereal growing regions of the world, including Africa. In Morocco, damage due to this pest has first been noticed during the 80's, mainly in high altitude areas, but recently, the pest has become more serious, and spread out to all the cereal growing plains of the country. The heaviest populations are still found in the mountain regions where our surveys of 1996 and 1997 showed that 100% of the barley fields were infested, with a mean of 46% of the plants showing aphid-feeding symptoms. The pest causes very typical symptoms: long longitudinal chlorotic white to yellow streaks on the leaves frequently associated with leaf rolling. This damage results in severe dry matter and grain yield losses when infestations are heavy. The best and most efficient way of controlling this pest has been the use of genetic resistance.

A RWA nursery (31 entries) from ICARDA was screened for resistance to this pest at the Aridoculture Center, Morocco. Six of these entries have already been selected as resistant in Morocco, and have been included as checks. A local susceptible cultivar 'Tamelalt' was also included as a check. The study was conducted in a growth chamber adjusted to 20±2°C and a photoperiod of 16h:8h (light:dark). Entries were planted in standard greenhouse wooden flats containing a mixture of 2/3 soil and 1/3 peat, at a rate of four seeds per hill. Each flat contained 12 entries including a check. When plants were at the two-leaf stage, they were thinned to three plants per hill, then infested with RWA at a rate of five nymphs per plant.

Flats were then covered with plastic cages having cheese cloth tops for ventilation. Insects used in the test were from a culture maintained at the Center on the susceptible cultivar 'Tamelalt', and originally started with aphids collected from neighboring fields. The material was evaluated three weeks after infestation using DuToit scale from 1-6, where 1 is the most resistant and 6 is the most susceptible.

To confirm the results of the screening under controlled environmental conditions, the same nursery was planted at Annoceur Experimental Station, situated in a high elevation region where RWA population levels are high. Entries were planted in one-meter long rows and replicated four times. A susceptible check was included in each replication. In the same location, a Moroccan barley land race collection of 759 entries, obtained from ICARDA, was screened for resistance to RWA. Entries were also planted in one-meter long rows, but not replicated. For both collections, the damage scoring was done when symptoms became clearly visible on the susceptible lines.

The RWA population levels were very high in the field during late spring, and allowed for excellent infestations of the field screened material. All entries of the Moroccan barley collection were highly susceptible to RWA. The results of ICARDA RWA nursery screening were very encouraging; both field and greenhouse results showed the presence of excellent sources of resistance to this pest. The growth chamber results showed that 20 out of the 31 entries tested were resistant. The results of the field test confirmed those obtained in the laboratory. All the lines that were resistant in the growth chamber were also resistant in the field (Table 2.35).

The fact that only 20 out of 31 lines of the RWA tested were resistant against the Moroccan populations indicates biotypic variation between the Moroccan and the Syrian RWA populations. Only those lines that confer resistance to the Moroccan populations will be used in the crosses to develop germplasm resistant to RWA in North Africa.

2.4.9.2.2. Screening at Tel Hadya.

Five promising winter barley lines from 1998 field tests were evaluated in the plastic house for confirmation. These lines went through an initial and an advanced screening in the greenhouse. In the initial screening, the material was evaluated in one replication only. The promising lines from this initial screening went through an advanced evaluation in four replications.

The selected entries and a resistant and a susceptible check were seeded in flats, using a randomized complete block design. Five seeds were planted per hill, and upon emergence the number of plants was thinned to three. The evaluation was done three weeks after the infestation using DuToit scale from 1-6, where, where 1=small isolated chlorotic spots on the leaves; 2=larger chlorotic spots on the leaves; 3=chlorotic spots tend to become streaky; 4 = mild streaks visible and leaves tend to roll lengthwise; 5=prominent white/yellow streaks present, leaves tightly rolled; 6=severe white/yellow streaks, leaves tightly rolled and start to die. The plastic house-screening test confirmed the resistance of one line IFBON98-43 (3896/1-3/4/1246/1-3/3/3887/28//3892/1-3/5/Grivita).

Table 2.35. Reaction of ICARDA barley nursery for resistance to Russian wheat aphid, growth chamber and field tests, Morocco, 1999

Entry name	Growth chamber	Field
R001	R	R
STARS-9577B=R006	R	R
R034	R	R
R011	R	R
RO13	R	R
RO15	R	R
RO16	R	R
RO17	R	R
R018	R	R
R022	R	R
R023	R	R
R024	R	R
STARS-9301B=R027	R	R
R028	R	R
R029	R	R
R031	R	R
RWA.M46	R	R
RWA.M53	R	R
RWA.M54	S	S
RWA.M55	R	R
RWA.M56	R	R
Mo.B1337/WI2291//Bonita/Weeah	S	S
Mo.B1337/W12291//Stirling/FNCI-22	S	S
NE417/Arta	S	S
H.spont.41-1//ER/Apm	S	S
H.spont.41-1//ER/Apm	S	S
ER/Apm//Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres-362-1-1	S	S
Arar/H.spon.19-15//Arta	S	S
H.spont.38-3/6/Pld10342//Cr.115/Por/3/Bahtim /4/Ds/Apro/5/WI2291	S	S
SLB 45-40/H.spont.41-5	S	S
WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm	S	S
Susceptible check 'Tamelalt'	S	S

2.4.9.3. Development of Barley Germplasm Resistant to RWA

3914 progeny rows derived from resistant plants selected in 1998 from twenty-three F2 populations carrying resistance to RWA were evaluated for resistance to this pest under artificial infestation in the field at Tel Hadya. Seeds of each plant were spaced planted in two rows, 2 m long each. Because the germplasm is being developed for North Africa, barley cultivars from North Africa were included as checks for agronomic characters every 50 entry. Since in North Africa spring barley is predominant, only entries that showed spring growth habit were infested at tillering stage using about 10 aphids per plant. The material was evaluated three weeks later. Some 686 lines combining resistance to RWA and agronomic characters similar to the checks were selected. This material will go through one more cycle of selection, following the same procedure as in 1999, at Tel Hadya before it is sent to North Africa for testing.

2.4.10. Virology

2.4.10.1. Selection of BYDV Resistant Barley Plants in F2 Population of 68 Crosses

The F2 populations of 68 barley crosses in which one of the parents (QB813.2 a line kindly provided by Dr. A. Comeau) was BYDV-resistant and the other parent was chosen among different genotypes adapted to various agro ecologies in WANA, were monitored weekly during the 1998/1999 growing season following artificial inoculation with the virus (Table 2.36). All plants with clear BYDV symptoms were eliminated and seeds were harvested only from resistant, good looking plants. Two single plant selections from each cross were made on the basis of no symptoms and low BYDV concentration. The seeds from the rest of the good looking plants for each cross were bulked and BYDV resistance in the F3 populations will be monitored during the coming growing season.

2.4.10.2. Evaluation in Short Rows

The preliminary evaluation of 71 barley genotypes which has either resistance to Russian wheat aphid or wheat stem saw fly indicated that some lines could possess tolerance to BYDV as well (Table 2.37). These lines will be evaluated again in the next growing season.

Table 2.36. Symptoms of appearance and relative virus concentration in F2 populations of different barley crosses at three and four weeks following artificial inoculation with barley yellow dwarf virus

F2 population	Period after virus inoculation	% Symptomless plants	% of plants with different levels of virus concentration: High	Low	No virus
35	3 Weeks	23	49	23	28
36		41	38	22	40
38		35	38	23	39
39		48	27	34	39
40		45	25	34	41
42		41	25	30	45
45		47	27	25	48
47		49	14	29	57
49		41	26	25	49
52		47	20	22	58
33	4 Weeks	36	79	8	13
34		36	84	8	8
37		37	62	14	23
41		45	42	18	40
43		55	40	24	36
44		50	37	31	32
46		52	37	18	45
48		47	48	23	29
50		51	38	23	39
51		44	38	27	35

Number of plants used for each population ranged from 119 to 188.

Table 2.37. Reaction to BYDV infection of 71 barley genotypes in short (30 cm) rows after artificial inoculation with the virus

Nursery [a]	Number of lines tested	Lines with tolerance to infection [b]
RWA	35	1, 6, 13, 14, 15, 16, 31, 32
WSSF	36	11, 13, 14, 15, 25

[a] RWA=Russian Wheat Aphid Nursery, WSSF=Wheat Stem Sawfly Nursery.

[b] Evaluation was based on the severity of symptoms produced.

The re-evaluation of selected winter barley lines from different nurseries in 1-m rows showed that some lines such as WBCB98-24, IWBON98-88, IFBON98-60 and IFBYT98-12 were highly tolerant to BYDV infection (Table 2.38). The re-evaluation of some of the Syrian and Jordanian landraces indicated that some lines such as SLB10-11, SLB66-50, SLB66-14, SLB34-90, SLB05-13 and SLB22-19 were highly tolerant to BYDV infection (Table 2.39). It appears that the collection site 32 is a particularly rich source of resistance to BYDV. In addition, the evaluation of lines selected in 1998 from the different yield trial nurseries showed that some lines such as BIT98-2, BIT98-353, BIT98-458 and BAT98-64 were highly tolerant to BYDV infection (Table 2.40).

Table 2.38. Winter barley lines tolerant to BYDV infection after artificial inoculation with the virus

Entry	D.I. (0-9)	Biomass (g/m)	Grain wt. (g/m)	Height cm)
WBCB98-24	5	400	198	90
WBCB98-52	5	420	192	95
WBCB98-113	6	360	148	90
WBCB98-133	7	465	163	84
WBCB98-163	6	340	172	90
WBCB98-182	7	380	148	100
WBCB98-183	6	350	200	115
WBCB98-125	7	210	86	75
IWBON98-45	7	340	116	80
IWBON98-62	7	310	108	85
IWBON98-76	7	390	142	100
IWBON98-88	7	470	180	90
IWBON98-131	7	365	126	80
IWBON98-145	7	390	129	90
IWBON98-84	8	210	71	90
IFBON98-4	7	375	126	85
IFBON98-20	7	425	169	95
IFBON98-23	6	410	120	100
IFBON98-26	5	375	142	95
IFBON98-44	6.5	395	151	95
IFBON98-60	7	485	190	80
IFBON98-103	7	335	159	85
IFBON98-121	6	350	138	75
IFBON98-105	7	165	52	70
IFBYT98-1	5	370	147	100
IFBYT98-10	7	315	147	85
IFBYT98-12	5	450	221	95
IFBYT98-21	6	290	132	100
IWBYT98-22	5	335	126	100
IWBYT98-8	7.5	175	70	95
HBON98-16	7	345	126	90
HBON98-45	7	295	116	85
HBON98-17	8	195	54	80

D.I. (Disease Intensity from 0=min to 9=max).
WBCB=Winter Barley Crossing Block, IWBON=International Winter Barley Observation Nursery, IFBON=International Facultative Barley Observation Nursery, IFBYT and IWBYT=International Winter and Facultative Barley Yield Trials, HBON=Winter and Facultative Hulless Barley Observation Nursery.

Table 2.39. Syrian and Jordanian landraces tolerant to BYDV infection after artificial inoculation with the virus (SLB98-348 is a susceptible line)

Entry	D.I. (0-9)	Biomass (g/m)	Grain wt. (g/m)	Height (cm)
SLB09-018	6	400	184	80
SLB39-009	7	370	163	80
SLB39-033	5	425	183	80
SLB39-049	6	460	193	75
SLB10-011	6	425	203	80
SLB32-010	7	335	158	85
SLB32-017	6	435	195	85
SLB32-020	6	360	159	90
SLB32-045	5	360	168	85
SLB32-047	6	415	167	80
SLB32-098	6	450	187	80
SLB66-030	6	375	168	85
SLB66-050	5	435	208	80
SLB66-065	7	425	169	85
SLB66-014	6	445	215	90
SLB67-001	6	370	158	75
SLB67-006	7	460	193	90
SLB34-090	6	405	202	90
SLB12-093	7	485	211	85
SLB12-018	6	365	189	85
SLB40-005	6	420	164	90
SLB05-013	6	475	221	85
SLB42-002	7	355	153	85
SLB42-007	7	400	164	90
SLB55-019	5	425	212	80
Arta	6	440	185	80
SLB98-348	7	245	79	95

D.I. (Disease Intensity from 0 = min to 9 = max).

2.4.10.3. Evaluation in Small Plots

The evaluation in small plots of the best performing lines of different nurseries from previous season and yield loss determination in response to infection, showed that some lines such as 2BIT97-347, IFBON97-139, IWBCB98-45, BAT98-75, SCR98-204, BIT98-376 and BIT98-458 were all highly resistant/tolerant to BYDV infection (Table 2.41). The grain yield of these lines when infected with BYDV was almost equal to that of the healthy control

Table 2.40. Lines in the barley yield trials tolerant to BYDV infection after artificial inoculation with the virus

Entry	D.I. (0-9)	Biomass (g/m)	Grain weight (g/m)	Height (cm)
BIT98-2	4	530	249	95
BIT98-77	5	370	160	90
BIT98-88	5	465	184	95
BIT98-196	6	430	161	100
BIT98-199	7	410	164	85
BIT98-213	6	405	167	95
BIT98-224	7	470	169	85
BIT98-297	6	390	170	80
BIT98-349	6	345	167	105
BIT98-353	5	450	200	90
BIT98-355	6	460	195	90
BIT98-356	6	330	148	85
BIT98-367	6	475	213	100
BIT98-376	6	415	182	90
BIT98-394	6	350	172	85
BIT98-396	6	370	167	95
BIT98-403	7	490	232	95
BIT98-431	7	400	176	85
BIT98-434	7	420	187	95
BIT98-445	6	450	206	85
BIT98-450	6	405	190	100
BIT98-451	6	400	168	105
BIT98-452	6	385	196	97
BIT98-458	5	525	247	95
BIT98-467	6	420	187	95
BIT98-490	6	455	200	95
BIT98-364	8.5	210	94	70
BPT98-8	6	400	182	70
BPT98-15	6	365	167	70
BPT98-17	6	360	168	80
BPT98-104	6	550	160	95
BPT98-171	5	435	196	95
BPT98-197	6	410	164	85
BAT98-17	7	420	156	95
BAT98-35	6	400	126	115
BAT98-73	7	370	186	100
BAT98-75	6	455	214	90
BAT98-64	8	230	88	100

BIT=Barley Initial yield Trial, BPT=Barley Preliminary yield Trial, BAT=Barley Advanced yield Trial

Table 2.41. Barley lines from various nurseries and trials resistant to BYDV infection after artificial inoculation with the virus

Entry	D.I.	Biomass	Grain weight	Plant height	Yield loss %
1BIT96-185	7	385	187	80	21
1BIT97-410	7	315	154	78	9
2BIT97-284	5	480	169	113	18
2BIT97-347	6	575	251	110	3
2BIT97-388	7	470	191	88	2
BAT97-12	6	475	204	95	13
IFBON97-139	6	545	199	108	0
HBON97-3	7	430	196	85	2
IWBON97-142	6	415	177	90	4
IWBYT97-6	5	480	203	98	4
IWBCB98-24	5	415	196	90	0
IWBCB98-45	5	535	263	95	0
IWBCB98-52	5	505	206	93	0
IWBCB98-109	5	425	198	98	0
IFBON98-47	6	485	211	90	7
IFBON98-60	6	515	223	85	15
Sutter	5	545	201	108	2
BPT98-104	6	520	195	83	2
BPT98-171	5	380	130	98	5
BAT98-9	6	495	204	98	2
BAT98-75	6	515	234	90	4
WYSOR	5	395	172	100	9
HBON98-17	7	415	138	95	1
HBON98-45	6	450	157	98	14
IWBYT98-1	4	430	144	103	12
IWBYT98-8	5	455	145	103	0
IFBYT98-12	4	460	176	103	1
IFBYT98-21	4	470	181	103	8
BONMRA89-4	5.5	550	189	103	4
SCRI98-36	6	450	191	88	4
SCRI98-204	5	745	341	83	1
SCRI98-325	6	520	210	88	17
BIT98-355	5.5	445	189	83	13
BIT98-376	5	630	277	102	3
BIT98-447	6	530	144	115	8
BIT98-450	5	425	159	108	13
BIT98-451	5	550	217	113	0
BIT98-458	4.5	625	273	105	0
(susceptible check)	8	435	139	90	17

BIT=Barley Initial yield Trial, WBCB=Winter Barley Crosse Block, IWBON=International Winter Barley Observation Nursery, IFBON=International Facultative Barley Observation Nursery, IFBYT & IWBYT=International Winter & Facultative Barley Yield Trials, HBON=Winter & Facultative Hulless Barley Observation Nursery, BPT=Barley Preliminary yield Trial, BAT=Barley Advanced yield Trial

2.4.11. Grain and Straw Quality

Nearly all the breeding material is routinely tested for 1000 kernel weight and protein content. Breeding lines developed for specific purposes are also tested for straw and seed hardness (using the methodology described in the Annual Report for 1997) and for cooking time. The results of the several thousand analysis performed by the quality laboratory every year are reported under the relevant sections.

2.5. Participatory Breeding

2.5.1. Introduction

In recent years there has been an increasing interest towards participatory research in general, and towards participatory plant breeding in particular. Following the early work of Rhoades and Booth (1982), scientists have become increasingly aware that users' participation in technology development may increase considerably the probability of success for the technology.

In the case of plant breeding, the concept of participation is often associated with the concept of decentralization, defined as selection (not testing) in the target environment(s), and decentralized-participatory plant breeding has been proposed as a strategy to reach those areas and those farmers which have been so far bypassed by the benefits of the so called "formal breeding" by exploiting specific adaptation not only to various physical environments but also to various users.

Social scientists have been the first to experiment with various methodologies of participatory research, while in general biological scientists have been slower in accepting this innovative way of conducting research. Even now, in the case of participatory plant breeding (PPB), there are few plant breeding programs who either experiment it or practice it.

The barley project has started experimenting with participatory plant breeding in 1996 with a project supported by BMZ in Syria. In 1998 the number of countries collaborating with the barley project in the use of participatory plant breeding methodologies increased to 3 countries (Syria, Tunisia and Morocco), and in 1999 to six countries (Syria, Tunisia, Morocco, Yemen, Eritrea and Egypt). In this section we will present the main results obtained in Syria, Tunisia, Morocco and Yemen. The results obtained in Eritrea have been presented under "Major Achievements", while in Egypt the participatory activities started in November 1999 and the first results will be reported next year.

2.5.2. Participatory Breeding in Syria

The activities in Syria were the continuation of the project described in the Annual Reports for 1997 and 1998.
In 1999 we prepared a specific trial for each of the nine locations using the lines selected in 1998 by the farmers and the breeder (Table 2.42). One location was changed since the farmer who collaborated with us in Ibbin sold his property. The location was replaced by Tef Tanaz, not far from Ibbin and representing the same farming system and climatic and management conditions. The layout was as in 1998 and included systematic checks every ten entries. In one farmer's site (Al Bab), where the farmer has introduced a forage legume in the rotation (common vetch, *Vicia sativa*), the trial was planted twice, once after barley and once after vetch.

All the nine trials were also planted in Tel Hadya and Breda, two of ICARDA's research stations. The details of each trial are shown in (Table 2.42).

Table 2.42. Composition of the 1998/99 trials

Location (code)	Nr. of lines	Nr. of checks	Layout	Check
Tef Tanaz (01)	107	13	30x4	Rhn-03
Ebla (02)	117	15	33x4	Rhn-03
Tel Brak (03)	103	13	29x4	Tadmor
Jurn El-Aswad (04)	103	13	29x4	Tadmor
Baylonan (05)	116	12	32x4	Zanbaka
Al Bab (06)after barley	113	15	32x4	Sara
Al Bab (10)after vetch	95	13	27x4	Sara
Melabya (07)	120	12	33x4	Zanbaka
Bari Sharki (08)	107	13	30x4	Zanbaka
Sauran (09)	106	14	30x4	Arta

Each farmer was given a field book where he recorded the rainfall (measured through a rain gauge) and their selections. The field book reported for each entry the plot numbers in both 1997 and 1998. Therefore the farmers had the possibility of consulting the 1997 field book and the notes taken on those entries that were selected. In most of the locations, groups of between 4 and 11 farmers including the host farmer did selection. Their preferences, expresses with a score from 0=undesirable to 4=the best, were averaged and the mean score used for further comparisons.

Rainfall (Table 2.43) ranged from a minimum of 122 mm in Melabya to a maximum of 355 mm in Ebla. Rainfall distribution in the locations in Raqqa and Hassakeh provinces (location codes 03, 04, 05 and 07) was poor, with a late start of the rain that delayed crop establishment: the good rains in March came too late to compensate for the poor start. As a consequence, there was no grain produced in the three locations (03, 07 and 08) that received 130 mm rainfall or less (Table 2.44).

Table 2.43. Monthly and total rainfall (recorded by farmers through rain-gauges) in the nine locations[a]

Location (code)	S	O	N	D	J	F	M	A	M	Total
Tef Tanaz (1)	0	2.5	47	89	41	60	53	18	0	310.5
Ebla (02)	0	0.5	49	105	39.5	54.5	77	29	0	354.5
Tel Brak (03)	0	0	0	13.5	6	28.7	26	56	0	130.2
Jurn El-Aswad (04)	0	0	5	40.5	29.5	22.5	77	15	0	189.5
Baylonan (05)	0	0	0	53	24	22	41.5	22	0	162.5
Al Bab (06)	0	0	13	44	43	38	40	25	0	203
Melabya (07)	0	0	0	7	21.9	13	47	33	0	121.9
Bari Sharki (08)	2	0	8	41	19	15	38	5	0	128
Sauran (09)	0	0.5	21.5	71.3	29.5	25	42.5	22.5	0	212.8
Breda (BR)	0	1.8	20.2	40.8	19.6	30	72.8	12	0.6	197.8
Tel Hadya (TH)	0	2.2	38.6	88.4	39.5	51	62	25.1	0	307.2

[a] There was no rain from June to August

Table 2.44. Days to heading (DH), plant height (PH in cm), grain yield (GY in kg/ha), and 1000 kernel weight (KW in g) in nine farmers' fields (FF) and in two research stations (BR=Breda and TH=Tel Hadya)

Locations (code)	DHTH	PHTH	PHBR	PHFF	GYTH	GYBR	GYFF	KWTH	KWBR	KWFF
Tef Tanaz (01)	108.2	85.3	47.9	85.5	3566	1207	2841	43.8	32.2	39.2
Ebla (02)	109.8	81.2	47.1	78.4	3758	1077	2303	41.7	32.5	43.8
Tel Brak (03)	109.2	76.0	48.7	-	3348	997	-	41.3	35.2	-
Jurn Al Aswad (04)	109.5	85.1	49.3	50.4	3868	1024	1141	41.5	36.2	27.0
Belounan (05)	109.3	85.4	47.5	33.5	3361	919	366	41.0	34.8	22.2
Al Bab (06)	107.3	85.8	48.6	51.6	3481	1052	802	43.0	36.4	28.6
Al Bab (10)	108.3	85.9	49.1	43.4	3575	1076	520	41.9	37.2	26.5
Melabya (07)	108.8	83.0	46.6	-	3485	934	-	40.8	37.5	-
Bari Sharki (08)	108.5	78.0	46.1	-	3565	960	-	46.0	43.0	-
Souran (09)	108.9	80.9	43.3	60.3	3833	1006	1554	43.4	37.6	38.2

The results of farmers' and breeder's selection in farmers' fields are summarized in (Table 2.45). With few exceptions, the correlation coefficients between the visual score of the breeder and the mean score of the group of farmers and both grain yield and biomass were significant. There is no evidence of a stronger correlation between either the breeder or the farmer selection and the actual yield, indicating a similar ability of identifying the highest yielding entries. In very dry sites, such as J. Aswad, Bylounan and Al Bab, there was a positive and significant correlation between the visual score and plant height. In the two cases where it was possible to compare farmers' and breeder's selection (J. Aswad and Bylounan), the preference of farmers for tall plants appears to be much stronger than the breeder. Farmers' visual selection was strongly and positively correlated with larger kernels, with correlation coefficients nearly always significant (P<0.01) and larger than those between breeder's visual selection and kernel weight.

Eventually, the visual selection of the farmers and the breeder were always positively and significantly correlated. However, with the exception of J. Aswad, the correlation coefficients were low, indicating that the same entries were scored differently and that different entries were eventually selected.

Table 2.45. Simple phenotypic correlation coefficients[a] (in bold are those significant at P<0.01 and underlined those significant at P<0.05) between breeder's (B) and farmers' (F) visual score and grain yield (GY in kg/ha) total biological yield (BY in kg/ha, plant height (PH in cm) and kernel weight (KW in g). The data refer to farmers' fields

Location	Selected by	GY	BY	PH	KW	F
Tef Tanaz	B	.251	.228	-.008	.191	.409
	F	.342	.246	-.003	.382	
Ebla	F	-.064	.102	-.038	.283	
J. Aswad	B	.334	.483	.291	.116	.761
	F	.296	.518	.507	.232	
Bylounan	B	.169	.227	.252	.048	.330
	F	.662	.709	.743	.227	
Al Bab 6	F	.208	.224	.539	.410	
Al Bab 10	F	.503	.242	.804	.441	
Sauran	B	-.009	.098	-.029	.378	.469
	F	-.175	.010	-.194	.453	

[a] Correlation coefficients are based on different degrees of freedom in different trials

The relationships between the visual score given by the farmers and the breeder and four important characters such as grain yield, biomass, plant height and kernel weight was further investigated in Tel Hadya and Breda, where all the ten trials were also planted.

In Tel Hadya (Table 2.46) the correlations coefficients between the visual score of the farmers and grain yield were, on average, slightly larger than those between the visual score of the breeder and grain yield. The same difference occurs, with the exception of Sauran, in the case of biomass even though, as in the case of grain yield, the differences were not large.

In the case of both the farmers and the breeder, late maturity types received nearly always a higher score, while in general shorter lines were preferred, even though this was far from generalized. Only in a few cases there was a significant correlation between visual score and kernel weight, and in one case the correlation was negative.

Eventually, the correlation between the visual scores given by farmers and the breeder were strongly and positively correlated. The correlation coefficients were generally much higher that those observed in farmers fields (compare the last columns of (Tables 2.45 & 2.46). However, the correlation coefficients in Table 2.45 refer to the average visual score of a group of farmers, while those in (Tables 2.46 & 2.47) refer to the individual farmers who came to Tel Hadya and Breda to do the selection.

In Breda (Table 2.47) most of the correlation coefficients between the visual scores and grain yield were positive and significant, while there was a much lower correlation between the visual score and maturity, and even more so in the case of plant height and kernel size

The environment had a strong effect on selection as indicated by the comparison between the correlation coefficients between the visual score and the same trait in different environments. For example, the visual score were significantly and positively correlated with plant height in J. Aswad, Bylounan and Al Bab. However, when the same trials were evaluated at Tel Hadya, the correlation coefficients were either non significant or negative, and in Breda they were all non significant

An important issue can be addressed by examining the relationships between the selection in the research stations (Tel Hadya and Breda) and the yield in farmers' fields. This relationship is a measure of the relevance of centralized selection and can be measured by the correlation coefficients between the visual score given by the breeder to the entries in a given trial grown in Tel Hadya, and a number of traits measured in the same trial grown in a farmer field (Table 2.48)

The grain yield and the total biomass of the entries grown in the farmers' fields were generally independent from the visual score given by the breeder in either Tel Hadya or Breda. In the case of grain yield, only two correlation coefficients were significant, and they were both negative. In the case of biomass, four correlation coefficients were significant. One was negative, and the other three refers to high yielding locations known from previous years to give a similar discrimination among genotypes as Tel Hadya.

Table 2.46. Simple phenotypic correlation coefficients[a] (in bold are those significant at P<0.01 and underlined those significant at P<0.05) between breeder (B) and farmers visual score and grain yield (GY in kg/ha), days to heading (DH), plant height (PH in cm) and 1000 kernel weight (KW in g) in each of ten trials planted in Tel Hadya

Trial	Selected by	GY	DH	PH	KW	F
Tef Tanaz	B	.462	.488	-.027	.164	.938
	F	.425	.495	.030	.224	
Ebla	B	.350	.314	-.015	.169	.915
	F	.346	.419	.043	.165	
Tel Brack	B	.040	.072	-.142	-.078	.688
	F	.128	.251	-.204	-.062	
J. Aswad	B	.456	.302	-.028	.253	.894
	F	.455	.360	-.006	.302	
Bylounan	B	.211	.296	-.296	.045	.521
	F	.401	.326	-.435	.087	
Al Bab 6	B	.411	.375	-.260	.236	.810
	F	.433	.466	-.374	.341	
Al Bab 10	B	.132	.406	-.413	.339	.850
	F	.163	.434	-.397	.288	
Melabya	B	.272	.324	-.229	.242	.875
	F	.372	.360	-.351	.237	
B. Sharky	B	.376	.384	-.126	-.200	.822
	F	.393	.401	-.163	-.288	
Sauran	B	.324	.271	-.004	-.076	.823
	F	.328	.265	-.113	-.168	

[a] Correlation coefficients are based on different degrees of freedom in different trials

Table 2.47. Simple phenotypic correlation coefficients[a] (in bold are those significant at P<0.01 and underlined those significant at P<0.05) between breeder (B) and farmers visual score and grain yield (GY in kg/ha), days to heading (DH), plant height (PH in cm) and 1000 kernel weight (KW in g) in each of ten trials planted in Breda

Trial	Selected by	GY	DH	PH	KW	F
Tef Tanaz	B	.300	.198	.152	.197	.941
	F	.277	.158	.152	.219	
Ebla	B	.190	.092	.280	.251	.953
	F	.183	..087	.262	.283	
Tel Brack	B	.154	.106	-.017	-.014	.912
	F	.154	.076	-.027	.001	
J. Aswad	B	.250	.178	-.034	-.023	.929
	F	.270	.160	.029	.030	
Bylounan	B	.053	.233	-.170	-.001	.437
	F	.293	.344	.014	.087	
Al Bab 6	B	.230	.258	.029	.121	.912
	F	.189	.207	.038	.123	
Al Bab 10	B	.305	.126	.055	.189	.905
	F	.323	.195	.108	.196	
Melabya	B	.249	.089	-.003	.153	.901
	F	.271	.128	-.033	.144	
B. Sharky	B	.326	.203	.240	.159	.875
	F	.342	.228	.247	.174	
Sauran	B	.297	-.001	-.009	.291	.871
	F	.189	-.035	.139	.213	

[a] Correlation coefficients are based on different degrees of freedom in different trials

The difficulty to identifying the highest yielding entries in a given location when selection is made in another location is shown in (Table 2.49). The correlation coefficients between the grain yield measured in either Tel Hadya or Breda and the grain yield measured in the farmers fields were low, end even when significant, they show that only a maximum of 16% of the variation in grain yield in one location is explained by the variation in grain yield in the other location. This was the case between two dry locations such as Breda and Bylounan.

Table 2.48. Simple phenotypic correlation coefficients[a] (in bold are those significant at P<0.01 and underlined those significant at P<0.05) between breeder (B) visual score at Tel Hadya (TH) and Breda (BR) and grain yield (GY in kg/ha), total biological yield (BY), plant height (PH in cm) and 1000 kernel weight (KW in g) in farmers fields

Location	Selected by the breeder at	GY	BY	PH	KW
Tef Tanaz	TH	.163	.279	.119	-.128
	BR	.106	.235	.084	.084
Ebla	TH	.054	.158	.196	.016
	BR	-.048	.118	.274	.172
J. Aswad	TH	-.298	-.209	-.288	-.428
	BR	.059	.153	.089	.090
Bylounan	TH	-.099	-.136	-.302	-.320
	BR	.128	.007	-.170	-.109
Al Bab 6	TH	-.163	-.094	-.404	-.136
	BR	.134	.184	-.110	.014
Al Bab 10	TH	-.256	.003	-.521	-.251
	BR	-.018	-.041	-.186	-.022
Sauran	TH	.023	.254	.023	-.285
	BR	.075	.018	-.006	.223

[a] Correlation coefficients are based on different degrees of freedom in different trials

Table 2.49. Simple phenotypic correlation coefficients[a] (in bold are those significant at P<0.01 and underlined those significant at P<0.05) between grain yield (GY in kg/ha), plant height (PH in cm) and 1000 kernel weight (KW in g) in farmers fields (B), at Tel Hadya (TH) and Breda (BR)

Location	Research station	GY	PH	KW
Tef Tanaz	TH	.274	.594	.493
	BR	.167	.514	.559
Ebla	TH	.053	.591	.872
	BR	.304	.513	.632
J. Aswad	TH	-.108	.518	.146
	BR	.232	.439	.319
Bylounan	TH	-.175	.559	.146
	BR	.402	.375	.227
Al Bab 6	TH	-.043	.579	.380
	BR	.111	.449	.410
Al Bab 10	TH	.004	.722	.182
	BR	.129	.406	.569
Sauran	TH	.165	.683	.594
	BR	-.002	.776	.817

[a] Correlation coefficients are based on different degrees of freedom in different trials

At the end of this cycle of three years of participatory selection, the farmers choose to test in larger plots a total of 36 different breeding lines out of the original population of 208 breeding lines planted in the cropping season 1996/97. The main characteristics of the 36 lines are summarized in (Table 2.50). Farmers' preferences changed with the environment. White-seeded types were predominant in the most favorable locations, the two row types were the most commonly selected, even though six row types were selected in some locations. Landraces were the preferred types, particularly in the driest site, but in wetter sites and where lodging is a concern (B. Sharky).

Modern types were preferred to landraces. Eventually, uniform types were preferred everywhere. The last three columns show how many of the lines selected by the farmers in their field, were selected by the breeder either at Tel Hadya or Breda (centralized-non participatory selection) or in the farmers' fields (decentralized-non participatory selection).

Table 2.50. Main characteristics (seed color, B=black, W=white; row type, 2 and 6; land.=landraces, mod=unrelated to landraces; U=uniform, S=segregating; C-NP (TH or BR)=selected by the breeder on station; D-NP=selected by the breeder in the farmer's fields) of the lines selected by the farmers in their field at the end of three cycles of participatory selection

Location	Total	Black	White	2 Row	6 Row	Land.	Mod.	U	S	C-NP (TH)	C-NP (BR)	D-NP
Ebla	2	0	2	1	1	0	2	2	0	0	0	-
Tel Brack	9	5	4	9	0	9	0	7	2	1	1	-
J. Aswad	8	3	5	8	0	5	3	7	1	0	0	1
Bylounan	3	3	0	3	0	3	0	3	0	0	1	0
Al Bab 6	1	0	1	1	0	1	0	1	0	0	0	-
Al Bab 10	7	1	6	3	4	1	6	6	1	1	1	-
Melabya	11	6	5	2	0	10	1	8	3	1	2	-
B. Sharky	4	0	4	3	1	0	4	3	1	1	1	-
Sauran	4	0	4	4	0	1	3	1	3	0	0	0

2.5.3. Participatory Breeding in Tunisia and Morocco

In Tunisia and Morocco, the participatory barley breeding activities are conducted in collaboration with INRA in Morocco and IRESA in Tunisia.

In Morocco, four types of trials were conducted in farmers' fields and in the research stations. Table 2.51 summarizes the trials conducted in Morocco in terms of number of entries, the design used and the sites of testing.

Table 2.51. Nurseries and trials conducted in Morocco in farmer fields and research stations during the 1998-99 season

Type of trial	No. of entries	Plot size and experimental design	Research stations	Farmer fields
SEGMAG99	268	2 rows of 2.5 m long, unreplicated	Merchouch, Jemaa Shaim,	Zhiliga
NURMAG99	210	2 rows of 2.5 m long, unreplicated	Merchouch, Jemaa Shaim,	Oued Zem, Sidi Boumahdi
MORYT99	50	6 rows*2.5m*0.30m lattice design, 2 replications,	Merchouch, Jemaa Shaim,	Oued Zem, Sidi Boumahdi, Zhiliga, Bouhrazen
PPBMOR99	30	4 rows*2.5m*0.30m, RCBD with 2 replications,	Merchouch, Jemaa Shaim,	Oued Zem, Sidi Boumahdi, Chemaia, Zhiliga, Bouhrazen

Merchouch and Jemaa Shaim are the main research stations for barley breeding, representing the high rainfall areas (420 mm rainfall annually) and the semi-arid region (< 300 mm), respectively. Farmer sites were chosen to represent the main barley growing areas and to cover the diversity of ecosystems in which barley is grown. Zhiliga is a semi arid site in a hilly area with an average rainfall of 350 mm. Oued Zem is at the limit between the semi-arid and arid region, with an average annual rainfall of 300 mm and with low temperatures in winter. Sidi Boumahdi is located in the arid zone with 250 mm average rainfall. Chemaia is the driest site, with less than 200 mm of rain on the average, and very shallow soils. Bouhrazen is located in the high Atlas Mountains with a rainfall of less than 350 mm annually.

The trials planted in farmer fields were visited at least four times during the growing season to record agronomic characteristics, reactions to diseases and grain and straw yields. The collaborating farmers joined the breeder during the visits. The trials and nurseries at the research stations are visited at least 10 times. All of the nurseries and trials conducted at the research stations and farmer fields were visited by a group of at least 10 farmers, including the five collaborating farmers during the farmer traveling workshop. During this event, final selections were made and the criteria of farmers' selection were recorded. Grain and straw yield were estimated from the central rows. The trials at Bouhrazen were discarded because of the drought effects and the high heterogeneity of data.

During 1999 there were three methodological innovations. The first was the use of the residual maximum likelihood method to analyze the data. The analysis was done by fitting different models ranging from the lattice model, to the randomized complete block and to the spatial analysis using ASREML. The second was the use of clustering and ordination procedures to assist in the pattern analysis of genotype × environment interactions. Cluster analysis or numerical classification is one technique used to simplify the data set by grouping individuals with similar responses for all attributes. In the case of genotype × environment (G×E) tables of yields, clustering is used to simplify the data set by grouping the genotypes, over all environments, with similar response patterns for all yields. Then grouping the environments, over all genotypes, with similar response patterns for all yields. Biplots are used to represent the information contained in G×E tables in a two or three-dimensional graph. In a biplot, genotypes are displayed as points and environments are displayed as vectors scaled to have the same maximum magnitude as the maximum magnitude of the genotypes. Details of the interpretation of biplots will be given in the section reporting the results. The third was the use of similarity analysis to compare the selection done in different environments by the breeder and by the individual farmers. The analysis is based on the Dice coefficient (Czekanowski, 1917) and consists in reducing the selection data into a matrix of 1 (selected) and 0 (discarded), and then in the calculation of the Dice coefficient as 2a(2a+b+c) where a (1/1) is a case when a line is selected twice (for example by both the breeder and a farmer, or in two environments), b (1/0) and c (0/1) are the two possible cases when a line is selected only once out of two possibilities, and d (0/0) is a case when a line is discarded twice. The Dice coefficient (as indicated by the formula) does not consider the number of d's, and therefore is an index of similarity in positive selection only. 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 analysis were done using the program NTSYS-PC version 2.02 (Numerical Taxonomy System, Applied Biostatistics, N.Y.).

The importance of a given trait as a selection criteria used by farmers is assessed by the number of times it is cited in a nursery. During their participation to the workshop at ICARDA (see section 2.2.1), the farmer and breeder from Morocco made selection on MORYT99 and NURMAG99 planted at Tel Hadya.

The climatic conditions in Morocco were characterized by significantly lower than average annual rainfall at all sites. Detailed data are shown for the research stations representing the main barley growing regions (Table 2.52). The first useful rain came in late December, and therefore sowing was delayed. Severe drought occurred at all sites and only less than 10% of total rainfall was received after March and most of the soils are shallow. Foliar diseases such as leaf rust, powdery mildew and net blotch were observed at all sites and a severe attack of scald was recorded at Zhiliga. Heavy lodging was observed only at Merchouch research station known for its deep clay soils.

Table 2.52. Monthly rainfall (mm) during 1998-99 at three research stations representing different barley growing areas in Morocco

Month	Merchouch	Jemaa Shaim	Tessaout
September	25.7	0.0	1.3
October	17.8	5.0	0.5
November	0.0	0.0	0.0
December	46.5	39.0	36.1
January	57.1	55.0	45.5
February	25.6	52.0	36.8
March	28.5	36.0	39.7
April	0.2	16.0	0.4
May	20.3	13.0	35.7
June	0.0	0.0	1.0
July	0.0	0.0	0.0
Total rainfall	221.7	216.0	197.0
Long term average	420.0	280.0	200.0

The activities carried out in Tunisia included the evaluation of 566 new advanced lines provided by ICARDA in three different nurseries, namely NURMAG (210 lines), SEGMAG (268 lines) TUNYT (88 lines), and of locally developed germplasm in the ELITE 1 yield trial. This includes 25 lines already evaluated in 1997 and 1998. The research program was conducted in three research stations (Kef and Béja, the INRAT's research stations, and Moghrane, the ESA's research station), and three farmers' fields at Garn- El Halfaya, Foussana and El Fahs.

(Table 2.53) summarizes the trials conducted in Tunisia in terms of number of entries, the design used and the sites of testing while the agronomic practices and the climatic data of the different sites are summarized in (Table 2.54).

Table 2.53. Nurseries and trials conducted in Tunisia in farmer fields and research stations

Type of trial	no. of entries	Plot size and experimental design	Research stations	Farmer fields
SEGMAG99	268	2 rows of 2.5 m long, unreplicated	Le Kef, Beja, Moghrane	Garn- El Halfaya, Foussana
NURMAG99	210	2 rows of 2.5 m long, unreplicated	Le Kef, Beja, Moghrane	Garn- El Halfaya, Foussana, El Fahs
TUNYT99	88	6 rows*2.5m*0.30m lattice design, 2 replications	Le Kef, Moghrane	Garn- El Halfaya, Foussana
ELITE 1	25	RCBD (3 reps, 6 rows- 10 m long)	Le Kef, Beja, Moghrane	Garn- El Halfaya, Foussana, El Fahs

Table 2.54. Agronomic characteristics and climatic data in the locations used in Tunisia

Site	Tillage	Previous crop	Soil/land	Rainfall (mm)
Le Kef	2 tillage/Hersage/canadian plow	Food-legume /cereal	Vertic/calcareous	450
Beja	2 tillage (one mold board plow and one disk plow)/ Hersage	Food-legume	calcareous	600
Moghrane	2 tillage	Fallow		-
Garn-ElHalfaya	Plough in the stubbles	Durum wheat	slope land	-
Foussana	2 tillage (disk plow)	Fallow (grazed by sheep)	slope land	-
El Fahs	2 minimum tillage	Durum wheat		-

The climatic conditions in Tunisia were favorable till April (Table 2.55). All the sites received more than 300 mm rainfall before January 20, 1999. About 20% of the total rainfall came during the filling period (April-June 1999).

In general, foliar diseases did not occur seriously in all sites, due to unfavorable weather conditions during March and April. Drought and high temperatures limited the disease development to 2-4 (Logoering scale) for the most important barley diseases (powdery mildew, net blotch and scald). However, at Moghrane, net blotch caused heavy damage. Breeder's selection was carried out at the grain filling period (15-28 April 1999).

During the field days farmers and extension agents were briefly introduced to the trials and then divided into small groups. Each group was led either by a scientist or a research technician. Each farmer was assigned a survey sheet in which the experimental design of the Elite Yield Trial was laid out. Farmers were asked to move across the blocks, and to freely select the lines they liked most, and to justify their choices.

Table 2.55. Monthly rainfall (in mm) during 1998-99 season in four of the six locations used in Tunisia

Month	Foussana	Moghrane	Kef	Beja
September	39.8	69.1	46.5	59.7
October	24.4	100.6	53.1	57.4
November	47.3	13.8	69.4	146.9
December	13.5	37.5	18.1	59.4
January	107.0	244.1	117.3	110.2
February	0.0	0.0	13.9	61.8
March	40.0	48.0	36.6	87.8
April	14.9	6.8	7.8	20.0
May	31.5	26.3	49.3	15.3
June	21.1	15.7	28.7	21.7
July	0	0.0	0	0
Total rainfall	339.5	561.9	440.7	640.2
Long term average	-	-	450.0	600.0

There were poor correlations between yield (of grain and or straw) between the research stations and the farmers fields and between the farmers fields. A first example is shown in (Table 2.56), which shows the correlations coefficients between grain yield and straw yield measured in two farmer fields (Zhiliga and Sidi Boumahdi) and in two research stations (Merchouch and Jemaa Shaim). None of the correlation coefficients was significant, indicating that it is not possible to predict the yield of a line in a given location from its yield at any other location. A similar picture emerges from the analysis of grain yield and total biological yield measured in the thirty genotypes tested in the trial PPBMOR99, which was grown in two research stations and four farmers' fields (Table 2.57). Only three correlation coefficients were significant, and one of them was negative. The highest correlation coefficient was 0.429, indicating that only about 16% of the variation in biological yield at Merchouch was in common with the variation for the same trait measured in Zhiliga.

Table 2.56. Correlation coefficients between grain yield (upper row) and straw yields in the trial MORYT99 grown at two farmer fields (Zhiliga and Sidi Boumahdi) and two research station(Merchouch and Jemaa Shaim) in Morocco

	Zhiliga	S. Boumahdi	Merchouch
S. Boumahdi	0.220	1	
	0.014		
Merchouch	0.195	0.133	1.00
	0.005	-0.103	
J. Shaim[a]	0.043	-0.011	-0.077

[a] Biological yield not available

Table 2.57. Correlation coefficients between grain yield, biological yield, straw yield and harvest index in the trial PPB99 grown at four farmer fields (Zhiliga and Sidi Boumahdi) and two research station (Merchouch and Jemaa Shaim) in Morocco

	Oued Zem	S. Boumahdi	Zhiliga	Chemaia	J. Shaim
	Grain yield				
S. Boumahdi	0.160	1			
Zhiliga	0.290	-0.050	1		
Chemaia	0.342	-0.087	0.096	1	
J. Shaim	-0.295	0.165	-0.317	-0.254	1
Merchouch	-0.124	0.060	-0.378*	-0.204	0.262
	Biological yield				
S. Boumahdi	0.351	1			
Zhiliga	0.117	0.370*	1		
Chemaia	0.203	-0.107	-0.129	1	
J. Shaim	0.260	0.287	0.254	0.045	1
Merchouch	0.012	0.109	0.429*	0.077	0.280

* P< 0.05

The picture emerging from the ELITE 1 trials conducted in Tunisia is only slightly different (Table 2.58). The grain yields at Foussana, the lowest yielding location with 1300 kg/ha, were negatively correlated with those of Beja (the highest yielding among the research stations), while the grain yields at the other two farmers' fields, Tejerouine and Fahs (2120 and 4370 kg/ha, respectively) were positively correlated among them, and with those of Moghrane and Kef. Eventually, there was a strong positive correlation between yields at the two research stations of Beja and Le Kef.

Overall, the 1999 results confirmed those of the previous two cropping seasons in supporting the need for decentralized selection, i.e. for selection in the target environment.

Table 2.58. Correlation coefficients between grain yield in the trial ELITE 1grown at three farmer fields (Foussana, Tejerouine and Fahs) and three research station (Moghrane, Beja and Kef) in Tunisia

	Foussana	Tejerouine	Fahs	Moghrane	Beja
Tejerouine	0.182	1			
Fahs	-0.027	0.472*	1		
Moghrane	0.059	0.493*	0.462*	1	
Beja	-0.456*	0.246	0.247	0.369	1
Kef	-0.195	0.478*	0.191	0.354	0.725**

* P< 0.05; ** P<0.01

2.5.4. Participatory Breeding in Yemen

This activity is a collaborative project with AREA (Agricultural Research and Extension Authority) and is supported by the SWPPRGA (the System Wide Program on Participatory Research and Gender Analysis). It is located in the Kuhlan-Affar district in the Hajja province of Yemen. The area is representative of traditional dryland farming systems in the country's north western highlands, characterized by subsistence agriculture. In this area AREA's staff has conducted a project on terraces rehabilitation (supported by IDRC) with a participatory component.

The area is a steep mountain slope that descends, within a short distance, from an altitude of 2200 m to about 800 m at the wadi floor (Wadi Sharis). It could be divided into three major agroecological zones consisting of a mountain top (zone III), terraced mountain slopes (zone II, middle slope) descending into wadi bed (zone I, lower slope).

In three villages selected in the project area (Hasn Azam, Bit Al-Wali and Al-Ashmor), we planted successfully fifty barleys (four local varieties, collected from different areas in the Northern Highland, one local cultivars used as a common check, and 45 improved). The same genetic materials were also planted in the research station at Al-Erra using the same experimental design as in the villages. The experiments were planted in two replications in the three villages, with the individual plots arranged in a different number on the different terraces. The total number of terraces was 4,7 and 4 in Hasn Azan, Bit Al-Wali and Al-Ashmor, respectively. In AI-Erra research station a randomized complete block design (RCB) was used. Each entry was planted in 4 rows/plots, 3 m long and 25 cm apart.

Standard analysis of variance was performed: the environmentally standardized data were use to analyze genotype x environment interactions using the clustering and ordination procedures described earlier. The selections performed by the breeder and the farmers were compared by similarity analysis using the DICE coefficient: 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.

Each farmer made his selection by tying numbered labels at the end of selected plots. In Hasn Azam selection was also performed by a group of four women.

A number of quantitative data were measured: plant height, days to heading, days to maturity, biological yield and grain yield. The data were analyzed with a standard ANOVA for RCBD.

Significant differences were found among varieties over all locations for plant height, days to heading, days to maturity, 1000 kernel weight, biological and grain yield and harvest index (Table 2.59 & Table 2.60).

Table 2.59. Mean and range of plant height (PH), days to heading (DH), days to maturity (DM), and kernel weight (KW) of 50 barley lines grown at four locations, and comparison among landraces and improved

Location	Trait	Mean	Max	Min	Mean Impr.	Mean Land.
Hasn Azam	PH	62	85	42	63	61
	DH	61	80	49	59	54
	DM	92	106	78	92	84
	KW	42	59	28	43	53
Bait Al-Wali	PH	64	105	44	65	57
	DH	67	80	41	67	60
	DM	104	116	81	104	98
	KW	41	60	22	41	50
Al Ashmor	PH	56	76	35	58	57
	DM	79	94	62	83	77
	KW	39	50	27	40	45
Al Erra station	PH	47	61	33	46	44
	DH	47	54	42	46	45
	DM	93	106	70	82	92
	KW	38	49	29	38	41

Table 2.60. Mean and range of total biological yield (BY), grain yield (GY) and harvest index (HI) of 50 barley lines grown at four locations, and comparison among landraces and improved

Location	Trait	Mean	Max	Min	Mean Impr.	Mean Land.
Hasn Azam	BY	2895	4734	1451	2984	3361
	GY	1166	2414	499	1156	1304
	HI	0.40	0.63	0.23	0.40	0.39
Bait Al-Wali	BY	3581	5717	589	3208	3070
	GY	1409	2668	318	1213	967
	HI	0.39	0.50	0.16	0.39	0.30
Al Ashmor	BY	2697	4325	933	2744	2717
	GY	1437	2445	204	1570	1618
	HI	0.48	0.50	0.22	0.50	0.50
Al Erra station	BY	2762	4800	719	2781	2486
	GY	981	2175	497	896	815
	HI	0.37	0.50	0.21	0.32	0.33

Plant height is one of the most important characters in the rainfed areas. The farmers prefer tall plant to satisfy their needs for straw to feed their animals. Average plant height ranged from 64 cm at Bait Al-Wali (the location with the highest rainfall) to 47 cm at Al-Erra research station. On average, landraces were shorter than improved particularly at the wettest location.

Nearly 40% of the variation (after the data were environmentally standardized) was due to genotype x environment interactions (Table 2.61) with some entries, such as the landraces, being shorter than the average in every locations, other entries being taller than average in every locations, but many others showing a strong interaction with the locations.

Many traits have been used by farmers to compare new barley genotypes with their own cultivars, such as growth habit, tillering, phenology, and adaptation to the environmental condition and needs. It's worth to mention that farmers in all locations mentioned earliness and high tillering more often.

The mean number of days to maturity ranged from 79 in Al Ashmor to 92 days in Hasn Azam and Al-Erra, and to 103 days in Bait Al-Wali. The landraces were always about 5-7 days earlier than the improved genotypes except than in Al Erra where the stress conditions caused a premature desiccation

More than 50% of the variation (after the data were environmentally standardized) was due to genotype x environment interactions. Several lines were earlier than the average in some locations, and later than the average in others, and few were stable across environments. Among those were some of the landraces, which were consistently earlier than average in all locations, while others were considerably later than average in Hasn Azam and Al Ashmor but later in Bait Al-Wali and Al-Erra.

Kernel weight ranged between 42 g in Hasn Azam and 38 g in Al-Erra, with a large variability between entries within each location. The landraces had always larger kernels than the improved lines with differences up to about 10 g in Hasn Azam and Bait Al-Wali. The four locations were positively and strongly correlated with each other. Landraces showed consistently a kernel weight higher than average in all locations, while some improved lines had a kernel weight lower than average in all locations.

In the rainfed areas biological yield is considered an important character. This is particularly true under stress were the farmers use the straw to feed their animals and use grazing if there is not enough rain for the crop to complete its life cycle, or when expectations for grain yield are low.

The analysis of variance showed that the differences between the lines and the common check were significant for biological yield, grain yield as well as harvest index. The landraces had a higher biological yield than improved at Hasn Azam but the reverse was true at Al-Erra, while at Al Ashmor and Bait Al-Wali there were no differences. However, there was a large genotype x environment interactions (Table 2.61) that explained nearly 72% of the variation for environmentally standardized data.

The total biological yield at Al Erra and Bait Al-Wali were more closely correlated than the other two locations. As a consequence there was a predominance of specifically adapted lines (Figure 2.11) such as lines 8 and 19 in Hasn Azam and Al Ashmor, lines 12, 44 and 42 in Al Ashmor, and lines 2, 21 and 23 which yielded much more than the average in Al Erra and Bait Al-Wali. The lines performing well in the higher number of locations were lines 20 (the local landrace), 30 and 49, which produced more total biological yield in Hasn Azam, Bait Al-Wali and Al Erra, and slightly more than average in Al Ashmor.

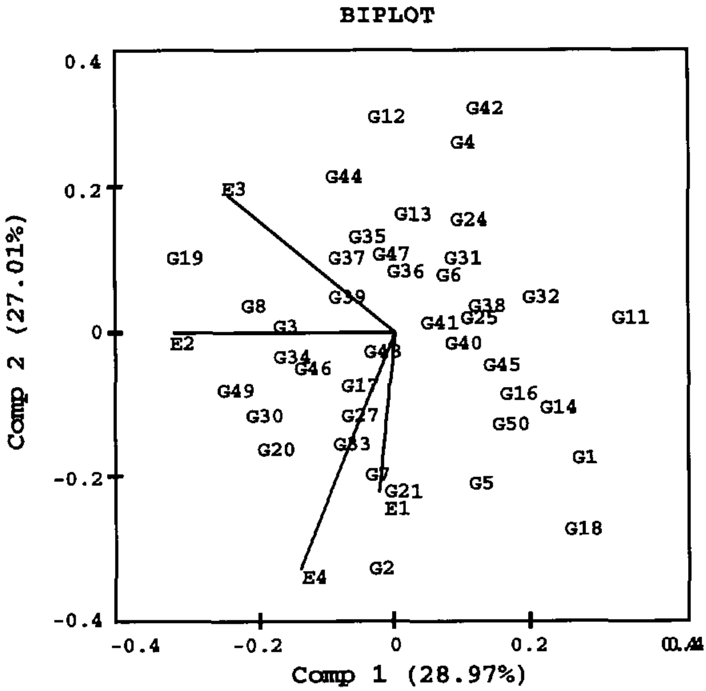


Figure 2.11. Biplot of total biological yield of 50 barley entries grown in four environments (E1=Bait Al-Wali, E2=Hasn Azam, E3=Al Ashmor, and E4=Al Erra).

Significant differences were found among genotypes in the four locations. The grain yield of the landraces was comparable with that of the improved except in Bait Al-Wali were it was about 20% lower.

As in the case of total biological yield, genotype x environment interactions (Table 2.61) explained nearly 70% of the variation for environmentally standardized data. (Figure 2.12) shows that Al Ashmor caused most of the interactions being negatively correlated with the other three locations, which, by contrast are positively correlated. As a consequence, the lines can be classified in three groups. The first group includes those entries with high grain yield in the three closely correlated locations (Bait Al-Wali, Hasn Azam, and Al Erra) such as lines 1, 2, 3, and 8, the second includes are the entries with high grain yield in Al Ashmor, such as lines 44 and 38 (the local landrace Sakhla), while the third includes the entries with an average or below average grain yield everywhere.

Significant differences were found among genotypes in the four locations. The harvest index of the landraces and of the improved were similar, except at Bait Al-Wali, where landraces were affected by lodging which reduced their harvest index. The genotype x environment interaction effects were larger on harvest index than on either grain yield or total biological yield (Table 2.61). However, the general pattern of the genotype x environment interactions was very similar to the one observed in the case of grain yield with Al Ashmor contributing the most to the interaction effects. In general lines with higher than average grain yield, also had a higher than average harvest index. However, there were genotypes with very high harvest index that were average for grain yield and had a very poor total biological yield. This might reflect differential ability of lines in grain filling.

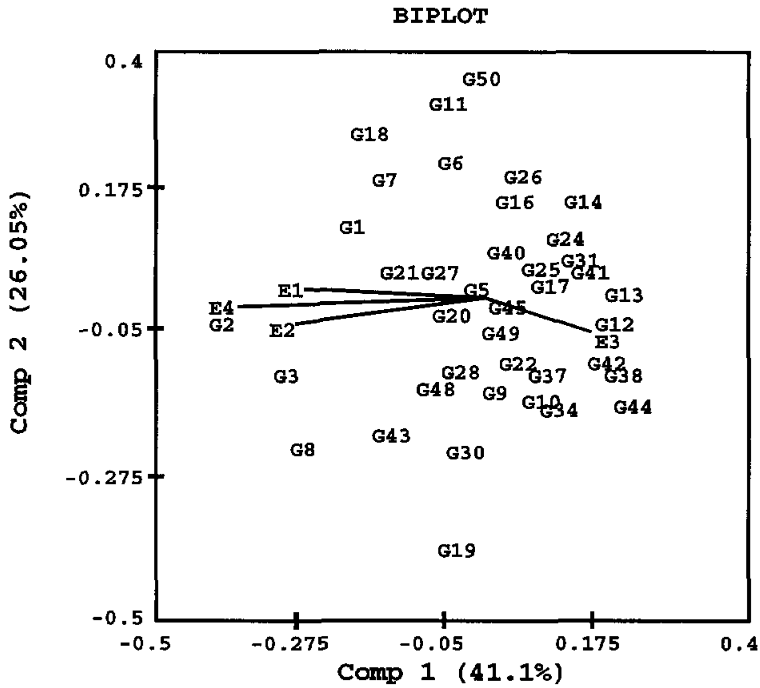


Figure 2.12. Biplot of grain yield of 50 barley entries grown in four environments (E1=Bait Al-Wali, E2=Hasn Azam, E3=Al Ashmor, and E4=Al Erra)

Table 2.61. Two-way hierarchical ANOVA for environmentally standardized grain yield (GY), biological yield (BY), days to maturity (DM), 1000 kernel weight (KW), harvest index (HI) and plant height (PH) of fifty barley lines grown in four environments

		msq (%)[a]					
Source	df	GY	BY	DM	KW	HI	PH
Genotypes	49	1.270	1.125	1.764	2.472	1.056	2.419
		(31.8)	(28.1)	(44.1)	(61.8)	(26.4)	(60.48)
G x E interaction	147	0.910	0.958	0.745	0.509	0.981	0.527
		(68.3)	(71.9)	(55.9)	(38.2)	(73.6)	(39.5)
Total sum of squares	199	0.985	0.985	0.985	0.985	0.985	0.985

[a]Percent contribution of Genotype and Genotype x Environment Interactions

The result of selections of farmers and breeder among lines over all locations is shown in (Table 2.62). In total, 38 lines were selected at least once: all the landraces were included in the selected group. None of the lines was selected everywhere by both the breeder and the farmer. Only four lines were commonly selected in Bait Al-Wali, five in Hasn Azam, four in Al Ashmor and three in Al-Erra. Eventually, the group of women in Hasn Azam selected only two lines.

Eleven lines which were selected between one and three times by the farmers and the women, were never selected by the breeder, while four lines selected by the breeder were never selected by either the farmers or the women.

The dendrogram representing the clustering analysis of the similarity coefficients (Figure 2.13)shows that, overall, the similarity, measured by the DICE coefficients, was low with a maximum value of 0.57. In some cases there was a close similarity between the selections made by the farmers and the breeder, as in the case of Hasn Azam where there was more similarity between the women and the breeder than between both of them and the farmers, and to a lesser extent in Al Ashmor. In the case of Bait Al-Wali, and even more at Al Erra, the similarity between the selections made by the farmers and by the breeder was very low.

For most of the traits the difference between the selections made by the breeder, by the women, and those made by farmers (Table 2.63) was not significant. The lines selected on station (Al Erra) by the breeder were significantly higher yielding (both in biomass and grain) than the lines selected by farmer's. Similarly the lines selected at Bait Al-Wali by the breeder yielded significantly more grain yield than the lines selected by the farmer's while the lines selected by farmer had significantly larger kernels than the lines selected by the farmer's.

Table 2.62. Barley lines selected at least once by either the farmers or the breeder and frequency of selection (maximum frequency is 9 for the total, 4 for the farmers, 1 for the women, and 4 for the breeder)

Entry No.	Entry Name	Total	Breeder	Women	Farmer
25	ACSAD 20 (97-98)	7	3	1	3
40	Bakkur (Kharen)	6	2	1	3
42	Sakhla (Kharen)	5	1	1	3
21	ACSAD 60 (97-98)	5	3	1	1
20	Balady	5	2	1	2
19	ACSAD 1420	5	3	1	1
8	ACSAD 1494	4	2	0	2
24	ACSAD 7 (97-98)	4	0	1	3
50	ACSAD 1125	4	1	1	2
10	ACSAD 1488	4	2	1	1
33	ACSAD 6 (97-98)	4	2	1	1
38	Sakhla	4	2	1	1
30	ACSAD 58 (97-98)	4	2	1	1
22	ACSAD 17 (97-98)	3	3	0	0
39	Balady	4	1	1	2
41	Balady (Tholla-Al-Ahmur)	4	1	1	2
12	ACSAD 1492	2	0	0	2
3	ACSAD 1468 (S)	2	1	0	1
2	ACSAD 1468 (S)	2	2	0	0
9	ACSAD 1486	2	1	0	1
16	ACSAD 1448	2	1	0	1
7	ACSAD 1478	2	1	0	1
23	ACSAD 14 (96-98)	2	1	0	1
4	ACSAD 1470	3	1	1	1
1	ACSAD 1466	2	2	0	0
29	ACSAD 13 (97-98)	2	0	0	2
34	ACSAD 34 (97-98)	3	1	1	1
14	ACSAD 1484	2	0	1	1
15	ACSAD 1496	1	0	0	1
13	ACSAD 1468	1	0	0	1
31	ACSAD 18 (97-98)	1	1	1	0
6	ACSAD 1476 (S)	1	1	0	0
47	ACSAD 1420	1	0	0	1
28	ACSAD 5 (97-98)	1	0	0	1
37	ACSAD 45 (97-98)	2	1	1	0
45	ACSAD 1422	1	0	0	1
36	ACSAD 36 (97-98)	1	0	1	1
17	ACSAD 1472 (S)	1	0	1	0

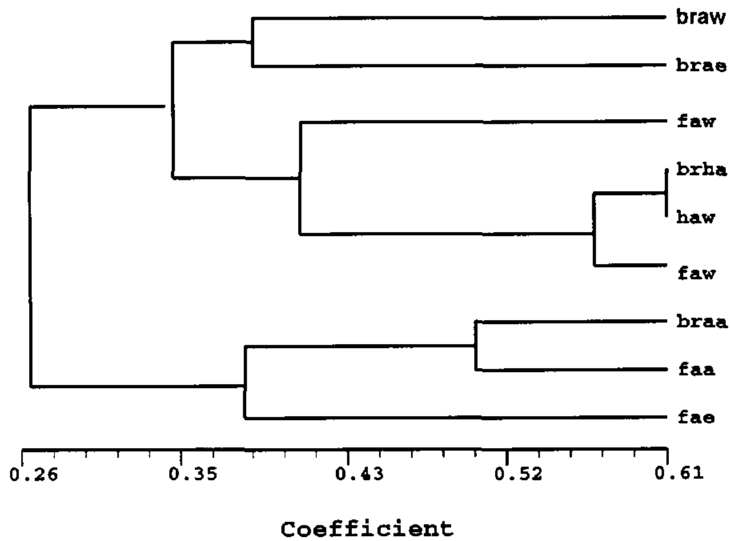


Figure 2.13. Dendrogram based on cluster analysis of the farmers (f), of the women (w) and of the breeder (br) selection in fifty barley lines grown in Hasn Azam (ha), Al Ashmor (aa), Bait Al-Wali (aw) and Al Erra (ae)

Although the selection made by the breeder on station was more efficient than that of the farmer, the selections made by both missed to identify most of the highest yielding lines in the farmer's fields (Table 2.63). If we consider as the highest yielding the top 10%, none of the highest yielding lines at Al Ashmor was included among the selections (made by both the breeder and the farmer) in Al Erra, while the selection made by breeder at Al Erra included only one of the highest yielding lines (both for grain yield and total biological yield) in Bait Al-Wali, and those made by the farmers included only one of the lines with the highest biological yield. Eventually, the selections made by the breeder and the farmers in Al Erra included two and one, respectively, of the highest yielding lines, for both grain yield and total biological yield, in Hasn Azam. The efficiency, defined as the number of high yielding lines in the three villages identified by selection on station, did not change by using as selection criteria grain yield and total biological yield.(Table 2.64)

Table 2.63. Comparison between breeder's (B sel) and farmers' (F sel) selection for plant height (PH), days to heading (DH), day to maturity, 1000 kernel weight (KW) total biological yield (BY), grain yield (GY) and harvest index (HI)

Location	Selected	PH	DH	DM	KW	BY	GY	HI
Al Erra	B sel	49.8	48.0	91.7	37.30	3331	1298	0.40
	F sel	45.7	47.8	90.1	38.42	2438	958	0.42
	t test	n.s.	n.s.	n.s.	n.s.	**	*	n.s.
Al Ashmor	B sel	57.4	-	76.0	40.58	3010	1756	0.59
	F sel	57.6	-	77.2	44.08	2683	1479	0.55
	t test	n.s.	-	n.s.	n.s.	n.s.	n.s.	n.s.
Bait Al-Wali	B sel	66.7	67.7	104.0	41.45	4500	1981	0.45
	F sel	64.0	63.4	100.7	49.41	3921	1529	0.43
	t test	n.s.	n.s.	n.s.	*	n.s.	*	n.s.
Hasn Azam	B Sel	65.7	54.7	89.6	47.73	3054	1234	0.41
	F Sel	65.8	55.4	90.7	46.30	3093	1153	0.37
	W Sel	61.4	55.4	89.8	45.90	2984	1111	0.37
	t test (B-F)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	t test (B-W)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	t test (F-W)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

* P< 0.05; ** P<0.01

Table 2.64. Number of high yielding entries (top 10%) for grain yield (GY) and total biological yield (BY) in the three villages included in the visual selection by the breeder and the farmers, and in the selection for grain and total biological yield at Al Erra station

	Selection criteria					
	Visual Breeder		Visual Farmer		GY	BY
Location	GY	BY	GY	BY	GY	BY
Al Ashmor	0	0	0	0	0	0
Bait Al-Wali	1	1	0	1	0	1
Hasn Hazan	2	2	1	1	2	1

As observed in similar experiments in other countries, selections conducted only in the station not only could lead to discard lines performing well in the three villages, but also affects the total number of lines preserved after one cycle of selection. As shown in (Table 2.65), the percent of lines after a cycle of different types of selection increases from 20% (centralized-non participatory selection) to 50% (decentralized-participatory selection).

In this case, decentralization seems to be the only factor that affects the amount of diversity left after one cycle of selection.

Table 2.65. Total number of entries selected with four different strategies of selection.

Strategy of selection	Number selected	%
Centralized-non participatory	10	0.20
Centralized-participatory	12	0.24
Decentralized-non participatory	26	0.52
Decentralized-participatory	25	0.50

2.6. Near East and West Asia

The germplasm development for the Near East is largely a product of the head quarters activities. Therefore in this section we will mainly report progress in breeding for continental areas with very cold winters, as well as specific collaborative activities with the National Programs of the countries of the Near East. Many of these activities are also part of the Mashreq and Maghreb project, and more details can be found in the reports of that project.

2.6.1. Syria

2.6.1.1. Verification Trials

The jointly conducted On Farm Verification Trials (OFVT) represents one specific type of collaboration with the Syrian national program. This is a very important collaboration because from the results of these trials recommendations are made to release varieties in Syria.

The OFVT with barley are conducted in several locations in each of the two stability zones, namely zone B receiving between 350 mm and 250 mm of annual rainfall, and zone C receiving about 250 mm of annual rainfall, respectively.

Promising lines to be tested in the OFVT are selected by ICARDA, DASR (Directorate for Agricultural and Scientific Research of the Syrian Ministry of Agriculture and Agrarian Reform) and ACSAD (Arab Center for Studies of the Arid Zones and Dry Lands) and are tested for a maximum of three years when they perform well. If they do not perform well they can be taken out after the first year.

The trials are conducted as RCB designs with three replications in zone B and four in zone C.

The OVFT for zone B in 1998/99 (Table 2.66) included ten promising lines and five checks. They were conducted in 7 locations with mean yields ranging from 722 kg/ha in Souran to 3280 kg/ha in Tel Hadya.

There were considerable genotype x environment interactions that explained 60% of the variation of environmentally standardized data. The yield of the lines in the seven environments is shown in (Figure 2.14), where the entries are indicated as G followed by the entry number, and the environments are indicated with E and are in the same sequence as in (Table 2.66). Some lines such as Pamir 9 (G15), Arabi Aswad (G13), Furat 2 (G8), Furat 1 (G2), and ACSAD 1424 (G14) were generally non adapted to all or most of the environments, while other such as Arta (G10) performed better than average in all environments, except the research station (E2). Eventually other lines performed well in a subset of environments. For example, Furat M-5408 performed well in Ghaitoun (E3), Jamilieh (E5) and Suran (E6), Hyb 85-6//As46/Aths*2 (G9) at Tel Hadya (E2) and Haran (E1), and ACSAD 1420 (G4) at Haran, Abtin (G4) and Ghaitoun.

Table 2.66. Grain yield (kg/ha) of lines in the on-farm verification trials in zone B in Syria

		locations						
Entry	Names	haran	t.hadya	ghaitoun	abtin	jamilieh	suran	hashisheh
1	A.Abiad	2260	3167	2063	2573	984	667	1526
2	Furat 1	1960	3261	2167	2333	984	604	1838
3	Roho//Alger/Ceres 362-1-/3/Mo B1337/WI2291	2074	3662	2089	2552	1146	589	1875
4	ACSAD 1420	2234	3657	2099	2771	1432	823	2062
5	Furat A-5468	2069	2954	2032	2849	1438	984	2229
6	Furat M-5408	2028	3032	2126	2938	1344	906	1401
7	Furat E-5406	1975	3808	1839	2776	1229	844	1266
8	Furat 2	1666	3282	2001	2240	1359	635	1740
9	Hyb 85-6//As46/Aths*2	2145	3943	1803	2662	1089	406	1260
10	Arta	2318	3302	2563	2938	1344	1172	2088
11	Alanda//Lignee 527/Arar	2086	3375	2370	2609	1099	589	1802
12	Lignee 527/Rhn//Rhn-03	1750	3860	2006	2771	1052	583	1740
13	A.Aswad	1772	2224	1933	2521	1203	771	1651
14	ACSAD 1424	1402	2392	1896	2302	1063	724	1542
15	Pamir 9	1640	3287	1594	2630	1005	526	1880
Mean		1959	3280	2039	2631	1185	722	1727
Max		2318	3943	2563	2938	1438	1172	2229
Min		1402	2224	1594	2240	984	406	1260

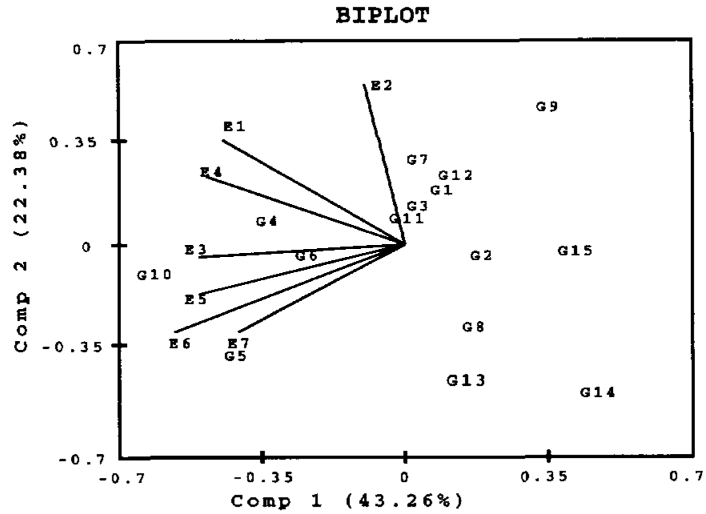


Figure 2.14. Biplot of grain yield of 15 barley lines grown in seven environments in Syria: genotypes (=entry) and environments (=locations) are given in (Table 2.66)

The OVFT for zone C (Table 2.67) included fifteen promising lines and two checks (the two local landraces since no new varieties have been officially released for the dry areas of Syria). They were conducted in 9 locations, but because of drought, data on all lines were collected only in three locations where the mean yields ranged from 748 kg/ha in Khabab to 1330 kg/ha in Breda.

Although there were only three environments, genotype x environment interactions explained 50% of the total variation of the environmentally standardized data. The biplot (Figure 2.15) shows that most of the interaction is due to Khabab, the lowest yielding locations, while there other two locations were positively correlated, and they were not very well represented by the model, as indicated by the short vectors.

The local landrace Arabi Aswad (G11) and Furat S-5715 (G9) were the best in terms of overall adaptation, performing above average in Khabab (E1) and Batraneh (E3). The top yielding line at Breda was SLB 34-65/Arar (G8) that performed poorly in the other two locations.

The pattern of genotype x environment interactions in Breda suggests that the variability within zone C may be larger that in zone B. If this is confirmed it would support the strategy for specific adaptation even within an area previously considered as homogenous.

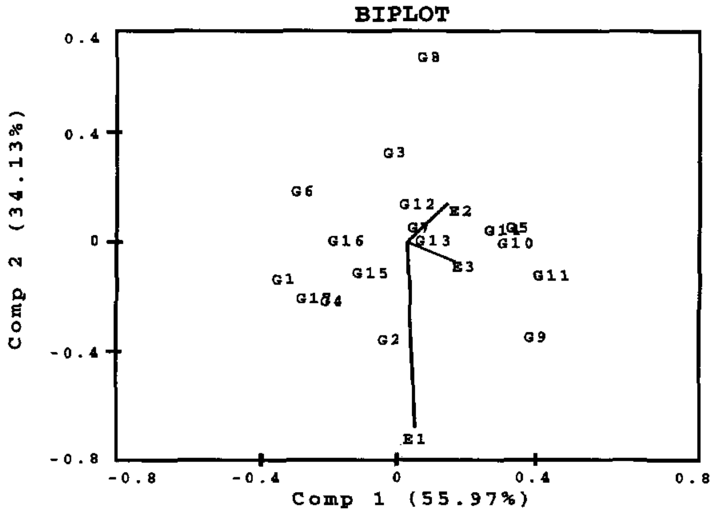


Figure 2.15. Biplot of grain yield of 17 barley lines grown in three environments in Syria: genotypes (=entry) and environments (=locations) are given in (Table 2.67)

Table 2.67. Grain yield (kg/ha) of lines in the on-farm verification trials in zone C in Syria

Entry	Names	Khabab	Breda	Batraneh
1	PI 386540/Arabi Abiad//SLB 60-97	792	1208	952
2	Furat A-5473	863	1226	1272
3	Moroc 9-75//H.Spont.41-1/Tadmor	607	1311	1206
4	A.Abiad	819	1213	1094
5	Zanbaka//Hml-02/Lignee 131	754	1432	1359
6	Furat A-5474	659	1214	1032
7	Furat A-5475	735	1391	1152
8	SLB 34-65/Arar	487	1430	1160
9	Furat S-5715	915	1501	1307
10	Local 2	762	1396	1385
11	A.Aswad	802	1452	1397
12	Furat R-5177	687	1327	1209
13	ACSAD 1420	722	1276	1301
14	Moroc 9-75/Arabi Aswad	765	1443	1300
15	WI2291/Tadmor	794	1303	1063
16	ACSAD-1424	751	1307	1009
17	Furat R-5398	812	1177	1058
Mean		748	1330	1192
Max		915	1501	1397
Min		487	1177	952

2.6.1.2. Variability within Syrian Landraces

The objective of this study was to describe the structure of the genetic diversity within barley landraces from one section of the Fertile Crescent. This will make it possible to identify sources of useful genes or genes complexes, and to generate useful information both for breeding, collection, and *in situ* and *ex situ* conservation.

The genetic material is a sample of the barley collection made by Weltzien (1982) chosen from five geographic regions representing south Jordan, north Jordan-south Syria, west Syria, central Syria, and north-east Syria (Figure 2.16). These are the main barley growing areas of the two countries. Jordan is characterized by a short vegetation period, seasonal rainfall, mild temperatures during winter, and high temperatures at grain filling. The south of Syria has typically basalt-weathered soils with an average annual rainfall of 380 mm and mild temperatures during the winter month, except in the area around Site 39 situated on a high plateau (about 1000 m asl). In both north Jordan and south Syria, farmers grow only the white seeded landrace. Central Syria is home to some of the driest cultivated land in the country; the area receives an average annual rainfall of 150 mm, and the cultivation of barley is in the depressions in which soil and water are collected. Large areas are planted annually but a grain crop is obtained only 1-2 years in 5; when it is too dry for grain production the crop is grazed. The area is mostly planted with the black seeded landrace. West Syria has some of the most fertile soils in the country; barley cultivation is widespread and yield potential is high. The soils are deep and rainfall is higher than 300 mm. The northeast of Syria is at the end of the cereal belt of the country in an area characterized by a north-south decreasing rainfall gradient. This area is mostly planted with the black seeded barley.

In each of the five regions, we chose five collection sites, with the exception of Region 2 that was represented by only four collection sites. Each collection site was represented by 20 pure lines each derived from a single head of the original collection. In addition, we included ten modern varieties developed for favorable conditions, and ten lines developed for specific adaptation to the harsh environments of the Near East. The trial was planted for two consecutive seasons in Syria both at ICARDA's research stations located near Tel Hadya, (36o01' N; 37o20' E, elevation 300 m asl, 340 mm mean annual rainfall) and near Breda (35o56' N; 37o10' E, elevation 354 m asl, 240 mm mean annual ra:nfall). The data were analyzed according to a nested ANOVA for each year and location. Calculation of the best linear unbiased estimates (BLUEs) for the entries in each year and location was done according to the Residual Maximum Likelihood (REML) method.

Figure 2.16. Collection regions and sites

Large variation was detected between regions, as well as between sites within regions, and between lines within sites (not shown), for most of the recorded characters. The extent of variation within regions changed with the character and for the same character depended on the year and location. West Syria was the most diverse region in days to heading, while central Syria had the largest variation for plant height in both locations and years. West Syria was also the region with the largest variation for grain yield in Breda in

1998, while north Jordan-south Syria had the largest variation for grain yield in Breda in 1999 and in both years in Tel Hadya (Table 2.68). This indicates that the description of variation within and between landraces depends on the characters measured and on the evaluation site.

Table 2.68. Variance within regions for days to heading, plant height and grain yield

	Days to heading		Plant height in Breda		Plant height in T-Hadya		Grain yield in Breda		Grain yield in T. Hadya	
Region	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
South Jordan	0.03	0.00	0.00	1.13	0.13	1.07	1121	0	2039	8922
North Jordan-South Syria	1.49	4.34	0.00	0.00	1.66	0.00	3536	12069	28885	25608
West Syria	3.17	8.66	4.99	1.65	0.00	2.92	5923	1665	9374	24816
Central Syria	0.00	0.26	9.53	3.20	3.46	9.11	1473	0	16967	21013
North-East Syria	0.16	0.61	0.00	2.04	1.97	2.60	1366	0	5778	168

Lines which originated from north-east Syria were the most prostrate, the poorest in vigour in the early stages of growth, and the most cold tolerant, while lines collected in Jordan had an erect growth habit, were very vigorous in the early stages, and were the most cold susceptible.

Lines from Jordan and south Syria were on average 3-5 days earlier in heading than lines from west, central, and north-east Syria (Figure 2.17). Lines from northeast Syria were the tallest and the lowest yielding at Tel Hadya, while lines from west Syria were the shortest and the highest yielding at Tel Hadya. At Breda, lines originated from north Jordan-south Syria yielded more than lines from other regions.

The information on variability of landraces generated by this study will be used to construct mixtures with various degrees of heterogeneity, will provide a model of utilizing agricultural biodiversity that can be used in other crops and/or countries, and will also help in formulating collection and evaluation strategies.

The fact that the amount of variation depends on both testing site and year has to be taken into account in formulating *in situ* conservation strategies.

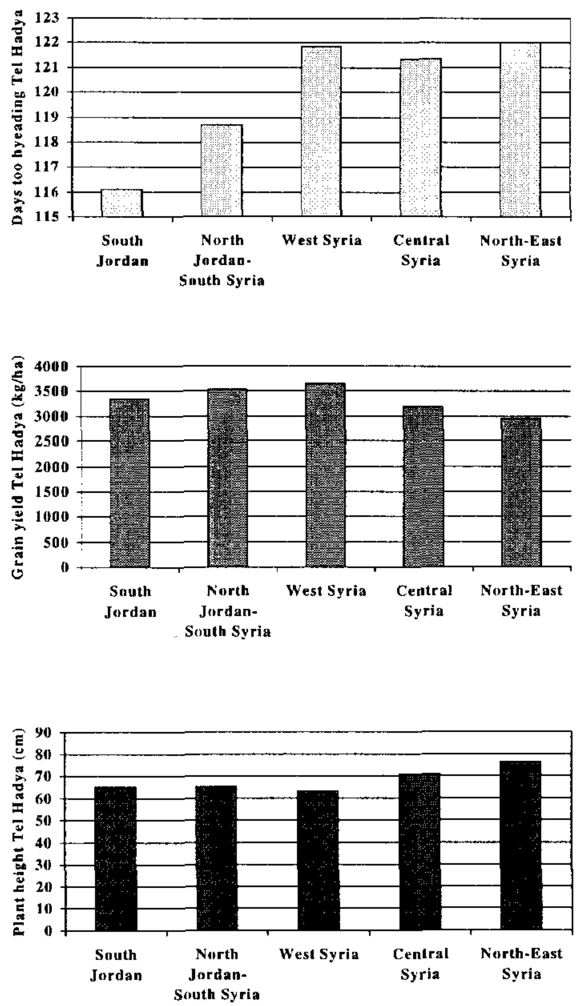


Figure 2.17. Variation between regions for days to heading, grain yield and plant height at Tel Hadya

2.6.2. Jordan

During 1999 we continued our collaboration with Jordan both through the University of Jordan (UOJ) in Amman and the National Center for Agricultural Research and Technology Transfer (NCARTT). In four locations (Khanasri, Ramtha, Rabba and Ghweer), representing a wide range of environmental conditions and of soil types, we tested a new adaptation nursery with 80 entries and two replications, and an adaptation trial with 20 lines and three replications.

The adaptation trial included fourteen lines selected from the adaptation nursery evaluated in 1998, three lines from the adaptation trial of 1998, and the variety Rum.
The four locations represent very distinct environments with Khanasri and Rabba being the two extremes. Rabba is included in these trials to provide an estimate of yield potential, even though it is not located in a typical barley growing area.

The adaptation nursery performed poorly in Khanasri and was not harvested. The grain yield was also very low in Ramtha (83 kg/ha) and between 600 and 1600 kg/ha in Ghweer and Rabba (Table 2.69). One line (entry 25 in Table 2.67) was the top yielding in both Ghweer and Ramtha and ranked fourth in the highest yielding location where it yielded 20% of the line with the highest yield potential. A second line (entry 13) performed among the best 10% in all three locations. Both lines derive from crosses between *H. spontaneum* and Tadmor, as a further indication of the value of the wild progenitor and the landraces in breeding for extreme stress conditions.

Table 2.69. Average grain yield of a special nursery for Jordan grown in three locations, and yield of two lines out yielding the checks in all three locations

Entry	Name	Ramtha	Ghweer	Rabba
25	Esp/1808-4L//Hml-02/3/H.spont.41-5/Tadmor	150	1500	2450
13	H.spont.41-1/Hml//H.spont.41-1/Tadmor	130	750	2300
89	Zanbaka	70	650	1800
28	Arta	60	350	1950
87	Sara	50	350	2200
Mean		83	617	1634
Max		150	1500	3050
Min		30	250	600

The results of the adaptation trial are summarized in (Table 2.70) and in (Figure 2.18). The average grain yield ranged from few kg/ha in Khanasri to about 1 t/ha in Rabba. The highest yielding entries were WI 2291/Tadmor in Ghweer (66% more than Rum), SLB 22-82//SLB 39-60/H.spont.41-1 in Khanasri (30% more than Rum), SLB 23-52/H.spont.41-3 in Rabba (59% more than Rum) and Zanbaka/H.spont.38-1//SLB 05-96 in Ramtha (more than twice the yield of Rum). As observed in the adaptation nursery, the best material is a combination of either *H. spontaneum* germplasm or landraces or both.

There were large genotype x environment interactions (Figure 2.18) that made it impossible to identify lines well adapted to more than one location. After removing the effect of the location by using standardized data, WI 2291/Tadmor (entry #1) was still the highest yielding line in Ghweer (E1), Zanbaka/H.spont.38-1//SLB 05-96 (entry #11) and PI 386540/Arabi Abiad//SLB 60-97 (entry #16) were the highest yielding in Ramtha, Harmal//Kv/Mazurka/3/Arabi Aswad/WI2269 (entry #2) was the highest yielding in Rabba, and SLB 22-82//SLB 39-60/H.spont.41-1 (entry #6), SLB 18-76//SLB 39-60/H.spont.41-1 (entry #10) and SLB 34-65/Arar (entry #17) were the highest yielding in Khanasri.

Table 2.70. Average grain yield of the adaptation trial evaluated in four locations in Jordan.

Entry	Name	Ghweer	Khanasri	Rabba	Ramtha
1	WI 2291/Tadmor	1383	22	501	70
2	Harmal//Kv/Mazurka/3/Arabi Aswad/WI2269	546	16	1411	47
3	Avt/Attiki//Aths	580	19	645	30
4	Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/5/Satter 2/Numar	780	6	956	43
5	SLB 22-82/H.spont.41-1	896	46	942	47
6	SLB 22-82//SLB 39-60/H.spont.41-1	846	55	1015	20
7	SLB 23-52/H.spont.41-3	813	42	1413	50
8	SLB 23-52//H.spont.41-4/SLB 39-60	1063	28	1013	70
9	SLB 18-76/H.spont.38-3	730	33	967	57
10	SLB 18-76//SLB 39-60/H.spont.41-1	746	48	1351	53
11	Zanbaka/H.spont.38-1//SLB 05-96	746	15	951	113
12	H.spont.41-1/Tadmor//SLB 39-60/H.spont.41-1	680	33	951	80
13	Arta	746	26	815	27
14	Zanbaka	813	2	1214	30
15	Sara	930	15	899	43
16	PI 386540/Arabi Abiad//SLB 60-97	646	13	995	107
17	SLB 34-65/Arar	563	50	1106	53
18	Rum	830	42	889	40
	Mean	797	28	1002	54

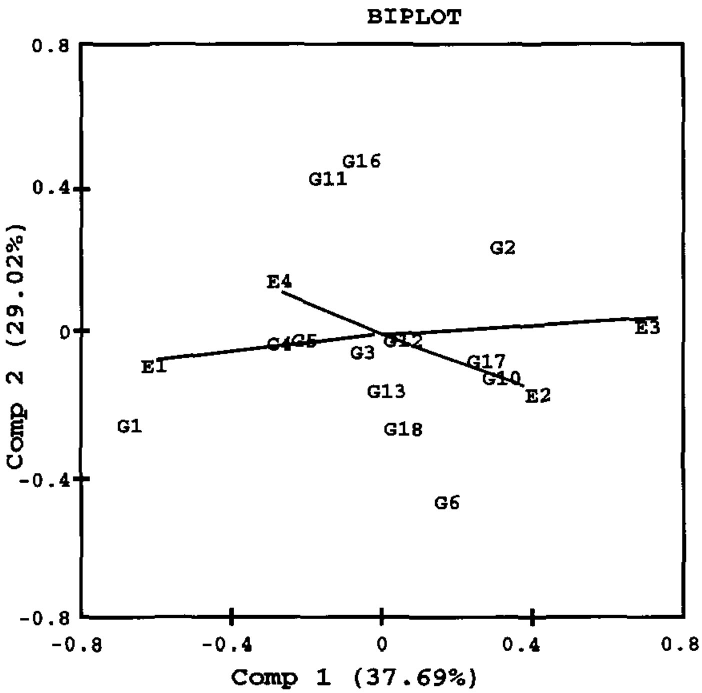


Figure 2.18. Biplot of grain yield of 18 barley lines grown in four environments in Jordan (E1=Ghweer, E2=Khanasser, E3=Rabba, and E4=Ramtha)

2.6.3. Lebanon

The interaction with Lebanon covers activities conducted in the ICARDA research stations at Terbol and Kfardane (reported in the relevant sections, interaction with the national program through the activities of the Mashreq and Maghreb project (reported in the reports of that project), and a special decentralized breeding program aiming at developing varieties specifically adapted to Lebanon. This activity includes the distribution of three nurseries. The first includes F2 bulks which are planted in Terbol and Kfardane for selection of germplasm specifically adapted to wet and dry environments in Lebanon, the second includes the selected F2 bulks from the year before, and the third is a yield trial made up of the bulks selected from the nursery the year before.

In 1999 the first nursery included 994 F2 bulks and 17 checks and the second included 112 F3 bulks and 7 checks, while the yield trial will be distributed for the first time in 2000. Both nurseries were unreplicated with systematic checks and were tested in Terbol and Kfardan.

In the first nursery the best checks were Rihane-03 in Terbol and Alanda-01 in Kfardane. In Terbol, 476 entries yielded as much as Rihane-03 or more, and the maximum yield advantage over Rihane-03 was 75%. Table 2.71 shows only the ten highest yielding entries in Terbol: they were all 6-row bulks, resistant to lodging and with high yield potential.

In Kfardane, only 28 entries yielded as much as Alanda-01 or more, with yield advantages ranging from 2 to 30%. (Table 2.71) shows only the ten highest yielding entries: these are all different from the ten highest yielding entries in Terbol, and all yielded less than Alanda-01 in Kfardane. This shows that even in a relatively small country like Lebanon there is scope in pursuing specific adaptation and that this can be easily achieved through a decentralized breeding system.

In the special nursery for Lebanon, only five entries out yielded the recently released Mari/Aths*2 in Kfardane an only with modest yield increases (up to 8%) (Table 2.72). In Terbol, 23 entries out yielded Rihane-03 and with yield advantages up to 45%. As observed in the previous nursery, the top yielding entries in the two locations were all different. Two of the top yielding entries in Kfardane, yielded similarly to Rihane-03 in Terbol, while all the highest yielding entries in Terbol yielded less than Mari/Aths*2 in Kfardane.

2.6.4. Turkey

Barley is a very important crop in Turkey with an acreage of 4 million ha, a production of 8.8 million tons and an average yield of 2200 kg/ha. The area under the responsibility of the Central Research Institute for Field Crops (CRIFC) produces approximately 45% of the total barley production of Turkey. Cold winters and relatively low rainfall (300-450 mm) are the main characteristics of the region. Climatic variations in the area are large and fluctuations in crop yield occur frequently, and due to a number of constraints, crop reductions or failures are frequent. The most important abiotic stresses in the Central Anatolian Plateau include cold, terminal drought and heat stresses at grain filling. Diseases are also important in this zone, and scald and barley stripe are the major biotic factors affecting barley yield.

CRIFC's Barley Breeding Program collaborates with the barley project at ICARDA to develop better performing varieties for the provinces of Sivas and Kayseri, where yields are still very low.

During last season, 9 different nurseries and yield trials were evaluated at Haymana station for a totalof 4259 lines and a total of 51 lines were selected. The characteristics and the yield level of the most promising lines selected from the nurseries are given in (Table 2.73).

The low frequency of selection is associated with the addition of malting quality as a new objective in the barley breeding program in Turkey: all 51 lines selected have sound malting characteristics with considerable yield level.
The cropping season in 1999 was very unusual due to a severe and very long drought period in April and May (Table 2.74).

2.6.5. Iraq

Similarly to Syria, a severe drought caused extensive crop failures across the rainfed areas of Iraq. The special nurseries composed of two row black-seeded types were planted at four locations, but only in two, Rabbia and Telafer, it was possible to collect data (Table 2.75).

Most of the lines performing relatively well have *H. spontaneum* in their pedigree, and are similar to those performing well in the areas of Syria. These data confirm that the two regions can be safely considered as one target environment.

Table 2.71. Grain yield of the highest yielding F2 bulks in Terbol (TR) and Kfardane (KF)

Entry	Name	Grain yield (g/plot) TR	KF
	Best entries in Terbol		
4548	QB813.2/7/Lignee 527/NK1272/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/Copal 'S'	1050	300
4466	80-5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/6/CI 08887/CI 05761//Lignee 640/7/RWA.M47	1040	400
4579	Hyb 85-6//As46/Aths*2/4/Quinn/Rhn//Quinn/Lignee 640/3/Comp.Cr.229//Mzq/DL71	1010	480
4863	QB813.2/3/Lignee 527/Chn-01//Alanda/6/Alanda-01/4/WI2291/3/Api/CM67//L2966-69/5/Rhn-08/3/Deir Alla 106//DL71/Strain 205	1000	460
4590	Aw Black/Aths//Rhn-08/3/Alanda-01	1000	440
4680	Alanda/Hamra/4/Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala	970	500
4564	ACSAD 176/4/Quinn/Rhn//Quinn/Lignee 640/3/Comp.Cr.229//Mzq/DL71	970	510
4858	Lignee 527/Chn-01//Alanda/5/Arizona 5908/Aths//Avt/Attiki/3/S.T.Barley/4/Aths/Lignee 686/7/Alanda-01/5/CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/6/Aw Black/Aths//Rhn-08	960	430
4686	Alanda/Hamra//Alanda-01	950	250
4787	Apm/RL/4/Api/EB489-8-2-15-4//Por/U.Sask.1766/3/Cel/CI 03909-2/5/Atem/Egmont//Kob/3/Lignee 640/6/Arar//Hr/Nopal/7/Aths/Lignee 686/3/CI 16155//Lignee 640/Lignee 527	950	460
	Best Entries in Kfardane		
3765	SLB 05-96/3/Hml-02/Line 251-11-2//H.spont.38-2	840	700
4501	Comp.Cr.229//As46/Pro/3/Srs/4/RWA.M46	600	680
4512	Lignee 527/NK1272/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/Copal 'S'/7/Aths/Lignee 686	880	630
4719	Hamra//Lignee 527/Rhn/3/Mr25-84/Attiki//Alanda-01	380	620
3987	Emir/Sbt//CM67/3/F8-HB-854-23/121//148-221/4/CI 08887/CI 05761/5/ER/Apm/3/Arr/Esp//Alger/Ceres 362-1-1/6/Sara/7/H.spont.41-5/Tadmor//Moroc 9-75/6/Emir/Sbt//CM67/3/F8-HB-854-23/121//148-221/4/CI 08887/CI 05761/5/ER/Apm/3/Arr/Esp//Alger/Ce-	845	610
4178	Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/Alanda/5/CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/7/Aw Black/Aths//Arar/3/9Cr.279-07/Roho/4/Aths/8/Rhn-03//Lignee 527/NK1272/3/Lignee 527/Chn-01//Alanda	920	610
4905	Alanda/Zafraa//Aths/Lignee 686/4/Alanda/CI 16155//Alanda-01/Hamra/3/Aw Black/Aths//Rhn-08	630	600
4773	Acc # 116134-Coll # 89032-18/BF891M-617/4/Lignee 527/NK1272//Alanda/3/Mtn-01	760	600
4829	Arizona 5908/Aths//Lignee 640/3/Lignee 527/Arar/4/Manal/5/Manal/3/Lignee 527/NK1272//JLB 70-63	800	600
4645	Ager//Api/CM67/3/Cel/WI2269//Ore/4/Alanda/5/Comp.Cr.229//As46/Pro/3/Srs	680	600
4000	Rihane-03	600	400
4050	Alanda-01	580	540

Table 2.72. Row type (rt), grain yield (gy), days to heading (dh) and plant height in Terbol (TR) and Kfardane (KF) of the highest yielding F3 bulks in a special nursery for Lebanon

		Highest yielding entries in Kfardane						
Entries	Name	rt	gykf	gytr	dhtr	dhkf	phtr	phkf
91	Bco.Mr/Avt//Cel/3/Line 257-14/4/Rihane'S'-5/5/Harmal/4/Lth/3/Nopal//Pro/11012-2	6	462	789	116	110	103	74
65	Arar//Hr/Nopal/3/Alanda-01/Alanda-01	6	459	610	115	109	108	71
62	Rhn-03/3/Roho//Alger/Ceres 362-1-1/4/Rhn-03	6	439	790	121	114	108	71
24	Lignee 527/Chn-01//Alanda/3/Atahualpa	6	434	665	113	107	108	72
29	Alanda-01/4/WI2291/3/Api/CM67//L2966-69/5/Rhn-08/3/Deir Alla 106//DL71/Strain 205	6	429	665	116	111	110	69
		Highest yielding entries in Terbol						
109	Shyri-3/3/Arar//2762/Bc-2L-2Y	6	247	1104	114	108	115	71
101	Rihane-03/3/Bc/Rihane//Ky63-1294/4/Orge 905/Cr.289-53-2	6	352	974	110	105	102	82
61	Barbara/5/Api/CM67//Mona/3/DI//Asse/CM 65-1W-B/4/Asl-02/6/H.spont.20-4/Arar 28//WI2291/Bgs	6	354	955	142	99	145	69
59	M126/CM67//As/Pro/3/Alanda/4/Rhn-03	6	319	890	155	109	157	76
87	Bda/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/6/Baca'S'/3/AC253//CI 08887/CI 05761	6	362	889	111	107	110	72
57	Hml-02/Arabi Abiad*2/4/Sfa-02/3/RM1508/Por//WI2269/5/H.spont.20-4/Arar 28//WI2291/Bgs	2	364	875	106	102	117	81
106	Lignee 527/NK1272/3/Arizona 5908/Aths//Lignee 640	6	407	849	114	108	118	71
99	Rihane-03/3/Bc/Rihane//Ky63-1294/4/Rihane/Lignee 527	6	302	849	114	108	108	71
67	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee 686/4/Rhn-03	6	414	830	112	106	118	67
103	N-Acc4000-301-80/IFB974/3/Quinn/Bc//Aths/Antares	6	232	829	109	104	112	74
100	Rihane-03	6	237	764	117	113	113	71
119	Mari/Aths*2	6	427	604	113	109	112	69
60	Litani	2	149	304	-	111	-	71

Table 2.73. Grain Yied (GY in g/6m^2), sieve analysis (SA % >2.5 mm) and kernel distribution KD) of the most promising lines selected in 1998-99 at Haymana

Entry Name	MBRYT and FBRYT 1998-1999	GY	source SA	KD
Belt67-1608/Si/3/Dicktoo/Cascade/Hip/4/Icb-101326	WPBYT	4642	94	2
Roho//Aler/Ceres 362-1-1/3/Alpha/Durra	IBCB	3813	92	1
Antares/63-1294//Marageh	IBCB	3744	92	2
Friberga/Astrix	BIOOIN	4007	96	1.5
Alpha/Durra//Kenate/3/Alpha/Durra	BIOOIN	3932	93	1.5
Viringa's2/Zdm8307	BIOOIN	4631	92	2
Wieselburger/Ahor 1303-61//Ste/Antares	IBCB	3663	95	1.5
Alpha/Durra//Antares/Ky63-1294	IBCB	3762	91	2
Alpha/Durra//Sonate	WPBYT	3021	95	1.5
Sonja/Mst//P12222/3/Scio/4/Tokak	BIOOIN	2902	95	1.5
Antares/Ky63-1294//Viringa's'	BIOOIN	2858	96	1
Sc 860974/Zdm8265//Cwb117-5-9-5	BIOOIN	3277	95	1.5
Ste/Antares//Viringa's'	BIOOIN	4105	95	1.5
Belt67-1608/Sir/3/Dicktoo/Cascade//Hip/4/Antares/Ky63-1294	BIOOIN		98	1
S99//Kenya Research/Belle	BIOOIN	3447	95	1.5
80-5001/Md45-59-32	BIOOIN	3814	90	2
Scio/Slb 47-81//Radical	BIOOIN	3000	96	1.5
S99//Antares/Ky63-1294	BIOOIN	3424	95	1.5
Viringa's'/3/Scotia 1/Wa1356-70//1245-68/Boyer	BIOOIN	4417	93	2
Sadyk-3	IBCB	3462	94	1.5
K-273/Ks87c37	BIOOIN	4625	97	1.5
Clayton/Lignee 131	BIOOIN	3400	93	2
Alpha/Durra//Antares/Ky-63-1294	IBCB	3762	91	2
Yea389.3/Yea475.4	IBCB	4072	93	2
Sc 860974/Zdm8265//Cwb117-5-9-5	BIOOIN	3277	95	1.5
Viringa'S'/3/Scotia1/Wa1356-70//1245-68/Boyer	BIOOIN	4417	93	2
Antares/Ky63-1294//Viringa'S'	BIOOIN	2858	96	1.5
Scio/Slb 47-81//Radical	BIOOIN	3000	96	1.5
Belt67-1608/Slr/3/Dicktoo/Cascade//Hip/4/Antares/Ky63-1234	BIOOIN		98	1
Ste/Antares/Viringa'S'	BIOOIN	4105	96	1.5

Table 2.74. Climatic data at Haymana

Months	Rainfall (mm)		Temperature	
	Long term	1998-99	Long term	1998-99
September	29.5	16.1	11.2	16.0
October	37.2	9.2	4.5	11.2
November	40.1	27.0	0.1	6.2
December	38.9	26.4	-2.2	2.0
January	24.7	31.2	-0.5	1.1
February	31.6	40.2	3.4	1.2
March	39.5	68.5	8.7	4.7
April	45.0	10.0	12.9	9.9
May	25.5	9.4	17.6	16.1
June	10.9	22.1	20.9	19.4
Total	322.9	260.1		

Table 2.75. Biomass (BY in kg/ha), grain yield (kg/ha) and harvest index (HI) at Rabbia of the lines visually selected in two locations with less than 125 mm rainfall

Entry	Name	BY	GY	HI
51	Moroc 9-75//H.spont.41-5/Tadmor	350	76.1	0.22
12	Moroc 9-75/Arabi Aswad//Iraqi Black	320	45.1	0.14
44	Moroc 9-75//H.spont.41-5/Tadmor	310	77	0.25
6	Moroc 9-75/Arabi Aswad//H.spont.41-3	300	63.4	0.21
95	Zanbaka//PI 386540/Arabi Abiad	300	26.5	0.09
26	H.spont.41-1/Hml//H.spont.41-1/Tadmor	300	34.9	0.12
11	Sls/Arabi Aswad//Iraqi Black	300	35.8	0.12
16	Zanbaka/H.spont.41-4/4/ER/Apm// Lignee 131/3/Lignee 131/Arabi Abiad	280	23.2	0.08
62	Zanbaka/H.spont.41-2	260	16.6	0.06
20	Zanbaka	260	29.9	0.12
2	Iraq (local check)	200	11.2	0.06

2.6.6. Iran

The Iranian barley improvement program has close contacts with ICARDA in terms of germplasm exchange. In 1998/99 seven ICARDA winter barley nurseries have been tested and many promising lines have been selected (Table 2.76).

Table 2.76. Total (T) and selected (S) number of entries from different winter barley nurseries at various stations in Iran, 1998-99

	Station											
	Maragegh		Sararood		Qhamloo		Shirvan		Uromieh		Zanjan	
Nursery	T	S	T	S	T	S	T	S	T	S	T	S
SegPop National			73	70							132	84
Seg Pop F2-F6	1117	427	794	39	358	115	369	369			150	31
IWPBYT-CH-CW	980	58										
A	120	15	40	13	20	2	96	18			24	3
B	72	24	40	9	33	7	65	16	40	26	40	9
URBYT	24	8	24	11	24	4	24	2	24	3	24	5
IWBON-CH-CW99	150	28			150	6	150	7	150	10	150	18
IEBON-CH-CW	50	9	50	23	50	13	50	8	50	5	50	28
IWBCB-CH-CW99	136	124	136	40	136	30					136	39
IWBYT-CH-CW99	24	2	24	15	24	16	24	11			24	17
IWBI00IN-CH-CW	1750	96										
EWBYT	268	51	126	27	50	17	90	13			121	20
IWFHON98 (Hulless)			35	12								

In Maragheh the crop was affected by prolonged drought, heat (temperature in May-June above 30°C) and cold (-13°C in January without snow cover). On the station, total rainfall was 197 mm compared with 351mm in the last season. This resulted in a decrease of plant height, biomass yield, grain size and quality, and grain yield. Because of good soil management, yields at the station were considerably higher than on the farmers' fields. In the uniform regional yield trial (URBYT) 16 lines (out of 24) out yielded the check variety Sahand by 5-36%. The most productive lines and varieties include Yesevi-93 (2.9 t/ha, 136% of the check), YEA847-8A-2A-OAP3433 Gb/Tok (131% of the check), and YEA 762.2/YEA 605.5 (128% of the check). The last line has a good grain size. The data received at DARI Institute are consistent with the results of yield trials at Shirvan and Ardabil experimental stations. Therefore, these lines are considered as candidates for on-farm verification trials. In the advanced yield testing, only some lines performed similarly to the check Sahand and a few better than the best check. The line Cum-50/1146 had a stable yield increase (8-10%) during the last two years. The two-row line Roho/Mazurka//ICB-103020 was the top yielding in the BYTA2 with a 17% yield advantage over the check Sahand. In this extremely harsh season a very interesting material has been identified in different nurseries, including cold tolerant lines as Cyn/DT (108% of the check), Kozir (105% of the check) and K-88M1 (126% of the check), lines with good growth vigor such as Kuban-1 (102% of the check), early lines such as YEA26.5/13006//YEA 17.27/3/CWB 117-7-77-9-7 (110% of the check), lines with high yield potential in favourable conditions such as Omega (116% of the check), Sadik-2 (109% of the check) and the awnless variety Rapidan (3.4 t/ha, 136% of the check).

In Sararood (318 mm rainfall) yields levels were higher than in Maragheh, but lower than normal. The low yields were caused by drought at germination and during most of May and throughout June, combined with high temperatures at grain filling, and a 3-day frost just prior to heading. Barley breeders at Karmanshah have developed new promising lines, which were or will be submitted either for on-farm verification trials or for introduction into cultivation. One of this is the recently released variety Sararood-1 (the ICARDA line Chim/An57//Albert). During 8 years testing the average yield has been 3.1 t/ha with a 16% increase over the checks. The variety is becoming very popular among farmers and its seed multiplication is underway. In the advanced yield trials the new promising lines that have been identified on the basis of stable agronomic performance during 2-5 years testing are: Xemus (3.7 t/ha for 5 years, 129% of the check), CWB 117-77-9-7/ICB 194973 (4.3 t/ha for 2 years, 127% of the check), CWB 117-77-9-7/ICB 194973 Ieh (4.3 t/ha for 2 years, 127% of the check). All promising lines were not seriously affected by powdery mildew, net blotch, and leaf rust, their stress tolerance was higher than the check varieties Walfajer and Sahand, and have the same maturity as the checks. Yield potential is significantly higher particularly in the more favourable conditions.

At Qamloo germination was poor because of early drought, with the first rain occurring in mid-November, after the onset of cold. Winter was colder than last year, with an absolute minimum of -18°C and a total of 124 days with below freezing temperature. The crops also suffered from a late frost (-1°C) just prior to heading, coupled with prolonged severe drought from April to June, which required a 20mm irrigation to save the breeding material. Two lines were identified in the advanced trials, which are considerably better than the check Sahand: Wieselborger/Ahor1303-61//Steptoe/Antares (1.3 t/ha, 137% of the check), and ICB-100059 (1.2 t/ha, 125% of the check). Due to severe winters and very dry summer, diseases did not play a significant role. The first line has good cold tolerance, and it withstood -18°C without snow cover. This two-rowed line matures 4 days earlier than the check Sahand and has good grain size. 95 lines have been selected for evaluation in 2000.

At Hayderloo (Oroumieh) the season was extremely dry, with the lowest rainfall (170 mm) in 30 years. Drought was particularly acute in the beginning of the season (8.2 mm during the months of October and November, followed by 19.6 mm in December) and at heading and grain filling. High temperatures accompanied terminal drought in May (>30°C) and June (>32°C). This resulted in very low yield, ranging from 0.6 to 1.4 t/ha. In the URBYT only 4 lines showed the same yield level as the check variety Sahand. In the advanced trials six lines out yielded the check Sahand: YEA1819/YEA195.4//Grivita (1.4 t/ha, 140% of the check), Roho//Alger/Ceres, 362-1-1/3/Maragheh (1.4 t/ha, 139% of the check), ICB 105981/Pitayo (1.3 t/ha, or 131% of the check), and Wieselborger/Ahor1303-61//Steptoe/Antares (1.2 t/ha, 121% of the check). The last line was the top yielding in the advanced trials at Qhamloo station in Kurdistan. In BYTB2 three lines are worth mentioning, namely CWB 117-77-9-7/ICB 102893 (1.4 t/ha, 129% of the check), the source of salt tolerance Caraarpa (1.3 t/ha, 120% of the check), and Zarjaw//Rihane-03/Salmas (1.2 t/ha, 114% of the check). The last line produced the tallest plants (72 cm) and had the largest grain size (41.2 g). Out of 200 entries from the Observation Nursery, 18 lines with the highest levels of drought and cold tolerance have been selected, including

Sadik-1, Sadik-2, Sadik-4 and K-273/Morex, which performed better than the checks Tokak and Bulbul.

At Qaidar (Zanjan) rainfall was low (222 mm) with long dry periods early in the season and in June. Germination was poor or delayed to the spring in certain cases. Despite the relatively mild winter yields were very low. Some farmers harvested no seed at all. With the exception of the International Preliminary Winter Barley Yield Trials (IPWBYT), all the other winter barley nurseries have been tested on station. In the URBYT five lines yielded similarly or slightly higher than the check Sahand: ICB 111838 (1.1 t/ha, 107% of the check), CWB 117-5-9-5 (1.1 t/ha, 103% of the check) and Roho/Mazurka//ICB 103020 (1.1 t/ha, 102% of the check). These lines have a good yield potential and in more favourable environments they perform much better than the checks. Three lines from IWBYT-CH-CW99 out yielded the check variety Sahand: Productive/3/Roho//Alger/Ceres (1.6 t/ha, 160% of the check), another sister line from the same cross Productive/3/Roho//Alger/Ceres (1.4 t/ha, 143% of the check), and ICB 66/3/YEA 560.2//Luther (1.3 t/ha, 136% of the check). In the nursery IWBCB-CH-CW99 a line from the cross Productive/3/Roho//Alger/Ceres yielded 2.0 t/ha, or 200% of the check. In this nursery two awnless varieties, Wysor and VA 92-42-62, performed very well (170 and 180% increase over the check, respectively). The new nursery IWEBON-CH-CW99, including early lines with good growth vigor proved to be well adapted to the region. More than a half of the entries have been selected. Among the best there were Tipper//Alpha/Durra (2.3 t/ha, 213% of the check, record of the year) and Lignee 131/Arabi Abiad/3/ Roho//Alger/Ceres (1.7 t/ha, 157% of the check). This shows the need to target more and more specifically the germplasm for testing in specific environments.

At Shirvan rainfall was 220 mm with moisture deficits at the beginning and towards the end of the season. In the advanced trials 161 lines were tested and 34 were selected for further evaluation. In BYTA4 the best line (YEA168-4/YEA605-5//Lignee 131/Arabi Abiad) showed a significant yield increase (2.1 t/ha, 125% of the check). Another line, 3896/1-3/4/1246/1-3/3/3887/28/3892/1-3/5/Grivita, yielded 1.7 t/ha, or 100% of the check and is highly resistant to Russian Wheat Aphid in laboratory and in the field. Agronomically, the new source of resistance is very attractive and can be used in the areas where this insect causes serious yield losses. In BYTB1 seven lines performed better than check. The most interesting was Wieselborger/Ahor1303-61//Steptoe/Antares (1.7 t/ha, 128% of the check), which performed well also in Qhamloo, and Zanjan stations. Promising material has been identified in the crossing block, and in the observation nurseries, especially in IWEBON-CH-CW99, including lines that performed well in other testing sites such as Sadik-1, Sadik-2, YEA26-5/1306//YEA17-27/3/Roho//Alger/Ceres and Lignee131/Arabi Abiad//Alpha/Durra

At Ardabil the season was dry (about 187.6 mm). In URYT only two lines yielded better than the check Sahand, namely Yesevi-93 (1.5 t/ha, 127% of the check), and CWB 117-77-9-7/ICB 104073 (1.3 t/ha, 110% of the check). The last one has also performed very well in Sararood station. New lines have been selected from the observation nurseries, including Lignee131/Arabi Abiad//Alpha/Durra (2.3 t/ha), Sadik-1 (2.8 t/ha), Slr/Tipper (2.3 t/ha), K-273/Ste (2.1 t/ha), Radical/Zarjau (2.0 t/ha). All of them have increased cold tolerance in combination with resistance to other stresses. For comparison, the cold susceptible variety Rihane-03 produced only 0.7 t/ha, or 39% of the check.

The advanced line Chim/An 57//Albert confirmed its superior performance in this dry season, with an 8-year yield average of 3.1 t/ha (116% of the check). It was released under the name of Sararood 1.

Among the best advanced lines that have been tested over 2 or more years, the following showed consistently high yield: Xemus (3.7 t/ha , 129% of Sahand, with a grain size of 35.6g and resistant to diseases) and CWB-117-77-9-7/ICB 104073 (4.3 t/ha, 127% of Sahand, with a grain size of 36g and resistant to diseases) in the Kermanshah region; Yesevi-93 (2.6 t/ha, of 116% Sahand, with a grain size of 36g and tolerant to diseases) in the Maragheh region. This line also showed relatively good yield in Shirvan, Ardebil, and Ghamloo during 1999. At Ghamloo, the line Wieselborger/Ahor1303-61//Steptoe/Antares showed an excellent yield during this season (1.3 t/ha, 137% of Sahand, with a grain size of 32g, and cold tolerant).

2.6.7. Pakistan

In Pakistan we have not been able to start a program of decentralized breeding, and therefore the germplasm exchange follows the traditional system of the supply of international nurseries, consisting of unreplicated observation nurseries, where each entry is planted as two rows, and of replicated (three replications) yield trials where each entry is planted in plots usually of 8 rows at 20 cm distance and 2.5 m long. In 1999 two observation nurseries, for low rainfall and cold temperatures (BOLC) and for moderate rainfall (BOM) were evaluated in one and four locations, respectively, and the two corresponding yield trials (BYLC and BYM, were evaluated at one and two locations respectively.

In the BOLC grown at Sariab 55 entries out yielded the national check and of these 22 were also visually selected. The ten highest yielding are shown in (Table 2.77) together with the mean of the three checks (each repeated four times in the nursery).

It is interesting to note that most of the entries are two rows, and similar to those performing well in the dry areas of Syria and Iraq.

Table 2.77. Row type (RT), days to heading (DH), plant height (PH) and grain yield (GY in kg/ha) of the highest yielding entries in the barley observation nursery for low rainfall and cold temperatures (BOLC) tested in Sariab in Pakistan

Entry	Name	RT	DH	PH	GY
49	SLB 45-90/H.spont.41-2	2	105	40	1667
48	SLB 45-90/H.spont.41-2	2	107	57	1667
5	Roho//Alger/Ceres 362-1-1/3/Kantara/4/ Zanbaka/3/ER/Apm//Lignee 131	2	107	50	1667
43	Zanbaka/H.spont.41-5	2	104	74	1667
35	Zanbaka/H.spont.41-2	2	105	56	1667
33	Zanbaka/H.spont.41-2	2	104	56	1500
31	Moroc 9-75//H.spont.41-5/Tadmor	2	105	72	1500
27	Moroc 9-75//H.spont.41-5/Tadmor	2	107	47	1500
54	SLB 45-90/H.spont.41-2	2	107	52	1333
89	Ramage Composite 4/Rhn	6	107	66	1333
106	Harmal (mean)	2	105	50	1125
107	Matnan-01 (mean)	6	106	53	833
108	National check (mean)	0	105	42	917

The BOM was grown at Islamabad, Seri Nawrauf, Sariab and Faisalabad, but yield data were only available from Seri Nawrauf and Sakrand. The highest yielding entries (Table 2.78) had large yield increases (47-66%) in Seri Nawrauf than in Sakrand (3-20%). Only one entry (entry # 2) out yielded the national check in both locations.

The BYLC were only grown at Sakrand where four lines out yielded the local check by between 8 and 23% (Table 2.79). In the BYM that was tested at Faisalabad and Sakrand the highest yielding entries (Table 2.80) out yielded the national check by between 8 and 29%. Two entries, Alanda//Lignee 527/Arar (entry #14) and Alanda-01 (entry #21) out yielded the national check in both locations.

Table 2.78. Grain yield (GYSN in kg/ha) at Seri Nawrauf, percent lodging (LDG), days to heading (DH) and grain yield (GYSAK in kg/ha) of the highest yielding entries in the barley observation nursery for moderate rainfall (BOM) tested in Seri Nawrauf (upper half) and Sakrand (lower half) in Pakistan

Entry	Name	GYSN	LDG	DH	GYSAK
	Seri Nawrauf				
44	Roho//Alger/Ceres 362-1-1/3/Kantara/4/WI2291	4067	0	97	3333
89	Jaidor/Asse//NK1272/3/Arig 8	3733	0	96	2667
57	Quinn/Lignee 640	3733	0	97	2000
39	Roho//Alger/Ceres 362-1-1/3/Kantara/4/Carina	3667	0	98	2333
2	Alanda-01//Gerbel/Hma/5/Chn-01/3/Arizona	3633	0	99	4000
66	Deir Alla 106//DL71/Strain 205/3/Lignee 527/NK1272	3600	0	101	2000
72	Lignee 527/Rhn//Cr.270-2-3	3600	60	101	3000
	SAKRAND				
26	WI2291/WI2269//WI2291/Bgs/3/Hml/WI2	2400	0	97	4667
88	Deir Alla 106//DL71/Strain 205/3/F4 Bulk//Sutter*2/Numar	2067	0	101	4333
24	Alanda/Hamra-01//Gloria'S'/Copal'S'	2267	0	97	4333
12	Ballan/6/Man/4/Bal.16/Pro//Apm/DwII -1Y/3/Api/CM67/5/N-Acc4000-123-80	2467	0	104	4333
11	Alanda/Hamra-01/3/Nacha 2//Lignee 640/Hma-01	2133	0	101	4000
71	Man/Huiz//M69-69/3/Apm/Rl//H272/4/CP/Bra/5/Joso'S '/6/F6-4-Kf	2333	0	96	4000
47	Roho//Alger/Ceres 362-1-1/3/Kantara/4/Bowman	3400	0	96	4000
91	U.Sask.1766/Api//Cel/3/Weeah/4/Arar	3400	0	96	4000
2	Alanda-01//Gerbel/Hma/5/Chn-01/3/Arizona	3633	0	99	4000
100	National check (mean)	2444	15	98	3889

Table 2.79. Grain yield (GY in kg/ha) of the highest yielding entries in the barley yield trial for low rainfall and cold temperatures (BYLC) tested in Sakrand in Pakistan

Entry	Name	GY
8	Clipper/Arabi Abiad//Tipper	533.3
7	Arta/WI2291	516.7
19	Mari/Aths*2//Arizona 5908/Aths/3/Alanda	516.7
17	Alanda//Lignee 527/Rhn	466.7
24	National Check	433.3

Table 2.80. Days to heading (DH), plant height (PH in cm) and grain yield (Gyfal in kg/ha) at Faisalabad and grain yield (GYsak in kg/ha) of the highest yielding entries in the barley yield trial for moderate rainfall (BYM) tested in Faisalabad and Sakrand in Pakistan

Entry	Name	DHfal	PHfal	GYfal	GYsak
14	Alanda//Lignee 527/Arar	97	109	817	633
5	ER/Apm//Lignee 131/3/Mo.B1337/WI2291	98	107	633	550
21	Alanda-01	97	112	767	550
19	Alanda-01/4/Arizona 5908/Aths/Asse 3/F208-74	100	113	633	533
6	ER/Apm	98	105	683	500
24	National Check	96	103	633	500

2.6.8 Afghanistan

Only recently we started testing breeding material in Afghanistan. In 1999 the three nurseries and yield trials described earlier were tested in three locations, namely Qala Azad, Urdokan and Kandahar. In the BOLC that was tested at Qala Azad no entries out yielded the national check. However, 7 lines were visually selected including six sister lines derived from the cross Tadmor/WI2291. In the BOM tested at Kandahar, yield were very high with five entries yielding more than 8 t/ha and more than fifty entries out yielding the national check. In (Table 2.81) we only show those entries that were the highest yielding and were also visually selected by the national scientists. These had yield advantages over the national check of between 40 and 58%, have a similar phenology, but, with few exceptions are taller than the national check. Also in the BOLW that was tested at Urdokan, several entries out yielded the national check: in (Table 2.82) we show those that were also visually selected. In this location, the best entries were usually earlier than the national check and had a yield advantage up to 45%. The type of germplasm that was successful in this location was very diverse and ranged from lines with Syrian landraces in their pedigrees, to lines that did not have any relationships with landraces.

There were few entries out yielding the national check in the international yield trials, and even in the case of the BYM tested at Kandahar the maximum yield advantage was 14% (Table 2.83).

Table 2.81. Row type (RT), days to heading (DH), plant height (PH in cm), grain yield (GY in kg/ha) and percent lodging (LDG) of the highest yielding entries in the barley observation nursery for moderate rainfall (BOM) tested at Kandahar in Afghanistan

BOM99	Name	RT	DH	PH	GY	LDG
27	Courlis//Alanda/Hamra-01	6	98	100	8704	0
93	Alanda-01	6	95	80	8440	0
94	Lignee 527/NK1272//JLB 70-63	6	98	85	8376	0
75	Lignee 527//Lignee 527/NK1272	6	96	100	8336	20
92	Lignee 527/Ssn//Bc/3/Arar	6	98	90	8080	0
91	U.Sask.1766/Api//Cel/3/Weeah/4/Ar	6	99	85	7864	0
82	Lignee 527//Lignee 527/NK1272	6	95	90	7856	25
76	Lignee 527//Lignee 527/NK1272	6	96	100	7856	15
48	Roho//Alger/Ceres 362-1-1/3/Kantara/4/Bowman	2	97	95	7736	0
72	Lignee 527/Rhn//Cr.270-2-3	6	95	90	7680	20
100	National check	6	96	83	5504	25

Table 2.82. Days to heading (DH) and grain yield (GY in kg/ha) of the highest yielding entries in the barley observation nursery for low rainfall and mild temperatures (BOLW) tested at Urdokan in Afghanistan

Entry	Name	DH	GY
34	Rhn-03/3/Deir Alla 106//7028/2759	114	2360
32	Tadmor/WI2291	111	2184
38	SLB 39-05/4/7028/2759/3/69-82//Ds/Apro	112	1944
92	Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq/4/Aths/Lignee 686/3/Arizona 5908/Aths//Mari/Aths*2	111	1944
93	Ballan/DD-14/Rhn-03	115	1856
95	U.Sask.1766/Api//Cel/3/Weeah/4/Giza 121/Pue/5 /Aths/Lignee 686/3/Arizona 5908/Aths//Mari/Aths*2	113	1824
42	Moroc 9-75/Arabi Aswad/4/Hml-02/Arabi Abiad/3/Api /CM67//Nacta	109	1808
31	Tadmor/WI2291	115	1776
96	Alanda-01/4/WI2291/3/Api/CM67//L2966-69/5/DD-14/Rhn-03	115	1768
73	As46/Aths*2/5/Cr.115/Por//Bc/3/Api/CM67/4/Giza 120/6/Aw Black/Aths//Arar/3/9Cr.279-07/Roho	112	1704
11	WI2291/4/7028/2759/3/69-82//Ds/Apro/5/Zanbaka/3/ER/Apm//Lignee 131	112	1680
94	Giza 121/CI 06248/4/Apm/IB65//11012-2/3/Api/CM67//Ds /Apro/5/M5/Galt//As46/6/Arar/19-3//WI2291	110	1632
102	National check	117	1630

Table 2.83. Days to heading (DH), plant height (PH in cm) and grain yield (GY in kg/ha) of the highest yielding entries in the barley yield trial for moderate rainfall (BYM) tested in Kandahar in Afghanistan

Entry	Name	DH	PH	GY
16	Chn-01/3/Arizona 5908/Aths//Bgs/4/Lignee640/Hma-01	94	90	1832
22	Alanda-01	95	85	1831
14	Alanda//Lignee 527/Arar	94	90	1821
11	Rhn-03//Lignee 527/NK1272	94	102	1784
19	Alanda-01/4/Arizona 5908/Aths//Asse/3/F208-74	96	93	1747
17	Baca'S'/3/AC253//CI 08887/CI 05761/4/JLB70-01	94	97	1717
9	Deir Alla 106//Mzq/DL71/3/F4 Bulk//Sutter*2 Numar	98	100	1710
23	Alanda-01/Hamra	95	87	1699
1	Assala-04	95	95	1691
10	Lignee 527/NK1272/5/Deir Alla 106//DL70/Pitayo/3/RM1508/4/Arizona 5908/Aths//Avt/Attiki/3/Ager	94	88	1632
8	Rhn-03/3/Lignee 527/Chn-01//Lignee 640/Bda	95	82	1630
7	Lignee 527/Chn-01/6/80-5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120	91	85	1618
18	WI2291	95	102	1613
24	National Check	94	90	1612

2.7. North Africa

Barley is the second most important cereal crop in North Africa; the total barley area in the North African countries (Algeria, Egypt, Libya, Morocco and Tunisia) is close to 5 million hectares. In North Africa, barley is the most important crop for small, low-income subsistence farmers in the more marginal environments and in dry areas. The overall objective of our work in North Africa is to improve barley productivity under small farmers' conditions by exploiting specific adaptation and by making use of indigenous knowledge in selecting in low yielding environments.

The two main activities in 1999 were:(1)Decentralized barley breeding that involves all the five North African countries (Egypt, Libya, Tunisia, Algeria and Morocco), and (2) Farmer participation that involves Tunisia and Morocco and is co-financed by IDRC. The farmer participation work has been reported in section 2.5.3, and therefore in this section we will report only the activities of the Decentralized Barley Breeding Program. During 1998-99 three types of nurseries were distributed to the five countries:

1. Segregating populations for North Africa

These contains F3 bulks and is divided in two nurseries:

SEGEL99, containing mostly early maturity germplasm, planted in Libya, Egypt and in one location in southern Morocco, and SEGMAG99 planted in Algeria, Tunisia, and Morocco (Table 2.84).

2. Special nurseries for North Africa

For the first time these have been divided in two groups: NUREL99, containing mostly the early germplasm selected in 1998 from the SEGEL, planted in Libya and Egypt, and NURMAG99, containing the entries selected in 1998 from the NUREL, planted in Algeria, Tunisia, and Morocco (Table 2.84).

3. Yield trials for Libya, Egypt, Morocco, and Tunisia (Table 2.85)

These trials include the entries selected from the NURMAG and the NUREL in each of the five countries and both the local and the improved checks. The trials area designed as alpha-lattices with two replications

Table 2.84. Segregating populations (SEGMAG and SEGEL) and special nurseries for North Africa (NURMAG and NUREL) distributed for 1998-99 cropping season with number of lines and number of locations

	SEGMAG99 (SEGEL99)[a]		NURMAG99 (NUREL99)[b]	
Country	N of lines	N of locations	N of lines	N of locations
Libya	92	3	80	3
Egypt	92	3	80	3
Algeria	268	3	210	4
Tunisia	268	5	210	6
Morocco	268 + 92	5+1	210	6

[a] SEGEL99 was planted in Egypt, Libya, and one location in Morocco.

[b] NUREL99 was planted in Egypt and Libya.

Table 2.85. Barley yield trials distributed to North Africa in 1998-99 cropping season with number of lines, number of replications and number of locations

Country	N of lines	N of replications	N of locations
Libya	80	2	4
Egypt	25	2	4
Tunisia	88	2	4
Morocco	50	2	4

2.7.1 Segregating Populations (SEGMAG99 and SEGEL99)

In Morocco, selection in SEGMAG99 was done in three locations: Merchouch (221 mm rainfall), Jemaa Shaim (216 mm), and Zhiliga. Selection was done by the Moroccan barley breeder at all locations and by three farmers at Merchouch, five farmers at Zhiliga, and six at Jemaa Shaim. On the basis of agronomic performance and resistance to major diseases the breeder selected forty-seven entries at Merchouch, forty-nine at Jemaa Shaim, and fifty-four at Zhiliga. In total he selected 126 entries: three entries were selected in all three locations; eighteen entries were selected in two locations (eight at Jemaa Shaim and Zhiliga, five at Jemaa Shaim and Merchouch and five at Merchouch and Zhiliga). Name and pedigree of the entries selected by the breeder in Morocco in all three locations are reported in (Table 2.86).

Table 2.86. Entries selected from SEGMAG99 by the breeder in Morocco in all three locations

Entr	Cross	Pedigree
22	Rhn-08/Arar/3/M6/Robur 35-6-	ICB96-0024-0AP
28	Chn-01/CC89//Arial/3/Lignee	ICB96-0033-0AP
222	Aths/Lignee 686/5/Arizona	ICB96-0870-0AP

In Merchouch the three farmers selected from 19 to 52 entries, none was selected by all three farmers, nineteen entries were selected by two farmers. In total seventy-five entries were selected, thirteen were in common with the breeder. In Zhiliga the five farmers selected from 19 to 39 entries, none was selected by all farmers, two entries were selected by four farmers and by the breeder, while seven entries selected by three farmers were not selected by the breeder. One of the entries selected by four farmers was Saida, an Algerian landrace.

In Jemaa Shaim the number of entries selected by the individual farmers varied from twenty-five sixty-eight, three entries were commonly selected by all farmers and the breeder. Seven entries, selected by the breeder were not selected by any of the farmers. Entry 166 was the most frequently selected entry across locations, as it was selected by four farmers in Zhiliga, by six farmers in Jemaa Shaim and by the breeder in the same two locations.

(Table 2.87) shows name and pedigree of the entries that were selected more frequently by farmers in Morocco.

Table 2.87. Name of entries in SEGMAG99 most frequently selected by farmers at three locations in Morocco

Entry	Cross	Location
36	Aths/Lignee 686/5/Alanda-01/4/WI2291/3 /Api/CM67//L2966-69/6/Rhn-08/3/Deir Alla 106//DL71/Strain 205	JS[a]
56	Alanda-01/4/WI2291/3/Api/CM67//L2966-69/7/Gustoe/6/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272	JS
166	CYDBA89#49/Hevel1965//Saida/3/Lignee527/Aths//Lignee527/NK1272	JS, Zhi
89	Shyri-3/Atahualpa	Mer
144	Line 9-26 F27/QB813.2	Mer
250	Giza 121/CI 06248/4/Apm/IB65//11012-2/3/Api/CM67//Ds/Apro/5/M5/Galt//As46/6/CI 16155//Lignee 640/Lignee 527	Mer
260	Saida	Zhi

[a] JS=Jemaa Shaim, Zhi=Zhiliga, Mer=Merchouch

In Tunisia selection was done by the breeder at five locations, three research stations (Beja, El Kef, and Mograne) and two farmers' fields (Tajerouine and Foussana). Sixty entries were selected in total. Two entries (n. 53 and 224 in (Table 2.88) were selected in all five locations.

Table 2.88. Entries selected from SEGMAG99 in five locations in Tunisia

Entry	Cross
53	Aths/Lignee686//Lignee527/Aths
224	Lignee527/Aths/5/Ager//Api/CM67/3/Cel/WI2269//Ore /4/Alanda

In Algeria selection was done at only one location, El Krhoub. Twenty-five entries were selected. Five entries were in commonly selected in the three countries. A total of 116 entries were promoted to further testing in NURMAG00.

Selection in SEGEL99 was done at Jemaa Shaim in Morocco, at Sofit and Azizia in Libya, and at Sakha in Egypt. Fourteen entries were selected in Morocco, forty-nine in Libya, and thirty-four in Egypt. Four entries were selected in all three countries, twenty-three were selected in two. A total of sixty-six entries were promoted to next year testing.

2.7.2. Special Nursery for North Africa (NURMAG99 and NUREL99)

The NURMAG99 comprised 210 entries (198 new lines and 12 checks).

In Morocco selection was done in two research stations (Merchouch and Jemaa Shaim), and in two farmers' fields (Oued Zem and Sidi Boumahdi). The breeder and the collaborating farmers visited the nursery planted in farmers' field several times during the season. At maturity final selection was made the farmers' selection criteria were recorded.

As in the SEGMAG99 the farmers tend to select more populations at the research stations than in the farmers' fields (Table 2.89).

Fifty-two lines were promoted to yield testing in 1999-2000 and were included in the MORYT00.

In Tunisia selection was done by the breeder in five locations (Tejerouine, Fahs, Mograne, Beja, and El Kef). One line was selected in all five locations, fourteen in four locations. Seventy-one entries were included in the yield trial TUNYT00.

Table 2.89. Number of lines selected by farmers and breeder within the NURMAG99 nursery (210 lines) in the research station at J. Shaim and in the farmer fields at Oued Zem and Sidi Boumahdi

Selected by	Jemaa Shaim	Oued Zem	Sidi Boumahdi
Farmer 1	25	20	5
Farmer 2	48	30	34
Farmer 3	27	17	12
Farmer 4	54	22	48
Farmer 5	48	29	-
Farmer 6	31	-	-
Breeder	26	30	30

- Not involved in the selection

In Algeria thirty-seven entries were selected in the only location where selection was performed.

There were 80 entries (75 new entries and five checks) in NUREL99. The nursery was planted in Egypt and Libya and selection was done in two locations in each of the two countries.

In Egypt forty entries were selected in total, eight in both locations. In Libya forty-three entries were selected, six in both locations. Twenty-five entries were selected in both countries.

2.7.3. Yield Trials for North Africa

Data of the yield trials were received only from Morocco, and the results were presented and discussed in the 'farmer participation' section (section 2.5.3).

2.8. East Africa and Yemen

Most of the activities conducted in collaboration with the national programs in Eritrea and in Yemen have been reported elsewhere see sections 2.2.2 and 2.5.4.

The most important activity in Ethiopia, in addition to the distribution of the traditional international nurseries, was the distribution of a new nursery assembling sources of specific traits as shown in (Table 2.90). The nursery has been assembled with the objective of assessing the adaptation of sources of traits that are important in barley breeding in Ethiopia. This is particularly important in the case of the sources of resistance to diseases and to Russian Wheat Aphid before using them in a decentralized breeding program for Ethiopia.

Table 2.90. Specific trait nursery distributed in Ethiopia during 1999

No of entries	Attributes
2	Adapted to low rainfall areas with cool winter
3	Adapted to moderate rainfall areas
4	Early
4	Early, resistant to powdery mildew
1	Early, tall under drought
1	High 1000 kernel weight
3	Malting quality
31	Resistant to RWA
1	Resistant to leaf rust and scab
14	Resistant to net blotch
14	Resistant to powdery mildew
3	Resistant to scald
6	Resistant to scald, powdery mildew
4	Yield under drought
7	Resistant to covered smut

2.9. Central Asia and Russia

The activities of the barley project in Central Asia and Caucasus (CAC) countries included agro-climatic characterization of the environments and the analysis of the type of germplasm needed. In this second season, a total of 360 entries of winter barley germplasm were evaluated. Some lines performed well in local environments and were selected for the further use in the breeding program (Table 2.91).

Table 2.91. Total (T) and selected (S) number of entries from different winter barley nurseries in various countries of Central Asia

No. of entries	Country							
	Uzbekistan		Kyrgyzstan		Tajikistan		Turkmenistan	
	T	S	T	S	T	S	T	S
IWBYT-CH-CW99	24	7	24	2	24	11	24	4
IWBON-CH-CW99	150	57	150	10	150	7	150	10
IEBON-CH-CW99	50	19	50	4	50	8	50	5
IWBCB-CH-CW99	136	24	136					

In Central Asia the main limiting yield factors are drought, heat and low soil fertility. The most important diseases are net blotch and smut. Sunny bug is the most damaging insect. The yield of winter barley in rainfed areas ranged from 700 to 1300 kg/ha. At the end of April, during heading, there was a cold spell with air temperature between -5°C and -7°C, that caused between 10 and 90% head sterility. Early heading varieties were completely sterile and did not produce any seeds so that selection was biased towards late maturing winter barley lines. Therefore, the results of this season were not very typical.

2.9.1. New Winter Barley Varieties

In addition to the variety Sararood-1 released for cultivation in Iran, other winter barley varieties continued to perform well in a number of countries.

In the Russian Federation, a new winter barley variety Dobrinya-03, developed as a result of the collaboration between ICARDA and the Krasnodar Research Institute of Agriculture (KRIA), was submitted for official state trials in all the regions of the North Caucasus, as well as in some countries of the former Soviet Union. Dobrinya-03 derives from locally developed lines and germplasm from Europe (Donor) and USA (Jefferson).

Initially the variety was targeted for the coldest zones of the steppe due to its cold tolerance. The yield of Dobryina-03 in the northern zone and in the central zone is shown in (Table 2.92).

Dobryina-03 performed well in the foothill zone with warm winters and deep snow cover, because of its tolerance to snow mould. This underlines the importance of multi-location yield trials. The variety was included into the recommend list for farmers cultivation in the foothills of the north Caucasus in the Adygey Republic in the north Caucasus. In this area, Dobrynia-03 showed a considerable advantage in disease resistance and yield. The grain yields of Dobrynia-03 and the check Kozir obtained at Giaginsk, Koshehable, and Krasnogvardeisk experimental stations in the Adygey Republic were: 2390 and 1680 kg/ha; 5670 and 5400 kg/ha; 7060 and 5670 kg/ha, respectively. Farmers started the seed multiplication of the new variety, and in 1999 the area planted with this variety reached 1430 ha. In 1999 more than two thousand tons of certified seeds have been produced for distribution in the targeted areas.

Table 2.92. Yield (kg/ha) of the winter barley Dobrynia-03 in the northern and central zones of Krasnodar territory

	Yield		
	Bastion	Vavilon	Dobryina-03
Station/Variety	Northern zone		
Eisk	6910	7350	6700
Kuzhevsk	6750	6580	7030
N-Pokrov	4110	4210	4680
Kanev	4270	4430	4580
Average zone	5510	5642	5747
	Central zone		
Y-Labinsk	5450	4880	6680
Kavkaz	5340	5380	5990
Korenovsk	4070	4100	4080
Average zone	4950	4786	5583
Average total	5230	5214	5665

The winter barley variety Pavel was submitted for official state trials in 1999. The new variety was developed through physical mutagenesis with the treatment of dry seeds of the winter barley line K-307 (Radical/K-253) by ionizing irradiation of 10 k-roentgen. The variety derives from a plant selected from the M3 generation. Its main characteristics are the following: six-row head with long rough awns, one thousand kernel weight of 40-45 g, and a protein content of 10-11%. The new variety is resistant to lodging, and tolerant to rusts and net blotch (Table 2.93). Pavel is recommended for different areas and climatic zones of the North Caucasus.

Table 2.93. Characteristics of the winter barley Pavel in the advanced yield trials at Krasnodar, Russia

Variety	TKW, g	Head number/m^2	Disease resistance, score *P.hordei*	Disease resistance, score *R.secalis*	Yield (kg/ha)
Kozir	40.3	605	4	7	5445
Michailo	43.2	610	4	8	5620
Pavel	43.5	640	6	8	5930
LSD 0.05	1.3				340

2.10. Central and Latin America

In Mexico, farmers in the Yaqui Valley showed interest in barley as a potential new feed irrigated crop. Barley grain has is used locally by hog producers who export meat to Japan. Barley is preferred over other grains because it has positive effects on the fat marbling in the meat.

Two experiments were conducted with the objective of studying different agronomic practices, such as number of irrigation, split nitrogen fertilization and chemical control of lodging in four barley lines and one durum wheat variety Altar, used as a check since represent the main variety under cultivation in the Yaqui valley.

The yield of three hull-less barley, namely Petunia tall, Petunia short, and Bichy, was compared with a covered barley (Cabuya) under three and four irrigation schemes. Split nitrogen application at planting (50 kg/ha) first node (100 kg/ha) and boot stage (75 kg/ha) were superimposed in a RCBD with four replications. The large plots size (19 m long by 3.2 m wide) allowed farmers and hog producers who attended a field day, to have a more realistic view of the performance of the barley lines.

Two varieties, Cabuya and Petunia tall, suffered severe lodging under limited irrigation and low fertilization. The chemical treatment (Ethrel) resulted in a height reduction but did not prevent lodging. Under a three-irrigation regime, barley yielded more than wheat. The highest yield (6.6 t/ha) was obtained with Cabuya under reduced irrigation, compared with 5.5 t/ha obtained with Altar. However, an extra irrigation increased wheat production to 6.9 t/ha - a gain of 1.4 t/ha - while the extra irrigation failed to increase barley yield.

The Northern Mexican States suffered a prolonged drought that has lasted for more than three years; this situation could create a favorable environment for barley adoption. Yield of the hulless barley lines Petunia dwarf and Bichy were 5.5 and 5.1 t/ha, respectively; both lines are short and did not suffer from lodging regardless of heavy N fertilization (225 kg/ha). Results of quality test using near infrared technology are presented in (Table 2.94). Hullless barley quality was superior to covered barley lines (Tocte and Cabuya) since they had higher values for almost all quality parameters.

Table 2.94. Feed quality parameters of five barley genotypes determined by Near Infrared Technology (NIR) in Lacombe, Canada

Cultivar	Lysine Content	Protein Digest.	Energy Digest.	Dig. Energy
Petunia dwarf	7.29	79.67	93.83	3704.39
Petunia	6.50	79.48	88.69	3584.28
Bichy	6.20	79.92	93.00	3494.13
Cabuya (covered)	4.76	75.14	72.13	2788.19
Tocte (covered)	4.53	82.29	71.73	2816.38

During the winter in CIANO (in the Yaqui Valley), the hulless barley line Bichy, an early maturing line (110 days from planting to harvest) was sown on beds separated by 80 cm with tree-rows bed in one-hectare seed increase. Additional treatments were nitrogen application (150 kg/ha) at the first node and two supplementary irrigations. The harvest is expected in March 2000. In the same emptied land an early sorghum variety will be sown for grain production. Another crop to be considered for planting is soybeans, sown two months earlier than the traditional planting date, to avoid the build up of the white fly populations. Soybean is not grown in the Yaqui Valley as in the past, due to the insect problem.

The covered barley line (Cabuya) has two traits that need to be improved-susceptibility to stem rust (*Puccinia graminis*) and lodging resistance. During the winter of 1998-

99, crosses were made with a dwarf barley line resistant to stem rust. The F1 was sown in the summer at the Toluca Experiment Station where the first backcross to Cabuya took place. Segregating populations were sown at CIANO during the winter of 1999-2000, for screening against stem rust susceptibility and tall plants; a second backcross to Cabuya will be made with selected dwarf resistant plants.

2.10.1. Disease Screening

2.10.1.1. Leaf Rust

Artificially inoculations with pathogen fresh spores several times during the growing cycle during the winter in the Yaqui Valley fail to produce an epidemic in the nurseries. The pedigree method was changed to the bulk method for population advance. Since 1982, this is the first season without epidemics of leaf rust in barley nurseries at the CIANO Experimental Station, due to extreme dry conditions prevailing during the growing cycle.

2.10.1.2. Scald and Stripe Rust

During the summer of 1999, in the Toluca Experiment Station an artificial epidemic of scald was created in seven hectares planted with barley. At selection time, resistant plants were identified and seed of selected plants was graded to eliminate those entries with disease-contaminated grain. Stripe rust epidemic was present in all nurseries.

2.10.1.3. Head Scab

Two morphological markers (anther extrusion and lateral floret) were mapped close to a molecular marker (MWG503) in the centromeric region of Chromosome 2. The correlation ($r = 0.6$) of resistance to head scab (fungal spreading) and two morphological markers was determined in two-doubled haploid populations. Indirect selection for head scab (Type II) became possible by using morphological markers as selection criteria where the disease is not present, such as in the Yaqui Valley.

Selection for plants lacking small lateral florets or with small lateral florets has become a useful selection tool used in the barley program across all Experimental Stations.

There are three main areas of research on head scab; the first is to develop new barley populations, with more than one source of scab resistance involved in the cross, to improve resistance levels. Twenty-four F5 lines from the cross Svanhals/M.Selva//Azafran/3/Gob24DH, with three different resistant parents in their pedigree (Savanhals, Shyri and Gobernadora), were screened for the first time. One F6 line, Aleli/Azafran//Atahualpa/3/Gob 96DH belongs to the same group with Shyri, Atahualpa and Gobernadora in the pedigree.

The second area of research deals with the transfer of scab resistance into a malting background. A set of 125 doubled haploid lines known as RECLA, acronymic for Latin American barley network, were screened in the field. Results were presented in the third Latin American Barley workshop in Colonia, Uruguay. In addition to head scab screening the double haploid set (RECLA) was screened for several diseases in nine countries of the region. Preliminary malting quality data on the lines will be produced in Canada.

The development of scab resistant hull-less barley in two and six-rowed background is the third area of research. The resistance to Scab present in Chevron was transfered to six-rowed lines in different combinations. Advanced hulless lines were yield tested in Toluca during the summer of 1999. Hullless barley was found to reduce toxin (DON) content when threshing by 57 per cent using susceptible hulless cultivars. Our strategy is to produce resistant hulless cultivars that will show nothing or little toxin content and can be recommended in areas where Fusarium is a problem, such as the Yangtze lower basin in China. Standards required in Canada for toxin present in the grain are 0-0.5 ppm for swine, and a maximum of 2 ppm in other species (up to 5 ppm for non-reproducing ruminants).

2.10.1.4. Stem Rrust

Dr. Julio Huerta identified the stem rust spores as *Puccinia graminis* f. sp. *secalis*. Two populations were found segregating for stem rust: the RECLA doubled haploid population, composed of 125 DH two-row lines developed for transferring head scab resistance into malting background for the Southern Cone of South America, and some F4 lines from the Limon/Bichy cross, a population developed to incorporate BYD resistance into the hulless line Bichy.

2.10.2. Winter Yield Trials (Ciano)

Advanced barley lines were yield tested using a lattice design (8x8) with 2 replications. The plot size was 5 m long and 1.6 m wide. All experiments were sown in raised beds (two-rows bed). While the trials with hulless barley are sown in pre-irrigated soil, the other trials were sown in dry soil that received irrigation immediately after planting.

In the past seasons yield trials were sown in 3 rows-bed that resulted in more lodging, plants were more prone to lodge during irrigation in windy days. In our experience planting two-rows bed reduce the lodging problem but yield drops considerably as compared to 3-rows bed planting. A total of 992 advanced barley lines were yield tested under irrigation at CIANO Experiment Station. Experimental lines were classified in four different groups: six-rowed (112 lines) two-rowed (224), hulless (488) and early maturing barley (168).

Grain yield for the top ten advanced lines in each group is presented in (Tables 2.95, 2.96, 2.97 & 2.98). High yields were obtained with six-rowed lines, while two-rowed barley had a similar yield than hulless and early maturing barley. The early maturing barley received three irrigations, one less than other groups.

Lines with good yield and tolerant to lodging will be sown again in 3 rows-bed, with high nitrogen fertilizer doses, to explore the possibility to achieve higher yields than those reported in (Table 2.95).

Table 2.95. Yield (t/ha) of the top ten six-row barley sown in CIANO Experimental Station during the winter of 1998-99

Genotype	Yield
CI10622/CI5824//Paico/3/Gloria/Copal/4/BBSC	7.6
P.Sto/LBIran/UNA80//Motan/4/BBSC	7.4
Puebla/Cardo//Tocte	7.2
Jazmin/Cardo//Tocte	7.1
Lino/Rmro//DC/Sen/3/Mja/Rmro//Nispero	7.1
Cardo/Virden/3/Cen/Cal//Sen/4/Tocte	7.0
Jazmin/Cardo//Tocte	6.9
Cardo/Virden//Aloe	6.8
M9878//Cen/2*Cal/3/Tocte	6.8
M9878//Cen/2*Cal/3/Tocte	6.8

Table 2.96. Yield (t/ha) of the top ten two-rowed barley sown in CIANO Experimental Station during the winter of 1998-99

Genotype	Yield
Tocte/Tumbo//Shyri	6.6
Gob/Humai10//Canela/3/Shyri	6.3
Tocte/Tumbo// Shyri	6.3
Arupo/K8755//Mora/3/Cerise/Shyri//Aleli/4/Canela	6.1
Cerise/Shyri//Aleli/3/Canela	6.1
Canela/BSRD1.10/3/Claudia/DS4886//Shyri	6.0
Aleli/3/Arupo/K8755//Mora	5.9
Arupo/K8755/Mora/3/Cerise/Shyri//Aleli	5.9
Lino/Rmro//DC/Sen/3/Aleli	5.9
Canela/Shyri	5.8

Table 2.97. Yield (t/ha) of the top ten hulless barley sown in CIANO Experimental Station during the winter of 1998-99

Genotype	Yield
Penco/Chinia	6.2
Cerraja/3/Adave/Bermejo//Higo/4/DC/Sen	6.2
Penco/Chinia	6.1
Penco/Chinia	6.1
Petunia/Titiribi	6.0
Stipa/Chinia	6.0
Petunia/Titiribi	5.9
Petunia/Chinia	5.9
Stipa/Petunial//Kolla/BBSC	5.9
Penco/Chinia	5.9

It is worth to notice different head scab resistant sources, alone or in combination, as parents among the lines with high yield (Gob/Humai, Arupo/K8755//Mora, and Shyri). Breeding for scab resistance has become the main priority for some countries in America and Asia, who are afraid of toxins present in fusarium contaminated grain. The toxins are known to cause severe problems for human and animal health.

Despite the large number of two-rowed hulless lines tested, only six-row hulless lines were found among the top ten. Six-row barley has a higher yield potential but is more susceptible to head scab than two-row barley. A few years ago, a project was initiated to transfer head scab resistance into six-row hulless barley, some advanced lines were found resistant and preliminary yield trials were conducted in the Toluca Experiment Station during the summer of 1999.

The accessions with extreme earliness (90 days from planting to harvest) do not figure among the highest yielding entries reported in (Table 2.98). The short stature with few tillers, characteristics from early maturing lines, point to yield trials with three rows beds in order to improve stands.

Table 2.98. Yield (t/ha) of the top early maturing barley sown in CIANO Experimental Station during the winter of 1998-99

Genotype	Yield
M9878/Tocte//Cen/2*Cal	6.4
Fresa	6.2
Asahi5/2*Aleli	6.1
Asahi5/2*Aleli	6.0
Hlla/Gob/Hlla/3/Canela	5.8
Gloria/Copal//Ben/3/S.P./4/DC/Sen/5/Lent	5.3
Hlla/Gob/Hlla/3/Canela	5.3
Fresa	5.2
Sumbard400/Bermejo//Sen/3/Tocte/4/Sumbard...	5.2
Ase/2CM//B.7.6.B.B/3/Cardo/4/Cent/2*Cal	5.1

2.10.3. Summer Yield Trials (El Batan)

During the summer, 1008 advanced lines were sown at El Batan Experiment Station for yield testing. Due to a hail-storm several yield trials (mostly with six-row lines) located in the southern part of the Experiment Station were lost (488 lines in total). Using the reserve seed of the lost entries, new trials were sown in the CIANO Experiment Station during the winter of 1999-2000.

The summer season at El Batan began with a dry spell for several weeks, and one irrigation was used to keep plots in good shape. Late in the season heavy rains caused some lodging. The top ten entries are presented in (Table 2.99). The best two-row lines yielded 7.0 t/ha, slightly more than the two-row lines at CIANO (6.6 t/ha).

Among the high yielding lines there were four genotypes combining two sources of head scab resistance: these lines will be screened under artificial inoculation with fusarium next summer.

2.10.4. BYDV screening

Research on barley yellow dwarf (BYD) aims to characterize 153 barley lines for their individual reaction to three BYD biotypes: MAV, PAV, and RPV. Artificial inoculation with greenhouse-reared aphids was done under field conditions in

Toluca. Three individual plots for each entry were inoculated with three biotypes in isolation. A fourth plot (the check) was kept free from aphids by frequent insecticide application.

The identification of BYD resistant cultivars (Table 2.100) with high yield potential and resistance to other diseases such as stripe rust, leaf rust stem rust and scald resulted in their utilization as new parents in our crossing program.

66 lines resistant to three BYD biotypes were identified through several years of testing, these lines were assembled in a special nursery (Miscellaneous BYD). Among the lines there are six-row, two-row, hulless, and covered types.

The 66 BYD resistant lines are being studied for their virus titer content (few lines had low titer virus-a measure of true BYD resistance) and with polymerase chain reaction (PCR) to detect the Yd2 gene presence. Preliminary results showed diversity on the resistance sources present in this material.

Table 2.99. Yield (t/ha) of the top ten two-rowed barley sown in El Batan Experimental Station during the summer of 1999

Genotype	Yield
ND10277/Shyri//ND11231/Shyri/3/Azafran/4/Canela/Gob96DH	7.0
Canela/Azafran//M. Selva	7.0
Bermejo/Aleli//Mora/3/Canela	7.0
Arupo/K8755//Mora/3/Aleli	6.9
Melusine/Aleli/3/Matico/Jet//Shyri/4/Icaro/Gob96DH	6.8
Petunia 2/3/Arupo/K8755//Mora/4/Aleli	6.8
Gob 96DH//Gob/Humai10/3/Aleli	6.8
Gob 96DH//Gob/Humai10/3/Aleli	6.7
Melusine/Aleli/3/Matico/Jet//Shyri/4/CI5791/CAL607//Shyri/5/M.Selva	6.6
Gob 89DH/3/Arupo/K8755//Mora/4/M.Selva	6.6

Table 2.100. Yield (t/ha) and disease reaction of barley cultivars to rust (leaf, stripe, stem), scald and three BYDV biotypes (MAV, PAV, and RPV) under artificial field inoculation with greenhouse reared aphids in Toluca, Mexico, 1999

Genotype	BYD	Scald	Leaf	Rust stripe	Stem	Yiled
Petunia 1	R	R	TR	5MS	R	7.1
Madre Selva	R	R	TR	R	TS	7.1
Cardo/Virden//Aloe	R	-	R	R	-	6.7
Limon	R	R	TR	TR	TS	6.6
Palton	R	TR	TR	TR	-	6.6
Incienso	R	TR	TR	5MS	TS	6.5
Petunia 1	R	TR	R	TS	TR	6.2

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11.2. Contributors

The Following have contributed to the Annual Report for 1999:

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3. DURUM WHEAT IMPROVEMENT

3.1. Introduction

In 1999 the CIMMYT/ICARDA durum program has conducted activities on development of germplasm with improved yield stability and grain quality; and in collaboration with the NARSs of WANA region on resistance to abiotic and biotic stresses and grain quality. The development of gene stocks of resistance to the different constraints had received high priority.

Development of stress resistant and stable productive durum genotypes with the appropriate grain quality for the temperate drylands in North Africa.

3.2. Specific Objectives for 1999

3.2.1. Biodiversity Conservation and Utilization

Thirty-one landraces for the Moroccan Atlas mountains were screened for seed storage protein composition and particularly for the protein bands related to gluten strength. Nineteen accessions were found to carry gamma 45 band (good gluten strength quality) whereas 9 the gamma 42 band (poor gluten strength quality).

Further, more than 7000 segregating populations (F2-F8) originating from crosses with local landraces and wild relatives were tested for resistance to yellow rust, leaf rust, BYDV, wheat stem sawfly, and RWA at Tel Hadya, Terbol, and Breda stations, as for Septoria tritici and leaf rust at latakia station. The screening for resistance to Hessian fly, dryland root rot, and leaf rust were conducted in Marchouch and Sidi Aidi station stations, Morocco. Thirty percent of these populations were selected. The selection criteria emphasized the tolerance/ resistance to dryland adaptation, and root rot and Hessian fly resistance.

3.2.2. Improvement

The improvement of durum productivity and stability, resistance to abiotic and biotic stresses, and grain quality through breeding are presented as follows:

3.2.2.1. Yield and Yield Stability

Yield and yield stability for the Mediterranean Temperate drylands of North Africa were tested in several sites in North Africa (Table 3.1). Below are shown the genotypes with the largest productivity and yield stability under dryland conditions.

Table 3.1. Grain Yield and Yield Stability

Genotype	Grain yield(kg/ha)	Yield Stability
Omgenil-3	2868	12.69
Mrb3/Mna-1	2780	11.41
Lagonil-3	2656	9.83
Lagonil-1	2617	9.09
Albit-9	2641	8.85
Omrabi5 (Check)	2527	8.25
Korifla (Check)	2474	7.14
Waha (Check)	2414	7.05
Haurani (Check)	2030	5.21

3.2.2.2. Resistance to Drought and Heat Tolerance

Fourteen new durum genotypes with high productivity and high tolerance to drought and nine to heat tolerance are developed. The parental materials for these genotypes were the high yielding and abiotic stress tolerant lines of CIMMYT/ICARDA durum program hybridized either among themselves or crossed with wild relatives. These lines are also distributed to the national durum breeding programs for use either directly in commercial production or/and in the breeding program.

Developed genotypes with drought tolerance:

Mrf1//Mrb16/Ru
Heca-1//Ch1/Brch
Zna-1/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5
Msbl-1/4/Quadalete//Erp/Mal/3/Unk
Blrn/Mrf-2
Stj3//Dra2/Bcr
Lagamarb-1
Altar84/Stn//Wdz-2
Ainzen-1
Msbl-1//Awl2/Bit
Arthur71/Bcr//Mrb3
Bcr/Sbl5//Ae.peregrinacylindros 401047

Lgt3/3/Gdfl/T.dicds-SY 20013//Bcr
Stj3/3/Gdfl/T.dicds-SY 20013//Bcr

Developed genotypes with heat tolerance:

Azeghar-1.
Rutucha-1
Yousef-1
Aghrass-1
HFN94N MOR NO 40/Blrn
Bcr/Sbl5//T.urartu
Bcr/Sbl5//Ae.peregrinacylindros 401047
1346/Lahn//Bcr/Lks 4
Gidara-2

Correlation and contribution of some traits dryland grain yield

Trait	Correlation coefficient	Contribution (%)
Agronomic score	0.627	39.3
Date to maturity	-0.454	6.1
Plant height	0.199	1.15
Stem sawfly resistance	-0.179	1.69
Date to heading	-0.468	1.25

The progress made in drought tolerance shows that several durum genotypes are developed with larger grain yield performance (Table 3.2).
The genetic background of this material is consisted of genotypes originating from parental material that was developed for dryland; crosses were made with this material with the aim to pyramid genes for drought resistance. Further, crosses with wild parents were conducted for transgressive inheritance of genes of drought resistance and productivity (Table 3.3).

3.3. Tolerance to High Temperatures in Durum

The yield performance of three hundred and twenty durum wheat genotypes has been evaluated under late-planting at Tel Hadya, Aleppo, Syria (Table 3.4). Chlorophyll fluorometry was then used to determine the *in vivo* tolerance of photosynthetic membranes to high temperatures in leaves of a subset of seventeen lines which covered a wide range of yield. An important variation was noted for

Tc, the threshold temperature for photosystem-II denaturation and for Tp, the peak temperature corresponding to maximal Fo fluorescence. A strong correlation was noted between the two traits (r=0.69**). A significant correlation (r=0.52*) was noted between Tc and yield under late-planting conditions. Earliness was also found to be strongly correlated with yield (r=0.75***). Various durum lines derived from a cross between the heat susceptible durum variety Korifla and the heat tolerant accession *T. dicoccoides* 600808 were screened for the tolerance of photosynthetic membranes to high temperatures. The potential interest of the accession *T. dicoccoides* 600808 as source of heat tolerance has been confirmed.

Among the abiotic stresses affecting wheat production, heat is probably the most frequent. Crops can adapt to high temperatures by escape, avoidance and tolerance. Escape is effective only in case of terminal heat stress. The main way of avoidance is probably through latent heat via transpiration. Under ample water supply, leaf temperature was found to strongly correlate with stomatal conductance and grain yield. This mechanism of heat avoidance can however develop only when stomata are open, i.e. under irrigation or limited water stress.

Table 3.2. Resistance to abiotic stresses drought resistance

ADYT-Nr	Name/Cross	Grian yield (kg/ha)
220	Azul-3	1421.0
320	Ruff/Fg//Turk1/3/Gil3	1242.0
417	Omgenil-3	1230.6
318	Ruff/Fg//Turk1/3/Stj6	1210.0
213	Mrf2/3/Bcr//Fg/Snipe	1200.4
120	Azul-2	1163.0
221	Azul-5	1155.9
715	Atlal/4/Stn//Hui/Somo/3/Yav/Fg//Roh	1128.9
218	Mrf1//Mrb16/Ru	1066.9
912	Azul-1	1052.0
620	Lagamarb-1	1051.9
803	Lagonil-2	1046.5
605	Altar84/Stn//Wdz-2	1039.5
810	Zna-3	1039.3
413	Ainzen-1	1029.5
102	Mrb5	692
107	Haurani	594
111	Korifla	606
	Grand mean	736
	LSD (5%)	326.8
	CV%	14.1

Table 3.3. Newly bred durum genotypes with larger grain yield than durum checks

PDYT-Nr	Cross/Name	SN	Grain yield kg/ha)
210	Msbl-1//Awl2/Bit	82	1561.2
924	Stj3/3/Gdf1/T.dicdsSY20013//Bcr	1108	1480.5
624	Stj3/3/Gdf1/T.dicds-SY 20013//Bcr	303	1355.5
518	Bcr/Sbl5//Ae.peregrinacylindros 401047	259	1298.0
113	Lgt3//Bcr/Sbl5	36	1233.0
418	Bcr/Sbl5//Ae.peregrinacylindros 401047	239	1214.6
1018	Buc/Chr//Prl/3/Pvn/4/Awl3	408	1213.2
701	Stj3/3/Gdf1/T.dicds-SY 20013//Bcr	304	1186.1
1024	Gidara-2	0	1136.7
620	Stj3/3/Gdf1/T.dicds-SY 20013//Bcr	299	1135.8
724	Gnt/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5	613	1134.5
513	Bcr/Sbl5//Ae.peregrinacylindros 401047	255	1134.3
923	Mrf2/3/Gdf1/T.dicdsSY20013//Bcr	1024	1113.9
512	Bcr/Sbl5//Ae.peregrinacylindros 401047	254	1098.7
114	Stj3//Dra2/Bcr	48	1080.0
213	Heca-1//Chl/Brch	90	1057.6
	Mrb5		753
	Haurani		612
	Korifla		680
	Grand mean		764
	LSD		275.4
	CV%		11.4

Table 3.4. List of the seventeen durum wheat genotypes tested for their heat tolerance, with their rank, grain yield, and days to heading under late-planting conditions, and their critical and peak fluorescence temperature

Genotype	Rank	Grain Yield ($t.ha^{-1}$)	Days to heading (days)	Tc (°C)	Tp (°C)
Awlbit2	1	3.23	51	44.0±0.59	51.1±
Massara-1	20	2.84	50	43.0±0.28	50.8±
Outrobl	40	2.75	57	44.3±0.15	50.5±
Omguer2	60	2.64	50	44.8±1.02	49.8±
Mrb3/Mnal	80	2.58	50	43.7±0.49	50.3±
Omegnil 1	100	2.54	50	43.6±0.88	49.6±
Zeina 3	120	2.48	54	44.3±0.81	51.0±
Chahra 1	140	2.43	54	43.9±1.03	50.5±
Mrb5/Albit1	160	2.36	54	43.6±0.81	51.0±
Sbl1//Khb1/Amarelo	180	2.29	50	44.2±0.82	51.2±
Ruff/Fg//Turk1/3/Gil4	200	2.20	52	42.7±0.47	49.6±
Korifla	220	2.13	55	42.9±1.29	49.6±
Mrb9/Boohai//Mrb5	240	2.05	54	43.0±1.40	50.0±
Haurani	260	1.98	55	41.8±1.90	47.5±
Chen/Altar84//Gil4	280	1.83	58	43.6±0.59	51.0±
Stj4/Stj2	300	1.58	56	44.1±0.65	49.7±
61-130/414-44//Cak79	320	1.10	65	41.9±2.36	48.6

Heat tolerance consequently could play a major role in crops affected by both drought and heat, as in the Mediterranean climates. Membrane stability at high temperatures, estimated by measurements of solute leakage, has been proposed many years ago as criteria of heat tolerance. Heat tolerant wheat genotypes were found to have a higher membrane stability. The heritability of the trait was found to be high. The measurements of solutes leakage is however time-consuming.

Chlorophyll fluorescence could represent an alternative method for evaluating heat tolerance. Leaf fluorescence can provide useful information on photosynthetic electron transport activities. Fluorescence measurements have been then proposed for the study of disorders affecting the photosynthetic system and more especially the PSII, the most labile component. However, no attempt was made until now to correlate the tolerance evaluated from fluorescence measurements and yield under heat stress in field conditions. To study the tolerance of photosynthetic membranes resistance to high temperatures, different fluorescence parameters can be used, as the ratio of fluorescence decrease (Rfd) from the maximum to the steady-state fluorescence, or the critical temperature (Tc) above which the apparent Fo level of fluorescence increases. This last parameter is easy to measure. It has been used to evaluate the tolerance to high temperatures in cultivated and wild wheats of the *Triticum* and *Aegilops* genera. This study allowed to identify some Chaml and *T. dicoccoides* 600808 with high Tc value.

The aims of the present study were i) to study the relationship between the critical temperature Tc of different durum wheat genotypes and their yield in the field, under severe heat and water stress, ii) to analyse the role of this mechanism of tolerance in such conditions, compared to escape and avoidance mechanisms, iii) to search for new sources of photosynthetic tolerance to high temperatures and to confirm the potential interest of some progenitors already identified as *T. dicoccoides*-600808 in breeding for heat tolerance.

Three lines (61-130/414-44//Cak79, Stj4/Stj2 and Chen/Altar84 //Gil4) were however found to have lower yield than expected from Tc values. They were also the latest flowering among the tested lines. At the opposite, Awalbit2 and Massara-1, characterised by high yields and intermediate Tc values (44.0 and 43.0 °C respectively) were among the earliest genotypes. In fact, yield obtained under field conditions was found to strongly correlate with earliness ($r=0.82^{***}$; Figure.3.1), each day of precocity leading to an increase of yield of approximately 0.1 t ha^{-1} which is in good accordance with our previous results obtained (Nachit *et al.* An. Rep. 1996). Those results suggest that more efficient way for improving adaptation of durum to terminal high temperature is probably by selecting for both earliness and higher tolerance of photosynthetic membrane.

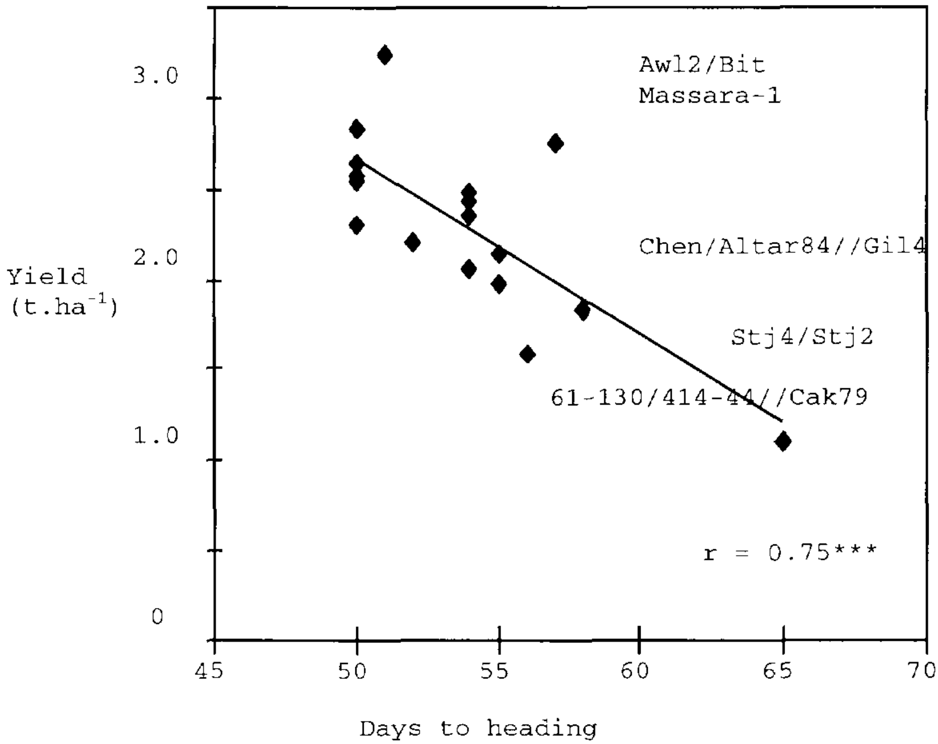

Figure 3.1. Relationship between earliness and yield under field conditions

Six lines derived from the cross Korifla x *T. dicoccoides* 600808 covered a consistent range of Tc values (from 44.1 to 46.1 °C), but with all Tc values being superior to those of most the durum wheat genotypes (Table 3.5). The average heat tolerance of these lines is likely to be related to the high tolerance of the photosynthetic membranes to high temperatures registered in *T. dicoccoides* 600808. This result suggests that this wild wheat accession could be of particular interest in enhancing heat tolerance in durum wheat. The same accession has also proved to have a high osmotic adjustment capacity and then to be potentially useful in breeding programs for drought tolerance.

Table 3.5. Critical temperature among various *T. durum* wheat and *T. durum* x *T.dicoccoides* lines (means with the same letter are not significantly different, P=0.05)

Genotype	Tc (°C)
T. durum Korifla x *T.dicoccoides* 600808 line n°12	*46.1(a)*
T. durum Korifla x *T.dicoccoides* 600808 line n°7	*45.3(ab)*
T. durum cv. Mexicali	*44.5(abcd)*
T. durum Korifla x *T.dicoccoides* 600808 line n°1	*44.5(abcd)*
T. durum cv. Hedba3	*44.4(abcd)*
T. durum Korifla x *T.dicoccoides* 600808 line n°4	*44.3(abcd)*
T. durum Korifla x *T.dicoccoides* 600808 line n°16	*44.2(abcde)*
T. durum Korifla x *T.dicoccoides* 600808 line n°1	*44.1(abcde)*
T. durum cv. Chen's Altar	*43.5(abcde)*
T. durum cv. Waha	*42.6(cde)*
T. durum cv. Uveyik	*42.4(de)*

Developed Genotypes with resistance to diseases, insects, and viruses:

In 1999 season durum genotypes combining resistance to rusts with septoria tritici resistance. Some of these genotypes carry resistance from the wild relatives. For the BYDV, Hessian fly, and Russian wheat aphid, the resistance was introgressed to high yielding genotypes. These genotypes are used as parental material for hybridization. Promising genotypes are shared with national programs for use in breeding programs or advanced for large scale testing in farmers fields. Seed multiplication is also made for these promising genotypes to NARS and farmers seed requests. The genotypes with incorporated resistance are as follows:

a) With resistance to yellow, leaf, an stem rust; and septoria tritici

Outrob4
Bcr/3/Ch1//Gta/Stk/4/Bcr/Lks4
Ossl1/Stj5
Outrob-1

Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr
Outrob-2
Bcrch-1
Bcr/Sbl5//Ae.peregrinacylindros 401047
Heca-1/3/Gdfl/T.dic20013//Bcr
D68-1-93A-1A//Ruff/Fg/3/Mtl-5/4/Lahn
Gnt/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5
HFN94N37/Mrb5/3/Brch/T.dic 20017//Hcn

b) With BYDV resistance

Ruff/Fg//Turk1/3/Mgr1
Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr
Waha
Ruff/Fg//Turk1/3/Gil3
Bcr//Badri/Sapi/5/Khb1/4/Rabi/3/Gs/AA//Plc
Mrb3/4/BYE*2/TC//ZB/W/3/Cit/5/Ru/Pelissier

c) With Hessian fly resistance

CM829
Telset
Bezaiz

d) With Russian wheat aphid resistance

Haucan/Aeg.400020//Mtl1/3/Mla3
Terbol97-2
Altar 84/Stn/Wdz-2

Developed Genotypes with good Grain quality

Several advanced genotypes (Table 3.6) were developed with values for gluten strength (SDS and SDSN), protein content (%), and vitreousness (low yellow berry). The genetic background of these genotypes is diverse and originate from crosses with durum landraces and improved germplasm and bread wheat. Progress is also made in improving the baking quality parameters.

To develop durum germplasm with specific traits for the environments of Morocco, Algeria, and Tunisia, in addition to the resistance to the above-mentioned abiotic and biotic stresses, segregating populations (7000) and yield trials (10) were grown in Marchouch station. In addition, 250 advanced lines and 150 segregating populations are grown in Sidi Elaidi, Douyet, J. Shaim. Tessaout, Tiaret, Constantine, Setif, Beja, and Elkef. Out of this, several populations and lines were selected and advanced for further testing in 1999/ 2000 season. The selected populations and advanced lines carry resistance to Hessian fly and root rots

Table 3.6. Durum genotypes combining high quality parameters, particularly for gluten strength and high protein content were developed

Genotype	SDS	SDSN	Protein content	TKW	Vitreousness
Ruff/Fg//Turk1/3/Brch	55	9.0	16.3	34.6	99
Ruff/Fg//Turk1/3/Stj6	51	7.9	15.6	37.9	99
Stj3/4/Stn//Hui/Somo/3/Yav/Fg//Roh	45	7.4	16.5	31.3	100
Kyp1/Mrf-1//Dra2/Bcr	48	7.9	16.4	27.1	100
Gbch-1//Stj/Mrb3	47	7.2	15.4	33.3	98
HFN94N8/Mrb5//Zna-1	47	7.1	15.1	27.7	100

3.4. Training

Part of the training and supervision of degree-training theses, was conducted within this activity. 3 Ph. D students: 1 Algerians and 2 Moroccans.

1) Mapping durum quality in durum. This work is conducted to map the quality traits in several mapping population. The traits are measured in different agro-ecological zones and the mapping is made at CIMMYT/ICARDA durum breeding program in collaboration with the Tuscia University. Ms. I. Elouafi, Morocco, is associated with this work and she is preparing her Ph. D thesis on this subject
2) Relationship of Stress tolerance and AFLPs markers. This work is conducted to associate the stress physiology traits in the durum population Zenati BouteillexWaha. The traitsls are measured in contrasting environments. This work is conducted in collaboration with the Constantine University, Algeria. Ms. A. Bamoun, Algeria, is associated with this work and she is preparing her Ph. D thesis on this subject
3) Quality parameters of durum for Moroccan durum bread is studied in collaboration with the Agronomy and Veterinary Institue of Rabat. Mr. M. Boujnah, Morocco, is associated with this work and she is preparing her Ph. D thesis on this subject

3.5. Testing in Farmers Fields

The effect of rotation on durum quality has shown that yield and quality parameters, particularly protein content and sedimentation test were improved significantly.These preliminary data shows clearly the advantage of introducing a legume species in rotation with wheat in the favorable and semi-arid areas. This will allow the improvement of both grain yield and quality parameters over the most predominant practice of wheat after wheat. This rotation can additionally lessen the pest incidence and severity. These results will not be apparent if this type of trials are conducted in the experiment stations known for their high nitrogen and phosphorous contents. Such trials will be conducted more in the future to analyze the effects of rotation, fertilization and other agronomic practices on quality parameters, including protein types.

3.6. Breeding for Biotic Stress Resistance

The breeding for resistance to septoria tritici resistance continues to be a challenging task. Although it is a disease of the favorable environment, the CIMMYT/ICARDA durum dryland breeding program has given it high priority, as it is endemic also during the favorable seasons in the dry areas of the Mediterranean region. Further, intensive wheat growing in these regions and supplementary irrigation have increased its occurrence. The newly bred lines show important progress made in resistance to septoria tritici in the program (Table 3.7). The lines show resistance average score below The sources of resistance are of wide genetic base background.

Table 3.7. Newly bred lines with broad resistance to *Septoria tritici*

PDYT-Nr.	Average	Range
306	4	3-5
624	3	2-5
803	3	1-4
812	4	2-5
908	3	2-5

Although leaf rust is the most important disease of durum irrigated and favorable conditions, in the favorable in dry areas can also attack durum and affect yield negatively. As all commercial cultivars available in farmers field are susceptible to leaf, the joint dryland durum program took the initiative to incorporate leaf resistance to the drought tolerant improved genotypes. These resistance should combined with dryland diseases, such as yellow rust.

Because of the fluctuating environmental conditions, particularly in relation to rainfall and temperature, biotic stresses such as rusts and septoria tritici their occurrence/attack can vary from season to season depending on the climatic conditions. Therefore, resistance to multiple disease resistance strategy is adopted in the breeding to cope with this frequent occurring event. Furthermore, the output of this approach improves also the yield stability under these variable conditions. The lines showing resistance with multiple disease (Table 3.8, 3.9) have also different genetic background, which will permit further the pyramiding of these resistance genes, in order to produce genotypes with larger sources of resistance and possibly genotypes-candidates for durable resistance.

Table 3.8. Combining resistance leaf rust with other diseases for the Mediterranean dryland

ADYT9 9-Nr	Name/ Cross	Leaf rust	Yellow rust	Stem rust^	Septoria tritici	Common bunt
103	Otb4	R-MR	R-MR	R	R-MR	MR
210	Ossl1/Stj5	R-MR	R-MR	R	MR	MR-MS
505	Otb-1	1MR	R	MR	R-MR	MS
509	Terbol97-2	MR	R-MR	MR	MR	MR-MS
615	Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr	5-MR	R	5-MR	MR	MR-MS
713	Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr	10-MR	R-MR	10-MR	MR	MR
809	Ossl-1/Gdfl	R	R-MR	R	MR	MR
813	Otb-6	MR	R-MR	10-M	MR	MR

Table 3.9. Newly bred lines with resistance to Multiple diseaes (rusts+*Septoria tritici*)

PDYT-Nr	Yellow ruwt	Leaf rust	Stem rust	Septoria tritici
403	R	MR	R	MR-MS
420	R	R	MR	MR-MS
606	R	MR	MR	MR-MS
720	MR	MR	MR-R	MR
721	MR	R	MR-R	MR-MS
801	R	R	MR	MR-MS
815	R	R	MR-R	MR

3.7. Cereal Viruses

3.7.1. BYDV Resistance in Wheat x *Thynopyrum ponticum* Derived Lines

A total of 3705 seeds obtained from 140 mature wheat plants regenerated from the callus obtained from culturing immature embryos of a number of wheat x *Thynopyrum ponticum* derived lines were planted in Giffy 7 pots, vernalized and then transplanted in the field. All plants were BYDV-inoculated at the seedling stage. Resistant individual plants were identified on the basis of no BYDV symptoms and no or low detectable virus by using the TBIA. Seeds from the best performing lines were harvested, and cytological studies are in progress to see whether or not the BYDV resistance genes, assumed to be located on one of the two telocentric chromosomes, have been introgressed into the 42 wheat chromosomes.

3.7.2. Screening Cereal Breeding Lines For Their Reaction to Barley Yellow Dwarf Virus (BYDV)

Cereal breeding lines are evaluated for their reaction to BYDV at three stages. During the first year, the breeding lines are evaluated in 30-cm short rows, which permits the evaluation of large number of entries. During the second year, the entries that showed during the 1st year tolerance to infection based on symptoms produced, are planted in 1 m rows and the lines are evaluated on the basis of diseases index, biomass and grain weight and height. During the third year, only good performing lines form the second year are planted in 4x1m plots, which permit the evaluation of grain yield loss due to BYDV infection by comparing infected plots to the healthy ones. From previous experience in cereal crops, yield loss evaluation was found to be the most reliable factor in determining resistance to BYDV infection.

3.8 Durum Wheat

3.8.1. Evaluation in Short Rows

The preliminary evaluation of 211 durum wheat lines from different nurseries indicated that some of these lines, based on the severity of BYDV symptoms produced, can be defined as tolerant to infection (Table 3.10). Some of these lines in addition to BYDV resistance, has resistance to either Russian wheat aphid or wheat stem sawfly.

Table 3.10. Preliminary evaluation of durum wheat genotypes in short 30 cm rows for their reaction to BYDV infection after artificial inoculation with the virus during the 1998/1999 growing season

Nursery [a]	Number of Lines tested	Lines with tolerance to infection [b]
DKL- 1999	180	2, 13, 51, 53, 59, 62, 63, 76, 84, 96, 99, 101, 103, 106, 112, 114, 117, 118, 119, 121, 125, 127, 130, 135, 137, 141, 146, 147, 158, 161, 163, 166, 175, 179
RWA	11	1, 10
WSSF	20	2, 3, 4, 5, 6, 7, 8, 10, 11

[a] DKL=Durum Wheat Key Location Disease Nursery, RWA=Russian Wheat Aphid Nursery, WSSF= Wheat Stem Sawfly Nursery.
[b] Evaluation was based on the severity of symptoms produced.

3.8.2. Evaluation in 1-m Rows

The re-evaluation of selected durum wheat liens from the previous season indicated that some lines such as DKL-98-2, DKL-98-6, DKL-98-10 and DKL-98-17 were tolerant to BYDV infection on the basis of disease index and grain and biomass weight (Table 3.11). These lines will be further evaluated during the next growing season.

3.8.3. Evaluation in Small Plots

The evaluation of best performing lines of different nurseries from previous season in small plots, which permits yield loss determination in response to BYDV infection, showed that some lines such as Wana-97-27, DKL-97-65, DKL-97-151, DCC-97-71, DKL-98-10 and 12th-IDS-227 were tolerant to infection (Table 3.12). However, yield loss due to BYDV infection in these lines varied from 0% (DKL-98-10) to 34% (Wana-97-27).

Table 3.11. Performance of durum wheat lines selected on the basis of previous seasons preliminary evaluation in short rows, planted during the 1998-1999 growing season in 1 m rows, and showed tolerance to BYDV infection after artificial inoculation with the virus

Entry	D.I. (0-9)	Biom. (g/m)	Gr.wt. (g/m)	Plant H. (cm)
DKL-98-2	5	400	165	90
DKL-98-6	6	445	174	90
DKL-98-10	5	585	213	95
DKL-98-17	5	475	141	100
DKL-98-23	6	350	98	95
DKL-98-67	6.5	275	101	90
DKL-98-83	6	270	100	85
DKL-98-161	5	310	111	80
DKL-98-163	6	310	100	90
DKL-98-178	6	360	119	85
DKL-98-186	6	410	132	85
DKL-98-198	6	385	109	115
DKL-98-119	8	220	52	85

DKL=Durum Wheat Key Location Disease Nursery.

Table 3.12. Best performing durum wheat lines from previous seasons planted in 4×1 m plots during the 1998-99 growing season and evaluated for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, biomass and grain weight, and grain yield loss(%)

Entry	D.I.	Biom.	G.WT.	P.H.	Yield loss %
Wana-97-19	6	405	109	90	39
Wana-97-21	5	425	92	100	65
Wana-97-27	5.5	500	156	105	34
Wana-97-48	6	345	129	100	45
DKL-97-34	6	380	117	95	30
DKL-97-65	6	430	158	98	15
DKL-97-151	5	400	133	103	26
DCC-97-16	7	320	116	85	8
DCC-97-68	5	400	139	93	30
DCC-97-71	5	330	136	88	8
DCC-97-73	6	310	121	83	26
DCC-97-85	6	425	114	85	15
DCC-97-120	6	265	106	78	30
DKL-93-156	6	275	103	93	16
DOT-96-73	7	265	98	85	7
DKL-98-10	6	280	110	80	0
DKL-98-182	6.5	275	106	93	15
DKL-98-198	5.5	345	93	113	9
12th-IDSN-74	6	290	113	78	6
12th-IDSN-227	6	315	105	105	2

Wana=Wanaddin Durum Observation Nursery, DCC: Durum Core Collection, DKL=Durum Wheat Key Location Disease Nursery.

4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

The spring bread wheat improvement program at ICARDA is a joint collaborative project between CIMMYT and ICARDA. The CIMMYT/ICARDA spring bread wheat improvement program emphasizes research for the dry areas of West Asia and North Africa (WANA) Region, while CIMMYT-Mexico concentrates in developing germplasm and technologies for the more optimum environments (the irrigated and high rainfall areas) of the region. Improvement of winter and facultative bread wheat, grown in the high elevation and lowland areas with severe cold winters is handled through the joint TURKEY/CIMMYT/ICARDA program based in Ankara-Turkey.

In this report wheat production in West Asia and North Africa (WANA) Region is discussed and some of the results of spring bread wheat breeding, pathology, virology, entomology and biotechnology research are presented. Changes in the program methodology are highlighted and future research thrusts are outlined.

(Osman S. Abdalla)

4.1.2. Wheat Production in West Asia and North Africa (WANA) Region

In WANA, bread wheat is the principal food source for the majority of the population, which on average consumes more than 185 kg/capita/year, the highest per capita consumption in the world. Thus bread wheat is considered a strategic crop in WANA region due to its important role in the diet and the economy of the region. However, productivity and total wheat production in WANA is generally low and does not meet the increasing demand for wheat. Many countries in the region are substantial net importers of bread wheat, even in the best production seasons (Table 4.1). This trend is expected to continue on the rise based on the observed on-going increase in urbanization and particularly so if current high rate of population growth continued.

Thus the main goal of CIMMYT/ICARDA joint spring bread wheat improvement program is to enhance food security through achieving sustainable improvement in spring bread wheat productivity, yield stability and end-use quality in the rain-fed, low-rainfall areas, of West Asia and North Africa (WANA) region. In achieving this goal, the project aims at supporting resource-poor farmers in WANA region and protecting the environment. A prerequisite to the success of this project is close collaboration and partnership with NARS in WANA as well as collaboration with advance research institutes with similar objectives.

Table 4.1. Wheat Production in Selected Countries in WANA

Country	Area Harvested (Ha)	Production (Mt)	Yield (Kg/Ha)	Imports- (Mt)	Export (Mt)	Self Sufficiency
Morocco	2399510	3307523	1208	2077079	1291	61%
Algeria	1646290	1541073	903	2867875	4	35%
Tunisia	875749	1259427	1397	981449	237	56%
Libya	45514	65096	1541	420772	0	13%
Egypt	961957	5238496	5423	5809376	6	47%
Syria	1525310	3268351	2142	466119	190273	87%

Source: FAO Statistics, 1990-99

4.1.3. Breeding Methodology

The breeding methodology followed in CIMMYT/ICARDA joint spring bread wheat improvement program for WANA continues to emphasize the following:

I) Targeted crossing program to combine desired traits associated with productivity and yield stability in the different agro-ecological zones in WANA.

II) Multilocation testing to expose the germplasm to the prevailing biotic and abiotic stresses in the region.

III) Decentralization of selective research activities to NARS based on comparative advantage (e.g. Hessian fly research to INRA-Morocco).

Since 1998 crop season, the spring bread wheat program for WANA region has been under going restructuring and reorganization to clearly reflect targeted environments and germplasm adaptation. Based on moisture availability the germplasm is targeted to Low Rainfall (LR) environments (250-350 mm annual rainfall) or Moderate Rainfall (MR) environments (>350 and <600 mm annual rainfall). Within moisture regimes, based on adaptation to temperature stress, the germplasm is targeted to Continental (CA) areas or Sub-continental (SC) areas. Eventually the germplasm classification will reflect adaptation to (a) WANA Continental LR and MR areas (e.g. *West Asia*: T. Hadya-

Syria) and (b) WANA Sub-continental LR and MR areas (e.g. North Africa: Settat-Morocco).

The Continental areas germplasm is meant for non-irrigated Mediterranean continental drylands (annual rainfall 250-400 mm) with fluctuating rainfall pattern and cold winters where cold damage can occur around tillering and/or anthesis. Germplasm targeted to such areas combine drought tolerance, cold tolerance, high yield potential and yield stability. The major biotic stresses in such areas include yellow rust, common bunt and wheat stem sawfly.

The subcontinental areas germplasm is targeted to Mediterranean temperate drylands (annual rainfall 250-500 mm) with fluctuating rainfall pattern and mild winters. Germplasm targeted to such areas combine drought and heat tolerance with high yield potential. The major biotic stresses in those areas include leaf rust, Septoria blotch, tan spot, barley yellow dwarf virus (BYDV) and Hessian fly.

The crossing program of 1998/99 season reflected the new emphasis in the program where research on dry areas of WANA is prioritized. (Table 4.2) shows that 59% of the crosses made were targeted to low rainfall areas and 41% were directed to moderate rainfall areas.

(O. Abdalla, A. Yaljarouka and M. El Karim)

Table 4.2. Frequency Distribution of Dryland Crosses, CIMMYT/ICARDA, 1998/99.

A) Low Rainfall Areas (LRA)	No. of Crosses	% LRA	% Total DL* Crosses
Drought+Cold Tolerance	138	39%	
Drought+Insect Resistance (HF, WSS&RWA)	131	37	
Drought+Yellow Rust+Septoria Resistance	67	19%	
Drought+Quality	18	5%	
Total Low Rainfall Areas	354	100%	59%
Moderate Rainfall Areas (MRA)	No. of Crosses	% MRA	% Total DL* Crosses
Drought+Rusts&Septoria Resistance	123	49%	
Drought+Heat Tolerance	107	43%	
Drought+Quality	21	8%	
Total Moderate Rainfall Areas (MRA)	251	100%	41%
Total Dryland (LRA+MRA)	605		100%

4.1.4. Improvement of End-Use Quality

In WANA, bread wheat is the principal food source for the majority of the population. Various types of bread, ranging from flat bread to leavened bread, and local baked products are made at the different regions in WANA. Such products vary in their quality requirements. Generally bread-making quality of wheat flour is largely a function of its gluten protein composition.

Responding to increased demand, by NARS, for improved-quality wheat germplasm recently more efforts are being made to address wheat quality issues. Currently quality screening is carried out at late stages (International Nurseries) in the breeding program. Efforts are under way to screen for quality at early stages to avoid that inferior quality germplasm reaches the International Nurseries. In addition, the frequency of crosses with good quality parents will be increased. In (Table 4.3) lines with good bread-making quality attributes are listed.

4.1.5. Results of Advance Yield Trials

In 1998/99 season a total of 5 trials each of Advance Wheat Yield Trial-Moderate Rainfall Areas (AWYT-MR) and Advance Wheat Yield Trial-Low Rainfall Areas (AWYT-LR) were conducted at ICARDA main research stations at Tel Hadya, Breda and Terbol. The objective of these trials was to identify superior lines for Regional Wheat Observation Nursery (WON) that will be to be distributed to NARS in WANA region. Based on long-term weather data theses test stations represent a gradient in moisture and temperature stresses. Breda represents continental areas with sever drought and cold stress, Tel Hadya is moderately dry and cold, while Terbol represents moderate/high rainfall areas and cool temperature. However, the weather in 1998/99 season was abnormal and all research stations received below average rainfall and thus the season provided an excellent opportunity for identifying drought tolerant lines. To identify lines adapted to moderate rainfall (MR) areas, supplemental irrigation (40 mm) was applied before heading at Tel Hadya, ICARDA main research station.

Table 4.3. Quality attributes of good bread-making lines identified from 1997/98 regional observation

Nursery/Entry	Name/Pedigree	Grain Color	Grain Hardness	TKW g	Protein %	FAB %	FDT Min	FST Min	FMT BU
WON-SA, 1997/98									
56	OPATA/BOW//BAU/3/OPATA/BOW	W	M	39.6	11.9	62.5	4.6	6.8	90.0
68	NAI60/HN7//SX/3/F134-71/CROW'S'	R	M	33.0	12.5	61.5	5.5	7.4	60.0
77	W3918A/JUP/3/NAI60/HN7//SX	W	S	30.9	13.4	61.0	5.0	6.5	60.0
159	RSK/5/…/6/BOW'S'*2/PRL'S'	W	M	34.2	12.5	61.0	4.8	6.6	50.0
WON-FA, 1997/98									
78	SHUHA'S'//VEE'S'/SNB'S'	W	M	37.4	13.8	63.5	5.7	6.0	60.0
129	KAUZ'S'//BOW'S'/CM64798.7H.3H	W	M/H	36.5	12.3	63.0	5.0	7.2	50.0
130	SHUHA'S'//TSI/VEE'S'	W	M	34.5	14.8	64.0	5.0	7.0	55.0
131	RSK/5/…/6/BOW'S'*2/PRL'S'	W	M	33.4	13.1	62.0	5.6	7.3	40.0
133	VEE#7//MT773/EMU'S'	W	M	33.7	13.6	62.5	5.0	5.5	95.0
GOOD QUALITY		W	M/H	>30.0	>11.0	<63.0	>3.0	>3.0	<100

Color: W=White; R=Red. Hardness: S=Soft; M=Medium; H=Hard.
TKW=Thousand Kernel Weight; FAB=Flour Absorption; FDT=Farinograph Development Time; FST=Farinograph Stability

(Tables 4.4 & 4.5) list some of the top yielding lines relative to the checks in Advance Wheat Yield Trials-Moderate Rainfall (AWYT-MR) and Advance Wheat Yield Trials-Low Rainfall (AWYT-LR), respectively. The checks used were "Cham-4" for AWYT-MR and "Cham-6" for AWYT-LR. Promising advance lines exhibited 5-42% yield superiority over "Cham-4" under moderate rainfall conditions, while under low rainfall conditions 6-17% yield advantage over "Cham-6" was observed.

(O. Abdalla, A. Yaljarouka, N. Rebeiz and M. Kraim)

Table 4.4. Promising lines from advance yield trial-AWYT-MR, 1998/99

Entry no.	Genotype	YLD (Kg/Ha)	YLD%Cham4
117	KAUZ'S'//BOW'S'/CMH64798.7H.3H	5497	142%
112	TEVEES'S'BOL'S'/PVN'S'	5070	132%
215	SHUHA'S'/4/NIF/SOTY//NAD63/CHRIS	5508	138%
310	TRACHA'S'//CMH76-252/PVN'S'	5038	142%
121	TUI'S'//CMH76-252/PVN'S'	5735	105%
406	VEE'S'/GH'S'//STAR	5480	114%
602	BLOYKA'S'/KAUZ'S'	5298	110%

Table 4.5. Promosing lines from advance yield trial-AWYT-MR, 1998/99

Entry no.	Genotype	YLD (Kg/Ha)	YLD%Cham4
217	SHUHA'S'/4/NIF/SOTY//NAD63/CHRIS	2738	117
223	SHUHA'S'3/RMN F12-71/SKA//CA8055	2467	106
322	TRACHA'S'//CMH76-252/PVN'S'	2819	106
321	CHAM6/GRU90-202580	2829	107
406	TEVEE'S'/KARAWAN'S'	3083	117
423	TUI'S'//KASYON/GENARO81	2970	113
418	GOMAM/GRU90-205266	2838	108
602	KAUZ*//K134(60)/VEE	2685	106

4.1.6. Yield Stability and Adaptation of Spring Bread Wheat in the Mediterranean Dryland

The international nurseries play an important role in germplasm dissemination as well as generation of information about germplasm adaptation from multilocation international

testing. Such information is critical in planning future crosses and eventually determines up-coming germplasm. It generally takes about two years to compile data from multilocation international testing. In such activity NARS collaboration cannot be under estimated.
Here we briefly present results of 1997/98 multilocation international yield trials testing with special emphasis on yield stability and germplasm adaptation.

4.1.6.1. Regional Wheat Observation Nurseries for Favorable and Semi-arid Areas

Regional Wheat Observation Nursery for Favorable Areas (WON-FA) and Semi-arid Areas (WON-SA) were send out for evaluation in more than 30 locations each during 1997/98 season. However, only 14 and 15 cooperators reported data in time to be included in this report for WON-FA and WON-SA, respectively.

Yield and selection frequency of the most promising lines identified by NARS cooperators from WON-FA-98 and WON-SA-98 is presented in (Table 4.6 & Table 4.7), respectively. Since yield is reported from unreplicated plots, extreme caution should be taken in considering this data. However, high frequency of selection across sites is the best indication of the adaptation of selected lines. Hence, these lines should be considered for further evaluation.

Table 4.6. List of WON-FA*, 1997/98, lines with the highest selection frequency across 14 locations in WANA

Nursery/Entry	Name/Pedigree	Selection Frequency	Mean Yield
WON-FA,1997/98		%	(Kg/Ha)
11	BOCRO-4	64	6324
21	TOWPE	50	4763
1	CASKOR	43	8573
5	MAYON/MTL'S'	43	8095
8	DOVIN-2	43	7644
148	TEVEE'S'/KAUZ'S'	43	7258
136	MAYON/3/TI/TOB//ALD'S'	43	5662
19	PREW	43	5426
62	NS732/HER//SHUHA'S'	43	4090
4	FKG#3/TRT'S'//VEE#9/3/COOK/VEE'S'//DOVE'S'/SERI	43	4051

WON-FA*=Regional Observation Nursery for Favorable Areas

Table 4.7. List of WON-SA* 1997/98 lines with the highest frequency of selection across 15 Locations in WANA

Nursery/Entry	Name/Pedigree	Selection frequency	Mean yield
WON-SA,1997/98		%	(Kg/Ha)
6	DOVIN-2	47	6431
5	DOVIN-1	47	4637
84	W3918A/JUP//SHUHA'S'	40	8361
16	BOCRO-4	40	6550
37	MON'S'/ALD'S'//ALDAN'S'/IAS58	40	6373
49	MAYON//CROW'S'/VEE'S'	40	6112
38	KAUZ'S'/SERI	40	5885
169	BACANORA 86/3/NAI60/HN7//SX	40	4202
7	TOWPE	40	4058
106	CHAM4/4/FCT/3/GOV/AZ//MUS	40	3864
104	W3918A/JUP//SHUHA'S'	40	2543

WON-SA, 1997/98=Regional Wheat Observation Nursery for Semi-arid Areas

4.1.6.2. Regional Wheat Yield Trials for Favorable and Semi-arid Areas

The mean yield of the 3 top-yielding cultivars, expressed as a percentage of the local check yield, in each test site of 1998/99 Regional Bread Wheat Yield Trial for Favorable Areas (RWYT-FA) and Semi-arid Areas (RWYT-SA) is shown in (Figure 4.1) and Figure 4.2, respectively. Local check performance is indicative of site-specific adaptation. The range of observed yields in RWTY-FA was from 3208 kg/ha (Tel Hadya, Syria) to 8069 kg/ha (Terbol, Lebanon) and for RWYT-SA was from 491 kg/ha (Ismailia, Egypt) to 4629 kg/ha (Hassaka, Syria). In both yield trials, the 3 top-yielding cultivars derived from CIMMYT/ICARDA germplasm yielded more than the locally adapted checks across most test sites (Figures 4.1 & 4.2). In general, these results indicate that the spring bread wheat improvement program has been successful in providing NARS in WANA with high-yielding germplasm, adapted to their local environments and with potential for release as new varieties to enhance wheat production.

In (Figure 4.3), the yield response of cultivar #17 in RWYT-FA is regressed over site mean yield across 22 test sites of the Regional Bread Wheat Yield Trial for Favorable Areas (RWYT-FA). At most test sites, the yield of cultivar #17 was higher than the site mean yield. These results show that cultivar #17 (MON'S'/ALD's'//BOW'S') combines high yield and wide adaptation. Similarly, the superior performance of "FLORKWA-2" across most of the 19 test sites of RWYT-SA is an indication of its high yield and wide adaptation (Figure 4.4). Thus in addition to germplasm that exhibit high yield and specific adaptation, many lines in the germplasm provided by CIMMYT/ICARDA program express wide adaptation as well and as a consequence yield stability.

(O. Abdalla, A. Yaljarouka, B. Ocampo, M. El Karim and WANA NARS)

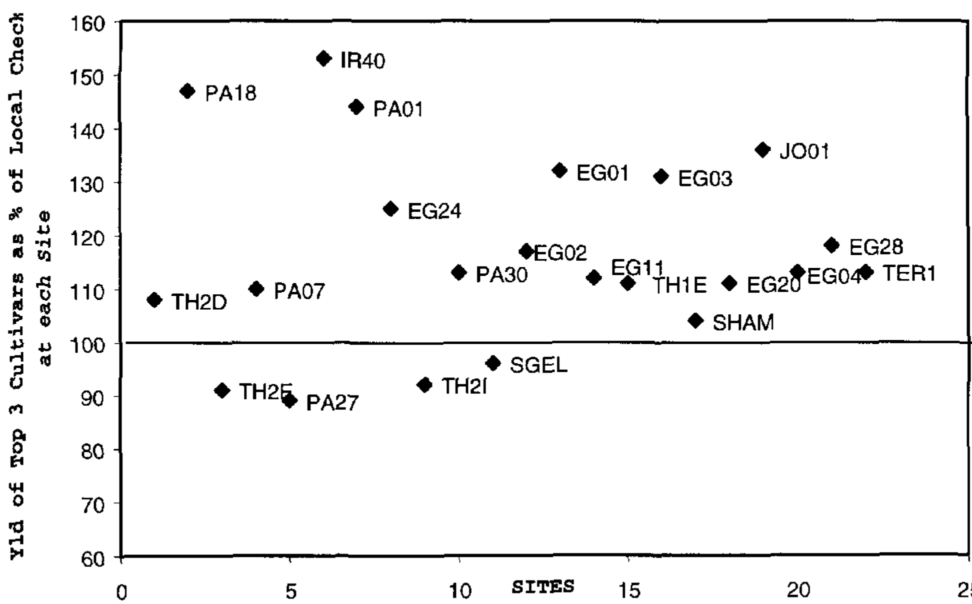

Figure 4.1 Yield Performance of Top-yielding 3 Test Cultivars at each Site Relative to the Local Check at 22 Sites in WANA, RWYT-FA98.

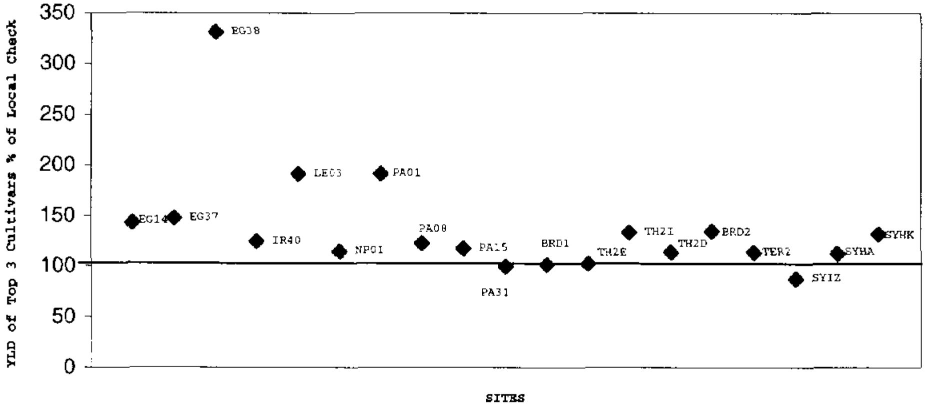

Figure 4.2 Yield of Top-yielding 3 Test Cultivars at each Site Relative to The Local Check in 19 Dryland Locations in WANA, RWYT-SA98.

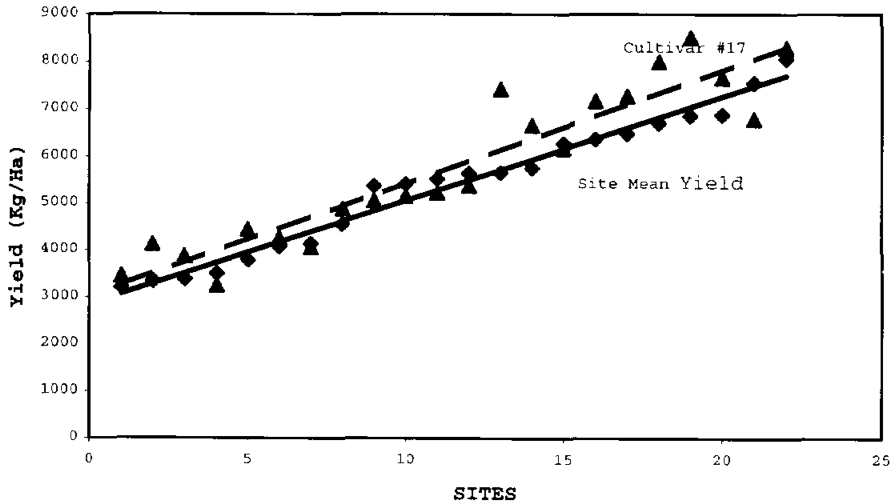

Figure 4.3 Yield Performance of "Cultivar #17" across 22 Locations in WANA, RWYT-FA98.

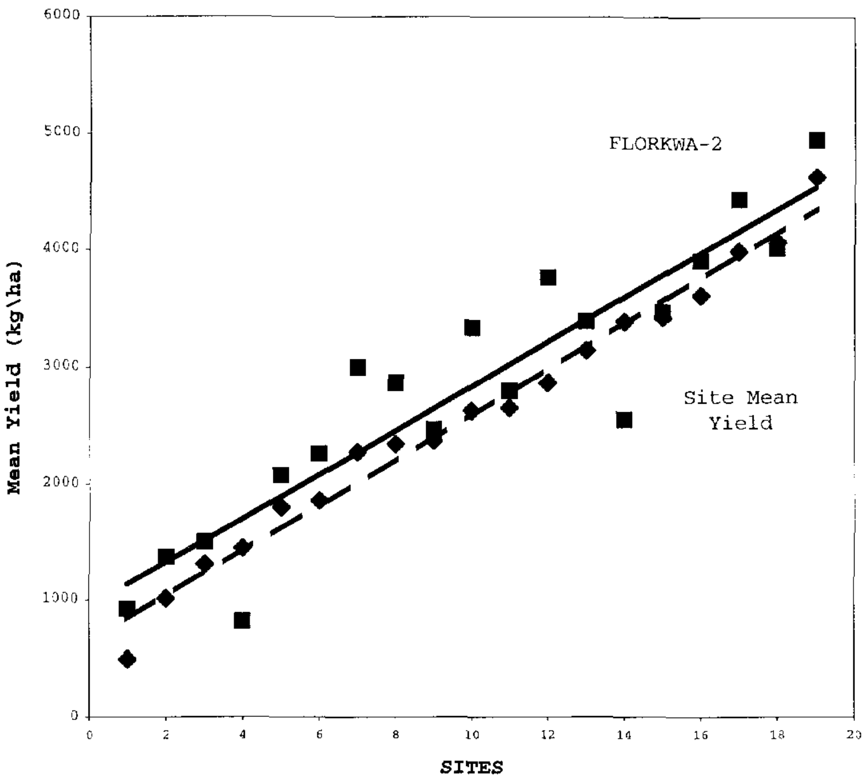

Figure 4.4 Yield Performance of "FLORKWA-2" across 19 Dryland Sites in WANA, RWYT-SA 1997/98.

4.1.7. Agricultural Technology Utilization and Transfer (ATUT) Project

This is a tripartite project involving FCI-ARC, Egypt, ARS-USDA, Beltsville-MD and CIMMYT/ICARDA joint wheat improvement program. The role of CIMMYT/ICARDA SBW program in collaboration with the Pathology and Biotechnology units at ICARDA is to produce Recombinant Inbred Lines (RIL) with and without stripe rust resistance from crosses involving long spike wheat from Egypt. Doubled haploid techniques are used in developing the RIL. The FCI-ARC, Egypt is expected to conduct field evaluation of the derived material while ARS-USDA is expected to develop micro-satellite markers for the major traits (yellow rust resistance, heat tolerance and high tillering capacity) of the derived populations.

Sources of yellow rust resistance were identified and crosses involving high tillering yellow rust resistant source and susceptible long spike wheat were made. Currently development of doubled haploids is under way and progress is reported under biotechnology section of this report.

4.2. Pathology

2.1. Screening for Resistance to Individual Diseases

Cereal rusts are the most prevalent bread wheat diseases in WANA region. The levels of resistance to yellow, leaf and stem rusts identified in breeding nurseries are shown in (Figure 4.5). High resistance levels to leaf rust were present in all the nurseries. Sources of resistance to leaf, yellow and stem rusts were identified among adapted bread wheat lines that also have acceptable agronomic traits. List of resistant lines is shown in (Tables 4.7, 4.8, 4.9, & 4.10). Leaf rust (Table 4.8) resistant lines could be tested in North Africa, those resistant to yellow rust (Table 4.9) would be adapted to western Asia region, and resistance to stem rust (Table 4.10) would be recommended for Nile Valley region.

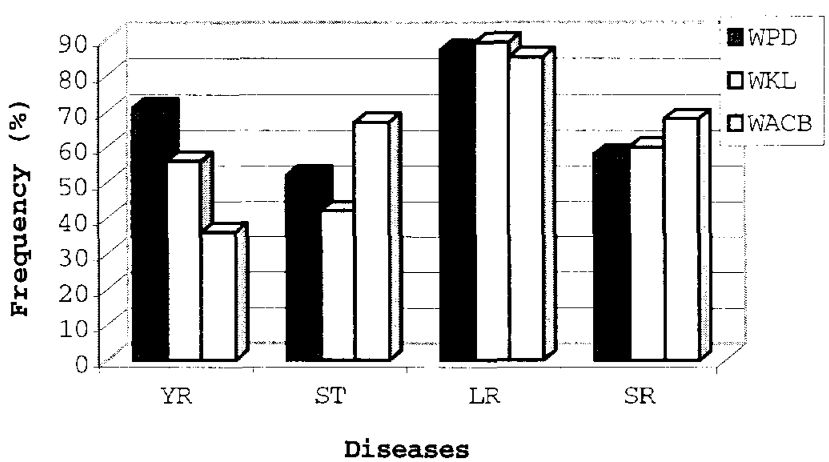

Figure 4. 5. Effective resistance in bread wheat to septoria and rusts

Resistance to septoria is very important for bread wheat lines targeted for exploitation by the NARS of North Africa. Twenty-two bread wheat lines (Table 4.10) were selected within the breeding nurseries.

Bread wheat lines listed in (Tables 4.8 to 4.9) are targeted to areas where the disease incidence is relatively high. High resistant lines will slow the development and spread of the disease. Hence, the exploitation of variable sources of resistance will ensure the durability of the varieties to be cultivated in a given region.

Table 4.8. Bread wheat lines resistant* to leaf rust (*Puccinia recondita*)

Plot	Name	Pedigree	Source	SN
1	Dovin-2	CM 84655-02AP-300AP-300L-3AP-300L-3AP-0L	WLR98	19
2	Dove'S'/Buc'S'//STAR'S'	ICW93-0168-4AP-0L-2AP-0L-0AP	WKL98	44
3	V-84021//Bol'S'/Pvn'S'	ICW92-0073-0AP-1AP-0L-2AP-0L-0AP	WKL98	61
4	GOV/AZ//MUS/3/DODO/4/BOW	CM 79515-044Y-1M-02Y-07M-3Y-3B-0Y-0PZ-2M	WKL98	82
5	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y	WKL98	101
6	Seri 82/SHUHA'S'	ICW91-0030-0Br-5AP-0TS-4AP-0L-1AP-0AP	WKL98	192
7	VEE/5/SKH8/4/RRV/WW15/3/BJ//ON*3/BON	ICW86 1034-300L-300AP-0L-5AP-0L-0AP	WKL98	219
8	Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-4AP-0AP	WPD98	3
9	Vee'S'/Nac//Kauz'S'	ICW93-0192-1AP-1AP-3AP-0AP	WPD98	79
10	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP	WPD98	93
11	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP	WPD98	97
12	Dove'S'/Buc'S'//Carp	ICW93-0170-2AP-0L-3AP-0L-1AP-0AP	WPD98	294
13	CHAM 4//Maya'S'/Sap'S'	ICW92-0545-0AP-4AP-0L-1AP-6AP-0AP	WPD98	317
14	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-3AP-0AP	WPD98	322
15	BOCRO-4		WAB98	12
16	Bocro-1	CM 67430-1AP-1AP-1AP-1AP-0AP	WAB98	30
17	NS732/Her	SWM 11179-2AP-3AP-1AP-1AP-0AP	WAB98	32
18	F//68.44/Nzt/3/Cuc'S'/4/Algeria.M 28	ICW89-0293-2AP-0AP-2AP-0TS-0AP	WAB98	35
19	Gv/Ald'S'/5/Ald'S'/4/Bb/G11//Cno67/7C/3/Kvz/Ti	ICW87-0092-0AP-2AP-0L-2AP-0L-0AP	WAB98	58

Resistant* lines have score of less than 30MR

Table 4.9. Bread wheat lines resistant* to yellow rust (*Puccinia striiformis fsp. Tritici*)

Plot	Name	Pedigree	Source	SN
1	4777//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Shi#4414/Crow'S'	ICW93-0089-1AP-0L-4AP-0L-0AP	WYR98	37
2	4777//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Shi#4414/Crow'S'	ICW93-0089-3AP-0L-2AP-0L-0AP	WYR98	38
3	4777//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Vee'S'/Snb'S'	ICW93-0096-1AP-0L-4AP-0L-0AP	WYR98	41
4	Tr380-16-3A614/Chat'S'//Cmh76-252/Pvn'S'	ICW93-0065-8AP-0L-1AP-0L-0AP	WKL98	41
5	Bow'S'/Crow'S'//BAU'S'	ICW91-0682-4AP-0AP-1AP-1AP-0AP	WKL98	135
6	Seri 82//Shi#4414/Crow'S'	ICW91-0030-0Br-5AP-0TS-4AP-0L-1AP-0AP	WKL98	192
7	Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-4AP-0AP	WPD98	3
8	4777(2)//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Tsi/Snb'S'	ICW92-0600-1AP-3AP-3AP-0AP	WPD98	54
9	Karawan_1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-1AP-2AP-0AP	WPD98	94
10	4777//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/MILLAWA	ICW93-0112-1AP-0L-4PH-0AP-0AP	WPD98	121
11	Dove'S'/Buc'S'//Carp	ICW93-0170-2AP-0L-2AP-0L-1AP-0AP	WPD98	292
12	Dove'S'/Buc'S'//Carp	ICW93-0170-2AP-0L-3AP-0L-2AP-0AP	WPD98	295
13	CHAM 4//Maya'S'/Sap'S'	ICW92-0545-0AP-4AP-0L-1AP-6AP-0AP	WPD98	317
14	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-3AP-0AP	WPD98	322
15	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-4AP-0AP	WPD98	323
16	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-1AP-1AP-0AP	WPD98	324
17	Tsi/Vee'S'//Bobwhite #1	ICW89-0273-4AP-0L-1AP-0AP-2AP-0TS-0AP	WAC98	39
18	Maya'S'/Sap'S'	CM59008-6AP-1AP-4AP-2AP-2AP-0AP	WAC98	40
19	Gv/Ald'S'/5/Ald'S'/4/Bb/G11//Cno67/7C/3/Kvz/Ti	ICW87-0092-0AP-2AP-0L-2AP-0L-0AP	WAC98	58

Resistant* lines have score of less than 30MR

Table 4.10. Bread wheat lines resistant* to stem rust (*Puccinia graminis fsp. Tritici*)

Plot	Name	Pedigree	Source	SN
1	4777//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Vee'S'/Snb'S'	ICW93-0096-1AP-0L-4AP-0L-0AP	WSR98	37
2	GOV/AZ//MUS/3/DODO/4/BOW	CM 79515-044Y-1M-02Y-07M-3Y-3B-0Y-0PZ-2M	WKL98	82
3	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y	WKL98	101
4	VEE/5/SKH8/4/RRV/WW15/3/BJ//ON*3/BON	ICW86 1034-300L-300AP-0L-5AP-0L-0AP	WKL98	219
5	Vee'S'/Nac//Kauz'S'	ICW93-0192-1AP-1AP-2AP-0AP	WPD98	78
6	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-1AP-1AP-0AP	WPD98	93
7	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-1AP-2AP-0AP	WPD98	94
8	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-3AP-1AP-0AP	WPD98	95
9	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-4AP-3AP-0AP	WPD98	96
10	Bloudan/3/Bb/7C*2//Y50E/Kal*3/4/Kauz	ICW92-0326-12AP-0L-3AP-0L-1AP-0AP	WPD98	249
11	Kasyon/Genaro.81//Nac/Vee'S'	ICW92-0284-4AP-0L-4AP-0L-1AP-0AP	WPD98	308
12	T.aest.Ast/SPRW'S'//CA8055/3/Gh'S'/Anza	ICW92-0486-0AP-0Br-6AP-0L-1AP-0AP	WPD98	316
13	CHAM 4//Maya'S'/Sap'S'	ICW92-0545-0AP-4AP-0L-1AP-6AP-0AP	WPD98	317
14	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-3AP-0AP	WPD98	322
15	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0AP	WPD98	325
16	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0AP	WPD98	326
17	NS732/Her	SWM 11179-2AP-3AP-1AP-1AP-0AP	WAB98	32
18	Skh8/4/Rrv/Wwi5/3/Bj'S'//On*2/Bon/5/Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow'	ICW88-0209-3AP-0L-5AP-0L-0AP	WAB98	36
19	Maya'S'/Sap'S'	CM59008-6AP-1AP-4AP-2AP-2AP-0AP	WAB98	40
20	Gv/Ald'S'/5/Ald'S'/4/Bb/G11//Cno67/7C/3/Kvz/Ti	ICW87-0092-0AP-2AP-0L-2AP-0L-0AP	WAB98	58
21	Hys//Drc*2/7C	SWM 72394-4H-1H-1P-S	WAB98	83

Resistant* lines have score of less 30MR

Table 4.11. Bread wheat lines resistant to Septoria (*Mycosphaerella graminicola*)

Plot	Name	Pedigree	Source	SN
1	Vee#7//Kasyon/Bow'S'	ICW93-0060-1AP-0L-1AP-0L-0AP	WST98	22
2	Bow'S'/Crow'S'//BAU'S'	ICW91-0682-4AP-0AP-1AP-1AP-0AP	WST98	23
3	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-2AP-0AP	WST98	28
5	NS732/Her//Ures/Bow'S'	ICW91-0255-0TS-10AP-0TS-1AP-0L-0BR-0AP	WST98	32
4	GOV/AZ//MUS/3/DODO/4/BOW	CM 79515-044Y-1M-02Y-07M-3Y-3B-0Y-0PZ-2M	WKL98	82
5	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y	WKL98	101
6	LIRA/SHA5	CP02645-11C-0Y-030M-7Y-2Y-0M	WKL98	214
7	Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-4AP-0AP	WPD98	3
8	Vee'S'/Nac//Kauz'S'	ICW93-0192-1AP-1AP-2AP-0AP	WPD98	78
9	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-1AP-1AP-0AP	WPD98	93
10	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-1AP-2AP-0AP	WPD98	94
11	Karawan-1/4/Nif/3/Soty//Nad63/Chris	ICW92-0609-1AP-3AP-1AP-0AP	WPD98	95
12	Kasyon/Genaro.81//Nac/Vee'S'	ICW92-0284-4AP-0L-4AP-0L-1AP-0AP	WPD98	308
13	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-2AP-0AP	WPD98	321
14	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-4AP-0AP	WPD98	323
15	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0AP	WPD98	326
16	Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-2AP-2AP-0AP	WPD98	327
17	KAUZ'S'//Bow'S'/Cm64798.7H.3H	ICW91-0313-0Br-6AP-1AP-1AP-1AP-0AP	WPD98	335
18	Hys//Drc*2/7C	SWM 72394-4H-1H-1P-S	WAB98	83

Resistant lines have score of less or equal ≥ 3,8

4.3. Virology

4.3.1. Screening Cereal Breeding Lines for their reaction to Barley Yellow Dwarf Virus (BYDV)

Cereal breeding lines are evaluated for their reaction to BYDV at three stages. During the first year, the breeding lines are evaluated in 30-cm short rows, which permits the evaluation of large number of entries. During the second year, the entries that showed tolerance to infection based on symptoms produced in the 1st year, are planted in 1 m rows and the lines are evaluated on the basis of diseases index, biomass and grain weight and height. During the third year, only good performing lines form the second year are planted in 4x1m plots, which permit the evaluation of grain yield loss due to BYDV infection by comparing infected plots to the healthy ones. From previous experience in cereal crops, yield loss evaluation was found to be the most reliable factor in determining resistance to BYDV infection.

4.3.2. Spring Bread Wheat Evaluation in Short Rows

The preliminary evaluation of 174 spring bread wheat lines from different nurseries, and based on the severity of BYDV symptoms produced, indicated that some of them were tolerant to infection (Table 4.12). In addition to BYDV tolerance few lines were tolerant to Russian wheat aphid or wheat stem sawfly.

Table 4.12. Preliminary evaluation of spring bread wheat genotypes in short 30 cm rows for their reaction to BYDV infection after artificial inoculation with the virus during the 1998/1999 growing season.

Nursery[a]	Number of lines tested	Lines with tolerance to infection[b]
WKL-1999	140	1, 5, 9, 15, 22, 27, 29, 31, 32, 33, 42, 49, 54, 55, 57, 61, 65, 70, 73, 78, 81, 82, 85, 87, 96, 99, 106, 115, 119, 133
RWA	16	2, 16
WSSF	18	1, 2, 3, 16, 17

[a] WKL=Spring Bread Wheat Key Location Disease Nursery, RWA=Russian Wheat Aphid Nursery, WSSF=Wheat Stem Sawfly Nursery.

[b] Evaluation was based on the severity of symptoms produced.

4.3.3. Spring Bread Wheat Evaluation in 1 m Rows

The re-evaluation of selected spring bread wheat lines, from the previous season evaluation, indicted that some lines such as WKL-98-2, WKL-98-13, WKL98-21, WKL-98-234, WON-SA-98-1, WON-SA-98-8, WON-SA-98-10, WON-SA-98-137 and WON-FA-98-112 were tolerant to BYDV infection on the basis of disease index, biomass and grain weight (Table 4.13). These lines will be further evaluated during the next growing season.

Table 4.13. Performance of wheat lines, selected on the basis of previous seasons preliminary evaluation in short rows, planted during the 1998-1999 growing season in 1 m rows, and showed tolerance to BYDV infection after artificial inoculation with the virus

Entry	D.I. (0-9)	Biom. (g/m)	Gr.wt. (g/m)	Plant H. (cm)
WKL-98-2	6	440	142	100
WKL-98-13	6	390	143	85
WKL-98-18	5	305	109	85
WKL-98-21	4	445	153	85
WKL-98-30	5	335	128	85
WKL-98-63	6	405	138	95
WKL-98-144	5	280	107	90
WKL-98-165	6	335	113	100
WKL-98-177	6	320	117	95
WKL-98-179	7	325	111	85
WKL-98-185	6	325	117	80
WKL-98-212	7	300	115	85
WKL-98-217	6	320	130	80
WKL-98-228	6	390	135	95
WKL-98-234	5	450	153	80
WKL-98-206	7	225	68	90
WON-SA-98-1	4	455	179	85
WON-SA-98-8	5	435	188	90
WON-SA-98-10	5	490	179	90
WON-SA-98-15	5	415	161	95
WON-SA-98-20	6	415	167	85
WON-SA-98-41	6	450	164	85
WON-SA-98-47	6	465	190	90
WON-SA-98-62	6	450	174	95
WON-SA-98-81	5	435	156	95
WON-SA-98-137	5	655	197	100
WON-SA-98-157	6	385	175	75
WON-SA-98-165	6	485	186	90
WON-SA-98-176	6	450	187	85
WON-FA-98-55	6	330	124	80
WON-FA-98-79	6	380	130	85
WON-FA-98-99	6	385	135	85
WON-FA-98-106	6	350	127	85
WON-FA-98-112	6	600	193	105
WON-FA-98-123	6	455	159	100
WON-FA-98-130	6	410	134	85
WON-FA-98-138	5	490	166	100
WON-FA-98-140	6	385	142	95
WON-FA-98-144	6	445	172	90
WON-FA-98-146	7	340	136	95
WON-FA-98-81	8	195	66	80

WKL=Bread Wheat Key Location Disease Nursery, WON-SA=Wheat Observation Nursery Semi-arid Areas, WON-FA=Wheat Observation Nursery Favorable Areas.

4.3.4. Evaluation in small Plots

The evaluation of best performing lines, from the different spring bread wheat nurseries, in small plots of 4x1 m rows, showed that some lines such as PS-97-29, PS-97-38, WKL-97-178, WKL-97-186, WKL-98-234 and WON-FA-98-106, were tolerant to BYDV infection (Table 4.14). Tolerance to BYDV infection in the above lines was better than that of Maringa, a worldwide BYDV-resistant/tolerant variety.

4.4. Entomology

4.4.1. Hessian fly Resistance

Hessian fly is the most devastating insect pest of wheat in Morocco. Host plant resistance has been the most practical and economical means of controlling this pest. Ten resistance genes, *H5*, *H7H8*, *H11*, *H13*, *H14H15*, *H21*, *H22*, H23, H25 and H26 were identified as effective against Hessian fly in Morocco. Also, several other sources of resistance were found and are being characterized. The effective genes and the sources of resistance have been used in the bread wheat-breeding program to develop resistant varieties, and already three bread varieties have been released.

A nursery of 143 entries comprising crosses using the effective resistance genes and the sources of resistance with some Moroccan adapted bread varieties was evaluated in the field at the experimental station Marchouch. Each entry was planted in 2-m long rows in a randomized complete block design with 2 replications. The evaluation for resistance was made in April, and was based on symptoms; susceptible plants were stunted and dark green where as resistant plants were not stunted and retained their light green color.

133 lines showed good level of resistance. Most of these lines also had good agronomic characters. (Table 4.15) lists some of the lines that were identified to be resistant to Hessian fly in Morocco. These lines are being re-tested in this same location and other Hessian fly hot spot locations in Morocco for confirmation and selection for adaptation under local environmental conditions.

(O. Abdalla, S. Lhaloui (INRA, Morocco) and M. El Bouhssini)

Table 4.14. Best performing bread wheat lines from previous seasons planted in 4×1m plots during the 1998-99 growing season and evaluated for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, biomass and grain weight, and grain yield loss (%)

Entry	D.I.	Biom.	G.WT.	P.H.	Yield loss %
PS-97-19	4	265	81	100	11
PS-97-29	5	305	104	100	1
PS-97-38	6	305	104	88	0
WKL-96-30	6	310	104	85	15
WKL-97-3	5	325	101	88	6
WKL-97-151	6	305	107	88	8
WKL-97-169	5	325	107	100	7
WKL-97-178	5	385	150	88	1
WKL-97-186	4	460	146	115	6
WCB-96-9	5	360	113	88	27
WKL-98-228	5	305	96	93	0
WKL-98-234	6	340	127	88	0
Maringa	5	380	89	130	20
WON-FA-98-99	5.5	360	108	93	0
WON-FA-98-106	5	410	138	88	0
WON-FA-98-140	6	360	110	88	0
WON-SA-98-8	6	310	106	90	0
WON-SA-98-10	5	340	115	93	11
12^{th}-IBW-459	6.5	385	109	92.5	29

PS=Pest Series nursery, WKL=Bread Wheat Key Location Disease Nursery, WON-FA=Wheat Observation Nursery Favorable Areas, WON-SA=Wheat Observation Nursery Semi-arid Areas.

Table 4.15. List of lines representating families resistant to Hessian fly in Morocco

HFON*-99 Entry No.	Name/Pedigree	Cross No.
98	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233
120	TEVEE-1/SHUHA-6	ICW94-0103
76	TEVEE-1/KARAWAN-2	ICW94-0104
78	SHUHA-2//NS732/HER	ICW94-0233
89	PREW//NS732/HER	ICW94-0239
100	TRACHA-2//NS732/HER	ICW94-0262
104	CHILERO-4//NS732/HER	ICW94-0274
108	BOCRO-4/TEVEE-2	ICW94-0321
119	TEVEE-1/SD 8036	ICW96-0119
123	SD 8036/DORRAGE	ICW96-0220
124	SD 8036/MEMOF-22	ICW96-0222
125	NS732/HER//KAUZ	ICW96-0228

HFON=Hessian Fly Observation Nursery

5. FACULTATIVE AND WINTER BREAD WHEAT

5.1. Introduction

The winter and facultative wheat improvement activities were conducted as per plan, with the complementary contributions of the parties involved in the Turkey-CIMMYT-ICARDA partnership, and the close collaboration with the NARS in Iran. Joint work with CAC countries witnessed a boost as a result of specific resources allocated by the CGIAR to IARC's working with NARS in this region.

At the farm level, wheat production in rainfed areas was depressed enormously due to unfavorable climatic conditions that prevailed in the CWANA region, resulting in appreciable reductions of national wheat yield and total production, particularly in Iran and Turkey.

This reports summarizes the major results of work conducted within the framework of the joint partnership for winter and facultative wheat, with more details on ICARDA's input into this partnership, focusing on work conducted at ICARDA-Syria, Iran, and the CAC countries.

(H. Ketata)

5.2. Growing Conditions

The environmental conditions during the 1998-99 season were marked by mild winter and dry and hot spring and summer throughout the region. Rainfed wheat areas were particularly affected. In Turkey, The relatively warm winter (Table 5.1) was followed by high temperature in May, while rainfall throughout the country was very low in May and June. In contrast to last year, diseases were not important, but the drought and heat affected wheat growth and yield drastically, resulting in an underestimate of 20% reduction of national wheat production as compared to last season. Rainfed wheat fields with yield of around 1t/ha were common in the Central Anatolian Plateau.

At Tel Hadya, Syria, growing conditions were favorable up until April but rainfall was nil thereafter, and peak temperature was high, reaching 40° C in May (Table 5.1). With adequate sprinkler irrigation of disease screening fields at ICARDA, it was possible to maintain a good level of yellow rust infection in both the A and the C blocks, where locally produced and introduced germplasm are tested, respectively. In addition, the drought-cum-heat stress in May depressed grain yield, particularly in the rainfed field, where average yield was 2.8 t/ha versus 3.3 t/ha in the semi-irrigated field (30mm).

In Iran, winter temperature was above normal in most of the country (Table 5.1). Growing conditions of the rainfed winter wheat areas were the driest in three decades. In many areas, the final crop was 10-20 cm tall with no grain on the plants, which had to be grazed. Overall national wheat production suffered an estimated 25% reduction.

(H. Ketata)

5.3. Germplasm Development and Screening

Major breeding activities were conducted in Turkey, with complementary work in Syria. At ICARDA, crossing as well as testing for yellow rust, BYDV, Russian wheat aphid, cold tolerance under controlled conditions, and grain quality was carried out, as in the previous season. The terminal drought and heat that prevailed in May through June enabled an efficient screening for this frequent stress combination, using the rainfed versus the irrigated fields at Tel Hadya. (Table 5.2) lists the major facultative and winter wheat nurseries grown in Turkey and Syria, or distributed to requesting cooperators in the CWANA region. As in the previous season, the F1 and F2 populations are not similar in Turkey and Syria, and head rows are only grown in Turkey, because of limited amount of seed collected from individual spikes. Yellow rust infection was excellent at Tel Hadya, good at Haymana, and acceptable at Eskisehir. Leaf rust was taken on fixed materials grown at Adana and Edirne. Root rot occurred at Cumra, and offered an opportunity to discard seemingly susceptible entries from the PYT and the HR's. However, the high soil variability with respect to the appearance of this disease shed doubt on the effectiveness of this screening. Screening for root rot disease must include infected vs noninfected treatment on contiguous plots of the same entry. The most promising entries from the different yield trials are shown along with their important characteristics in (Tables 5.3 through 5.8). Although a larger number of entries were selected for more advanced testing in 2000, only those entries that did extremely well, both in Turkey and Syria, are reported. The introduced bias for the good performance in Syria stems from the repeated observation that the best entries in Syria are good performers in most of CAC countries, whereas the best materials in the Central Anatolian Plateau of Turkey tend to be late in the CAC.
It is therefore decided to pay attention to germplasm yield performance at Tel Hadya, more than was done in the past,

Table 5.1. Meteorological characteristics* for five testing sites, 1998-1999 season

	Konya, Turkey				Eskisehir, Turkey				Maragheh, Iran				Sararood, Iran				Tel Hadya, Syria			
Month	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	<0
Sep	32.2	5.8	6	0	32.7	4.0	22	0									43.1	11.6	0	0
Oct	31.4	-0.3	48	1	30.0	-1.0	34	1	26.0	0.0	1	0	30.6	1.0	1	0	34.6	6.0	2	0
Nov	20.4	-1.4	20	2	20.4	-5.8	47	6	19.0	-2.0	26	8	23.2	-1.8	35	10	28.2	4.4	39	0
Dec	13.3	-8.1	114	17	16.5	-7.4	30	12	18.0	-9.0	28	25	24.6	-6.0	2	12	19.0	-2.8	88	3
Jan	14.8	-9.1	21	24	14.6	-7.4	41	20	5.0	-11.5	37	29	13.2	-10.4	108	21	16.6	-3.0	40	8
Feb	14.2	-7.0	20	22	14.5	-14.8	79	18	11.5	-13.5	27	25	17.5	-8.6	71	21	20.0	-4.4	51	5
Mar	18.6	-8.4	22	17	18.8	-6.1	56	19	15.5	-7.0	27	26	22.0	-4.2	33	15	25.5	-0.5	62	1
Apr	25.5	-1.0	9	1	26.4	-2.2	41	5	23.0	-3.5	44	9	27.7	-2.0	26	6	33.9	2.5	25	0
May	31.0	2.2	15	0	31.0	-1.8	1	2	32.0	-3.5	8	2	37.2	1.8	12	0	40.0	6.7	0	0
Jun	32.9	9.6	20	0	32.8	6.2	22	0	32.0	7.0	0	0	38.0	8.0	0	0	38.8	13.2	0	0
Jul	37.5	12.0	7	0	37.3	9.7	11	0	35.0	9.5	6	0	41.2	10.6	14	0	41.4	18.4	0	0
Total			301	84			383	83			202	124			302	85			307	17

* Max and Min: absolute maximum and minimum temperature. Rnf: precipitation in mm. "<0": days with subzero temperature.

when selection was primarily for disease resistance. The results show a clear improvement of germplasm resistance to yellow rust. However, more work is needed for the improvement of leaf rust resistance, an important disease in some environments of the CAC countries.

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5.4. Genetic Stocks

The development of fixed genetic material with specific desirable attributes continues to take a primary position in the project objectives. Advanced Yield Trial (AYT99) entries were tested by the ICARDA scientists, under controlled conditions for the identification and confirmation of genetic resistance or tolerance to specific stresses.

5.4.1. Barley Yellow Dwarf Virus (BYDV)

Winter wheat breeding lines are evaluated for their reaction to BYDV at three stages. During the first year, they are screened under artificial infection in 30-cm short rows, thus enabling the preliminary testing of a large number of entries. Those lines that show tolerance, based on the symptoms produced, are retained for confirmative testing the following season, using 1-m row plots, and the assessment of disease index (0-9 scale), biomass and grain weight (yield) per plot (g), and plant height (cm). In the third year, the best performing entries of the second-year evaluation are planted in 4x1m plots, for the additional assessment of grain yield loss due to BYDV, by comparing infected versus non-infected plots of the same breeding line. From previous experience, yield loss assessment was found to be the most reliable method for determining plant resistance to BYDV.

Out of the 258 entries included in the Preliminary-BYDV testing, 37 entries were found to possess tolerance to BYDV. This includes 14 from AYT99RF, 21 from AYT99IR, and 2 from the entomology project (THD95-49: resistant to Russian wheat aphid, and DARI-8-HK, resistant to wheat stem sawfly). Some of the AYT99 entries were also selected by the breeders for other desirable traits, including high grain yield and yellow rust resistance, e.g. entries 9086, 9111, 9551, 9564, and 9593.

Table 5.2. Type and size of TCI* facultative and winter wheat nurseries, 1999

Nursery	No. Entries	Test sites in
F1	1810	Syria, Turkey
Segregating Populations		
F2	1714	Syria, Turkey
F3	1327	Syria, Turkey
F4, F5, F6,…Head rows (HR)	30,000	Turkey
Preliminary Yield Trials (1 rep):		
For irrigated or high rainfall conditions (PYT99IR)	1510	Syria, Turkey
For rainfed, moisture-limited conditions (PYT99RF)	1040	Syria, Turkey
Intermediate Yield Trials (2 reps):		
For irrigated or high rainfall conditions (YT99IR)	275	Syria, Turkey
For rainfed, moisture-limited conditions (YT99RF)	150	Syria, Turkey
Advanced Yield Trials (3 reps):		
For irrigated or high rainfall conditions (AYT99IR)	150	Syria, Turkey
For rainfed, moisture-limited conditions (AYT99RF)	100	Syria, Turkey
International Nurseries/Trials:		
Second Winter Wheat Observation Nursery-Irrigated Cond. (2ndWWONIR)	83	CWANA
Second Winter Wheat Observation Nursery-Rainfed Cond. (2ndWWONRF)	85	CWANA
Eighth Facult./Winter Wheat Observation Nursery (8thFAWWON)	165	CWANA
Third Elite Yield Trial for Irrigated Conditions (3rdEYTIR); 3 reps	25	CWANA
Third Elite Yield Trial for Rainfed Conditions (3rdEYTRF); 3 reps	20	CWANA
Special Nurseries (introductions, special germplasm)	variable	Syria, Turkey

Table 5.3. Characteristics* of most promising entries of the Preliminary Yield Trial for Irrigated Environments, 1999 (PYT99IR)

Source 99	Name	Origin	Fn	Yield KG/HA	Color	PSI	PRT	TKW	BUNT
5176	KS82W422/SWM754308//KS831182/KS82W422/3/F900K	TCI	F5	7438	R	57	13.3	34	MR
5419	AGRI/NAC//ATTILA	MX-TCI	F7	9105	A	54	11.9	36	S
5470	WA476/3/391//NUM/5/W22/5/ANA/6/TAM200/7/85ZHONG56/8/KS82W409/SPN	TCI	F7	6450	A	53	12.5	33	-
5718	VORONA/TR810200	MX-TCI	F7	8065	A	51	12.3	33	S
5770	AU/3/MINN//HK/38MA/4/YMH/34A/5/CT/GGT/6/AGRI/BYJ//VEE	TCI	F6	10055	A	46	12.3	35	MS
5774	KS82W422/SWM754308//KS831182/KS82W422/3/KS82W409/SPN	TCI	F6	9290	A	57	13.9	33	MR
5821	AGRI/NAC/5/JUP/4/CLLF/3/II14.53/ODIN//CI13431/6/KRC66/SERI	TCI	F6	10135	R	49	11.6	35	S
5951	ID800994.W/VEE//PIOPIO/3/MNCH	TCI	F6	10115	A	66	12.0	36	MS
5956	TAM200/JI5418//RSK/NAC	TCI	F6	9000	R	65	13.0	40	S
6001	SW89-5124//AGRI/NAC	MX-TCI	F6	9463	A	68	12.6	36	S
6002	SW89-5124//AGRI/NAC	MX-TCI	F6	9250	A	65	12.9	39	S
6003	SW89-5124//AGRI/NAC	MX-TCI	F6	9318	A	67	13.1	39	S
6048	AGRI/NAC//KAUZ	MX-TCI	F6	9095	A	50	11.8	36	S
6109	ES14/SITTA//AGRI/NAC	TCI	F6	8843	A	50	11.8	37	MS
6120	55.1744/MEX67.1//NO.57/3/SITTA/4/KS82W409/SPN	TCI	F6	9523	A	57	11.9	33	MS
6126	55.1744/MEX67.1//NO.57/3/SITTA/4/KS82W409/SPN	TCI	F6	9600	A	46	12.1	41	S
6234	JI5418/4/NAI60/HN7//BUC/3/F59.71/GHK/5/SDV1	TCI	F6	8905	A	52	11.6	41	MR
6326	TJB368-251/BUC//APF/BOW	OR-TCI	F5	8435	A	57	13.6	31	MS
6327	TJB368-251/BUC//APF/BOW	OR-TCI	F5	8465	A	53	13.7	30	S
6466	NZT/BEZ1//ALD/4/NAD//TMP/CI12406/3/EMU/5/CRDN/6/78014-40	OR-TCI	F5	8785	R	42	11.6	38	S
6481	TJB368.251/BUC//WEAVER	OR-TCI	F5	8615	R	43	11.6	36	MR

* Color (grain): A=amber or white, R=red; PSI: particle size index, measures hardness, expressed in %, PRT=grain protein, in %; TKW=1000-kernel eight in g; Bunt: MR: moderately resistant, S=susceptible; MS=moderately susceptible.

Table 5.4. Characteristics* of most promising entries of the Preliminary Yield Trial for Rainfed Environments (PYT99RF), 1999

Name	Cross ID	Source99	Yield	Fn	YR	Bunt	Color	PSI	Protein	TKW
CRR/ATTILA	CMSW92WM00262S	895	4463	F7	0R	R	A	68	12.4	37.4
CHAM6//1D13.1/MLT/3/SHI4414/CROW/4/KVZ/AU//GRK	TCI932332	892	4475	F7	20MS	MS	A	59	12.5	41.0
TRK13/4/SNB/HN4//SPN/3/WTS//YMH/HYS	TCI932069	951	3163	F7	0R	MR	-			
CHAM6//1D13.1/MLT/3/SHI4414/CROW/4/KVZ/AU//GRK	TCI932332	889	3050	F7	0R	S	A	62	12.2	39.2
NESSER/OK81306	CMSW93WM0209	1329	3000	F6	1MS	R	A	37	14.2	52.4
BILINMIYEN96.27	F2.96.27	837	2875	F5	1MS	S	A	49	11.6	40.4
AU/CO652337//CA8055/3/TAST/SPRW//CA8055/4/F35.70/MO73	TCI932295	969	2763	F7	0R	MR	R	66	13.6	40.9
NESSER/OK81306	CMSW93WM0209	1328	2713	F6	0R	R	A	37	15.2	50.3
CA8646/GRK//ES85.24	TCI935119	973	2450	F7	0R	R	R	56	13.1	34.7
KS82W409/SPN/4/YMH/TOB//MCD/3/LIRA	TCI930087	1009	2425	F7	0R	MR	A	63	12.7	36.6
CTK/3/ATL66/CMN//TX2607-6/4/SS8/LLFN/3/BEZ/NAD//KZM74/BB//CC/CNO*2/3/TOP156/BB/5/GUN91	TCI945220	588	2213	F5	1MS	MR	R	51	13.3	44.0

* As in Table 5.3.

Second-year testing showed a number of AYT98IR and AYT98RF entries to possess a good level of tolerance to BYDV (Table 5.8). In particular, entry 9052 (VORONA/TR810200) very tolerant to BYDV, also possessed good resistance to both yellow rust and leaf rust. It is followed by entries 9018 and 9313.

Entries with reconfirmed BYDV tolerance in 3rd year testing are shown in (Table 5.9). The line TRK13/KAUZ (AYT98RF-9411) incurred no yield loss from exposure to BYDV. Other interesting genotypes are TAST/SPRW//ZAR, DAGDAS, and W.THIN-DL-69. All of these entries are useful progenitors for BYDV tolerance.

(K.M. Makkouk, W. Ghulam, H. Ketata)

5.4.2. Russian Wheat Aphid

Russian wheat aphid, *Diuraphis noxia* (Mordvilko), causes serious damage to wheat in certain countries (e.g. in North Africa), mostly in dry years. The aphid injects a toxin into the plant tissue that destroys the chloroplast membrane, causing longitudinal chlorotic streaks to develop. Host plant resistance has been the most practical and economical means of controlling this pest.

A total of 281 winter wheat lines were screened during 1999, in the ICARDA field at Tel Hadya for resistance to RWA. The entries were planted in hill plots, 10 seeds/hill, using an alpha lattice design with 2 reps. One susceptible check for each crop species was used every 10 entries. This field experiment was infested at the tillering stage with about 10 nymphs per plant. The evaluation was done three times at three weeks intervals using DuToit scale from 1-6, where 1=small isolated chlorotic spots on the leaves and 6=severe white/yellow streaks and tightly rolled leaves. The promising lines selected from the field went through two stages screening in the greenhouse, initial and advanced. In the initial screening, the material is evaluated in only one rep. The promising lines from this initial screening were subjected to an advanced evaluation, using 4 replications. The method of infestation and evaluation is similar to that of the field, except that plants are planted in standard greenhouse flats and infested at one leaf stage.

The results of the field and greenhouse screenings confirmed the resistance of two entries (score <3). These are: the Turkish cultivar Dagdas, and the breeding line: AYT98RF-9361 (ZCL/3/PGFN//CNO67/SON64(ES86-8)/4/SERI/5/UA-2837).

Five segregating F2 populations carrying RWA resistance were evaluated in the field at Tel Hadya. Plants at tillering stage were infested by RWA nymphs using about 10 insects/plant. As symptoms developed, susceptible plants were rogued out. Resistant F2 plants were harvested individually and will be planted in Nov 1999, as F3 progenies at Tel Hadya. Individual plants will be evaluated and advanced similarly as described for the F2's.

(M. El Bouhssini, A. Joubi, H. Ketata)

5.5. Yellow Rust

All advanced and segregating facultative and winter wheat materials are screened for diseases in Syria, Turkey and Iran, with an emphasis placed at ICARDA on yellow rust and common bunt. The project germplasm now has reached a satisfactory level of yellow rust resistance, but efforts continue to look for and incorporate complementary or additional genes for resistance into the new germplasm. In addition to the field screening, conducted under artificially created epiphytotics, further confirmatory evaluation is effected by the pathologists to identify genotypes with desirable resistance that will be made available for use by collaborating researchers.

A special study, started in 1998, has shown evidence of slow-rusting in yellow rust. Fifty winter wheat entries of diverse origin were artificially infected at tillering, and disease development and progress was monitored from the onset of first visible pustules on foliar tissues up until flowering. Scores were taken on disease reaction, severity and incidence. Although each test entry had its own specific behavior, data analysis made it possible to divide the entries into 4 contrasting groups, designated as G1, G2, G3, and G4.

Entries of group G1 did not incur any visible disease stress. The pathogen either could not multiply on the host plant, or was inhibited to spread but to a very limited leaf area (below and up to 15%) with only minute, nechrotic spots, visible on the affected leaves. The percent affected area was therefore nil or very low throughout the season. Entries in this group (e.g. the Turkish cultivar Sultan) are classified as resistant.

The other extreme group, G4, included typically susceptible entries. Startup sporulation occurred about 5 days earlier than in other groups, and leaf coverage by the disease progressed rapidly, reaching 80% or more by heading, and 90-100% by flowering. Examples of G4 entries are the Turkish cultivar Gerek and the Iranian cultivar Sardari.

Table 5.8. Performance of winter wheat lines in second-year testing for BYDV, as grown in 1m-rows at ICARDA, Tel Hadya, under artificial inoculation with BYDV during 1998-1999

		BYDV					
Name	Source98	D.I* (0-9)	Biomass (g/m)	Grain yield (g/m)	P.height (cm)	Yellow rust	Leaf rust
AE.VENTRICOSA//T.TURGIDUM/2*MOS/3/BOW/NKT	9006	6	325	113	90	10MS	20MS
BOW/PRL//F12.71/BEZ/3/OK82282	9018	5	330	102	90	2R	0R
HATUSHA/KAUZ//TRK13	9025	5	325	98	90	60S	15MS
DYBR1982.83/842ABVD C.50//KAUZ/3/PLK70/LIRA	9034	7	335	116	90	0R	10MR
RSK/CA8055//MNCH	9036	6	325	102	100	40S	0R
YMH*2/TRM//MO88/3/1D13.1/MLT	9050	6	285	90	85	30MS	0R
VORONA/TR810200	9052	4	400	121	90	0R	10MS
TRK13/KAUZ	9054	7	325	95	85	10MS	30S
TRK13//KA/NAC	9056	7	360	112	85	20MS	20S
ERYT3374/88 (PURDUE 5396/OD66//LAN/3/OD16)	9079	7	340	118	80	60S	5MR
SULTAN	9085	6	400	117	85	60S	80S
DAGDAS	9010	7	175	52	95	50S	60S
CHAM6//1D13.1/MLT	9313	5	355	108	95	10MR	10MS
UNKNOWN	9336	4	295	96	95	60MS	0R
MEX COMP3/4/TRK13/5/NE887U122	9389	5	390	119	100	70MS	100S
TRK13/KAUZ	9411	7	325	106	100	20MS	60S
GUN	9415	6	370	110	100	80SMS	100S
KINACI	9424	6	345	103	90	50MS	40SMS
KATIA	9425	7	185	61	95	100S	0R

* D.I.: disease index.

Table 5.9. Performance* of BYDV most tolerant wheat germplasm in 3rd year testing under artificial inoculation at ICARDA, Tel Hadya, 1998-1999

Entry	DI	BM	GWT	PH	YL
99ZHONG257//CNO79/PRI	6	360	132	85	5
CA8055/GRK	6	405	129	100	13
BEZ//BEZ/TVR/3/KREMENA/LOV29/4/ KATIA	6	400	136	113	0
TAST/SPRW//ZAR	6	400	127	90	2
BOW/PRL//F12.71/BEZ/3/OK82282	4	425	136	110	24
VORONA/HD2402	4	470	148	78	28
HATUSHA/KAUZ//TRK13	4.5	370	108	93	30
DAGDAS94	5	395	123	108	1
TRK13/KAUZ	5	370	103	105	0
KINACI97	4	395	128	98	19
CAN-93-21	4	350	83	118	9
ATAY/GALVEZ87	5	390	98	103	10
W.Thin-DL-69	4.5	295	96	105	0
GLENLEA (CHECK)	6	320	109	115	0

* DI: symptom disease index, based on degree of disease appearance on wheat plants, and expressed on a 0-9 scale, with lower values indicating lower-degree symptoms. BM: biomass, determined on a per-plot basis, and expressed in g/plot of 4mx1m.GWT: grain weight (g) per plot. PH: plant height(cm) of infected plants. YL: percent grain weight loss, due to BYDV infection.

Group G3 included susceptible types that are similar to G4 entries for their initial infection, but the fungus multiplication and appearance on the leaves was subsequently slower. The disease severity curve of G3 plateaued at lower level as compared to G4 (Figure 5.1), with the leaf coverage by the disease towards heading reaching half that of G4. Examples of entries belonging to this category are the Russian cultivar Bezostaya and the Turkish cultivar Dagdas.

Finally, in group G2, plant behavior in response to the pathogen is intermediate between G1 on one hand, and G3 and G4 on the other. Plant reaction is generally of the "moderate susceptibility", or susceptibility with low severity. Although clear yellow rust pustules are visible on the leaves, they were both slower to develop initially, and to progress over the leaf area subsequently. The leaf coverage by the rust pustules at heading is about half that of group G3, or one fourth that of G4. Examples of G2 entries include the Turkish cultivar Kinaci and the ICARDA line Tast/Sprw//Zar.

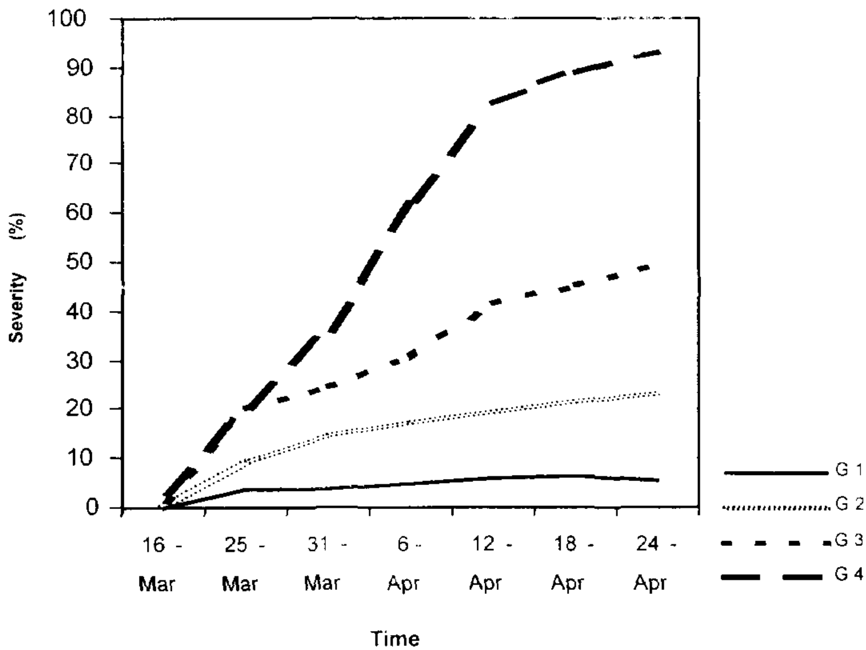


Figure 5.1. Four types of wheat response to yellow rust.

In both G2 and G3, there is a reduction of the infected leaf area, and of the speed of the disease progress on plant tissue, as compared to G4, and therefore, both enjoy the "slow-rusting" advantage. However, the slow-rusting is more intense in the case of G2, leading to a much more limited yield depression in G2 as compared to G3. The expected yield loss due to yellow rust (GP Annual Report, 1996, facultative and winter wheat section) is negligible in G2, and much more important in G3 and even more so in G4. This is indeed confirmed by results of small plots grown at ICARDA in 1999, where G3 and G4 yields represented 68% and 54% the yield of G1. In contrast, G2 yield did not significantly differ from G1 yield. Our experience indicates that some of the highest yielding types in the CWANA region belong to the G2 group.

Genetically, the G2 types would be less conducive to appearance of new rust races, as they exert less selection pressure on the fungus than do G1 types, and therefore would contribute to enhancing the durability of host plant resistance to yellow rust.

(H. Ketata, M. Jarrah, A. Yahyaoui, M. Naimi)

5.6. International Cooperation

5.6.1. Turkey

In addition to the field and lab breeding work, the following activities were conducted during 1999:

- A joint meeting of the Turkey-CIMMYT-ICARDA (TCI) partners was organized in February at Ankara to discuss the importance of root-rot diseases in Turkey and the CWANA region. Root rot diseases were found important in certain environments. It was decided that the 3 partners will conduct research to better quantify the losses due to root rot and to develop resistant germplasm.
- The Turkey-CIMMYT-ICARDA (TCI) partners jointly held their annual planning meeting in March at Eskisehir, with the participation of scientists from the 2 CG Centers and from different agricultural research institutes in Turkey, primarily Ankara, Konya, and Eskisehir.
- A traveling workshop on winter wheat improvement was jointly organized during 14-18 June in Turkey, with the participation of 43 wheat researchers from 8 CAC countries, and from Iran, Morocco, and Pakistan, in addition to the 2 CG Centers. The participants visited farmer's fields and research stations in the regions of Ankara, Konya, and Eskisehir, where they observed and selected w/w germplasm, exchanged information on w/w in their respective countries, and made suggestions for enhancing their collaboration with ICARDA and its partners. An outcome of the workshop was the decision to strengthen the exchange of w/w germplasm among CAC countries through intra-regional collaboration.

5.6.2. International Nurseries

Seed for the international nurseries: 3rd WWONIR, 3rd WWONSA, 4th EYTIR, 4th EYTRF, and 9th FAWWON was harvested from plots at Konya, Turkey, and checked at the ICARDA Seed Health Lab, at Aleppo, Syria before dispatch to cooperators.

Data returned from cooperators for 1st WWONIR, 1st WWONSA, and 7th FAWWON were compiled, and results distributed to cooperators. Some of the most promising entries of these three nurseries are shown in (Tables 5.10, 5.11, & 5.12).

(H. Ketata, H. Braun, B. Akin, M. Jarrah, A. Bagci, and NARS cooperators)

Table 5.10. Entries with highest selection frequency in 1st WWONIR

Entry	Name	SEL*	CLD*	HD*	YR*	LR*
249	JUP/4/CLLF/3/II1453/ODIN//CI1 343//WA00477	6	R	M	R	MR
235	OK82282//BOW/NKT	5	S	E	R-MS	R-S
252	1D13.1/MLT	5	MS	M	MR-MS	R-S
264	NAI60/HN7//BUC/3/FALKE	5	MS	E	R-MS	R
246	GRK//ESDA/LIRA	4	MS	M	MR	R-MS
255	VORONA/HD2402	4	MR	M	R	R-MS
279	BEZ2B/CGN//VRZ	4	R	L	MR	MR-MS
201	BEZOSTAYA1 (winter check)	0	MR	M	R-S	R-S
202	SERI82 (spring check)	0	S	E	S	R-S

* SEL: selection frequency (out of 11), CLD: response to cold, HD: heading, YR: yellow rust, LR: leaf rust. Scores: R: resistant, MR: moderately resistant, S: susceptible, MS: mod. Susceptible. For diseases, a range is given, as appropriate; M: medium, E: early, and L: late.

Table 5.11. Entries with highest selection frequency in 1st WWONSA*

Entry	Name	SEL	CLD	HD	YR	LR
321	DODGE//PLK70/LIRA/3/KSK46/BUC	4	R	M	MR	R-S
322	CA8055/GRK	4	R	M	R-S	S
343	TX71A1039.V1*3/AMI//SDY/OK780 47/3/CTY	4	R	L	R-MS	R
345	BEZ//BZ/TVR/3/KREMENA/LOV29/4 /KATIA1	4	MS	E	R-MS	S-MS
353	ZARGOON/SEFID	4	MS	E	R-S	S
324	NWT/3/TAST/SPRW//TAW12399.75	3	MR	M	R-S	S
301	BEZOSTAYA1 (winter check)	0	R	M	MS-S	R-MS
302	SERI82 (spring check)	0	S	E	S	R-S

* Refer to Table 5.10 for abbreviations.

Table 5.12. Most-frequently selected entries of the 7th FAWWON*

Entry	Name	SEL	CLD	HD	YR	LR
133	F6038W12.1	11	MR	M	R	S
36	OK82282//BOW/NKT	10	S	E	MR	S
35	AE.VENT//T.TURG/2*MOS/3/BOW/NKT	9	S	L	MS-S	S
55	TJB16.46/CB306//2*MHB/3/BUC	9	S	L	S	MS
130	F23S1.1	9	MR	E	MS	S
183	MIRLEBEN	9	MS-MR	L	MR	S
1	BEZOSTAYA1 (winter check)	6	MR	L	MS	S
2	SERI82 (spring check)	4	S	E	S	S

* Refer to Table 5.10 for abbreviations. SEL: selection frequency out of a total of 59 sites.

5.6.3. Iran

The season was extremely dry, and many farmers in the rainfed wheat areas did not harvest a crop. On-station yield generally ranged between 0.3-1.5 t/ha in Maragheh (197 mm precipitation), 0.5-2.5 t/ha in Sararood (318 mm), 0.4-2.4 at Qamloo (238 mm, plus 20 mm irrigation), 0.3-1.5 t/ha at Heydarloo (170 mm), and 0.0-1.0 t/ha at Zanjan (222 mm). No yellow rust developed with the exception at Ardebil, in the irrigated fields, with a reaction of up to 70S on certain genotypes. This station will be considered for use as a hot spot for yellow rust screening. A high level of partial spike sterility was observed in the irrigated field at this station, which is due to a high infestation with a stem borer or to late frost or both.
The harsh conditions enabled the breeders to identify drought tolerant germplasm in most of the research stations. It is again noted that wheat germplasm selected under the Central Anatolia Plateau (CAP) conditions has a poor performance in the dry areas of western and northwestern Iran. This is primarily due to the difference in temperature pattern at and beyond flowering. The month of June is generally hot in these areas of Iran, and is much cooler in CAP. The growth and grain-filling period in June is much compressed in Iran as compared to the Turkish CAP, which explains the shriveled grain and short stature of the same genotypes in Iran as compared to CAP of Turkey. In contrast, selection at ICARDA, Tel Hadya, is effective in identifying genotypes suitable for the dryland, winter-wheat areas of Iran. Again, the two environments share in common the terminal heat-cum-drought stress. This is also the case in most of Central Asia (refer to section 5.6.4, below).

The advanced line KVZ/TM71/3/MAYA'S'/BB/INIA/4/SEFID (IW89-1-10838-0MA-0MA-0MA-6MA-0MA) was released under the name of Azar2. It performed well at different research stations in the rainfed winter wheat areas of Iran, especially at Maragheh and Ghamloo. Other promising lines await further confirmation of their superior performance before their submission for release. This includes SBN//TRM/K253, SABALAN/1-27-56-4, OGOSTA/SEFID, and FENKANG15/SEFID.

(H. Ketata, M. Roustai, D. Sadekzadah, M. Tahir)

5.6.4. Central Asia and the Caucasus.

All CAC received TCI nurseries (8th FAWWON, 2nd WWON's, and 3rd EYT's) for evaluation in the 1998-99 season. Other spring wheat germplasm was also received from ICARDA, Aleppo. In several areas of the CAC, the spring materials selected in Tel Hadya, performed very well, especially in Azerbaijan and Tajikistan, and to a lesser extent in Turkmenistan and Kyrgyzstan. The winter types, selected in the Central Anatolia Plateau (CAP) of Turkey are generally not suitable for most of CAC wheat areas, because of contrasting environmental conditions at grain filling: these conditions are much more similar to those in northern Syria, where grain filling is consistently depressed by terminal heat-cum-drought stress. Facultative types with cold tolerance and rapid grain fill are most suitable to the majority of the wheat growing areas in CAC.

The season was generally marked by mild winter across the Region. This led to an early development of yellow rust, which reached an epidemic level in Azerbaijan, Uzbekistan, and Tajikistan. Breeders selected resistant germplasm from the international nurseries. The NARS awareness of the importance of yellow rust made them ask for more germplasm and for training in disease management. In Kyrgyzstan, tan spot continues to be the major wheat disease, and resistant germplasm is selected by the breeders for further testing and use in crossing. Cereal leaf beetle (*Oulema melanopa*), an insect that feeds on the green leaf tissue, is particularly damaging in certain areas of Kyrgyzstan, Uzbekistan and Turkmenistan. The breeder in Kyrgyzstan, together with the ICARDA entomologist selected 160 entries from a total of 3500 entries. The selected entries seemed resistant, and will be retested in the 1999-00 season.

From the TCI nurseries, three lines were selected in Turkmenistan, and one each in Georgia and Uzbekistan, and were submitted to their respective State Variety Testing Commissions, a required step before variety release.

Fourteen wheat researchers from 8 CAC countries participated in the winter wheat traveling workshop, organized in Turkey, during 14-18 June, 1999 (refer to section 5.5.1.3 above). This included the National Wheat Coordinators from each of the 8 CAC countries, who met with representatives of ICARDA and CIMMYT and agreed on strengthening intra-regional collaboration through exchange of germplasm and visits. This will be coordinated through a CAC Wheat Improvement Network (CACWINET): to be jointly supported by CIMMYT and ICARDA.

Fifteen wheat researchers from CAC received a practical training on "Use of PC in wheat research" for 8 days in February 1999, and a 3-month English language training.

(H. Ketata)

6. FOOD LEGUME PROJECT IMPROVEMENT

6.1. Kabuli Chickpea Improvement

The kabuli chickpea improvement is a joint program with ICRISAT, India. The main objective of the program is to increase and stabilize kabuli chickpea production in the developing world. Of the five main regions, where chickpea is grown, the Mediterranean region and Latin America produce mostly kabuli-type chickpea. Five to ten percent of the area in the other three main production regions (Indian subcontinent, East Africa, and Australia) is also devoted to the production of the kabuli type. The kabuli chickpea is also grown at high elevation areas (>1000 m elevation) in West Asia, especially in Afghanistan, Iran, Iraq, and Turkey; and in the Atlas Mountains of North Africa.

Ascochyta blight and Fusarium wilt, are the two major diseases of chickpea. Leaf miner in the Mediterranean region and pod borer in other regions is the major insect pests. Drought is the major abiotic stress throughout the chickpea growing areas and cold (assumes importance) in Mediterranean environments and the temperate region especially for winter sowing. The kabuli chickpea is mainly grown as a rainfed crop in the wheat-based farming system in areas receiving between 350 mm and 600 mm annual rainfall in the West Asia and North Africa (WANA) region. In Egypt and Sudan, the crop is only grown with supplemental irrigation and in South Asia, West Asia and Central America, a small part of area is grown with supplemental irrigation.

In WANA, where the crop is currently spring-sown, yield can be increased substantially by advancing sowing date from spring to early winter. Winter sowing results in increased productivity and also allows the crop to be harvested by machine.

Major efforts are underway to stabilize chickpea productivity by breeding cultivars resistant to various stresses, such as the diseases (Ascochyta blight and Fusarium wilt), insect pest (leaf miner), parasite (cyst nematode), and abiotic stresses (cold and drought). The exploitation of wild *Cicer* species for transfer of genes for resistance to different stresses and widening the genetic base of chickpea are the areas receiving high research priority at the Center. DNA fingerprinting in *Ascochyta rabiei* is being pursued for mapping the pathogen variability in the region.

During 1999, several collaborative projects continued to operate.

Studies on characterization of chickpea genotypes and *Ascochyta rabiei* isolates using restriction fragment length polymorphism (RFLP) are carried out in collaboration with the University of Frankfurt, Germany. Research on the development of irrigation-responsive cultivars is being conducted with the Agriculture Research Center, Giza, Egypt. Fusarium wilt resistance screening was done in association with the Department of Plant Pathology, University of Cordoba, Spain. The screening for cyst nematode resistance is carried out in association with the Institute of Agricultural Nematology, C.N.R. Italy. The project on development of kabuli chickpea for the Mediterranean Environments similar to West Australia and Izmir is carried out in collaboration with Aegean Agricultural Research Institute (AARI) Izmir, and Australian Council of International Agricultural Research (ACIAR).

6.1.1. Chickpea Breeding

Major objectives of the breeding are (1) to develop cultivars and genetic stocks with high and stable yield and segregating populations to support National Agricultural Research Systems (NARSs) and (2) to conduct strategic research to complement objective 1. Specific objectives in the development of improved germplasm for different regions are:

1. **Mediterranean region:** (a) Winter-sowing: resistance to ascochyta blight, tolerance to cold, suitability for machine harvesting, medium to large seed size; (b) Spring sowing: cold tolerance at seedling stage, resistance to ascochyta blight and Fusarium wilt, tolerance of drought, early maturity, medium to large seed size.
2. **High elevation areas:** Spring-sowing: cold tolerance at seedling stage, resistance to ascochyta blight, terminal drought tolerance, early maturity, and medium to large seed size.
3. **Indian subcontinent and east Africa:** Resistance to ascochyta blight and/or Fusarium wilt, drought tolerance, early maturity, small to medium seed size, response to supplemental irrigation.
4. **Latin America:** Resistance to Fusarium wilt and root rots, and large seed size.

Major strategic research projects are:

1. Exploitation of wild *Cicer* species for transfer of resistance genes for cold and cyst nematode, and for widening the genetic base of chickpea.
2. Pyramiding of genes for resistance to ascochyta blight.
3. Identification of races of Fusarium wilt in the WANA region.
4. Increasing shoot biomass-yield in chickpea.

6.1.1.1. Use of Improved Germplasm by NARSs

6.1.1.1.1. International Nurseries/Trials and other Breeding Lines

During 1999, more than fourteen thousand samples of diversified chickpea materials were distributed to NARSs in 45 countries. These materials included different international nurseries, specific genetic materials for research purposes, and improved elite lines requested by NARSs (Table 6.1.1).

6.1.1.1.2. On-farm Trials in Syria

On-farm trials were conducted in many countries including Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Morocco, Syria, Tunisia, and Turkey. Some of the high yielding lines were identified for seed increases and registrations. The results of Chickpea On-farm in Syria are discussed in this section.

Four improved chickpea lines namely, FLIP 91-63C, FLIP 92-155C, FLIP 92-164C, and FLIP 93-93C, along with the improved check, Ghab 3 were included in the On-Farm trials conducted during the winter season. The Directorate of Agricultural and Scientific Research, Ministry of Agriculture and Agrarian Reforms along with ICARDA conducted these trials and the results were reported from 10 environments, during 1998/99. The year 1998/1999 was comparatively a dry year with erratic distribution of rainfall during the season resulting in low seed yields of the traditional spring chickpea. The seed yields of the On-Farm Trials at different locations are given in (Table 6.1.2).

Table 6.1.1. Number of entries distributed to the national programs in different countries in the form of international yield trials and specific nurseries in 1998/99

Country	No. of sets Trial/nursery	No. of Entries	Breeding Lines(No)	Total no. of Entries
Algeria	14	760	-	760
Australia	10	496	-	496
Azerbaijan	5	243	-	243
Bangladesh	1	63	-	63
Bhutan	4	218	-	218
Brazil	1	35	-	35
Bulgaria	2	76	-	76
Canada	6	266	34	300
Chile	1	35	-	35
China	1	63	-	63
Egypt	7	319	-	319
Ethiopia	11	543	-	543
France	10	496	-	496
Georgia	14	732	-	732
Greece	1	41	-	41
Hungary	5	259	-	259
India	9	405	-	405
Iran	16	872	22	894
Iraq	5	265	-	265
Italy	7	341	-	341
Jordan	4	158	1	159
Kazakhstan	6	278	4	282
Kuwait	1	41	5	46
Kyrghyztan	3	123	-	123
Lebanon	4	206	-	206
Lesotho	3	155	-	155
Libya	9	429	-	429
Mexico	8	414	-	414
Morocco	4	202	-	202
Pakistan	21	889	-	889
Palestine	3	123	-	123
Peru	2	76	-	76
Portugal	3	117	-	117
Romania	5	253	-	253
Russia	3	123	-	123
Saudi Arabia	1	51	-	51
Slovakia	2	126	-	126
South Africa	1	41	-	41
Spain	9	405	30	435
Sudan	3	167	-	167
Syria	31	1673	-	1673
Tunisia	13	653	-	653
Turkey	24	1128	287	1415
Yemen	1	63	-	63
Total	294	14422	383	14805

The seed yields for the entries in the trial were highest at Tartous (range between 3349 and 4203 kg/ha) and were followed by Idleb (range between 2811 and 3315 kg/ha). However, at Homs and Hama, all the entries gave much lower yields as compared to other locations. Across locations highest mean seed yield of 2202 Kg/ha was obtained for FLIP 93-93C followed by FLIP 92-164C (2094 kg/ha), FLIP91-63C (2058 kg/ha), FLIP 92-155C (1945 Kg/ha), and Ghab 3 (1883 Kg/ha). The seed size was highest for FLIP 92-164C (35g/100-seed) and this entry also exhibited higher level of tolerance to Ascochyta blight and cold.

This trial will be conducted for one more season to have better idea about adaptation of the lines over a period of three years.

In addition, chickpea demonstration trials (using Ghab 3 and local) were conducted at different locations and field day was organized at one site by the Directorate of Extension, which was well received by the farmers.

6.1.1.1.3. Pre-release Multiplication and Release of Cultivars by National Programs

A large number of lines have been chosen by different NARSs during 1998/99 from the chickpea materials supplied from ICARDA for on-farm testing and pre-release multiplication. We supplied small quantities of seeds of some of these lines as per request of NARSs for multi-location or on farm testing.

To date, NARSs in 22 countries have released 78 lines as cultivars, from the improved germplasm furnished by ICARDA (Table 6.1.3).

6.1.1.2. Screening for Stress Tolerance

6.1.1.2.1. Cultivated Species

6.1.1.2.1.1. Wilt Resistance

Fusarium wilt (induced by *Fusarium oxysporum* Schlecht. Emend. Snyd. & Hans. f. sp. *ciceri* (Pad wick) Snyd. & Hans) is the second most important disease of chickpea worldwide. It is both soil-borne and seed-transmitted. Breeding for Fusarium wilt-resistance has been one of the main objectives in chickpea improvement. In this effort, the major bottleneck has been the presence of different races of the pathogen.

Table 6.1.2. Seed yield (kg/ha), 100-seed weight (100-SW), Plant height (PTHT), Days to flowering (DFLR), Days to maturity (DMAT), Ascochyta blight reaction (AB score), and Cold tolerance reaction (CT score) of chickpea entries in the on-farm trials conducted jointly with the Directorate of Agriculture and Scientific Research, Syria and ICARDA during 1998/99

Entry	Al-Ghab	Bashkoy	Idleb	Hama	Heimo	Homs	Skailbieh	Tartous	Tel Hadya	Yahmoul	Mean	100-SW (g)	PLHT (cm)	DFLR	DMAT	AB score[a]	CT score[a]
FLIP 91-63C	2600	1881	3202	663	1651	1140	1849	3507	1543	2537	2058	33	54	116	147	5	3
FLIP 92-155C	2537	1619	3143	728	1877	846	1709	3349	1277	2364	1945	33	55	117	148	3	3
FLIP 92-164C	2512	1688	3315	684	1577	1796	2060	3778	1424	2105	2094	35	56	117	148	3	2
FLIP 93-93C	2900	1754	3123	1041	1795	1344	2119	4203	1312	2432	2202	32	59	116	145	3	2
Ghab 3	2612	1666	2811	1071	1469	795	1738	3635	1087	1944	1883	27	52	114	144	5	3
Mean	2632	1722	3119	837	1674	1184	1895	3694	1329	2276	2058		55	116	146		
LSD ($P \leq 0.05$)	82	209	664	150	204	450	415	547	194	435	128						
C.V. %	1.5	5.7	10.0	8.4	5.7	17.8	10.3	7.0	6.8	9.0	12.0						

[a] Scale: 1-9, where 1=free, 9-killed

Table 6.1.3. Kabuli chickpea cultivars, released by national programs

Country	Cultivars Released	Year of Release	Specific Features
Algeria	ILC 482	1988	High yield, Ascochyta blight (ABL) resistance
	ILC 3279	1988	Tall, ABL resistance
	FLIP 84-79C	1991	Cold, ABL resistance
	FLIP 84-92C	1991	ABL resistance
China	ILC 202	1988	High yield, for Ginghai pr.
	ILC 411	1988	High yield, for Ginghai pr.
	FLIP 81-71C	1993	High yield
	FLIP 81-40WC	1993	High yield
	ILC 3279	1996	ABL resistance
Cyprus	Yialousa (ILC 3279)	1984	Tall, ABL resistance
	Kyrenia (ILC 464)	1987	Large seeds
Egypt	Giza 88	1994	High yield under irrigation
	Line 195	1995	High yield under irrigation
	Giza 3	1999	High yield under irrigation
France	TS1009 (ILC 482)	1988	ABL resistance
	TS1502 (FLIP 81-293C)	1988	ABL resistance
	Roye Rene (F 84-188C)	1992	Cold, ABL resistance
India	Pant G 88-6 (derived from a cross with ILC 613)	1996	Botrytis grey-mould resistance, released for Tarae area
Iran	ILC 482	1995	High yield, ABL resistance
	ILC 3279	1995	High yield, ABL resistance
	FLIP 84-48C	1995	High yield, ABL resistance
Iraq	Rafidain (ILC 482)	1991	ABL resistance, high yield
	Dijla (ILC 3279)	1991	Tall, ABL resistance
Italy	Califfo (ILC 72)	1987	Tall, ABL resistance
	Sultano (ILC 3279)	1987	Tall, ABL resistance
	Pascia (FLIP 86-5C	1995	ABL resistance, high yield
	Otello(ICC6306/NEC206)	1995	ABL resistance, desi, feed
Jordan	Jubeiha 2 (ILC 482)	1990	High yield, ABL resistance
	Jubeiha 3 (ILC 3279)	1990	High yield, ABL resistance
Lebanon	Janta 2 (ILC 482)	1989	High yield, wide adaptation
	Baleela (FLIP 85-5C)	1993	Green seed consumption
	Al-Wady (FLIP 86-6C)	1998	High yield, Large seeded
Libya	ILC 484	1993	High yield, ABL resistance
Morocco	ILC 195	1987	Tall, ABL resistance
	ILC 482	1987	High yield, ABL resistance
	Rizki (FLIP 83-48C)	1992	Large seed, ABL resistance
	Douyet (FLIP 84-92C)	1992	Large seed, ABL resistance
	Farihane (FLIP 84-79C)	1995	Large seed, ABL resistance
	Moubarak (FLIP 84-145C)	1995	Large seed, ABL resistance
	Zahor (FLIP 84-182C)	1995	Large seed, ABL resistance
Oman	ILC 237	1988	High yield, irrig. conditions
	FLIP 87-45C	1995	High yield, ABL resistance
	FLIP 89-130C	1995	High yield, ABL resistance
Pakistan	Noor 91 (FLIP 81-293C)	1992	High yield, ABL resistance
Portugal	Elmo (ILC 5566)	1989	ABL resistance
	Elvar (FLIP 85-17C)	1989	ABL resistance
Spain	Fardan (ILC 72)	1985	Tall, ABL resistance
	Zegri (ILC 200)	1985	Mid-tall, ABL resistance
	Almena (ILC 2548)	1985	Tall, ABL resistance
	Alcazaba (ILC 2555)	1985	Tall, ABL resistance

Table 6.1.3. Cont'd. …

Country	Cultivars Released	Year of Release	Specific Features
Spain	Atalaya (ILC 200)	1985	Mid-tall, ABL resistance
	Athenas (ILC 2xCA2156)	1995	Large seed, ABL resistance
	Bagda (ILC 72xCA 2156)	1995	Large seed, ABL resistance
	Kairo (ILC 72xCA 2156)	1995	Large seed, ABL resistance
Sudan	Shendi	1987	High yield, irrig. conditions
	Jebel Marra-1 (ILC 915)	1994	High yield, irrig. conditions
	Wad Hamid-1(FLIP89-82C)	1998	High yield, large seeded
	Matama-1 (FLIP 91-77C)	1998	High yield, irrig. conditions
Syria	Ghab 1 (ILC 482)	1986	High yield, ABL resistance
	Ghab 2 (ILC 3279)	1986	Tall, ABL resistance
	Ghab 3 (FLIP 82-150C)	1991	High yield, cold & ABL res.
Tunisia	Chetoui (ILC 3279)	1986	Tall, ABL resistance
	Kassab (FLIP 83-46C)	1986	Large seeds, ABL resistance
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds, wilt resistance
	FLIP 84-79C	1991	ABL, cold resistance
	FLIP 84-92C	1991	Large seed, ABL resistance
Turkey	ILC 195	1986	Tall, ABL resistance
	Guney Sarisi 482	1986	High yield, ABL resistance
	Damla (FLIP 85-7C)	1994	ABL resistance
	Aziziye (FLIP 84-15C)	1994	ABL resistance
	Akcin (87AK71115)	1991	Tall, ABL resistance
	Aydin 92 (FLIP 82-259C)	1992	Large seed, ABL resistance
	Menemen 92(FLIP 85-14C)	1992	Large seed, ABL resistance
	Izmir 92 (FLIP 85-60C)	1992	Large seed, ABL resistance
	Gokce (FLIP 87-8C)	1997	Large seed, moderate ABL res.
USA	Dwelley (Surutato x FLIP 85-58C)	1994	ABL resistance
	Sanford (Surutato x FLIP 85-58C)	1994	ABL resistance

ABL=Ascochyta blight

During 1998/99, 159 lines were evaluated against Fusarium wilt in Fusarium sick plot at Tel Hadya, Syria to confirm their reaction to Fusarium wilt. Out of these 107 lines were free from damage (rating 1), 20 lines were resistant/tolerant (rating 2 with 20% killing) and 22 lines were moderately tolerant (rating 3) with 21-40% killing of plants on 1 to 5 scale (Table 6.1.4).

Table 6.1.4. Reaction of chickpea lines in different trials to Fusarium wilt in Fusarium wilt sick plot, at Tel Hadya, 1998/99

		Type of material			
Rating Scale	% of plants killed	Lines for reconfirmation	CIFWN	Lines in Differential set	PYT and IYT lines
1	0	107	25	5	97
2	1-20	20	10	3	32
3	21-40	22	2	1	84
4	41-60	8	1	0	240
5	61-100	2	2	0	357
Total		159	40	9	810

6.1.1.2.2. Segregating Material

The breeding material comprising 44 F_3 bulk populations and 977 F_5 progenies, were grown in wilt-sick plot for evaluation for Fusarium wilt resistance (Table 6.1.5). Out of these 17 bulk populations in F_3 and 809 progenies in F_5 showed resistance reaction., Individual resistant plants from each cross in F_3 were selected and bulked separately. From F_5, 68 progenies were bulked for increase and testing for next season.

Table 6.1.5. Reaction of breeding materials to Fusarium wilt in Fusarium wilt-sick plot at Tel Hadya, 1998/99

Generation	Reaction on 1-9 scale					
	1	2	3	4	5	Total
F_5 Progenies	758	51	96	64	8	977
F_3 Bulk	0	17	19	7	1	44

6.1.1.2.2.1. Ascochyta Blight

Aschochyta blight (*Ascochyta rabiei*) is one of the devastating diseases of chickpea in the different chickpea growing areas of the world. This disease occasionally comes in epidemic form and causes heavy yield losses, some times leading to complete failure of the crop (100% yield loss). Although various chemical and cultural practices have been identified to combat this disease but usage of these is not economical with the presently cultivated varieties or land races those have low level of tolerance to this disease. Thus host resistance or tolerance is very important to control this disease. At ICARDA, efficient field and laboratory screening techniques for Ascochyta blight resistance, have been developed and so far more than 25,000 accessions of chickpea germplasm and improved genetic materials have been evaluated, and only a few resistant sources to Ascochyta blight pathogen have been identified. These sources have been shared with the NARSs in chickpea growing areas for their testing and use under local conditions. Further, the multi-location testing for ascochyta blight has revealed the differential reaction of some of the supplied chickpea lines to the existing Ascochyta blight pathogen in some areas. This indicated the presence of variability in the Ascochyta blight pathogen. Some of these lines with good agronomic background and showing resistance to Ascochyta blight at a particular location were identified by NARSs and released for general cultivation. But the shifts in the pattern of resistance or breakdown of resistance reported occasionally caused a great concern in development of ascochyta blight resistant genotypes. This breakdown or shift in reaction to Ascochyta blight pathogen from resistant to susceptible seem to be due to the presence of perfect or sexual stage of the pathogen leading to creation of more variability in the pathogen, and making the selection for resistance more difficult. Earlier studies on inheritance of Ascochyta blight indicated that this disease is controlled by single dominant or resistance gene and some of the chickpea lines with resistance were identified and reported. So for, only few sources of resistance have been identified and used for understanding of inheritance pattern of the disease across the locations and regions. The variability in the Ascochyta blight pathogen has been characterized at ICARDA with the help of Molecular biological tools and grouped into three pathotypes, Pathotype 1, Pathotype 2, and Pathotype 3. Most of the lines identified as resistant and released for general cultivation in one or the other country are tolerant to Pathotype 1 or 2 and none is resistant to Pathotype 3. The researches at ICARDA have observed that the Pathotype 3 is widely distributed throughout the region including Syria. So for Ascochyta blight, the evaluation of germplasm and breeding materials is done against the mixed population of three Pathotypes under field conditions, and Pathotype 3 under controlled conditions in the plastic house. Thus to improve the level of tolerance to Ascochyta blight, efforts are being made to combine different genes from different sources through the gene pyramiding project.

A large number of crosses are made and breeding materials developed every year which are screened for Ascochyta blight. Evaluation of these materials is done under field conditions in the Ascochyta blight nursery using infected debris from the previous season crop and spore suspension when infection is low from the debris.

6.1.1.2.2.1.1. Evaluation of Segregating Populations for Resistance to Ascochyta Blight

The reaction of F_2, F_3, F_4 and F_5 generations to the existing race populations of Ascochyta blight under field conditions at Tel Hadya is given in (Table 6.1.6).

No progeny was rated 1 or 2. However, 122, 558, and 1061 F_5 progenies were rated 3, 4 and 5, respectively (on a 1-9 scale with 1=free from damage and 9=killed). On the basis of agronomic traits and Ascochyta blight reaction, 604 progenies were bulked in F_5 for their increase and yield evaluation next season. From F_3 and F_4 bulks the individual resistant plants were selected for further evaluation.

Table 6.1.6 Reaction of breeding materials in F_2, F_3, F_4 and F_5 generations to Ascochyta blight at Tel Hadya, 1998/99

	Scale (1-9)									
Generation	1	2	3	4	5	6	7	8	9	Total
F_5 Tall	0	0	30	151	318	463	210	33	17	1222
F_5 Large	0	0	0	1	7	47	40	7	0	102
F_5 General	0	0	92	407	736	891	357	98	14	2595
F_4 Progeny	0	0	55	305	356	437	207	43	15	1418
F_4 Bulk	0	0	0	8	22	15	10	0	0	55
F_3 Bulk	0	0	2	22	16	19	15	4	0	78
F_2 Bulk	0	0	0	1	5	67	27	5	0	105
Total	0	0	179	895	1460	1939	866	190	46	5575

Scale: 1=free from damage; 2=highly resistant; 3=resistant; 4=moderately resistant; 5=intermediate; 6=moderately susceptible; 7=susceptible; 8=highly susceptible; and 9=all plants killed.

6.1.1.2.2.1.2. Evaluation of Elite Lines from Different Trials for their Reaction to Ascochyta Blight

Seven hundred and ninety three lines included in different yield trials and nurseries were evaluated for reaction to Ascochyta blight in the Ascochyta blight nursery in the field (Table 6.1.7).

None of the lines exhibited 1 or 2 rating. However, 56 and 212 lines with rating of 3 or 4, were resistant or moderately resistant.

Table 6.1.7. Reaction of New germplasm, CIABN and PYT lines to Ascochyta blight at Tel Hadya, 1998/99

Trial Name	Disease Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
New Germplasm	0	0	0	0	0	4	7	43	46	100
CIABN	0	0	4	23	11	2	0	0	0	40
PYT lines	0	0	52	189	144	154	78	24	12	653
Total	0	0	56	212	155	160	85	67	58	793

6.1.1.2.2.1.3. Reaction of the Entries to Ascochyta Blight in Chickpea International Ascochyta Blight Nursery (CIABN) at Tel Hadya

The CIABN comprised 40 test entries and a susceptible check, which was repeatedly sown after every two test-entries. The repeated susceptible check was uniformly killed throughout the nursery. Among test entries, 4,23, and 11 had a rating of 3, 4, and 5, respectively. In general, the severity of ascochyta blight infection was much less as compared to the previous year.

6.1.1.2.2.1.4. Reaction of Breeding Materials in the Gene Pyramiding Project

In the gene-pyramiding project to combine sources of resistance to Ascochyta blight, resistant parents with diverse origin were crossed. Two hundred and nineteen F_5 progenies and 107 F_8 progenies were grown under field conditions for evaluation for Ascochyta blight reaction. The results (Table 6.1.8) revealed that 8 progenies in F_8, and 74 progenies in F_5, were resistant (with 3 rating), and another 26 progenies in F_8, and 73 in F_5, were tolerant to Ascochyta blight (rating=4). Sixty test entries originating from the gene pyramiding project were evaluated for yield and other agronomic traits along with four checks both during spring and winter season. The seed yield for winter-sown varied from 669 to 2064 kg/ha, and for spring-sown from 170 to 854 kg/ha. The seed yield in spring was poor due to severe drought during the season. The seed size in these lines varied from 20 to 38 g/100-seed that needs further improvement. The five heaviest yielding entries from winter-sown crop included, S98756, S98812, S98808, S98829, and S98811 with seed yields of 2064, 2043, 1916, 1833 and 1824 kg/ha, respectively.

Table 6.1.8 Reaction of segregating populations/lines to Ascochyta blight (in gene pyramiding project) at Tel Hadya, 1998/99

Generation	Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
F_5 Progenies	0	0	74	73	24	36	11	1	0	219
F_8 Progenies	0	0	8	26	24	35	12	1	1	107
Total	0	0	82	99	48	71	23	2	1	326

Ascochyta blight rating: 1=free, 9=all plants killed.

6.1.1.2.2.1.5. Screening for Resistance to Pathotype-3 of Ascochyta Blight Pathogen under Controlled Conditions at Tel Hadya

Research in the ICARDA Biotechnology laboratory has classified *A. rabiei* isolates into 3 groups based on the reactions to a set of differentials. Pathotype-3 is the most virulent of these 3 path type groups. Most of the advanced germplasm has been screened only for resistance to the less virulent pathotypes 1 and 2. To identify lines with resistance to Pathotype-3, a set of 402 breeding lines selected for their resistant reactions to Ascochyta blight under field conditions in the previous year were grown in the pots during 1998/99 and were arranged on benches in a complete randomized design in 3 replications. A row of the susceptible check, ILC 263, was planted after every 5 test-row entries. The 4 weeks old seedlings were spray-inoculated with an isolate of Pathotype-3. The pots were then covered with transparent plastic for 48 hours for development of infection. Four weeks after inoculation, the reaction to Ascochyta blight was recorded.

Out of the 402 lines screened, none could be rated as highly resistant with a rating of less than 4. Ten lines (FLIP 94-97, FLIP 94-99, FLIP 95-118, FLIP 95-150, FLIP 95-164, FLIP 95-175, FLIP 96-160, FLIP 96-22, FLIP 96-64 and S97034) exhibited a rating of 4, 52 lines were rated at 5, and all the others exhibited a rating between 6-9. The reactions of the selections with 4 and 5 will be confirmed during the coming season. Out of the 61 lines selected from the 1998 screening for confirmation, 25 exhibited moderate resistant reaction (rating of 5 or less, on the 1-9 scale). Among these 25 lines, three (FLIP 94-510, FLIP 89-126 and FLIP 93-178) were rated as highly resistant with a rating of less than 3, while 5 (FLIP 93-106, FLIP 93-145, ILWC 106, FLIP 91-020 and FLIP 94-52) were rated as resistant (rating<4). The rest were moderately resistant with ratings between 4 and 6. None of the entries had a rating above 6, confirming the reliability of the method and the resistances in the entries.

6.1.1.2.2.2. Cold Tolerance

Cold tolerance is one of the most important pre-requisites for writer-sown chickpea. Even for spring-sown crop cold tolerance at early seedling stage is important. Efforts have been under way since the initiation of chickpea project and breeding for cold tolerance is the integral part of the chickpea improvement work at ICARDA. During 1998/99 season progenies from inter-specific crosses in F_3 and F_5 generations were grown in autumn for evaluation for cold tolerance under field conditions. In addition 47 test entries from the cultigens included in Chickpea International Cold Tolerance Nursery were also evaluated for cold tolerance. The season was very mild with respect to cold and all the breeding material in different generations exhibited cold tolerance with rating ≤ 4.

6.1.1.2.2.3. Drought Tolerance

In the dry areas during spring terminal drought occasionally affects the crop and reduces the seed yield.

A reliable screening technique involving delayed sowing of chickpea by three weeks during spring at a relatively drier site, and preliminary evaluation of materials on 1 (=resistant) to 9 (=susceptible) scale to discard susceptible lines was developed at ICARDA. Based on this technique 1000, 544, and 600 germplasm lines were evaluated in 1997, 1998, and 1999, respectively. The lines found resistant in the year 1997 and 1998, were re-evaluated for confirmation of their reaction to drought in 1999. The year 1999 experienced low rainfall and the distribution of rainfall was uneven in most areas in the WANA region, and led to a severe drought; and caused heavy losses to the spring-sown chickpea. This natural disaster, however, was utilized for screening of chickpea materials against drought stress and a good number of resistant sources were identified by various NARSs. At ICARDA from the chickpea lines grown for confirmation of their resistance to drought, 22 lines with a rating of 3 on 1 to 9 scale (where 1=free from drought damage, and 9=no pod formation and no seed yield) were found resistant. The details of drought tolerant lines are given in (Table 6.1.9). It is apparent from the table that there was no association between the country of origin and the drought tolerance of the lines.

In addition, a total of 600 new germplasm lines were evaluated for drought tolerance during 1999, and only 16 and 73 of these lines with rating of 2 and 3 exhibited drought tolerance. These lines will be evaluated next season for confirmation of their reaction.

Table 6.1.9. Drought tolerant sources in kabuli chickpea

Entry Name	Pedigree	Origin	Score*
ILC 19	-	Jordan	3
ILC 588	NEC 1628-1	India	3
ILC 1306	PI 339221	Turkey	3
ILC 1799	NEC 2904	Syria	3
ILC 3101	ICC 10315	Turkey	3
ILC 3105	ICC 10319	Turkey	3
ILC 3182	ICC 10736 PIC	Turkey	3
ILC 3210	ICC 10769, CRIC-37092	Turkey	3
ILC 3216	ICC 10776 PIC	Turkey	3
ILC 3321	No. 38 (Collection from Jissr Shoghour)	Syria	3
ILC 3832	Pch 80	Morocco	3
ILC 3843	Pch 102	Morocco	3
ILC 4291	INIAM	Mexico	3
ILC 4945	FLIP 81-387C/X79TH123/ILC 1929 x ILC 200	ICARDA/ICRISAT	3
ILC 5766	IP 1138-1	Pakistan	3
ILC 6023	PI 468928	Mexico	3
ILC 6056	WRPIS	USA	3
ILC 7067	FLIP 86-45C/X82TH101/ILC 215WH x ILC 195WH	ICARDA/ICRISAT	3
FLIP 87-51C	X85TH146/ILC 2398 x FLIP 83-13C	ICARDA/ICRISAT	3
FLIP 87-58C	X85TH264/ILC 3777 x FLIP 83-46C	ICARDA/ICRISAT	3
FLIP 87-85C	X85TH248/ILC 3398 x FLIP 83-46C	ICARDA/ICRISAT	3
FLIP 88-42C	X85TH230/ILC 3395 x FLIP 83-13C	ICARDA/ICRISAT	3

*Where, 1=resistant, early flowering, very good early plant vigor, 100% pod setting; 9=highly susceptible, lack early plant vigor, no flowering, no pod setting.

6.1.1.2.3. Wild Species

6.1.1.2.3.1. Cold Tolerance

Thirty-eight accessions from different wild *Cicer* species were grown for confirmation of their tolerance to cold. As the season was mild no useful inferences for cold tolerance could be drawn.

6.1.1.3. Germplasm Enhancement

6.1.1.3.1. Improvement in Shoot Biomass Yield

Low shoot biomass in the Mediterranean basin is an important reason among others which contribute toward poor yield. Our previous results show that seed yield in chickpea is highly correlated with biomass yield (above-ground plant parts). During the year 306 progenies in F_5 were grown for biomass evaluation and 66 promising progenies were bulked for increase and evaluation next season. Twenty-seven test entries along with three checks were grown in a preliminary yield trial for evaluation for biomass yield and other agronomic characters during winter at Tel Hadya and Terbol. The biomass in different entries ranged from 2717 to 4435 kg/ha at Tel Hadya, and 4841 to 6665 kg/ha at Terbol. The results of some of the high biomass entries along with some other important traits are presented in (Table 6.1.10).

Table 6.1.10. Seed yield, biomass, plant height (PTHT), 100-seed weight (100-SW),and harvest index (HI) of some of the high biomass lines in PYT-Biomass at Tel Hadya and Terbol, 1998/99

	Seed yield (kg/ha)			Biomass yield (kg/ha)					
Entry	Tel Hadya	Terbol	Mean	Tel Hadya	Terbol	Mean	PTHT (cm)	100-SW (g)	HI (%)
S 98014	1387	2003	1695	3817	6087	4952	48	38	34
S 98017	1593	1999	1796	4371	6026	5198	49	43	35
S 98031	1656	1823	1740	4226	6096	5160	51	52	34
S 98060	1428	1857	1643	4074	5842	4958	63	32	33
S 98061	1366	2415	1891	4127	6665	5396	59	34	35
S 98063	1578	1917	1748	4267	5261	4764	57	30	37
S 98064	1785	1932	1859	4106	5871	4989	55	33	36
S 98069	1679	2095	1887	4435	5970	5202	58	35	39
S 98071	1502	2387	1845	3889	6214	5051	56	33	37
S 98073	1454	1775	1615	3951	4841	4396	54	34	39
Ghab 1	1665	2181	1923	3576	6059	4818	45	29	40
Ghab 3	1501	2381	1941	3677	6383	5030	51	26	39
Ghab 2	702	1788	1245	2717	5665	4191	50	26	30
Mean	1298	1759		3709	5555				
C.V.	8.5	12.6		7.0	9.2				
LSD (at P=0.05)	380.5	640.1		801.3	1053.0				

6.1.1.3.2. Improvement in Seed Yield in the Cultigen

Three hundred and ninety two newly-bred lines were evaluated in 7 preliminary yield trials (PYTs) in winter and 473 lines were evaluated in eight PYTs in spring at Tel Hadya. Eighty one lines were superior to the check-ILC 482 (the check in winter) and 68 lines were superior to he check ILC 1929 (the check in spring) in seed yield. However at Terbol, 303 entries during winter, and 323 entries during spring were evaluated for their yield in 5 trials each (Table 6.1.11). Nine test entries in winter-sown and 34 test entries in spring-sown were superior to the check in seed yield at Terbol.

In general, the seed yields were good for winter and poor for spring planting in 1998/99 season. The winter-sown chickpea produced 124% more seed yield than the spring-sown chickpea at Tel Hadya, and 112% more at Terbol, with an overall increase of 117%. On the basis of overall mean seed yield for these locations for the last sixteen years, winter sowing gave 73% increase over spring sowing.

Table 6.1.11. Performance of newly developed lines under winter and spring-sown conditions at Tel Hadya and Terbol, 1998/99

Location and season	No. of trials	No. of entries: Tested	No. of entries: Exceeding check	Seed yield(kg/ha): Mean over locations	Seed yield(kg/ha): Mean of the highest yielding entry
Tel Hadya					
-Winter	7	392	81	1333	1934
-Spring	8	473	68	596	1083
Terbol					
-Winter	5	303	9	1726	2508
-Spring	5	323	34	814	1602

6.1.1.4. Cyst Nematode Resistance

The chickpea cyst nematode, *Heterodera ciceri* is distributed in several Middle East countries. Earlier studies on evaluation of a large number of accessions of the cultigen for resistance to cyst nematode in collaboration with the Institute of Nematology at Bari, Italy revealed absence of resistance in the cultivated species. The evaluations of wild *Cicer* accessions, however, revealed that resistance is available in *C. reticulatum*, *C.bijugum*, and *C.pinnatifidum*. Among the crossable species, *C. reticulatum*, only one accession (ILWC 292) was resistant to cyst nematode. The crosses between cultigen and ILWC 292 were made to incorporate genes for cyst nematode resistance into the cultigen and a good success has been achieved.

A Preliminary Yield Trial involving 18 Nematode resistance derived lines along with two checks was conducted at Tel Hadya during 1998/99. The results indicated that the derived lines were low in seed yield and possess small seed size (range 12.0 to 17.0 g/100-seed) and colored seeds. Efforts are being made to improve their seed quality.

During 1998/99, 3429 plants in various segregating generations were screened for cyst nematode resistance under controlled conditions in the plastic house at Tel Hadya (Table 6.1.12). Ninety plants in F_2, 303 plants in F_4, 36 plants in F_5, 1185 plants in F_6, and 434 plants in F_7 that showed resistance behavior (0 to 2 rating) were selected.

Eleven lines from the cross between FLIP 87-69C with ILWC 292 were multiplied in Terbol in the off-season during 1998.

A trial on the pathogenicity of Heterodera ciceri on chickpea was conducted in the field in microplots during this season. The experiment included, 5 entries, 10 treatments of populations of nematodes (from 0-128 eggs/gm soil) in 10 replications. The three derived entries, (NEMR13, NEMR14 and NEMR15) and the two parents (ILWC 292 and FLIP 87-69C) were selected to be planted in this experiment in microplots to assess their limit of tolerance and estimate their yield losses. These newly developed lines have tolerance to cyst nematode but they are small and dark-colored seeds. Soil samples from the 500 microplots are taken and sent to Italy to extract the different stages of nematodes. Efforts are needed to improve their seed quality. The studies are not yet completed and the results will be repeated next season.

6.1.1.5. Interspecific Hybridization and Improvement in Cold Tolerance

A large number of breeding materials in different generations was sown in autumn for evaluation for cold tolerance. As the season was very mild with little cold damage, evaluation was not done.

6.1.1.6. International Testing Program

The international testing program on Kabuli chickpea is an instrument for the dissemination of germplasm and improved production practices, in the form of international nurseries and trials, to the national programs in and outside the WANA region. The germplasm represent early segregating populations in F_3 and F_4 generations, and elite lines with wide or specific adaptation, special morphological or quality traits, and resistance to major biotic and abiotic stresses. Nurseries are sent only on request and often include germplasm specifically developed for a particular region or a national program. A list of nurseries supplied for the 1999/2000 season is given in (Table 6.1.13).

The testing program helps in identification of genotypes with specific and wide adaptation. The performance data sent by cooperators all over the world permit assessment of genotype x environment interaction and help in targeting breeding efforts for specific agro-ecological conditions.

The salient features of the 1997/98 international nursery results received from cooperators are presented here. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

The Chickpea International Yield Trial-Spring (CIYT-SP) was distributed to 43 locations (21 countries) but field data were received from 19 locations (seven countries). As at two locations the trial was planted in winter, the overall entry means for seed yield were calculated from 17 locations. The grand mean of entries across locations was 1614 kg/ha. The five heaviest yielding test entries included FLIP 94-61C, FLIP 94-88C, FLIP 93-166C, FLIP 94-111C and FLIP 93-176C. The location mean for seed yield varied from 638 kg/ha in Maragheh (Iran) to 3916 kg/ha in Taluqan (Afghanistan).

The results of the stability analysis for seed yield revealed that the entries FLIP94-88C, FLIP94-61C, and FLIP94-111C had above average mean, regression coefficient (b) equal to 1, and deviations from regression approaching zero. Thus these entries exhibited general adaptation across environments. The entry, FLIP 95-56C, had above average mean seed yield, regression coefficient exceeding unity, and deviation from regression approaching zero, and was thus responsive to high yielding environments.

The Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) was distributed to 46 locations in 19 countries but results were received for 19 locations in 10 countries. As in four locations the trial was planted in spring, these locations were excluded, and the overall means were calculated from 15 locations. The grand mean across locations was of 2455 kg/ha. The five heaviest yielding test entries included FLIP 95-69C, FLIP 95-60C, FLIP 92-169C, FLIP 95-64C, and FLIP 95-57C. The location mean for seed yield varied from 753 kg/ha in Beqa'a (Lebanon) to 3734 kg/ha in Homs (Syria).

Table 6.1.12. Reaction of plants from interspecific crosses in F2, F4, F5, F6 and F7 generations to cyst nematode in the greenhouse at Tel Hadya, 1998/99

Generation	Cross no.	Parents	Scale[1]						
			0	1	2	3	4	5	Total
F2	X 98TH212	S 95345 X NEMR 12	3	13	25	75	89	31	236
	X 98TH213	S 95333 X NEMR 12	8	22	19	22	41	21	133
	Total		11	35	44	97	130	52	369
F4	X 96TH127	Sel 95TR 35-3-1 X FLIP 84-92C	6	74	55	59	2	0	196
	X 96TH128	Sel 95TR 37-1-1 X FLIP 82-150C	5	99	64	111	3	1	283
	Total		11	173	119	170	5	1	479
F5	X 95TH112	FLIP 84-92C X ILWC 119	1	7	4	15	1	0	28
	X 95TH113	FLIP 82-150C X ILWC 119	2	13	9	10	0	0	34
	Total		3	20	13	25	1	0	62
F6	X 94TH186	(ILC 482 X ILWC 119)X ILC 482	70	516	593	358	5	0	1542
	X 94TH187	(ILC 482 X ILWC 119)X ILC 482	0	0	6	0	0	0	6
	Total		70	516	599	358	5	0	1548
F7	X94TH188	(ILC 482 X ILWC 119) X ILC 482	13	118	181	382	31	2	727
	X94TH189	(FLIP87-69C X ILWC119) X FLIP87-69C	4	48	70	101	21	0	244
	Total		17	166	251	483	52	2	971

1/ Scale 0=no cyst formation on roots, 5= > 50 cysts on roots

Table 6.1.13. Distribution of Chickpea Nurseries to Cooperators in 1999

Chickpea International Nursery	No. of sets
Elite Nursery Winter (CISN-W-2000)	50
Elite Nursery Spring (CISN-S-2000)	49
Elite Nursery, South. Latitudes-1(CISN-SL1-2000)	15
Elite Nursery, South. Latitudes-2(CISN-SL2-2000)	6
Elite Nursery, Latin America (CISN-LA-2000)	13
F_4 Nursery, Mediterranean Region (CIF_4N-MR-2000)	20
F_4 Nursery, Southerly Latitudes (CIF_4N-SL-2000)	12
Ascochyta Blight Nursery (CIABN-2000)	42
Fusarium Wilt Nursery (CIFWN-2000)	30
Cold Tolerance Nursery (CICTN-2000)	21
Drought Tolerance Nursery (CIDTN-2000)	35
Total	293

The results of the stability analysis revealed that the linear portion of entry x environment (GxE) interaction was not significant and the non-linear portion was highly significant (Table 6.1.14). The entry FLIP 95-62C showed general adaptation, whereas the entries FLIP 95-64C and FLIP 94-25C were specifically adapted to the high yielding environments.

The Chickpea International Yield Trial Southerly Latitudes-1 (CIYT-SL1) was distributed to 17 locations in 11 countries. However, yield data were received from only four locations in four countries. The mean seed yield across locations was 1849 kg/ha. The five heaviest yielding test entries included FLIP 94-79C, FLIP 94-80C, FLIP 95-14C, FLIP 95-13C, and FLIP 94-93C. The location mean varied from 776 kg/ha in Navsari (India) to 2582 kg/ha in Lan Zhou (China). The results of the stability analysis on seed yield data revealed that the linear portions of entry x environment (GxE) interaction was not significant whereas the non-linear portion was highly significant (Table 6.1.14).The entry FLIP 94-76C exhibited general adaptation across environments, and the two other entries (FLIP 95-53C and FLIP 94-85C) were specifically adapted to favorable environments. The days to flowering of the entries across environments varied from 89 to 105 days. The location mean varied from 65 days in Navsari (India) to 107 in Hail (Saudi Arabia). The five earliest flowering test entries included FLIP 95-14C, FLIP 95-68C, FLIP 95-11C, FLIP 94-96C, and FLIP 94-85C.

Table 6.1.14. ANOVA for stability parameters for seed yield for the entries in CIYT-SP, CIYT-W-MR and CIYT-SL1 conducted during 1997/98

Source of variation	*CIYT-SP*		*CIYT-W-MR*		*CIYT-SL1*	
	Df	MS(x10)^3	df	MS(x10)^3	df	MS(x10)^3
Entry	23	119.732**	23	411.898**	23	340.465
Entry x Location	23	146.663**	23	94.580	23	71.297
Pooled deviation	360	58.700**	312	132.579**	48	206.620
Pooled error	816	43.843	720	65.098	192	133.313

* =Significant at P≤ 0.05, ** Significant at P≤ 0.01

The Chickpea International Yield Trial Southerly Latitudes-2 (CIYT-SL2) was distributed to 11 locations in 9 countries but no data were received.

The Chickpea International Yield Trial Latin America (CIYT-LA) was distributed to 15 locations in 10 countries but data were received only from La Molina (Peru). The mean seed yield across locations was 1719 kg/ha.

The data on seed yield for entries in Chickpea International Screening Nurseries -Winter (CISN-W), -Spring (CISN-SP), -Southerly Latitudes-1 (CISN-SL1), and -Latin America (CISN-LA) were reported from 20, 16, 1, and 1 locations, respectively. *Some of the test entries exceeded* the local check by significant margins at 5, and 3 locations, in CISN-W, and CISN-SP respectively. The five heaviest yielding entries across locations for these nurseries are given in (Table 6.1.15).

Table 6.1.15. The five heaviest seed yielding lines across locations in different chickpea international screening nurseries, 1997/98

Rank	CISN-W	CISN-SP	CISN-SL1	CISN-LA
1	FLIP 93-1C	S 95419	S 96017	S 95152
2	S 96029	S 96159	S 96102	S 95153
3	S 95346	S 95082	S 95111	S 96215
4	S 96019	FLIP 94-50C	S 96048	S 96242
5	FLIP 94-7C	S 95356	S 96147	S 96230

Chickpea International F_4 Nursery for Mediterranean Region (CIF_4N-MR) was supplied to cooperators for 29 locations in 15 countries, however, field data were returned from 12 locations. Individual plant selections were made by the cooperators from all the populations. The populations x94TH150, x95TH20, x95TH5, and x95TH12, were selected in 12, 12, 10, and 10 locations, respectively.

The Chickpea International Ascochyta Blight Nursery-A(CIABN-A) with kabuli lines was distributed to 37 locations in 16 countries and scores were received from six locations in four countries. None of the test entries showed resistance at General Toshevo (Bulgaria) and several test entries at Mashhad (Iran) and Alcala (Spain), showed resistant reaction.

The Chickpea International Ascochyta Blight Nursery-B(CIABN-B)with kabuli and desi lines was distributed to 28 locations (12 countries) and results were received from five locations in five countries. At Gachsaran (Iran), and Tel Hadya (Syria), almost all the test entries showed resistant reaction to Ascochyta blight (rating $\leq$ 5 on 1-9 scale). However at Elvas Portugal only two entries, FLIP 95-67C and S96147 exhibited moderately tolerant reaction (rating=5).

The Chickpea International Fusarium Wilt Nursery (CIFWN) was distributed to 46 locations in 23 countries but results were received from 11 locations in 8 countries. At Hisar in India, the disease was uniformly spread in the experimental area, and nine entries were scored as resistant ($\leq$ 20% plants killed). The entries S 96278 and ICCV 95506 showed the highest level resistance to Fusarium wilt.

The Chickpea International Drought Tolerant Nursery (CIDTN) was distributed to 53 locations in 26 countries but results were received from five locations in five countries. The susceptible check was killed only at three locations. Drought tolerance was scored on 1-9 scale (where 1=free from damage, and 9=killed or no yield) and the lines with rating $\leq$ 5 were scored as tolerant. Drought tolerant lines were recorded only at Shirvan (Iran), while at the other two locations, Badnapur (India) and Tel Hadya (Syria) score was at least seven and all the entries were in the susceptible range.

The Chickpea International Cold Tolerance Nursery (CICTN) was distributed to 39 locations in 22 countries but cold reaction was reported from five locations in three countries. The results from three locations in Iran revealed that fifteen entries were tolerant to cold. The most cold tolerant entries, included Sel 96TH11439, Sel 95TH1716, Sel 96TH11485, Sel 96TH11515 and Sel 96TH11518.

6.1.1.7. ICARDA/University of Cordoba (INIA) Collaborative Program on Fusarium wilt (*Fusarium oxysporum f.sp. Ciceris*) in Chickpea in the Mediterranean Region

Work on Fusarium wilt is jointly done by the University of Cordoba, Spain and ICARDA under the project "Identification of races of Fusarium wilt in the WANA region and development of genetic stocks for resistance to Fusarium wilt (*Fusarium oxysporum f. sp. Ciceris*)" sponsored by INIA-Spain and ICARDA.

The work done at Tel Hadya for screening for Fusarium wilt resistance is reported in earlier pages and the work done on Inheritance of Fusarium wilt resistance to race 0 in chickpea is reported here. Four parents namely, FLIP 82-78C, FLIP 84-43C, ILC 38 and ILC 50 were used to make 6 possible straight crosses at Tel Hadya in Syria. These crosses were grown to advance the generation and also to make the backcrosses with their parents. Finally Thus the following material comprising, 4 parents, 6 F1s, 6 F2s, and 6 Backcrosses developed at Tel Hadya were evaluated against Fusarium wilt race 0 at Cordoba under the controlled conditions to study the pattern of inheritance of Fusarium wilt (*Fusarium oxysporum f.sp. ciceris*). The details of the *materials are given as under:*

Parents: Resistant: FLIP 82-78C, FLIP 84-43C

Susceptible: ILC 38, ILC 50

F_1:FLIP 82-78C x FLIP 84-43C (X90T.H365), FLIP 82-78C x ILC 38(X90T.H366), FLIP 82-78C x ILC 50 (X90T.H367), FLIP 84-43C x ILC 38 (X90T.H368), FLIP 84-43C x ILC 50 (X90T.H369), ILC 38 x ILC 50 (X90T.H370)

F_2: X90T.H365, X90T.H366, X90T.H367, X90T.H368, X90T.H369, X90T.H370

BC1: X90T.H365 x FLIP 82-78C, X90T.H365 x FLIP 84-43C, X90T.H366 x FLIP 82-78C, X90T.H367 x FLIP 82-78C, X90T.H368 x FLIP 84-43C, X90T.H369 x FLIP 84-43C

Fungal isolates: Monoconidial isolates of *F.o. ciceris*: F_0 7802 (Race 0), F_0 8720 (Race 1), F_0 90117 (Race 6) were used for the present study.

Experimental Details: Chickpea parent lines were first tested for disease reaction to all isolates by the pot-culture method. Because of the reaction of resistant parents to each of the three races, parent lines, F_1, F_2 and BC1 crosses were then tested for disease reaction to race 0 isolate.

Isolates were grown on potato-dextrose agar (PDA) at 25°C *and a* 12-h *photoperiod of fluorescent and near-UV* light at 36 $\mu Em^{-2}s^{-1}$. Inocula for pot cultures were increased in a cornmeal-sand (CMS) mixture in 1 L flasks (400 g/flask) and incubated under the same conditions as isolates for 2 wk. Infested CMS was mixed thoroughly (1:10 w/w) with an autoclaved soil mixture (clay loam/sand.peat 1:1:1 v/v/v).

The inoculum density of *F.o ciceris* in the *infested* soil mixture was assessed before planting. Two 300 g soil samples were collected from the infested soil mixture, bulked, thoroughly mixed, and used for soil dilution plating. A 1-g sample of soil was placed into a vessel containing 100 ml of sterile 0.1 % water agar and stirred in a blender at 300 rpm for 5 min. One ml of this suspension was spread on each of four plated of V8 juice-oxgall-PCNB agar medium (VOPA) selective for Fusarium. The plates were incubated under the same conditions as isolated for 5 days. Colonies of Fusarium that grew on the selective medium were identified as F. oxysporum based on the presence of short monophialides shaped *micro conidia* in false heads, chlamydospores, and characteristically shaped macro conidia. Estimated of *F. oxysporum* f.sp. *ciceris* in the infested soil mixture ranged $233x10^3$ to $247x10^3$ colony forming units per g of soil among experiments.

Seeds were surface-disinfested, air dried, germinated and then planted (four per pot) in 15-cm-diameter clay pots filled with the infested soil mixture. Control plants were grown in a comparable mixture of non-infested CMS and autoclaved soil. Also, for each set of inoculated parent lines and crosses there were four replicate pots of lines P 2245, JG 62 and 12071/10054 inoculated, which served as check for the expected *reaction of race* 0 *isolated* of *F.o. ciceris.*

Plants were grown in a growth chamber at 25°C and 60-80% relative humidity, with a 14-h photoperiod of fluorescent light at about 350 $\mu Em^{-2}s^{-1}$. Plants were watered daily and fertilized with 100 ml of nutrient solution at weekly intervals. Disease reactions were assessed by the severity of symptoms on a 0-4 scale according to percentage of foliage with yellowing or necrosis in acropetal progression (0=0; 1=1-33; 2=34-66; 3=67-100% and 4=dead plant), every other day from the 15^{th} to 40^{th} day after planting. In addition to severity of symptoms, the time from *inoculation to symptoms* development was recorded for each plant. Upon completion of each inoculation experiment, isolations were made from surviving symptomatic and nonsymptomatic plants to confirm infection by the pathogen. Collar and stem tissues were washed in running tap water, cut into pieces 5-10 mm long, surface-disinfested in 1%

NaClO for 2 min, plated on VOPA and incubated under the same conditions as isolated for 7 days.

Plants those were free of symptoms and infection by *F.o. ciceris*, were considered as resistant. Plants, which had developed symptoms by 40 days after inoculation, or were free of symptoms but systemically infected by the pathogen were considered susceptible. Chi-square test with Yate's correction for one degree of freedom was carried out to determine goodness of fit of observed segregations to theoretical gene(s) segregating (6).

Results: The generation-mean analysis was done using parents, F1s, F2s and available back cross generations for six crosses, and different models with different parameters were constructed and compared to find the best fit model. The results pertaining to the joint scaling tests and estimates of gene affects for disease score on 0 to 4 scale (0=no infection, 4=100% killing) on three or more parameters models are presented here.

Cross I (FLIP 82-78C x FLIP 84-43C)

The test of goodness of fit using a 3-parameter model for this crosses revealed the significance of χ^2. This showed that additive and dominance parameters alone were not adequate to explain the Fusarium wilt reaction in this cross, and genic-interactions also played a role in the expression of Fusarium wilt reaction. The χ^2 value using m, d, h and l, was close to zero with 99.9% of the variation accounted for by these four parameters. This suggests that there was nothing beyond these 4 parameters to explain the Fusarium wilt, and among these additive (d), dominance (h), and dominance x dominance gene effects were significant.

Cross II (FLIP 82-78C x ILC 38)

The test of goodness of fit using a 3-parameter model for this cross revealed the non-significance of χ^2. This showed that additive and dominance parameters alone were adequate to explain the Fusarium wilt reaction in this cross.

Cross III (FLIP 82-78C x ILC 50)

The test of goodness of fit using a 3-parameter model for this crosses revealed the significance of χ^2 This showed that additive and dominance parameters alone were not adequate to explain the Fusarium wilt reaction in this cross, and genic-interactions also played a role in the expression of Fusarium wilt reaction. The χ^2 value using m, d, h and j, was close to zero with 100% of the variation accounted for by these four parameters. This suggests that there was nothing beyond these 4 parameters to explain the

Fusarium wilt, and among these additive (d), dominance (h), and additive x dominance gene effects were significant.

Cross IV (FLIP 84-43C x ILC 38)

The test of goodness of fit using a 3-parameter model for this crosses revealed the significance of χ^2 This showed that additive and dominance parameters alone were not adequate to explain the Fusarium wilt reaction in this cross, and genic-interactions also played a role in the expression of Fusarium wilt reaction. The χ^2 value using m, d, h and i was close to zero with 100% of the variation accounted for by these four parameters. This suggests that additive (d), dominance (h), and additive x additive (i) gene effects were important in the expression of disease resistance in this cross

Cross V (FLIP 84-43C x ILC 50)

The test of goodness of fit using a 3-parameter model for this crosses revealed the significance of χ^2, which showed that the Fusarium wilt reaction in this cross is also influenced by genic-interactions. The χ^2 value using m, d, h and l, was close to zero with 100% of the variation accounted for by these four parameters. This suggests that importance of additive (d), dominance (h), and dominance x dominance (l) gene effects in the inheritance of Fusarium wilt resistance.

Cross VI (ILC 38 x ILC 50)

The test of goodness of fit using a 3-parameter model (m, d, and h) for this cross revealed the significance of χ^2 This showed that genic-interaction also play a significant role in the expression of Fusarium wilt reaction. The χ^2 value using m, d, and i, was least with 98.5% of the variation accounted for by these three parameters. Suggesting that additive (d) and additive x additive gene effects were important.

The joint scaling test generally revealed that the genic interactions were present and responsible for the expression of Fusarium wilt resistance in chickpea. Examination of gene effects of all the crosses revealed that both additive and dominance gene effects were significant for most of the crosses and were thus important.

Further, the graphical analysis using 4x4 diallel crosses indicated that parents ILC 50 and ILC 38 had the highest concentration of dominant genes and high susceptibility followed by FLIP 82-78C and FLIP 84-43C which had high concentration of recessive genes and high resistance. These results thus revealed that recessive genes governed resistance to Fusarium wilt in the lines used in this study.

The correlation co-efficient between parental order of dominance (VrWr) and parental measurements was negative (-0.7593) contemplating the preponderance of dominant genes with positive effects.

6.1.2. Biotechnological Applications in Chickpea Improvement

6.1.2.1. Interspecific Hybridization between Cultivated Chickpea (*Cicer arietinum* L.) and the wild Annual Species *Cicer judaicum* Boiss., *Cicer pinnatifidum* Jaub. & Sp. and *Cicer bijugum* K.H.Rech

To be able to introduce resistance genes for biotic and abiotic stresses from the wild species into cultivated chickpea, interspecific hybrids between cultivated chickpea (*C. arietinum*) and three wild species (*C. bijugum*, *C. judaicum* and *C. pinnatifidum*) were investigated. Five kabuli-type *C. arietinum* cultivars (ILC 200, ILC 482, ILC 519, Amdoun-1 and FLIP 84-15C) and three desi-types (ICC 12004, ICC13729 and ICC 14903) were crossed with three accessions of each of the wild species (*C. bijugum,* ILWC 32, -62, -79; *C. judaicum,* ILWC 46, -61, -95; and *C. pinnatifidum,* ILWC 171, -236, -250). The wild species were selected according to their known resistance and tolerance for the biotic and abiotic stresses. The wild species were used as the pollen donor in each cross. The cultivars were emasculated in the morning, pollinated and then treated with hormone solution. Drop of hormone solution I, II and III were applied (one drop at the base of the pistil) in three different time periods: A (every day for the first 10 days), B (every second day till collection) and C (twice a day the first three days). All hormone mixture/time of application combinations were used with all cross combinations. Pods were collected 10-20 days after pollination. Putative fertilized ovules or, if possible, embryos were cultured on different media. Embryos and ovules that regenerated shoots were transferred to ½MS medium. Explants were taken from some putative hybrids to maintain them. Currently 25 plantlets are growing *in vitro* and different techniques are tried to root these plants (grafting, liquid culture).

In general, without hormone application no pod development was visible (Table 6.1.16): flowers started to turn brown two to three days after pollination and finally dropped. With hormone application pods developed normal for about 10-15 days, after which they turned brown and eventually dropped. When pods were collected within 15 days good ovules and embryos were found. Pods left longer than 20 days contained still ovules but they had started to shrivel and were turning yellow. Application of higher concentrations of hormones after pollination (solution II and III) enhanced the overall podsetting and ovule development but embryo development was not significantly different from crosses where solution I was applied see (Tables 6.1.16 & 6.1.17). The rate of podsetting after hormone application was high 42.5%, (Table 6.1.16). However, podsetting was to a limited extent only followed by ovule (12.8%) and embryo (1.2%) development. Podsetting (47.1%) and ovule development (19.7%) were best using application interval C, while for embryo development both A (1.3%) and C (1.3%) seem to have a more positive effect.

The best overall combination of hormone solution and time application interval was combination IIC, which resulted in the highest percentage of podsetting (55.4%), a high percentage of ovule development (19.3%) and a better development of rescued ovules and embryos into plantlets (data not shown). The highest percentage of ovules was obtained when using combination IIIC but this did not result in a high number of embryos. The highest number and percentage of embryos was obtained using combination IA. Unfortunately these embryos did not germinate well. In general: for pod development there are significant differences between the different time of application intervals, the type of hormone solution used and the different combinations between these two factors (Table 6.1.18). For ovule development the differences for time application intervals and hormone solutions are significant, but not for the separate combinations of time application and hormone solution (Table 6.1.18). Due to the low numbers of embryos obtained, no significant differences could be shown for either of the factors or their interaction. However, differences do exist as is shown in (Table 6.1.16). The overall effect of hormones and time application intervals between the various cross combinations was not significantly different (data not shown).

Interspecific crosses between the cultigen and the annual wild species have been made with kabuli as well as desi-type cultivars. The only successful crosses with the annual wild species used, have been done with desi type chickpea. Pod setting was not effected by the chickpea type (Table 6.1.17) however, for ovule development desi type chickpea resulted in a significantly higher percentage (9.7% vs. 5.6%). For the obtained ovules this response interacted with that of the hormone solution used as solution II gave almost three times as many ovules when desi type chickpea was used instead of kabuli. Although the data were not significantly different for embryos (due to the low numbers of embryos), the number of embryos obtained using desi (17) was considerably higher than when kabuli (8) was used. The same effect as with the ovules was seen when solution II was used. This indicates that desi-type chickpea are more compatible for interspecific hybridization with wild *Cicer* species than the kabuli-type cultivars and respond better to the application of high doses of hormones.

To confirm the hybridity of the material total DNA was extracted from leaf tissue of the putative hybrids and one F_1 plant of each of the parents by a miniature version of the modified CTAB protocol and used as a template for PCR amplification. First, different Sequence-Tagged Microsatellite Site (STMS) markers were screened for polymorphism between the parents and the markers, which showed distinct polymorphism, namely Tr1, Ta3 and Ta18 were identified. The amplified fragment patterns of the parental plants with their putative hybrids were compared to confirm hybridity.

Four hybrids have so far been identified by microsatellite analysis. These are hybrids between ICC 12004 (desi type) and ILWC 236 (*C. pinnatifidum*), ICC 13729 (desi type) and ILWC 236 (*C. pinnatifidum*), ICC 13729 (desi type) and ILWC 250 (*C. pinnatifidum*) and ILC 482 (kabuli type) with ILWC 61 (*C. judaicum*). Embryos of crosses between the cultigen and *C. bijugum* were obtained but died due to necrosis.

Deviances (under binomial errors and logit link, are distributed as chi-square in case the corresponding source has no effect).

6.1.2.2. Identification of Markers Linked to *Ascochyta Rabiei* Resistance Genes in Chickpea

It appears from the literature that the Ascochyta blight pathosystem is extremely complex. Not only the variability of the pathogen is very wide, but also the varietal response of chickpea to the disease. The mode of inheritance of the resistance seems to be complex and unresolved regarding whether the resistance is horizontal or vertical, whether its control is monogenic or polygenic, and whether it is quantitative or qualitative. However, it is possible to connect the resistance trait to molecular markers by linkage analysis, and this is the key to the exploitation of molecular markers. In the final analysis, the objective of using molecular marker is to substitute a quick, easy, cheap and reliable assay for the resistance trait, which is much more complex. In order to do so, we must establish the linkage between the trait and the molecular marker in terms of genetic linkage in segregating populations. Since several genes confer the resistance, knowledge of their genomic locations would further facilitate pyramiding and transfer of the resistance genes to acceptable genetic background through marker assisted selection. There has been a limited success in mapping of the resistance genes in the cultivated chickpea because of minimal polymorphism of the conventional molecular markers such as RFLPs, RAPDs, etc. DNA markers such as Sequence Tagged Microsatellite Site markers can overcome the problem of minimal polymorphism and allow construction of linkage map and tag genes of the resistance in an intraspecific cross. We used an intraspecific cross within *C. arietinum* (ILC 1272, susceptible parent X ILC 3279, resistant parent to pathotype II of the pathogen) and the cross was further advanced by single seed decent from F_2 to the F_6. One hundred and twenty of these lines were used for linkage map construction. Segregation analysis was performed with 67 polymorphic microsatellite markers. The amplified PCR products were analyzed for the length difference either by sequencing gel-silver staining system or by using ALF express DNA sequencer. Based on the analysis linkage groups were established at LOD 3.0 using MAPMAKER/EXP 3.0. Out of the 67 polymorphic markers, 50 of them formed 8 linkage groups which correspond to the chromosome number of the chickpea genome. Further addition of the markers into this map is in progress, which may help in linking the rest of the markers. A reliable screening technique for the blight resistance has been developed for this population and is being used for tagging the genes of resistance to the blight.

Table 6.1.16. Effect of hormones, time of application and their interaction on number and percentage pod, ovule and embryo development

	Hormone*				Time of Application**			Hormones and time of application									
	0	I	II	III	A	B	C	I&A	II&A	III&A	I&B	II&B	III&B	I&C	II&C	III&C	Total
Total no. of crosses	100	1142	1121	1046	1192	1148	969	396	415	381	367	421	360	379	285	305	3309
Pods	0	427	526	466	526	451	442	161	192	173	129	176	146	137	158	147	1419
(in %)	0	37.4	46.9	44.6	44.1	39.3	45.6	40.7	46.3	45.4	35.1	41.8	40.3	36.1	55.4	48.2	42.9
Ovules	0	125	165	133	126	132	165	48	54	34	29	56	47	58	55	52	423
(in %)	0	10.9	14.7	12.7	10.6	11.5	17.0	12.1	13.0	8.9	7.9	13.3	13.1	15.3	19.3	17.0	12.8
Embryos	0	15	13	13	18	10	13	7	6	5	2	5	3	6	2	5	41
(in %)	0	1.31	1.16	1.24	1.51	0.87	1.34	1.77	1.45	1.31	0.55	1.19	0.83	1.58	0.70	1.64	1.24

Hormone*: O: no hormone applied; I: 8 mg/l gibberillic acid (GA3), 1 mg/l Kinetin (KIN), 1 mg/l napthaline acetic acid (NAA); II: 200 mg/l GA3; III: 87.5 mg/l GA3, 25 mg/l NAA, 5 mg/l KIN; Time of application**: A: every day for the first 10 days; B: every second day until pod harvesting and C: twice a day for the first three days.

Table 6.1.17. Effect of hormones and cultivar type and their interaction on podsetting,ovule and embryo development

	Cultivar type		Hormones				Cultivar type in combination with hormones						
	Kabuli(K)	Desi	O*	I	II	III	K&I	K&II	K&III	D&I	D&II	D&III	Total
Crosses	940	971	100	663	634	614	327	313	300	336	321	314	1911
Pods	418	411	0	255	314	260	127	161	130	128	153	130	959
(in %)	44.5	42.3	0	38.5	49.5	42.3	38.8	51.4	43.3	38.1	47.7	41.4	50.2
Ovules	53	94	0	46	61	40	21	15	17	25	46	23	147
(in %)	5.6	9.7	0	6.9	9.6	6.5	6.4	4.8	5.7	7.4	14.3	7.3	7.7
Embryos	8	17	0	8	8	9	4	1	3	4	7	6	25
(in %)	0.9	1.8	0	1.2	1.3	1.5	1.2	0.3	1.0	1.2	2.2	1.9	1.3

* O: no hormone applied; I: 8 mg/l gibberillic acid (GA3), 1 mg/l kineti n (KIN), 1 mg/l napthaline acetic acid (NAA); II: 200 mg/l GA3; III: 87.5 mg/l GA3, 25 mg/l NAA, 5 mg/l KIN.

Table 6.1.18. Accumulated analysis of deviances for hormone and time application interval

Source	Df	Pods	*Ovules*	Embryos
Time	2	6.05*	34.03**	2.069
+Hormone	2	27.992**	7.785*	0.066
+Time*Hormone	4	12.318*	5.078	2.396

**,* Significant at 1 or 5% respectively

6.1.2.3. Variability and Migration of *Ascochyta Rabiei*

Gene flow or migration is an important evolutionary force acting on many phytopathogen populations. It either constrains evolution by preventing adaptation of the local pathogen population to the local conditions or promotes evolution by spreading new genotypes or new genes or combination of genes. Migration of the pathogen population has an effect on breeding for race specific (pathotype specific) resistance when breeding materials are screened under field conditions. However, knowledge on the extent of migration at micro-geographical scale in *A. rabiei* is lacking. In order to study extent of migration and pathogen population dynamics, chickpea field of international ascochyta blight nursery (CIABN) was inoculated (spayed) with isolates 1 to 6 during the cropping season 1998/99. After the development of the disease, disease samples were collected randomly from the CIABN as well as from the three neighboring fields. The pathogen was purified, single spored and DNA marker analysis was performed. The DNA patterns of the isolates were compared with that of the inoculated isolates. The DNA marker analysis revealed that none of the isolates sampled (63) in CIABN and in the adjoining fields resembled to the isolates sprayed. Over 75% of the isolates are similar (related) to the isolates of genotype H (pathotype III). The isolates similar to the genotype H are predominated in all the three fields. This observation suggested that the genotype H migrated to the CIABN, and migration plays an important role in the evolution of the pathogen. The genotype H displaced the population of the pathogen inoculated in the field. Predominance of genotype H in the neighboring fields (non-inoculated) is in close agreement with our studies in previous years.

6.1.2.4. Development of a Protoplast-Based System for Somatic Hybridization and Genetic Engineering of Chickpea

We have developed a highly reliable and efficient protoplast system for chickpea, which is applicable also for pea and lentil and suitable for direct DNA-transfer procedures. Since we failed to induce organogenesis on protoplast-derived chickpea callus (more than 4000 independent callus-lines have been regenerated but none showed shoot- or embryo-development within almost a year of culture) and severe limitations in obtaining transgenic pea from protoplasts exist, it was concluded, that a protoplast-based system for transformation and somatic hybridization in chickpea (whilst even less advanced than in pea) is not promising yet and for the immediate future. Therefore, it has been agreed to focus on *Agrobacterium*-based transformation protocols.

6.1.2.5. High-Efficient Regeneration and *Agrobacterium*-Mediated Gene-Transfer

By intensive use of transient expression assays (marker-genes *gusA*-and a modified *gfp*-gene) in analysing optimum conditions and susceptibility of chickpea, we have developed a robust and reliable *Agrobacterium*-mediated transformation system for chickpea. The protocol has been successfully adapted by different scientists and also on different varieties including desi-types.

The established protocol combines a simple and efficient regeneration process by TDZ-induced multiple shoot formation (minimizing the need for sophisticated tissue culture procedures), an easy-to-prepare and always available explant (minimizing the risk of contamination and allowing easy experimental planning) and the reliability and efficiency of *Agrobacterium*-mediated gene-transfer. The protocol is outlined in (Table 6.1.19).

However, the protocol is not variety neutral. Kabuli-type chickpea has a significantly lower tendency to produce multiple axilliary and adventitious buds. Since this intrinsic character could not be overcome by modifying culture media or phytohormone application, we intended to increase the transformation efficiency to a manageable level. We analysed the effect of ultrasound on improving transformation efficiencies. Analysing the transient expression of marker genes as well as calculating the number of transgenic plants obtained, we conclude that sonication significantly enhances the transformation rate in kabuli-type ILC482 but was not found necessary for desi-types.

As outlined in (Table 6.1.20), transformation rate was around 1% and transmission and expression of the introduced genes was observed in at least 3 subsequent generations.

Table 6.1.19. Material, procedure and duration for the production of transgenic chickpea

Material	Procedure	Duration (days)	Duration (accumulative)
Mature seeds	Surface sterilize, imbibe in water, remove seed coat and harvest embryo axes	1	1
On-culture of Agrobacteria, embryo axes	Harvest and suspend bacteria, decapitate embryo axes (sonication optional)		
Bacteria and explants	Cocultivate on medium supplemented with 10 :M TDZ	3	4
Explants, forming multiple shoots	Reduce and replace TDZ by *kinetin in 2 subsequent* subcultures	25-30	29-34
Explants forming multiple shoots	Apply stringent selection, stepwise increasing	80-100	110-134
Green shoots, >1cm	Harvest and graft or root	14-16	124-150
Plantlets	Transfer into soil and adapt to low moisture conditions	16-20	140-170
Plants	Growth, flowering and seed set, initial analysis	40-50	180-220
Plants	Ripening	20-30	200-250
From inoculation to seed			7-9 month

6.1.2.6. Vector Constructs for *Agrobacterium* and Direct DNA-Transfer

Since we modified the workplan and omitted any further attempt using direct DNA-transfer methods (e.g. protoplasts or particle bombardement), vectors did not have to be developed. However, using an appropriate selectable marker in *Agrobacterium*-mediated transformation might be of importance, as it is a critical factor in screening and selection for transgenic plants and it might become important when negotiating commercial applications.

We have excised the vst-gene (encoding the stilbene-synthase gene from *Vitis vinifera*, including regulatory sequences) and subcloned the gene into a pBIN-derived binary vector resulting in pKTV-VST1 harbouring a bar-gene for efficient selection. *Agrobacterium*-strain EHA105 has been transformed with this vector and the first transgenic kabuli-chickpea has been generated.

We assume, that the same binary vector can be used for introducing afp-genes, provided stable expression can be shown in subsequent generations.

We have demonstrated the applicability of npt-II in screening and selecting transgenic chickpea at least for desi-types see (Table 6.1.20).

Table 6.1.20. Summary of transformation efficiency, comparing T_0- and T_1-data. Transgenic character was confirmed by gus-assay, leaf-paint, pat-assay, leaf-disc test and gus- or npt-II PCR

Variety	Strain	Expl	Select	Positive T_0	TE [%]	Positive T_1
P1043	EHA101pIBGUS	572	Gluf	6	1.05	1/
P-362	EHA101pIBGUS	355	Gluf	4	1.13	
ILC482	EHA101pIBGUS	150	Gluf	3	1.33	2/3
P-362	EHA105pFAJ3068	200	Km	4	2	
ILC482	PHKvst	200	Gluf	1	0.5	n.d.

6.1.2.7. Chickpea Transformation at AGERI

A protocol for *Agrobacterium* mediated transformation of chickpea line ILC 482 was developed at the Department for Molecular Genetics at the University of Hanover, Germany. The technology is to be transferred to the Agricultural Genetics Engineering Research Institute (AGERI) in Cairo and to be extended to a wider range of germplasm.

Ten chickpea lines, harboring a moderately resistance reaction against Ascochyta blight, pathotype 3, were available, and 8 more lines will be available during 2000. The initial experiments at AGERI are being carried out with FLIP 88-85C and FLIP 82-150C,for which sufficient purified seed material was available during 1999.

Eight experiments have so far been conducted. The 1258/Aglo construct harboring the gene *coding for* β-glucoronidase and the bar gene have been used to determine transformation efficiency. The protocol has been followed as exact as possible, alterations have occurred due to equipment, growth room settings and antibiotics available at AGERI. Preliminary results of the conducted experiments are shown in (Table 6.1.21). So far, regenerants of experiment C1 have been transferred to the first sub culture medium (Sub4) with added BASTA herbicide for selection. Explants developed normal and the procedure of inoculation has not given any problems. The results of the GUS-assays indicated that tissue is being transformed and more important so, shoots are being transformed.

Table 6.1.21. Preliminary results of chickpea transformation experiments at AGERI, using the 1258/Aglo construct

Exp.*	Chickpea line	No. on Sub1**	No. on Sub2**	No. on Sub3**	No. on Sub4***	Percentage positive in GUS-assay	Percentage contaminated
C1	FLIP 82-150	320	273	210	210	0.6	0.07
C2	FLIP 82-150	430	390	185	-	1	0.47
C3	FLIP 82-150	348	-	-	-	-	1
C4	FLIP 82-150	351	266	-	-	1	0.11
C5	FLIP 82-150	225	136	-	-	1	0.21
C6	FLIP 82-150	381	365	-	-	1	0
C7	FLIP 82-150	597	204	-	-	1	0.66
C8	FLIP 88-85	184	174	-	-	0.8	0
Total		2836	1808	395	210	6.4	0.35

* Exp: Experiment number
** Sub1, Sub2 and Sub3: Subculture media with antibiotic
*** Sub4: Subculture medium with antibiotic and BASTA for selection

6.1.3. Chickpea Pathology

Diseases are a major factor limiting the production of chickpea in the WANA region. Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. is the most serious disease. It is particularly severe on chickpea when planted in the winter, low temperatures and continuous rains prevailing during this period favor crop-growth and also disease development. With the increasing population of aggressive pathotypes of the pathogen in the WANA region, the annual risk to Ascochyta blight epidemics continue to increase. It is, therefore, absolutely necessary to control the disease to increase and stabilize yields in the region. The major emphasis in chickpea pathology research continues to be on the identification of durable and stable sources of resistance to Ascochyta blight for use in breeding programs and in integrated management of the disease.

Wilt and root rots are the most prevalent soil-borne diseases of chickpea in the region. They are caused by a complex of pathogens. Among these, *Fusarium oxysporum* f.sp. *ciceris* (Padwick) Snyd. & Hans., the cause of chickpea wilt, is the most important in the region. It is more prevalent on the spring-sown crop as dry and hot conditions favor its development. Other soil-borne diseases in the complex include black root rot (*Fusarium solani*), and wet root rot (*Rhizoctonia solani*). These are favored by high moisture conditions and are important in the highlands of Ethiopia and under irrigated conditions in Egypt and Sudan. Dry root rot (*Rhizoctonia bataticola*) and stem rot (*Sclerotinia sclerotiorum)* also occur on chickpea in the region but overall, they are less important as single disease than Fusarium wilt.

6.1.3.1. Miniaturizing Field Inoculation Method to Screen for Ascochyta Blight Resistance

Following a 2-year study (Annual Reports 1997 and 98) to determine the best time of debris inoculation to increase the infection and development of Ascochyta blight in the screening nursery, it was concluded that the best time to inoculate with debris for optimum infection was in early January. Other alternatives to debris inoculations have been the use of spore suspension sprays and the use of infected susceptible checks to act as spreaders. During the 1998/99 cropping season a new trial was initiated to refine the field inoculation techniques. Five different methods of inoculation including, the use of infected seed of a susceptible cultivar as border rows or checks, the use of clean seed of the susceptible check, debris inoculation at planting, debris inoculation after germination, and spore suspension spray at the vegetative growth stage were compared with the non-inoculated control.

The development of Ascochyta blight severity on 4 chickpea cultivars (ILC 263, Ghab 1, Ghab 3, and FLIP 88-85C), using these different methods of inoculation were compared. The results confirm earlier findings that the complete killing of the susceptible cultivars takes place when inoculated with infected debris at planting. The most efficient method to inoculate field plots for optimum infection and disease development was to use spread infected debris 4 weeks after germination. This method of inoculation gave optimum infection on the susceptible cultivar and also produced a significantly higher level of infection on the moderately resistant cultivars as compared to the non-inoculated control.

Conditions were generally favorable for the development and spread of Ascochyta blight during the early phase of the 1998/99 season. Infection from the infected debris spread in the nursery in January produced good initial infection. Due to a dry spell that followed during the vegetative phase of crop growth, disease spread was not adequate. By the end of April, spore suspensions with *A. rabiei* were spray-inoculated on the entries in the nursery and a mist irrigation system was turned on to increase humidity and facilitate disease spread. Following these spray inoculations, good disease development occurred as could be observed by the severe infection of check mixtures and death of the highly susceptible checks. Thus, it was possible to distinguish different levels of reactions to *A. rabiei* between different genetic materials in the nursery.

6.1.3.2. Chickpea Fusarium Wilt

Steps were taken during the 1999 season to minimize germination problems that were encountered in the wilt sick plots during the 1998 season. These steps involved: a) the treatment of all seed with the fungicide Rizolex to minimize competitive infection mostly by *Rhizoctonia solani*, which was isolated on rotten seeds during the 1998 season, b) planting the trials by machine as opposed to the shallow hand-planting of the previous year, c) the avoidance of start-up irrigation to fasten germination following sowing as practiced in previous years. The above combination of strategies reduced the germination problems, improved the stand and infection of the material by the wilt pathogen for a good screening.

6.1.3.3. Integrated Management of Ascochyta Blight of Chickpea

Low temperatures of 15-25°C and high humidity of up to 100% prevailing during this period favor initiation of Ascochyta blight and its spread. Annual epidemics of the disease are thus usually weather-dependent. A good season for the chickpea crop is often favorable for Ascochyta blight epidemics. Because resistance to Ascochyta blight is often non-durable due partly to the variability of the pathogen, emphasis is laid on the evaluation of other methods of combating the disease through an integrated disease management approach. This approach integrates host resistance with minimal chemical use as seed treatments and timed foliar sprays, and the modification of agronomic practices.

During the 1998/99 cropping season, a set of experiments initiated during the 1996/97 cropping season to evaluate the effect of different control components in integrated packages for the management of Ascochyta blight on winter chickpea cultivars was continued. The following 4 cultivars, FLIP 88-85C, FLIP 90-96C, Ghab 1 and Ghab 3, with different levels of reaction to the disease were evaluated in all the packages. Seeds were treated with fungicides, and each package differed in one agronomic practice. Inoculum source for all the plots was from infected chickpea debris spread on the soil surface in the plots 4 weeks after crop germination. A split-split plot design with cultivars as main plots, seed treatments as sub plots and a cultural practice (sowing date, row spacing and fungicide timing) as sub-sub plots was followed. The different packages were evaluated at 3 different on-station locations (Tel Hadya, Heimo and Al-Ghab) in Syria, in collaboration with NARS scientists.

6.1.3.3.1. Timing of Fungicide Applications to Manage Ascochyta Blight of Chickpea

The fungicide Bravo (Chlorothalonil) has been found to be effective as a foliar spray to control Ascochyta blight of chickpea. The fungicide was applied once at 4 different growth stages (seedling, vegetative, flowering and podding) on the 4 chickpea cultivars with varying levels of reaction to the pathogen. Seeds of all cultivars were treated with the fungicide Tecto (Thiobendazol) except for the control treatment, which was not treated and received no foliar spray. Ascochyta blight severity was evaluated on a 1-9 disease rating scale (1=no disease and 9=severe disease) after podding.

The best disease control on all the 4 cultivars was obtained with a single fungicide spray made either at the seedling or vegetative growth stage. The disease reactions at these stages were significantly less than the non-sprayed control for all the cultivars at all the 3 locations (Table 6.1.22).

6.1.3.3.2. Integrating Planting Dates with seed Treatments and Host Resistance to Manage Ascochyta Blight

Five different planting dates in November, December, January, February and March, were used to evaluate treated and untreated seed of the 4 chickpea cultivars for reaction to Ascochyta blight at 3 locations. Ascochyta blight disease severity ratings were taken at podding for the 3 winter dates and at flowering for the 2 spring dates. Plot seed yields could not be determined because of the highly variable growth between plots due to the prevailing drought conditions during the season.

Table 6.1.22. Effect of timing of a single fungicide spray on Ascochyta blight severity of chickpea genotypes during 1998/99 season

Location	Growth stage of fungicide pray	Disease severity (1-9)[a]				
		FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	Seedling	3.0	3.0	4.0	3.6	3.4
	Vegetative	4.0	3.7	4.0	4.0	3.9
	Flowering	5.6	4.6	5.3	4.6	5.0
	Podding	6.0	4.3	6.3	5.3	5.5
	No spray control	6.0	5.3	7.2	5.8	6.1
	LSD (0.05)	0.6	0.7	0.7	0.7	
Heimo	Seedling	2.0	1.6	2.0	2.0	1.9
	Vegetative	2.0	2.0	2.0	2.0	2.0
	Flowering	2.6	2.0	2.0	2.0	2.1
	Podding	3.0	2.6	3.6	3.3	3.1
	No spray control	4.5	3.3	5.7	4.9	4.6
	LSD (0.05)	0.6	0.8	0.7	0.5	
Al-Ghab	Seedling	2.6	2.3	3.7	3.0	2.9
	Vegetative	3.3	3.0	4.0	3.0	3.3
	Flowering	4.3	4.0	5.0	4.0	4.3
	Podding	4.7	4.3	5.3	4.3	4.7
	No spray control	5.7	5.0	6.7	5.3	5.7
	LSD (0.05)	1.1	1.0	1.3	1.1	

[a]Based on a rating scale of 1-9 where 1=no infection and 9=plants killed

The lowest disease ratings were recorded with the March spring plantings for all the locations on treatments involving both treated and untreated seed. These were significantly lower than the early winter plantings of all the cultivars (Table 6.1.23). The highest disease severity ratings were obtained with untreated seeds of the first three plantings at the Al-Ghab and Tel Hadya. At Heimo only the first two plantings of untreated seed had significant high ratings for disease reaction. Overall, January plantings with treated seed gave the best control of disease at all the locations when compared with the earlier November or December plantings. Fungicide treated seeds significantly reduced Ascochyta blight severity on the early plantings, when compared with the untreated seed, at the Heimo location.

Table 6.1.23. Influence of planting date and fungicide seed treatment on Ascochyta blight severity of chickpea genotypes during 1998/99 season

Location	Planting date	Seed treatment	Disease severity (1-9)[a]				
			F 88-85	F 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	17 Nov	T	6.0	4.3	5.0	4.0	4.8
		NT	6.3	4.0	6.0	5.0	5.3
	19 Dec	T	5.7	4.7	5.0	4.6	5.0
		NT	6.0	4.3	6.0	4.6	5.2
	15 Jan	T	4.6	4.0	4.3	4.3	4.3
		NT	5.3	4.3	5.6	5.3	5.1
	16 Feb	T	4.3	3.6	4.3	3.3	3.9
		NT	4.6	4.0	5.3	4.0	4.5
	14 Mar.	T	3.0	3.0	3.0	3.0	3.0
		NT	3.0	3.0	3.3	3.0	3.1
	LSD(0.05)	T	1.0	1.1	1.1	0.7	
		NT	0.7	0.7	0.9	1.1	
Heimo	15 Nov	T	2.6	2.3	3.6	2.3	2.7
		NT	5.6	4.0	6.6	4.0	5.1
	17 Dec	T	3.0	2.0	3.3	2.3	2.7
		NT	5.0	3.3	6.0	5.0	4.8
	15 Jan	T	1.3	2.0	2.6	2.3	2.1
		NT	3.0	2.6	3.3	4.0	3.2
	18 Feb	T	1.6	2.0	1.6	1.3	1.6
		NT	2.6	2.6	2.6	2.0	2.5
	15 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	2.0	1.6	2.0	2.0	1.9
	LSD(0.05)	T	1.1	0.6	1.0	1.0	
		NT	1.3	1.0	1.2	1.5	
Al-Ghab	17 Nov	T	5.7	4.6	6.7	5.3	5.8
		NT	5.7	5.7	7.0	6.0	6.1
	15 Dec	T	5.3	4.6	6.3	5.0	5.3
		NT	5.7	5.7	6.0	6.3	5.9
	16 Jan	T	4.0	3.0	5.0	4.7	4.2
		NT	5.3	4.0	5.3	4.7	4.8
	14 Feb	T	3.0	3.3	3.0	2.7	3.0
		NT	3.3	3.0	3.3	3.0	3.2
	14 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	1.3	1.3	1.3	1.3	1.3
	LSD(0.05)	T	1.0	1.2	1.2	0.7	
		NT	1.1	0.7	0.8	1.1	

[a]Disease severity based on a scale of 1-9 modified from Singh et al., (1981) ; where 1=no infection and 9=plants killed. T=Treated seed with the fungicide, Tecto at rate of 3g/kg; NT=non-treated seed.

6.1.3.3.3. Integrating Row Spacings with Seed Treatments and Host Resistance to Manage Ascochyta Blight

Temperature and relative humidity are the main environmental factors that greatly influence the development and spread of Ascochyta blight on chickpea. Both parameters, but especially the latter, can be

influenced by plant density. Plant density between and within rows can be adjusted to reduce the canopy closure and thus lower rapid humidity build up during winter months. Adjustments however, have to be made such that optimum populations are maintained to achieve adequate yields in the absence of the disease. This can easily be achieved through inter-row rather than intra-row placings.
In the third integrated experiment, 4 row spacing (30 cm, 45 cm, 60 cm, and 75 cm) were used to determine the effect ratings were recorded as in the other trials. The seed density ranged from 60 seeds/m^2 in the closer spacing to 24 seeds/m^2 in the wider spacing.

There were, in general no significant differences in disease severity between the treated and untreated seed of the same spacing for all the locations. Within the treated seeds, significant differences were recorded between the closest (30 cm) and widest (75 cm) spacing for the susceptible cultivars only (Table 6.1.24). The disease severity was more with narrow spacing rather than broader spacing with the untreated seeds, there were no significant differences in disease severity between the narrow and wide row spacing for all the cultivars at all the locations.

6.1.3.3.4. Use of Systemic Activated Resistance to Manage Ascochyta Blight on Chickpea

The experiments, initiated during 1998 with BION for Ascochyta blight management were continued during 1999. Because of limited success with a field trial in the first season, only the plastic house trial was repeated in 1999. Seven out of the 10 chickpea lines with varying levels of reaction to Ascochyta blight as in 1998, were grown in pots in the plastic house. When the plants were four weeks old, they were sprayed with two different (high and low) concentrations of BION and covered by plastic for 24 and 48 hours. The BION-sprayed plants were then challenge-inoculated with an aggressive isolate of *Ascochyta rabiei* and covered for 24 hrs. Plants were observed for disease symptom development and rated on the 1-9 disease severity scale at 3 weeks after inoculations and again 3 weeks later just before podding.

BION sprays at both concentrations significantly reduced the severity of Ascochyta blight on only some of the 7 chickpea genotypes (Table 6.1.25). On some genotypes,the effect was more dramatic with the high concentration while on others it was with the lower concentration. The results were not consistent with the known cultivar reactions and may thus need further re-confirmation. To be of practical use, it will still be important to test and confirm the results under field conditions.

Table 6.1.24. Effect of row spacing on Ascochyta blight severity of treated and untreated chickpea genotypes at different locations in Syria during 1998/99 season

Location	Row spacing (cm)	Disease Severity (1-9)[a]				
A. Treated seeds		FLIP 88-85C	FLIP 90-96C	Ghab 1	Ghab 3	Mean
Tel Hadya	30	5.7	5.3	6.3	5.3	5.7
	45	6.0	4.6	5.7	4.7	5.2
	60	5.5	4.3	5.0	4.3	4.8
	75	4.6	4.3	5.0	4.0	4.5
	LSD(0.05)	0.7	1.1	1.2	1.1	
Heimo	30	3.0	3.0	5.0	3.6	3.7
	45	2.3	2.0	4.0	3.3	2.9
	60	2.3	2.0	3.3	2.3	2.5
	75	2.3	2.0	3.0	2.3	2.4
	LSD(0.05)	0.9	0.9	0.6	1.2	
Al-Ghab	30	4.6	5.3	5.7	5.0	5.2
	45	5.0	4.3	6.0	4.3	4.9
	60	4.3	4.3	4.3	4.3	4.3
	75	4.0	4.3	4.3	4.0	4.1
	LSD(0.05)	0.7	0.9	1.1	0.8	
B. Untreated seeds						
Tel Hadya	30	6.0	5.3	6.7	6.0	6.0
	45	6.3	5.0	6.7	4.3	5.6
	60	5.8	4.3	6.3	4.3	5.2
	75	5.6	4.3	6.3	4.3	5.1
	LSD(0.05)	1.3	1.1	1.2	0.9	
Heimo	30	4.0	3.0	4.3	4.0	3.8
	45	4.7	2.7	5.3	4.0	4.2
	60	3.3	3.0	4.3	3.3	3.5
	75	3.3	2.7	4.0	3.0	3.2
	LSD(0.05)	1.3	0.8	1.1	1.3	
Al-Ghab	30	4.7	5.3	6.3	5.3	5.4
	45	5.3	5.0	6.7	5.0	5.5
	60	4.7	4.3	5.3	4.7	4.7
	75	4.3	4.3	5.0	4.3	4.5
	LSD(0.05)	1.2	1.3	1.3	0.9	

[a]Disease severity on a scale of 1-9; where 1=no disease and 9=all plants killed

6.1.3.3.5. Use of Cultivar Mixtures to Manage Ascochyta Blight

To confirm promising results with cultivar mixtures obtained during the 1998 season, this trial was repeated using 2 chickpea cultivars, ILC 263 (susceptible), and Ghab 3 (resistant). The cultivars were mixed in different proportions (25:75; 50:50; 75:25) to test the reactions of the mixtures in comparison to the pure cultivars. The three mixture combinations were evaluated in field plots planted in a randomized block design in 3 replications. Disease development depended on infected chickpea debris-spread in the plots at the vegetative stages of plant growth. Disease was controlled in some of the pure cultivar plots with 2 foliar fungicide sprays to differentiate the effects of the mixtures on disease development. Two disease severity and incidence ratings were taken, the first just before flowering and the second at podding.

The two test cultivars maintained their susceptible and resistant reaction positions in the trial as indicated by significant differences in disease reactions in the pure unsprayed plots. The best mixture combination was one with a higher proportion of the resistant to the susceptible component (S25/R75). It gave a significantly lower disease reaction than the unsprayed susceptible control (Table 6.1.26). Other mixture combinations also gave better disease control as compared to the unsprayed susceptible control.

6.1.3.4. Epidemiology of Legume Diseases

The development and spread of different diseases depend on various factors and their interactions with each other. For effective disease management, understanding of these factors and their interactions are important.

Table 6.1.25. Effect of BION spray on Ascochyta blight severity of chickpea cultivars in the Greenhouse 1999

BION Treatment	Ascochyta blight disease severity (1-9) on different cultivars							
	Ghab 1	Ghab 3	F88-85	F90-96	ILC 190	F 93-210	ILC 1929	Mean
H 24 hrs	5.0	4.5	3.3	3.0	4.0	2.3	5.5	3.9
L 48 hrs	5.0	4.7	3.7	3.3	4.5	3.0	3.8	4.0
H 48 hrs	5.7	4.0	4.6	4.3	2.3	2.3	4.5	3.9
Control	7.0	6.3	6.7	5.0	5.0	5.0	7.0	6.0
LSD (0.05)	1.2	1.1	1.5	1.2	1.2	1.3	1.5	
SE	0.7	0.9	0.9	0.8	0.7	0.9	0.8	

H 24=High dosage of 0.08g/l covered for 24 hrs before pathogen inoculation; L 48=Low dosage of 0.04g/l covered for 48 hrs before pathogen inoculation.

Table 6.1.26. Effect of cultivar mixtures on Ascochyta blight severity and incidence of chickpea

Mixture treatment	First disease rating at Flowering		Second disease rating at Podding	
	DS (1-9)*	DI (%)	DS (1-9)	DI (%)
ILC 263/Ghab 3 50/50	4.7	53	5.8	63
ILC 263/Ghab 3 75/25	5.7	63	7.0	70
ILC 263/Ghab 3 25/75	4.3	50	5	60
Ghab 3 with 2 sprays	3.2	45	4.2	53
ILC 263 with 2 prays	5.7	70	6.8	80
Ghab 3 no spray	4.0	63	4.3	70
ILC 263 no spray	7.3	85	8.3	90
Mean	4.9	61	5.9	69
LSD (0.05)	1.0	25.3	1.1	24.0
SE	0.4	11.6	0.5	11.0

*Based on a disease severity rating scale of 1-9 where 1=no infection and 9=severe infection

6.1.3.4.1. Phoma and Ascochyta sp Interactions

During the 1998/99 season an experiment was initiated under controlled plastic house conditions to understand the interactions of *Phoma* and *Ascochyta* pathogens in disease symptom development and spread. This was necessitated by the likelihood that this interaction does occur in the nature and may be responsible for blight epidemics in some areas in the region. This hypothesis was based on the frequency of isolation of both pathogens from blighted fields in previous epidemic years.

In order to investigate these possible interactions, following 5 treatments were evaluated and compared: Inoculations with *A. rabiei* only, *Phoma* sp only, *Ascochyta* and *Phoma* mixture, *Ascochyta* then followed by *Phoma* 7 days later, *Phoma* then followed by *Ascochyta* 7 days later. Four chickpea cultivars (Ghab 1, Ghab 3, FLIP94-90C and S 95345) were grown in plastic pots in 3 replications. At 6 weeks old, plants were spray-inoculated with a culture of the pathogen or pathogen combination. Pots were covered with polyethylene sheets for 48 hrs following each inoculation to facilitate disease infection. The challenge inoculated treatments were done 5 days after removing the covers when infection symptoms could be observed. All plants were rated for symptom severity on a scale of 1-9 at flowering and at podding.

Maximum disease severity for all the cultivars was expressed by the treatment where *A. rabiei* blight was first inoculated and then challenged with *Phoma*, while the least was with *Phoma* alone or *Phoma* challenged with *A. rabiei*

(Table 6.1.27). There was thus an apparent synergistic reaction when *Ascochyta* inoculations were followed with *Phoma*. When the order was reversed, where *Phoma* was inoculated first then followed by *Ascochyta*, there was apparently some cross-protection, producing very low infections. This protection was apparent for all cultivars but not observed on the most susceptible cultivar in the last rating (Table 6.1.27). The reactions from the culture mixtures were comparable to Ascochyta followed by *Phoma* inoculations. From this study, it is clear that when these two pathogens occur together, their interactions can accelerate the development of blight epidemics. This also depends on which of the pathogens infects first. The mechanism of these interactions needs to be further investigated.

Table 6.1.27. Possible interactions between *Ascochyta rabiei* and *Phoma* sop in blight severity

	Disease symptom severity (1-9)*				
Treatment	Ghab 1	Ghab 3	F 94-90	S 95345	ILC 1929
A. At flower initiation					
Phnom only	2.0	1.7	2.3	2.3	2.7
Ascochyta only	4.7	4.0	4.0	5.3	7.7
Ascochyta/Ascochyta mixture	5.3	5.0	5.3	5.7	7.3
Ascochyta then *Ascochyta*	3.0	2.7	2.7	2.3	2.7
Ascochyta then *Ascochyta*	6.3	6.0	6.7	5.0	7.7
Mean	4.3	3.9	4.2	4.1	5.6
LSD (0.05)	1.6	2.2	1.2	2.2	1.4
SE	0.7	0.9	0.5	0.6	0.4
B. At pod initiation					
Ascochyta only	2.3	2.3	4.3	3.3	2.7
Ascochyta only	6.0	5.3	6.7	6.0	8.0
Ascochyta/Ascochyta mixture	7.0	6.7	6.3	7.0	8.7
Phoma then *Ascochyta*	5.3	3.7	3.7	4.0	8.0
Ascochyta then *Phoma*	7.3	7.0	7.3	6.7	8.7
Mean	5.6	5.0	5.7	5.4	7.2
LSD (0.05)	1.6	1.3	1.9	1.8	1.5
SE	0.7	0.5	0.8	0.8	0.6

* On a scale of 1-9 where 1=no infection and 9=severe infection resulting in death of plants.

6.1.4. Chickpea Entomology

Screening for resistance to chickpea leafminer under artificial infestation in the plastic house and in the field using a very late planting date confirmed the resistance of the two lines, ILC5901 and ILC3800.

6.2. Lentil Improvement

Average lentil yields are low because of poor crop management and the low yield potential of landraces. In South Asia and East Africa, diseases are also a major constraint to production. Accordingly an integrated approach to lentil improvement is being pursued at ICARDA covering the development of both improved production technology and genetic stocks. A high priority has been placed on transferring to national programs the results of research on lentil harvest mechanization systems to reduce the high cost of harvesting by hand in the West Asia and North Africa region.

6.2.1. Lentil Breeding

6.2.1.1. Base Program

6.2.1.1.1. Lentil Adaptation and Breeding Scheme

The lentil is an under-exploited and under-researched annual legume and often treated as an orphan crop even in major lentil producing countries. From the onset of lentil improvement at ICARDA, we studied the variation in the world germplasm collection to understand factors affecting lentil adaptation to direct the breeding program. Additional information on the specificity of adaptation within the crop has come from collaborative yield trials of common entries selected in different locations. Armed with this understanding of the specific adaptation of the lentil crop and the various consumer/end-use quality requirements of different geographic areas, we have designed the base-breeding program as a series of separate, but finely targeted streams linked closely to national breeding programs.

The three major target agro-ecological regions of production of lentil are: 1. S. Asia, E. Africa and Yemen 2. Mediterranean low to medium elevation and 3. High elevation area of West Asia and North Africa. These correspond to the maturity groups of early, medium and late maturity. Within each of these major regions there are specific target areas. Recently, the lentil improvement activities has been extended to Central Asia and Caucasus (CAC) region, where initial thrust has been given to study the adaptation and screening of diverse material suitable in agro-climatic conditions in CAC countries. In the region, Uzbekistan, Kazakhstan, Azerbaijan, Georgia and Armenia have been given priority for lentil improvement. The target areas/regions and key traits for selection/recombination are tabulated in (Table 6.2.1)

Table 6.2.1. Target agro-ecological regions of production of lentil and key breeding aims

Region	Key traits for recombination
Mediterranean low to medium elevation	
1. 300-400 mm ann. Rainfall	Biomass (seed+straw), attributes for mechanical harvest & wilt resistance.
2 < 300 mm ann. Rainfall	Biomass, drought escape through earliness.
3. Morocco	Biomass, attributes for mechanical harvest & rust resistance.
4. Egypt	Seed yield, response to irrigation, earliness wilt resistance.
South Asia, E. Africa and Yemen	
India, Pakistan, Nepal & Ethiopia.	Seed yield, early maturity, & resistance to rust, wilt & ascochyta blight diseases.
Bangladesh	Seed yield, extra earliness, and resistance to rust and Stemphylium blight.
Yemen	Seed yield, earliness and resistance to ascochyta blight.

Evolution of Breeding Program

The breeding strategies used for this annual, diploid, self-pollinated food legume have evolved with time. In Stage 1, the variation in the ICARDA lentil germplasm collection was directly exploited with selection made among and within landraces. These selections were distributed to national programs through the International Nursery Network to test for local adaptation. As a result, many of the early lentil cultivars released by national programs are selections from landraces in the ICARDA collection illustrating the value of direct exploitation of landraces.

The particular combinations of characters required for specific regions were often not found *"on the shelf"* in the collection. Consequently, ICARDA started hybridization and selections from segregating populations to produce Stage-2 material. The stable lines were then distributed to the national programs for testing in their respective agro-climatic conditions. Stage 2 resulted in the release of a number of cultivars in different regions.

However, lentil lines developed from selection at ICARDA in West Asia are mostly limited in adaptation to the home region. As a result, the breeding program has decentralized to work closely with national programs having different agro-ecological conditions. For these regions, as Stage 3, crosses are agreed with cooperators and made at ICARDA Tel Hadya; and then country-specific segregating populations shipped to national cooperators for local selection. More than 200 crosses are made annually at ICARDA targeted to address different stresses at specific agro-ecological region. Selections made by national programs are fed back into the International Nursery Network for wider distribution.

In Stage 4, the national programs use ICARDA-derived material in hybridization and selections are made locally.

6.2.1.1.2. Hybridization

The hybridization program at ICARDA uses parents of diverse origin with known traits with the aim to combine gene(s) to contribute to yield and resistance to major biotic and abiotic stresses. Generally, the landraces/cultivars of a specific region or country are used in crosses commissioned for that target environment. In some cases crosses are agreed with the NARS scientists according to their demand. Wide crosses among cultigens are also done by manipulating planting date and providing extended light period to the parents to attain synchrony in flowering. In addition, crosses are made to study inheritance pattern of specific trait(s) and to develop recombinant populations for biotechnological research. In this endeavor, a total of 234 cross combinations were made in 1998/99 season. Number of crosses made and reasons are shown in (Table 6.2.2)

6.2.1.1.3. Yield Trials

Selections from the breeding program for the Mediterranean low and medium elevation region are tested at three locations varying in their annual average rainfall, namely Breda (long-term average annual rainfall total 267 mm) and

Tel Hadya (323 mm) in Syria and Terbol (548 mm) in Lebanon in preliminary yield trials (F_7 generation) and advanced yield trials (F_8 generation). The lines are also re-tested simultaneously for vascular wilt resistance in the wilt-sick plot at Tel Hadya see Section 6.2.1.1.4. to ensure that only high-yielding, wilt resistant lines are advanced in the breeding program.

Table 6.2.2. Number of and reasons for crosses commissioned in 1998/99

# Crosses	Reasons (traits for incorporation in target regions)
46	For South Asia: Red cotyledon, earliness, resistance to wilt, rust and ascochyta blight, yield attributes
24	Nepal: Red cotyledon, earliness, resistance to wilt
24	Bangladesh: Red cotyledon, extra-early, rust resistance
3	Sudan: Yellow cotyledon, large-seeded, resistance to wilt
47	Mediterranean large-seeded: Yellow cotyledon, large seed (> 5.0 g), wilt resistance, high biomass
44	Highlands: Red and yellow cotyledon, winter-hardy, wilt and ascochyta blight resistance, high biomass
34	Mediterranean small-seeded: Red cotyledon, high biomass, resistance to wilt, early to medium maturity
3	Inheritance of boron deficiency

The 1998/99 season was drier than average in all the locations. Terbol, Tel Hadya and Breda received 293, 307 and 198 mm annual average rainfall respectively. The winter cold was less severe in Syria with 11 frost days at Breda and 19 frost days at Tel Hadya, where the long-term averages are 43 d at Breda and 37 d at Tel Hadya. By contrast, the winter was cooler and longer than average at Terbol in Lebanon, where 58 frost events were recorded in the 1998/99 cropping season.

The average seed yield varied from 1956 kg/ha at Terbol, through 759 kg/ha at Tel Hadya to 568 kg/ha at Breda (Table 6.2.3). The corresponding biomass yields were

6.9 t /ha in Terbol, 2.9 t/ha in Tel Hadya and 1.7 t/ha in Breda. The harvest index (HI) was 0.22, 0.21 and 0.26 in Terbol, Tel Hadya and Breda respectively. The percentage of lines yielding significantly more seed than the best check was greatest in Terbol (21.5%) followed by Tel Hadya (16.8%), and lowest in Breda (13.6%). The percentage of lines performed better than the best check for seed yield (excluding significantly different lines) was also higher in Terbol (30.4%), followed by Breda (24.2%), and Tel Hadya (20.9%). The percentage of promising lines (better than the best check) in yield trials was higher compared to 1987/88 season. These lines with resistance to wilt have been included into different categories of international nurseries. The mean coefficient of variation over trials for seed yield was highest in Tel Hadya (20%) and lowest in Terbol (6%). However, the mean coefficient of variation for biomass was higher at Breda (21%) followed by Tel Hadya (13%), and Terbol (7%).

Among the trials, 5 were arranged in 5x5 lattice, 3 were in 4x4 lattice and 2 were conducted in randomized complete block design. A comparison was made between the efficiency of analysis as a lattice design and as a randomized complete block design. Additionally, a comparison was made with the nearest neighbor algorithm in the software package AGROBASE/4. This nearest-neighbor analysis (NNA) takes the difference between the yield of a plot and the average of the two adjacent plots. For border plots, the two plots on the one side are taken as adjacent plots. Such information from the "moving blocks" of three plots is combined for each entry across the whole trial to estimate a mean neighbors difference, then repeated till convergence. The average advantage of lattice analysis for seed yield over that of randomized complete blocks was 17% over the trials across 3 locations (Table 6.2.3). The equivalent advantage of NNA over randomized blocks was 38% in the same trials. Clearly, NNA was superior to lattice analysis, which was, in turn, superior to analysis as randomized complete blocks. The use of NNA in yield trials provides precise comparison of treatment means and adjusted ranking of the genotypes, which is regarded as a method of adding value without any extra cost.

(A. Sarker, W. Erskine)

Table 6.2.3. Results of the lentil yield trials (preliminary and advanced) for seed (S) and biomass (B) yields (kg/ha) at three contrasting locations, Terbol (Lebanon), Tel Hadya and Breda (Syria) during the 1998/99 season

	Terbol		Tel-Hadya		Breda	
Parameters	S	B	S	B	S	B
Number of trials	4	4	10	10	3	3
Number of test entries*	79	79	191	191	66	66
% of entries sig. (P<0.05) exceeding best check**	21.5	5.1	16.8	16.8	13.6	10.6
% of entries ranking above best check (excluding above)	30.4	22.8	20.9	19.4	24.2	31.8
Yield of top entry (kg/ha)	2350	8157	1179	3839	773	2388
Best check yield (kg/ha)	1986	7466	830	3028	663	1860
Location mean (kg/ha)	1956	6902	759	2888	568	1652
Mean C.V. (%) over trials	6	7	20	13	13	21
Mean % advantage of lattice over RCB analyses	22	22	6	18	22	25
Mean % advantage of NNA*** over RCBD analyses	58	57	21	38	34	51

* Entries common over locations.
** Large-seeded checks: ILL 4400 long-term, ILL 5582 improved; small-seeded checks: ILL 4401 long-term, ILL 5883 improved.
*** NNA=nearest neighbor analysis

6.2.1.1.4. Lentil Pathology

The most important disease of lentil in the WANA region is vascular wilt caused by *Fusarium oxysporum* f. sp. *lentis* Vasud. & Srin. The other diseases that are either sporadic or of restricted importance in the region are rust caused by *Uromyces fabae* (Pers.) de Bary, the root rots, induced by a complex of pathogens, among which wet root rot (*Rhizoctonia solani* Kuhn) is most prevalent under wet conditions and Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) deBary) is common in some areas. Ascochyta blight (*Ascochyta lentis* Bond and vassil) and downy mildew (*Peronospora lentis* Gaumann.) periodically appear in fields but are presently of minor importance in the region.

Fusarium wilt being the major biotic constraint to lentil production in the region, receives high priority in lentil pathology research at ICARDA. Research on rust is carried out in a decentralised mode mostly in collaboration with the national programs of Ethiopia, India and Morocco. The parasitic weed, broomrape, (*Orobanche* spp.) is also important in the region and can cause complete crop failure under favorable environmental conditions.

The objectives of the lentil pathology research within the food legume project at ICARDA are: (i) screen and identify sources of single and combined resistance to the major diseases especially in the wilt/root rot complex, (ii) assist national programs in screening and identifying sources of resistance to other major diseases such as rust and ascochyta blight.

6.2.1.1.4.1. Screening of Breeding Material and a Core Collection for Resistance to Lentil Vascular Wilt

A total of 723 breeding lines and 392 germplasm accessions from the core collection, were evaluated or re-screened, in the wilt sick plot at Tel Hadya in the 1998/99 season, for their reaction to wilt. The lines tested are grouped into 3 categories: Cycle I-new untested lines (preliminary screening nurseries and germplasm accessions), Cycle II-lines tested previously for two seasons (preliminary yield trials), and Cycle 3-lines tested previously for three seasons (advanced yield trials). Forty seeds of each line were planted in 50 cm long rows with a row-to-row distance of 37.5 cm. The experiment was conducted in randomized complete block design with 3 replicates. The percent terminal wilt (% of wilted / dead plants) was recorded 3 times during the season. On the basis of highest score in any of the replicates, the lines were categorized into: (a) highly resistant (0-5% wilted plants at maturity), (b) resistant (>5-20% wilted plants. Lines showing wilt reaction >20% are regarded as susceptible and are discarded. Response to lentil vascular wilt under different categories ranged between 0-23% for advanced yield trials (Cycle 3), 0-55% for preliminary yield trials (Cycle 2) and 26-65% for preliminary screening nurseries and 91% for germplasm accessions (Cycle 1)(Table 6.2.4), indicates the reliability of the screening method. However, for breeding purposes, a specific subset of the resistant lines - those which have a maximum plot score of < 20 % wilted plants in the last score, in any of the replicates have been selected for advancement. It is worth mentioning that resistance level was higher in the small-seeded and early accessions as compared to that of large-seeded and late accessions.

The new sources of resistance from the core collection are of particular importance, because they represent diverse agro ecologies worldwide. This screening is a key and integral part of the breeding program. Resistant material from the breeding program are usually made available to NARS for re-evaluation under their own conditions and selection are made for release or inclusion in their breeding programs.

Table 6.2.4. Number of lines/accessions selected for resistance to vascular wilt during 1998/99 season in Tel Hadya sick plot

Nurseries	#Entries	#Selected	%Selected	%sel.under diff. categories
LIFWN	36	34	94	-
AYT-L	12	12	100	-
AYT-S1	22	17	77	84.1
AYT-S2	22	20	91	-
PYT-L	11	5	45	-
PYT-S1	15	11	73	71.4
PYT-S2	6	5	83	-
PYT-S3	17	14	82	-
PYT-E1	15	13	87	82.2
PYT-E2	15	9	60	-
PYT-E3	12	12	100	-
PSN-L	133	46	35	-
PSN-S	290	183	63	-
PSN-E	117	86	74	-
TOTAL	723	-	-	-
Core	392	69	18	-
New	257	22	9	17.6
Last year	135	47	35	-

6.2.1.1.4.2. Screening for Combined Resistance to Multiple Diseases

The wilt/root rot complex in lentil is common in some areas where the crop is grown under excess moisture and exposed to high temperatures and moisture stress at the end of the season. The main pathogens of this complex are: *Fusarium oxysporum* f. sp. *lentis*, *Rhizoctonia solani*, *R. bataticola* and *Sclerotinia sclerotiorum*. It has been difficult to identify resistance to this complex because of the nature and complexity of pathogens involved. In an effort to systematically screen for resistance to the main pathogens in the complex, screening for combined resistance was initiated.

A set of 13 accessions with known resistance to fusarium wilt and *R. solani* (1996/97 and 1997/98) was screened under plastic house conditions for resistance to *S. sclerotiorum*.

Twenty day-old seedlings grown in sterilized soil (10 plants/pot) were singly inoculated at the base of the plant with 0.7 cm mycelial plugs of the pathogen, taken from one week-old culture of *S. sclerotiorum*. The pots were then irrigated and covered with transparent plastic bags for 72 hrs. Disease ratings were taken 2 and 15 days after removing the covering as % of killed plants. The experimental design was CRD with three replications. Data were subjected to analysis of variance. Three lines (ILL 5883, -6994 and-7521) showed good level of resistance to wilt and *R. solani* and acceptable level of tolerance (based on biological and seed yield estimates) to *S. sclerotiorum* (Table 6.2.5). These lines will be tested next season, as components of an IDM package, under field conditions.

(B. Baya'a, A. Sarker, W. Erskine)

6.2.1.1.4.3. Screening for Rust Resistance

Lentil rust caused by *Uromyces fabae* is one of the devastating diseases in major lentil-producing countries, particularly in Bangladesh, Ethiopia, India, Morocco and Pakistan. Yield loss up to 69% has been reported in India. Research on lentil rust disease is decentralized. Screening against lentil rust is being done in hot spots at Pantnagar (India), Debre Zeit (Ethiopia) and Meknes (Morocco). The countries where rust is a major problem receive ICARDA's rust nursery and screen the test entries in their agro-climatic condition. We receive feed back from NARS and incorporate them in international nurseries and use in hybridization program. We report here recent results on rust screening of ICARDA lines from Pantnagar University of Agriculture and Technology in India and Debre Zeit in Ethiopia.

Table 6.2.5. Reaction of lentil lines to wilt/root rot pathogens under plastic house conditions during 1998/99

Entry	Sclerotinia						
	1999		1998		Rhizoctonia	BYLD	GYD
(ILL)	% dead	Severity	% dead	% dead	Fusarium	g/10 plants	g/10 plants
5883	56.40	5.77	58.3	16.7	01.7	9.17	3.95
6789	30.00	2.93	90.0	16.7	06.7	8.00	2.45
6976	53.30	5.27	54.0	33.3	00.0	1.83	0.28
6991	36.70	3.63	86.7	13.3	00.0	7.83	3.09
6994	50.00	5.07	45.0	26.7	00.0	9.17	3.84
7005	46.70	4.67	56.0	13.3	00.0	3.00	1.22
7012	33.30	3.73	79.3	20.0	03.3	9.50	3.22
7192	36.70	3.60	60.0	43.3	00.0	6.00	2.10
7193	43.30	4.40	36.0	50.0	03.3	7.83	3.42
7199	28.50	3.00	63.3	40.0	03.3	3.30	1.21
7502	43.30	4.47	47.3	23.0	00.0	5.83	1.88
7521	50.00	5.00	93.3	06.7	01.7	9.83	4.16
7713	20.00	2.20	64.7	20.0	01.7	5.17	1.12
LSD	22.80	2.04	22.0	19.2	18.2	5.17	0.80

*Severity was rated at 1-9 rating scale, where 1=healthy and 9=completely killed plants
BYLD=biological yield; GYD-grain yield

In Pantnagar, a total of 226 lines were screened under natural epiphytotic conditions. Reaction to rust was recorded twice on a 1 to 9 scale, where 1=free from infection, 3=resistant, 5=tolerant, 7=susceptible and 9=highly susceptible. Among them, 11 lines were resistant with a score of 3 (Table 6.2.6) and had few scattered pustules usually seen after careful searching. In Debre Zeit, Ethiopia, 268 lines were screened in different years. Of them, 18 entries were rated as highly resistant with a rating of 1 (with no pustules visible on plants).

Table 6.2.6. Rust resistant lines screened at Pantnagar, India and Debre Zeit, Ethiopia

Location	Rating	Name of the lines
Pantnagar, India	3	ILL 115, -149, -151, -153, -182, -277, -350, -362,- -1056, -4400, -4605
Debre Zeit, Ethiopia	1	ILL 358, -2501, -4065, -5675, -5724, -5745, -5748, -5782, -5871, -6002, -6008, -6924, -6028, -6049, -6242, -6471, -6788, -6821

(D.P. Singh, L. Kant (India), G. Bejiga, Y. Anbessa (Ethiopia), A. Sarker, W. Erskine)

6.2.1.1.4.4. Screening of Lentil Lines Against Stemphylium Blight

A total of 120 lentil varieties/lines from 5 countries viz. 65 from Bangladesh, 42 from Pakistan, 10 from Australia, 2 from Canada and 1 from New Zealand were screened against an Australian isolate of *Stemphylium botryosum*. Results of this experiment are presented in (Table 6.2.7). Among the varieties/lines, most of them showed a moderately resistant reaction. Eight Bangladeshi lines, 4 Pakistani lines and 1 Australian line were found to be resistant. Eight Bangladeshi lines, 11 Pakistani lines and 5 Australian varieties were susceptible against Stemphylium blight. All the entries from Canada and New Zealand were moderately resistant. The resistant lines will be re-evaluated for yield performance and resistance to Stemphylium blight.

(A.U. Ahmed, T. Bretag (VIDA, Australia), A. Sarker, Erskine)

Table 6.2.7. Reaction of 120 lentil lines against an Australian isolate of *Stemphylium botryosum* under glasshouse condition

Entry	Score	Reaction	Entry	Score	Reaction	Entry	Score	Reaction	Entry	Score	Reaction
BLL79666	3.7	MR	BLX84163 1	3.7	MR	ILXB87063	3.0	MR	099-20324	3.3	MR
BLL81116	3.0	MR	BLX84163 2	3.0	MR	ILXB87075	4.0	MR	099-20325	4.0	MR
BLL81129	3.0	MR	BLX84175	4.3	MR	ILXB87099	3.7	MR	099-20329	7.0	HS
BLL81152	5.0	S	BLX84176	5.0	S	ILXB87105	4.7	MR	099-20332	4.0	MR
BLL81196	6.0	S	BLX84183	3.7	MR	P86591	4.3	MR	099-20333	4.3	MR
BLL81196-1	4.3	MR	BLX84192	4.3	MR	BLL81162	4.7	MR	099-20341	6.3	S
BLL81196-2	7.0	HS	BLX84199	2.0	R	P87515	4.0	MR	099-20342	4.7	MR
BLL81196 3	4.0	MR	ILX87006	4.3	MR	P87519	3.7	MR	099-20343	5.3	S
BLL84228	3.7	MR	ILX87010	4.0	MR	099-20278	2.8	R	099-20345	5.0	S
BLL84233	3.0	MR	ILX87012	4.0	MR	099-20285	3.3	MR	099-20348	3.7	MR
BLL84247	4.7	MR	ILX87015	3.7	MR	099-20288	6.0	S	099-20349	4.7	MR
ILL5599	3.7	MR	ILX87016	3.0	MR	099-20290	4.3	MR	099 20351	5.0	S
BLL84258	6.7	S	ILX87018	4.0	MR	099-20291	2.3	R	099-20354	4.3	MR
BLL84271	5.3	S	ILX87039	5.0	S	099-20292	4.7	MR	099-20356	4.0	MR
BLL84299	4.7	MR	ILX87040	3.3	MR	099-20296	3.3	MR	099-20357	3.3	MR
BLX84033	3.7	MR	ILX87058	3.7	MR	099-20297	4.7	MR	099-20361	5.7	S
BLX84041	3.3	MR	ILL8006	3.0	MR	099-20299	2.3	R	099-20362	6.0	S
BLX84096	4.0	MR	ILX87106	2.7	R	099-20300	3.7	MR	COBBER	5.0	S
BLX84096-1	1.7	R	ILX87133	5.3	S	099-20303	3.0	MR	DIGGER	5.0	S
BLX84096-2	4.3	MR	ILX87135	3.7	MR	099-20306	3.0	MR	MATILDA	5.7	S
BLX84096-3	1.7	R	ILX87155	4.0	MR	099-20308	5.3	S	NORTHFIELD	5.0	S
BLX84108	2.3	R	ILX87156	3.0	MR	099-20309	3.0	MR	CASSAB	3.7	MR
BLX84115	4.3	MR	ILX87192	1.7	R	099-20310	3.3	MR	CUMRA	3.7	MR
BLX84137	5.0	S	ILX87247	3.3	MR	099-20313	3.7	MR	LAIRD	2.7	R
BLX84138	4.7	MR	ILXB87009	3.3	MR	099-20314	5.3	S	ANZAK	3.3	MR
BLX84144	3.3	MR	ILXB87019	3.0	MR	099-20316	2.7	R	ALDINGA	3.7	MR
BLX84149	3.3	MR	ILXB87026	2.0	R	099-20320	4.0	MR	SPINNER	4.0	MR
BLX84156	4.3	MR	ILXB87045	4.3	MR	099 20321	6.7	S	MATADOR	4.3	MR
BLX84159	3.7	MR	ILXB87052	3.7	MR	099-20322	4.3	MR	RICHLEA	4.7	MR
BLX84163	2.2	R	ILXB87062	3.3	MR	099 20323	5.3	S	KYE	5.0	S

R-Resistant; MR=Moderately resistant and S-Susceptible

6.2.1.1.5.1. Effect of Imidacloprid (Gaucho®) on BLRV and SbDV Spread under Artificial Virus Inoculation with Aphids

The usefulness of seed-dressing with a nitro guanidine group insecticide Imidacloprid (Gaucho®) to reduce spread of the aphid vectored bean leaf roll virus (BLRV) and Soybean dwarf virus (SbDV) was investigated in a field experiment conducted at Tel Hadya, Aleppo, Syria, using seven lentil genotypes: ILL 74 (resistant to BLRV and moderately resistant to SbDV); ILL 75 (resistant to BLRV & SbDV); ILL 2581, ILL 4401 (moderately resistant to BLRV and susceptible to SbDV); ILL 6015, ILL 7212, ILL 7949 (susceptible to BLRV & SbDV).

Lentil seeds were treated with Gaucho® at the rate of 0.5, 1 and 2 g/kg of seeds and compared with untreated seeds (control). The experiment was carried out in a randomized complete block design (RCB) with two replicates for both the inoculated and non-inoculated treatments. Each plot consisted of 2 rows (2 m long), 30 cm apart, with 3 cm spacing between plants within the row. Seventy days after sowing, all plants were artificially inoculated with the virus by using the aphid vector *Acyrthosiphon pisum*.

Results obtained showed that Gaucho treatment significantly improved lentil yields of moderately resistant and susceptible lentil genotypes, whereas the effect on the yield of resistant genotypes was not significant. In addition, Gaucho seed treatment was more effective in increasing seed yield of BLRV-inoculated plots as compared to SbDV-inoculated plots. In other words, the seed treatment was more effective in reducing BLRV spread than SbDV spread (Table 6.2.8).

Average values followed with the same letters in the same horizontal row are not significant.

(K.M. Makkouk, S.G. Kumari)

Table 6.2.8. Effect of Seed-Dressing Insecticide, Gaucho® on Yield of Lentil Genotypes Artificially Inoculated with Bean Leaf Roll Virus (BLRV) and Soybean dwarf Virus (SbDV)

		Yield (g)			
		Gaucho Concentration (g/ kg seeds)			
Genotype	Inoculum	0	0.5	1	2
ILL 74	Control (no virus)	132 a	125 a	122 a	120 a
	SbDV	98 a	99 a	113 a	117 a
	BLRV	120 a	121 a	119 a	119 a
ILL 75	Control (no virus)	119 a	120 a	114 a	116 a
	SbDV	99 a	106 a	109 a	115 a
	BLRV	110 a	114 a	112 a	115 a
ILL 2581	Control (no virus)	100 a	96 a	105 a	107 a
	SbDV	14 a	35 ab	52 bc	67 c
	BLRV	49 a	68 ab	80 bc	91 c
ILL 4401	Control (no virus)	220 a	227 a	230 a	220 a
	SbDV	14 a	35 ab	51 b	74 c
	BLRV	139 a	183 b	206 c	204 c
ILL 6015	Control (no virus)	178 a	185 a	182 a	184 a
	SbDV	32 a	37 a	53 a	81 b
	BLRV	72 a	132 b	134 b	143 b
ILL 7212	Control (no virus)	185 a	192 a	197 a	192 a
	SbDV	29 a	41 a	74 b	91 b
	BLRV	64 a	96 b	102 b	170 c
ILL 7949	Control (no virus)	234 a	239 a	249 a	244 a
	SbDV	75 a	91 a	133 b	149 b
	BLRV	52 a	120 b	157 c	195 d

LSD=22.1

6.2.1.1.5.2. Screening for Resistance to Faba Bean Necrotic Yellows Virus (FBNYV) and Bean Leaf Roll Virus (BLRV) in Lentil

Fifty three lentil genotypes (including 22 genotypes selected from previous season proved to be good yielders and highly tolerant to virus infection) were evaluated for their resistance to local isolates of FBNYV (SV66-95) and BLRV (SV64-95) using artificial inoculation by aphids. Genotypes tested were planted in field in two replicates, each represented by 2 rows of 1 meter length, with 35 plants per meter in a randomized complete block design (RCB) for both the inoculated and non-inoculated treatments. Yield loss (%) and symptoms severity (SS) (0-3 scale) based on symptoms produced were determined for all the genotypes tested and are summarized in (Tables 6.2.9 & 6.2.10).

Table 6.2.9. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with faba bean necrotic yellows virus (FBNYV) evaluated during 998/99

Lentil genotypes	Yield loss (%)
ILL 74, 6025, 6825, 7184, 7201, 8063, 8187, 8190, 8191	0
ILL 75, 85, 204, 213, 5818, 6031, 6235, 6264, 6816, 7659, 7697, 7706, 7949, 7971, 8189	1-10
ILL 2684, 5773, 7013, 7164, 7509, 7515, 7518, 7520, 7535, 7553, 7698, 7717, 7962, 7972, 7973, 8068, 8070, 8073, 8186	11-25
ILL 813, 5722, 6409, 7011, 7145, 7180, 7203, 7212, 7616	26-50
ILL 7513	51-100
Symptoms severity	
ILL 74, 75, 85, 204, 213, 2684, 5773, 5818, 6025, 6031, 6235, 6264, 6816, 6825, 7013, 7164, 7184, 7201, 7509, 7515, 7518, 7520, 7659, 7697, 7698, 7706, 7717, 7949, 7962, 7971, 7972, 7973, 8063, 8068, 8070, 8073, 8186, 8187, 8189, 8190, 8191	0
ILL 813, 5722, 6409, 7011, 7145, 7180, 7203, 7212, 7513, 7535, 7553	1
ILL 7616	2
None	3

* Symptom of infected plants was measured based on FBNYV symptoms (yellowing+stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

Table 6.2.10. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with bean leaf roll virus (BLRV) evaluated during 1998/99

Lentil genotypes	Yield loss (%)
ILL 6816	0
ILL 74, 75, 85, 213, 7659	1-10
ILL 204, , 6409, 7201, 7203, 7698, 7706, 8186	11-25
ILL 813, 2684, 5818, 6031, 6264, 6825, 7164, 7184, 7509, 7513, 7520, 7553, 7697, 7949, 7971, 8070, 8187	26-50
ILL 5722, 5773, 6025, 6235, 7011, 7013, 7145, 7180, 7212, 7515, 7518, 7535, 7616, 7717, 7962, 7972, 7973, 8063, 8068, 8073, 8189, 8190, 8191	51-100
Symptoms severity	
ILL 74, 75, 85, 204, 213, 813, 6409, 6816, 7659, 7698, 7706, 8186	0
ILL 5818, 6031, 7184, 7201, 7203, 7513, 7515, 7553, 7697, 8070, 8187	1
ILL 2684, 5722, 5773, 6235, 6264, 6825, 7145, 7164, 7180, 7212, 7509, 7518, 7520, 7535, 7616, 7717, 7949, 7962, 7971, 7972, 8189, 8190, 8191	2
ILL 6025, 7011, 7013, 7973, 8063, 8068, 8073	3

* Symptoms of infected plants was measured based on FBNYV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

Based on these results it was possible to divide the genotypes tested into four categories: (1) Highly resistant: genotypes which did not produce symptoms (SS=0) and grain yield loss was less than 10%; (2) Resistant: genotypes where SS=1 and grain yield loss was less than 25%; (3) Moderately resistant: genotypes where SS=2 and grain yield loss was less than 50%; (4) Susceptible genotypes: which had a yield loss above 50% and SS was 3. Results obtained during this growing season suggested that six genotypes were resistant to FBNYV and BLRV (ILL 74, 75, 85, 213, 6816 and 7659) and 18 genotypes were resistant to FBNYV only (ILL 204, 5818, 6025, 6031, 6235, 6264, 6825, 7184, 7201, 7697, 7706, 7949, 7971, 8063, 8187, 8189, 8190 and 8191). Moreover, five genotypes (ILL 74, 75, 85, 213 and 6816) were found to be resistant to BLRV and FBNYV for three years (Table 6.2.11).

Table 6.2.11. Reaction of selected lentil genotypes to artificial inoculation with faba bean necrotic yellows virus (FBNYV) and bean leaf roll virus (BLRV) tested over the period 1997-1999

		BLRV			FBNYV		
Genotypes	Origin	1997	1998	1999	1997	1998	1999
ILL 74	Chile	HR	R	R	R	R	R
ILL 75	Chile	HR	R	R	HR	HR	R
ILL 85	Tadjikistan	HR	R	R	R	R	R
ILL 213	Afghanistan	HR	R	R	HR	R	R
ILL 6816	ICARDA	MR	R	R	R	R	R

HR=Highly resistant; R=Resistant; MR=Moderately resistant; S=Susceptible.

(K.M. Makkouk, S.G. Kumari)

6.2.1.1.4.7. Screening for Resistance to *Sitona*

Sitona crinitus Herbst is the major insect pest of lentil in West Asia and North Africa. The larvae feeding in the nodules causes the main damage. In Morocco and in Syria, grain yield losses due to *Sitona* larvae were estimated at 25% and 20% respectively.

One hundred accessions of wild lentil species were screened for resistance to *S. crinitus* in the greenhouse. Ten accessions were sown in a pot (16×15cm) containing soil mixture (peat moss: sand: soil) using a randomized complete block design with 10 replications. Seeds were sown in a circular manner around the edge of the pot. Plants were infested when they were about 10 cm in height. Twelve Sitona adults were used to infest the 10 plants/pot, which were covered by well-aerated plastic cages (15x30 cm). Three days after infestation, the cages were removed, and individual plants were scored for leaflet damage using the visual damage score using a 1 to 9 scale (1, no damage; 2, 1-10% leaflets damage; 3, 11-20% leaflets damage; 4, 21-30% leaflets damage; 5, 31-40% leaflets damage; 6, 41-50% leaflets damage; 7, 51-70% leaflets damage; 8, 71-90% leaflets damage; 9, more than 90% leaflets damage. The 8 promising accessions, which showed low level of leaflet damage, were re-tested using the same procedure. The two accessions that showed the highest leaflet damage (72527 and 72534) in the first test were included as susceptible checks.

(Table 6.2.12) summarizes the final screening results. Only one accession 72882 showed a significantly lower leaflet damage (score of 3 in a 1 to 9 scale). This finding is the first report of resistance against *S. crinitus* H in lentil. However, and even if here is a strong correlation between leaflet damage and nodule damage (El-Demir et al., 1999), we are going to test this promising accession also for nodule damage under artificial infestation in the greenhouse and in the field.

Table 6.2.12. Visual Damage Score (VDS) of wild lentil accessions caused by *Sitona crinitus* H. adult feeding under artificial infestation in the greenhouse at Tel Hadya during 1998/99

Accession	Species	VDS
ILWL 4	*Lens orientalis*	7 b
ILWL 11	*Lens orientalis*	7 b
ILWL 71	*Lens orientalis*	9 a
ILWL 84	*Lens orientalis*	7 b
ILWL 87	*Lens orientalis*	6 bc
ILWL 90	*L.tomentosus*	5 c
ILWL 91	*L.tomentosus*	5 c
ILWL 93	*L.tomentosus*	6 bc
ILWL 239	*L. orientalis*	6 bc
ILWL 359	*L. orientalis*	3 d
LSD 5%		1.8

(M. El-Demir, N. Al Salti (University of Aleppo), M. El Bouhssini, A. Sarker, W. Erskine)

6.2.1.1.4.8. Genotypic Variation in Seedling Shoot and Root Characteristics

Lentil (*Lens culinaris* Medikus ssp. *culinaris*) grown in typical Mediterranean environments are often subjected to terminal drought. Drought tolerance is closely related to the distribution of root systems in the soil, which is, in general, the consequence of root development in early growth. We studied seedling root characters on a diverse set of lentil genotypes (40) for two seasons (1997-9) under field conditions and related these to adjacent yield trial data. Specifically, 35-days old seedlings grown in open air under field conditions were studied for stem length, stem weight, tap root length, lateral root number, total root length and total root weight. Combined analysis over years showed that the genotypes differed significantly with respect to these characters (Table 6.2.13). Yield per plant was highly correlated with taproot length (r=0.78), lateral root number (r=0.71) and total root length (r=0.63). Total root length was significantly correlated with lateral root number (r=0.82), root weight (r=0.73) and tap root length (r=0.68). Broad sense heritability estimates varied greatly (39-76%), where high to moderate heritability were exhibited by taproot length (76%) and lateral root number (68%). Clearly, taproot length and lateral root number are the important root traits associated with lentil performance under drought in a Mediterranean environment.

(A. Sarker, W. Erskine)

Table 6.2.13. Variability in shoot and root characteristics in lentil

Characters	Mean	S.D.	Min.	Max.	Sig. level	H %
Stem length (cm)	7.5±0.13	1.05	4.7	13.9	**	66
Stem wt. (g)	0.38±0.04	0.18	0.15	0.82	*	39
Tap root length (cm)	28.5±0.74	5.20	11.6	47.0	**	76
Lateral root number	31.5±0.73	7.78	16.0	66.0	**	68
Total root length (m)	3.01±0.18	0.72	0.68	7.05	*	53
Total root wt. (g)	0.35±0.03	0.09	0.12	0.92	*	41

Significant at: *P< 0.05%; ** P<0.01%
H%=Heritability estimate

6.2.1.1.4.9. Response of Lentil Genotypes to Salinity Tolerance

Soil salinity is one of the major impediments to agriculture. Salinity is reported to affect about 1 billion hectares, mostly located in arid and semi-arid regions. Saline soils of various natures and degree occupy over 80 million hectares in the Mediterranean basin

Under intensive crop management, it has been economically possible to desalinize the soil. For many agricultural purposes, however, the cost of desalinization is prohibitive. The most economic and wise approach to using saline soils is to grow crops with some degree of salt tolerance. Selection and breeding for salt tolerance in crop species thus seems to be the only efficient and economic alternative strategy to overcome the soil salinity problems. However, the availability of genetic variation at the inter and intra species level is a prime requirement for selecting and breeding crop plants to grow in saline soil.

Most crop species suffer initial salt injury at Ec values exceeding 4 dS/ m. Salinity occurs due to the presence of soluble Na^{+}, K^{+}, Ca^{++}, Mg^{++}, Cl^{-}, $So4^{--}$, $HCO3^{-}$in soil water. Among them, Na^{+}, Cl^{-} and $SO4^{--}$ are known to be important ions causing salinity in agricultural land.

Lentil is sensitive to salinity compared to other food legume crops grown in WANA region. It has been reported that critical level of soil salinity for lentil is 4 dS/ m. Research on salinity tolerance in lentil is being pursued in collaboration with CIHEAM, Bari, Italy. Six ICARDA lentil lines (ILL 4400, ILL 5582, ILL 5845, ILL 5883, ILL 6796 and ILL 8006) were included in this study at 4 salinity levels, viz., control (0.9 dS/m), 3 dS/m, 6 dS/m and 9 dS/m). The experiment was conducted in greenhouse in lysimeter at the Agronomic Mediterranean Institute, Bari, south Italy. Observations were recorded on plant height, leaf area, leaf number, leaf dry matter, shoot number, shoot weight, root/shoot ratio, flower number, pod number, grain weight, seed yield and straw yield.

It was observed that there was a progressive reduction in almost all the traits with increase in salinity levels. The lines showed differential response with salt concentration levels at various growth stages and yield.

Sensitivity to salinity at flowering stage

At the beginning of flowering it was noticed that there was decrease in flower number with the gradual increments in salt concentration levels compared to the check. This trend continued up to the end of flowering. Based on this observation, the lentil lines were classified into three categories (Table 6.2.14).

Table 6.2.14. Lentil lines classification at flowering stage

Lentil lines	Salt tolerance
ILL 5582	Sensitive
ILL 6796	
ILL 5883	Moderately tolerant
ILL 8006	
ILL 4400	
ILL 5845	Tolerant

Salinity effect on seed yield

Effect of different salinity levels on grain yield of six lentil lines was measured from each lysimeter separately. Analysis of variance showed that there were significant differences in various salinity levels and among the test lines under study. In general, the lentil seed yield gradually decreased with the gradual increments in EC-values of irrigation water. Reduction in seed yield caused by a certain concentration level widely varied from one line to another. Yield reduction in different lines with 3 dS/m values did not exert any significant effect on yield as compared with the fresh water treatment (0-6%). At 6 dS/m concentration, some lines exhibited drastic reduction in yield, which reached up to 44% (ILL 8006). However, irrigation water with 9 dS/m salt concentration level resulted in a drastic reduction in seed yield with varying degrees depending on genotypes. On the basis of yield reduction under various salt concentration levels, six lentil lines were classified as follows (Table 6.2.15). It can be concluded that water of an EC value of 3 dS/m or below can be used safely without any notable reduction in yield. Inherent tolerance to salinity among lentil genotypes can be exploited up to 6 dS/m salinity concentration. With relatively high concentration level up to 9 dS/m, the majority of the investigated lines were subjected to notable reduction in yield. Therefore, it is not at all advisable to grow lentil at high salt concentration level, unless we select proper variety as well as integrated crop, water and soil management.

Table 6.2.15. Classification of lentil lines based on yield loss under salinity condition

Lentil lines	Tolerance category
ILL 6796	Tolerant
ILL 5845	
ILL 5883	Moderately tolerant
ILL 4400	Slightly tolerant
ILL 5582	Moderately sensitive
ILL 8006	Highly sensitive

(A Ameen, A. Hamdy, N. Katerjee (CIHEAM, Italy), A. Sarker, W. Erskine)

6.2.1.1.4.10. Development of a regeneration and transformation system

There are several biotic factors, which limit yields of lentils. They are difficult to be addressed through classical plant breeding because of lack of genetic variability in the host plants (cultigen and wild relatives). These include the pea leaf weevil (*Sitona crinitus*) and broomrape (*Orobanche* spp.). The Centre for Legumes in Mediterranean Agriculture (CLIMA), The University of Western Australia has developed and is using a protocol to transform lupins (*Lupinus angustifolius*) and lentils through *Agrobacterium*-mediated transformation. The protocol provides a mechanism to address the above limiting biotic factors through the introduction of alien genes. The technology has been transferred to ICARDA through training and is being implemented at the Agricultural Genetic Engineering Research Institute (AGERI) in Egypt, until biosafety regulations are in place in Syria.

Transformation experiments conducted at CLIMA

Seventeen transformation experiments were performed with two cultivars: Digger and Northfield (ILL 5588). Digger is the lentil line used for routine transformation at CLIMA and was used as a reference to assess transformation capacity and success. Northfield is a line used in ICARDA's lentil-breeding program from which a genetic map has been developed at ICARDA using morphological, RFLP, RAPD and AFLP markers. Each experiment was done with approximately 100 Digger and Northfield seeds. Transformation experiments were done with three different constructs:

(1) 1258/Aglo construct harboring the gene coding for β-glucoronidase and the bar gene.
(2) pZBAMP 21.2 (sense)/Aglo, construct harboring a fungal resistance gene and the bar gene.
(3) pYRMP (sense)/Aglo, construct harboring the CMV resistance gene and the bar gene.

Constructs 2 and 3 were used for initial experiments, however, these constructs can not be used at ICARDA due to IP protection.

Detailed results are given in (Table 6.2.16). The explants of the last conducted experiment are currently on selective media for the 9th time, material from experiments 4 & 5 is setting seed in the glasshouse at CLIMA and clones from that material are currently being rooted at AGERI. Two experiments have been conducted to increase the efficiency of transformation; both have not given significantly better results than the original protocol.

Transformation experiments conducted at AGERI

Eighteen experiments have been conducted so far at AGERI. For these experiments, 3 ICARDA lentil lines were used: ILL 5588, ILL 5582 and ILL 5883. In all experiments the 1258/Aglo construct was used. The CLIMA protocol was adapted to the specific conditions at AGERI. Regenerants are being sub-cultured for the 6th time on selective media. Experiments 16-18 are still on the first selective medium. No major changes of the protocol were necessary. The explants have been checked for initial transformation using a GUS-assay indicating that the initial transformation rates were similar to the GUS-assays performed at CLIMA. Preliminary results for experiment 1-15 are given in (Table 6.2.17).

(D. Bianca, M. Baum, A. Sarker, W. Erskine)

6.2.1.1.4.11. Inheritance and Mapping of Gene(s) for Winter-Hardiness

Screening lentils for winter-hardiness has become a major feature for winter cultivation in high altitude regions of WANA and in northern America. Sufficient winter-hardiness is available in the cultivated lentil germplasm to enable survival of the crop in winter in these regions. However, the genes conferring winter-hardiness need to be identified and transferred to otherwise acceptable genetic backgrounds. Thus far progress has been slow due to the difficulty in the identification and transfer of the winter-hardiness genes using relatively unpredictable field screening. The problem of field screening for the winter-hardiness genes could be alleviated with the use of molecular markers in a marker assisted selection program. The objectives in this study were to determine the inheritance pattern of winter-hardiness genes, tagging of winter-hardiness genes with molecular markers, and to investigate the feasibility of using marker-assisted selection for winter-hardiness in lentil.

Five parental lines were crossed in a half diallel and the resulting populations were used to develop ten sets of F_6-derived recombinant inbreds. The RILs including parents and check lines were evaluated in 1998/99 season at Pullman, USA and Haymana and Sivas in Turkey in an Alpha-lattice design with three replications.

Each plot consisted of a single row, 1 meter long and spaced 0.3 m apart. Winter injury to the plants was recorded after occurrence of very cold periods during the winter at Pullman. Winter damage was scored four times but final winter survival was based on plant stand counts that were conducted before and after winter. Winter injury and survival data from each population were analysed independently using Proc Mixed Model in the statistical package SAS 6.11 software Adjusted least square means were used in QTL analysis.

A genetic linkage map on pop 6 (WA8649090 (hardy) x Precoz (susceptible) was constructed using AFLP, RAPD and ISSR markers. Currently, 145 markers that are spaced 5-15 cM were used in QTL analyses. A second linkage map on pop 7 (Prceoz x WA8649041) is being constructed to verify QTL detected in the current mapping population.

QTL analysis

One of the populations (WA8649090 x Precoz) was used for mapping winter-hardiness genes and for QTL analysis. Mapmaker/EXP 2.0 for Macintosh was used to establish a linkage map with a LOD score of 3.0 and recombination fraction of 0.4 Morgan. QTL analyses were conducted for winter injury scoring and final survival using a skeleton map in which markers were distributed every 10-15 cM. Map Manager QT 2.8 and Qgene 2.30 were used for QTL analysis.Single point marker regression analysis was used to identify putative QTLs. Simple interval mapping was carried out using the program Qgene.

Average air and soil temperatures were indicative of a 'test winter' that is sufficient to differentiate winter hardy and susceptible lines (Figure 6.2.1).

Table 6.2.16. Preliminary results of lentil transformation done at CLIMA, Australia

Strain used	Cultivar	SC*	MF1**	MF2	MF3	MF4	MF5	MF6	MF7	MF8	MF9	MF10	MF11	MF12	MF13	GH***
1258/Aglo	Digger	837	620	472	185	47	40	29	15	4	4	3	2	2	2	Y
	Northfield	843	641	504	204	70	42	34	11	6	5	4	1	0	0	N
		1680	1261	976	389	117	82	63	26	10	9	7	3	2	2	Y
PZBAMP 21.2	Digger	518	465	278	126	67	39	16	14	8	6	4	4	4	4	N
(sense)/Aglo	Northfield	540	530	440	240	123	68	32	20	14	8	4	3	3	3	N
		1058	995	718	366	190	107	48	34	22	14	8	7	7	7	N
PYRMP(sense)/	Digger	200	186	109	68	53	30	15	6	4	3	-	-	-	-	N
Aglo	Northfield	350	331	184	111	102	50	19	8	5	3	-	-	-	-	N
		550	517	293	179	155	80	34	14	9	6	-	-	-	-	N
Total		3288	2773	1987	934	462	269	145	74	41	29	15	10	9	9	-

* SC: number of explants placed on co-cultivation medium (initial medium used)

** MF: number of explants subcultured on selective medium

*** GH: Plants in glasshouse at CLIMA to produce seeds. (Y=Yes; N=No)

Table 6.2.17. Preliminary results of 18 lentil transformation experiments with 1258/Aglo conducted at AGERI, Egypt

Cultivar	Experiments	GUS-assay	SC*	MF1**	MF2	MF3	MF4	MF5	MF6
ILL 5588	2 to 6	0.77	854	699	482	202	66	14	1
ILL 5883	7 to 10	0.73	761	480	263	169	54		
ILL 5882	11 to 15	0.76	792	674	523	168	14		
Total	2 to 16	0.75	2407	1853	1268	539	134	14	1

* SC: number of explants placed on co-cultivation medium (initial medium used)

** MF: Number of explants subcultured on selective medium.

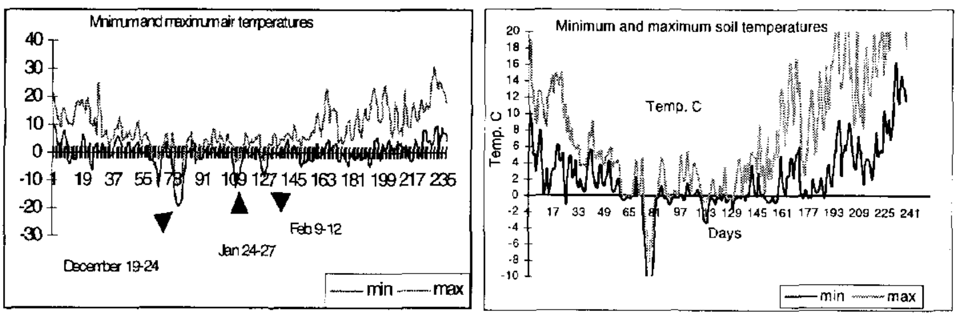


Figure 6.2.1. Average maximum and minimum air and soil temperatures during 1998-99 growing season at Pullman

No winter killing was observed at Haymana and Sivas locations while sufficient winter killing was evident to differentiate the RILs at Pullman. Parental line WA8649041 had an average survival rate of 95%; while ILL 1878, ILL669, and WA8649090 had 15.2, 17.3, and 55.2% survival rate, respectively. The most susceptible parent did not survive the winter (Table 6.2.18).

Mean survival of 10 RIL populations ranged from 5.3 to 71.3% (Figure 6.2.2).

Table 6.2.18. Winter-hardiness, winter injury and survival of parental lines at pullman survival

Parents	Winterhardiness	Winter injury (%)	Survival (%)
PRECOZ	Susceptible	100	0
ILL 669	Intermediate hardy	10-75	10-15
ILL 1878	Intermediate hardy	10-75	10-15
WA8649090	Hardy	5-50	0-80
WA8649041	Most hardy	0-25	90-100

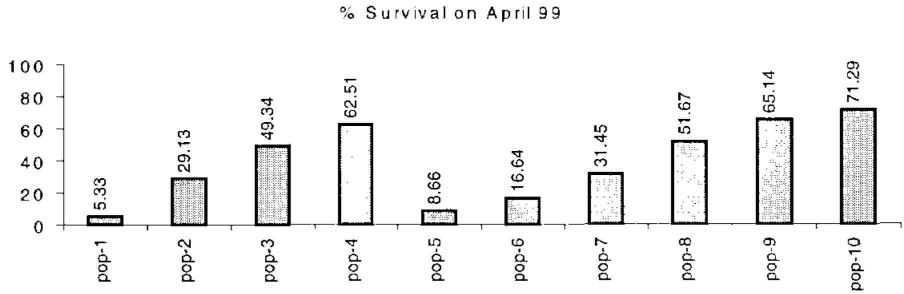


Figure 6.2.2. Average winter survival in 10 RIL populations

Average survival was highest in the hardy x hardy cross (Pop 10) followed by hardy by intermediate crosses (Pop 9, 4, and 8) while the lowest survival was obtained in crosses using the susceptible parent (pop 1, 6, 2, and 7). Frequency distributions of RILs indicated quantitative inheritance of winterhardiness in lentil.

Average winter injury increased during the winter, suggesting that survival is influenced by environmental factors with cumulative effects. Mean winter survival of the RILs in the mapping population (WA8649090 x Precoz) was 16.6 % and individual RILs ranged from 5 to 71%. Eight genomic regions were associated with survival. Four QTL were identified based on the first scoring and accounted for 61.5% of the phenotypic variation.

The same four QTL were evident from the analysis of the second scoring; however, the percentage of the variation was reduced. Two of these four QTLs were associated with plant architectural genes including growth habit and leaf size. Winter injury increased at the third and the fourth scoring, and four additional minor putative QTLs were detected in the different regions of the genome indicating different regions of the genome contribute to the survival at different stages. When final survival was evaluated, no significant QTL were detected, possibly because 80% of the RILs did not survive. Although we did not explore effects of agronomic practices on survival, it is evident from our research that better survival can be obtained by proper combination of plant architectural genes. The results indicate that winterhardiness is cumulative, and is conferred by a number of genes.

(A. Kaharaman, F.J. Muehlbauer, N. Aydin, A. Sarker, W. Erskine)

6.2.1.2. Use of Lentil Germplasm by NARSs

6.2.1.2.1 Advances for the Mediterranean Region

The ICARDA base program provides segregating populations and breeding lines to national programs in North Africa and West Asia for elevations below ca. 850 m around the Mediterranean Sea. To date, more use has been made by NARSs of lines than segregating populations and few lentil crosses are made outside ICARDA in North Africa and West Asia.

A list of lentil lines released as cultivars by NARS has been given at the end of this report and (Table 6.2.19) gives those lines selected for pre-release multiplication and/or on-farm trials by NARSs.

In Syria the red-cotyledon line ILL 5883 has been submitted to the variety release committee following its testing in on-farm trials over the last six years, where it yielded significantly more grain than the local check in different regions and rainfall zones. Additionally, it has improved standing ability for harvest mechanization over the local check and resistance to vascular wilt disease, the most important disease of lentil in Syria. Three other lines, viz, ILL 6994, ILL 7201 and ILL 7012 have been found promising in on-farm evaluation over years across locations are in the pipeline.

Large-seeded lentil occupies an estimated 20 % of the lentil area in Syria. The spread in Syria of the earlier-released, large-seeded line Idlib 1, which has good standing ability and yield, has been monitored through surveys. By 1998 the production of this variety had risen to 13%, representing an area of 16,000 ha out of the total area of lentil production of *ca.* 120,000 ha.

In Lebanon results from an adoption study indicate that Talya 2 has been spreaded in the Beqa'a valley and that yellow cotyledon is the preferred seed type in southern Lebanon. Accordingly, FLIP 86-2L (ILL 5988), a yellow cotyledon line has been registered for cultivation with the popular name Toula in the south of the country. Besides, ILL 5883 and FLIP87-56L have out-yielded Talya-2 and Toula in on-farm evaluation, are in pre-release stage.

In Jordan ILL 5582 was released in 1990 with its common name Jordan 3 for higher yield and good standing ability. In 1999 the national program has released ILL 5883. Additionally, two lentil lines (FLIP88-6L & FLIP84-147L) performed well in on-farm trials are awaiting release.

Through collaborative efforts with ICARDA, Turkey has released five varieties, viz., Firat 87(75Kf 36062), Erzurum 89 (ILL 942), Malazgrit 89 (ILL 1384), Sazak 91 (Nel 854) and Syran 96 (ILL 1939). For south-eastern Turkey, where winter red lentil is widely grown, Sayran-96 (ILL 1939) was registered by the S. E. Anatolian Regional Research Station for higher yield and wilt resistance. Besides, seven spring and eight winter lines are in pre-release verification stage.

Table 6.2.19. Lentil lines in on-farm testing or pre-release multiplication by NARSs

Mediterranean region	
Iraq	FLIP85-83L
Jordan	FLIP84-147L, FLIP88-6L
Lebanon	ILL 5883, FLIP87-56L
Morocco	FLIP86-15L, FLIP86-16L, FLIP87-19L, & FLIP87-22L
Syria	ILL 5883, ILL 7012, ILL 6994, ILL 7201
Tunisia	78S26002, FLIP90-13L
S. Latitudes	
Ethiopia	FLIP87-74L
Nepal	ILL 2580, ILL 4402
Sudan	FLIP88-43L
Yemen	ILL 4605, FLIP84-14L
Highlands	
Iran	ILL 590, ILL707, ILL857, ILL975, ILL4400
Turkey	Spring: FLIP90-3L,FLIP84-147L, FLIP87-8L,FLIP88-10L, FLIP84-112L, FLIP84-51L, FLIP84-59L & FLIP86-35L Winter: AKM-49, -62, -196, -302, -362, -363 and -395

In Iraq the large-seeded, yellow cotyledon line ILL 5582 was registered in 1994 as Baraka. In 1999, the country has released red cotyledon line, ILL 5883 for higher yield, wilt resistance and good standing ability. Another red cotyledon line FLIP85-83L is in the process of being released to farmers. To fuel the demand from Iraqi consumers for both red and yellow cotyledon lentils, the crop's area has been estimated to have grown to approximately 40,000 ha, to a large extent based on the new cultivars. A lentil adoption study is now being mounted in Iraq.

In Iran, Ill 6212 has been released for higher yield and wide adaptation for spring planting. Another three lines, ILL 662, ILL 857 and ILL 975 have been identified as promising for winter planting.

In Libya the line ILL 5582 has been released in 1993 with its name El Safsaf 3 for cultivation in the eastern region of the country, but also has given high yields under central-pivot, irrigated conditions in Central Libya at Meknosa.

In Tunisia the line ILL 5582, which showed consistency over the last few years continued to perform well. Another *macrosperma* type FLIP90-13L found to have wide adaptation over the last few years is considered as a potential variety for release to replace Ncir (ILL 4400) and Nefza (ILL 4606).

Lentil production and area continue to decline in Algeria but the lines ILL 468, ILL 4400, LB Redjas, Setif 618 and Balkan 755 are in seed production for future use by farmers.

In Morocco, Bakria (ILL 4605) was released in 1990. ILL 5562 has been proposed to release for higher yield, good seed quality (cream testa color), high level of rust resistance and wide adaptation. Another line FLIP86-35L is in the pipeline for release. In addition to higher yield and good level of rust resistance, the line has erect growth habit, suitable for mechanical harvest. There are several promising lines in catalogue trials, namely: FLIP86-15L (ILL 6001), FLIP86-16L (ILL 6002), FLIP86-19L (ILL 6005), FLIP86-21L (ILL 6007), FLIP87-19L (ILL 6209) and FLIP87-22L (ILL 6212), all with field resistance to rust.

In Egypt the line Sinai 1 (sel. ILL 4605) is becoming popular in the north Sinai because its early maturity avoids terminal drought stress under the low rainfall conditions. The variety is getting popularity in northern Sinai area. Giza 51 (FLIP84-51L) with small seeds was registered during 1996 because of its tolerance to high moisture conditions.

(National Agricultural Research Systems)

6.2.1.2.2. Advances for Southern Latitude Region

This region comprises the sub-continent of India and Ethiopia where an early flowering habit is required together with resistance to rust, ascochyta blight and wilt. The importance of foliar pathogens contrasts with other major areas of lentil production.

There are three strong lentil-breeding programs in Pakistan with two in Faisalabad and the remaining one is in Islamabad. Over the last five years ICARDA has worked closely with these programs in joint selection as the focus of a thrust to broaden the genetic base of lentils in South Asia. The cultivar Masoor 93, with ICARDA parentage, is proving popular with farmers in the Sialkot region on account of its rust resistance and high yield and reputed to cover more than 35% of the main production areas. Another cultivar Shiraz 96 (ILL 5865) has been released in high altitude areas of Pakistan for higher yield and winter-hardiness.

The major production problems in Bangladesh addressable through breeding are rust and Stemphylium blight diseases along with the development of extra-early cultivars. We have been making targeted crosses for Bangladesh of rust resistance sources with the local /recently released cultivars in the base program at Tel Hadya. Selections have now been made in Bangladesh of adapted rust resistant plants from segregating populations. As a result, Barimasur-2 (ILL 8007) was released in 1993 as the first rust resistant lentil cultivar in Bangladesh. Another rust-resistant line (ILX 87247), locally selected from the cross of L5 x FLIP84-112L (ILL 5782), was released as Barimasur-4 (ILL 8006) in 1995. It gave a yield advantage of 53 % over the local check and 28% over Barimasur-2. It also has resistance to Stemphylium blight and an erect plant stature suitable for inter-cropping in sugarcane, and mixed cropping with mustard, which is a widespread production practice for lentil in Bangladesh. Another four lines having high yield potential and combined resistance to rust and stemphylium blight are in pre-release stage. Two of them have been identified for late planting condition (about 1 month late) for medium highlands after harvest of autumn rice. An ACIAR project on lentil improvement is operating with the Pulses Research Centre, Bangladesh Agricultural Research Institute, where ICARDA is a cooperating partner.

India has a strong lentil-breeding program coordinated under the All India Coordinated Pulse Improvement Project of the Indian Council of Agricultural Research (ICAR). The All-India coordinated lentil trial program has recently started two *new* categories of trial/nursery, as a result of broadening the genetic base of lentil in S. Asia. These are: 1. Extra bold seeds (>35 g/1000 seeds) and 2. Extra early (maturity <110 d). The extra-early nursery is particularly important because it opens up a large new potential niche for lentil in India via. late-sown lentil (using an early maturing cultivar) following the harvest of a long-season rice crop. At present, there are 4 million ha left fallow in winter after the harvest of long-season rice in India annually. The new early lines mature in 110 days compared to the maturity of 135-145 days of landraces in North India. Overall, in the coordinated lentil-testing program, lines with ICARDA-derived parentage represent 38% of entries.

Rust resistance, selected in Morocco, is holding in Kanpur. We have established cooperation with Pantnagar Agricultural University on screening for rust resistance in breeding lines, the wild germplasm and the possibility of collaboration in the search for markers for rust resistance. Our vascular wilt resistance lines are being widely used as source parents within India.

Nepal grew around 170,000 ha of lentil spread from the Terai area adjacent to India to the lower Mid-Hills last season. ICARDA has been requested for specific targeted crosses by Nepali program. ILL 2580 and ILL 4402 are among entries being considered for release. Another line ILL 7537 has been identified as early, high yielding, and resistance to wilt-root rots complex and ascochyta blight and adapted to the mid-hills region.

Bilateral interaction-ICARDA directly with the NARSs of S. Asia-has been strong in the fields of the exchange of germplasm and in the development of tailored breeding material. The value to NARSs of such bilateral interaction has fueled the felt need for more support to regional activities on lentil improvement. At an ICARDA/ICAR sponsored seminar on 'Lentil in S. Asia' held in Delhi in 1991, participants from S. Asia were enthusiastic about the need and value of a regional network on lentil improvement and its potential for the development of the crop in their individual countries. We were catalytic in securing funding for a project entitled "Improvement of drought and disease resistance in lentils from the Indian Sub-continent" from the Australian Center for International Agricultural Research (ACIAR).

In Ethiopia Gudo(ILL 5748) and Ada'a(ILL 6027) were registered in 1995.

In Sudan, where lentil cultivation has grown from nothing to self-sufficiency with the cultivation of improvement varieties, Rubatab 1 (ILL 818). Aribo 1 (ILL 813) and Nedi (ILL 6467) in Northern province and Jabel Mara region.

In Yemen, precoz (ILL 4605) has been released with its popular name Dhamar 1, for better seed quality, yield and wide adaptation.

(National Agricultural Research Systems)

6.2.1.2.3. Advances for High Altitude Region

The high altitude region primarily consists of those regions of Afghanistan, Iran, Pakistan and Turkey where lentil is normally grown as a spring crop because of the severe winter cold. In Turkey the following lines are in registration trials for spring sowing at the Central Field Crops Research Institute, Ankara: FLIP90-3L, FLIP84-147L, FLIP87-8L, FLIP88-10L, FLIP84-112L, FLIP84-51L, FLIP84-59L and FLIP86-35L. Briefly, in Iran the lines ILL 590, ILL 857 and ILL 975 selected at Gazvin on the basis of winter-hardiness are in the pre-release stage and seven winter red lines are being entered for registration. A total of approximately 500 ha of winter lentil were sown in the Gazvin Province last year.

In Baluchistan (Pakistan) the lentil cultivar ShirAZ-96 (FLIP-85-27L) was released to farmers in 1996. The line was selected at the Arid Zone Research Institute, Quetta, on the basis of its cold tolerance and a larger seed size than the local cultivar.

In Afganistan, ILL 5582 and ILL 7180 have been released for commercial cultivation in Herat, Balkh and Takhar provines. The varieties produced 53% and 37% higher yield than local cultivars.

(National Agricultural Research Systems)

6.2.1.2.4. Advances in other Areas

The lentil industry in New Zealand has declined to a point where only 1500-2000 t of cultivar Rajah (FLIP87-53L) were grown in 1996. The successful commercialization of Rajah has helped to keep the lentil industry alive in New Zealand for the last few years. This is primarily due to its increased resistance to ascochyta blight in the field compared to Titore. Crops of Rajah have not required foliar application of fungicide compared to up to three applications with Titore. The New Zealand industry is under pressure from the emerging Australian competition.

In Australia there is now considerable interest in lentil. Prior to the testing of germplasm from ICARDA, lentil assessment in Australia was limited to a few lines representing phonological extremes: extra early and extra-late flowering and maturity. ICARDA's Mediterranean-adapted material has fitted in well into the vacuum. The area of lentils in Australia has increased from approximately 1,500 hectares in 1994 to over 85,000 hectares in 1999 based on improved varieties released in 1993 and 1994. The continued development and release of improved lentil varieties is needed to meet GRDC's aim of increasing pulse productivity by providing a range of desirable quality, high yielding, disease free profitable pulses that are well adapted to a range of soil types and environments. The Australian lentil crop is based on ICARDA-derived germplasm. They grow mostly Digger (FLIP 84-51L) a red-cotyledon line and so far have found many different markets for it. In 1998, CLIMA, Western Australia, has released Cumra (ILL 590) and Cassab (ILL 7200) for cultivation in low rainfall regions for higher yield and the Victorian Institute of Dryland Agriculture (VIDA), Horsham released Nugget (ILL 7180). Lentil varieties (Cumra, Cassab and Nugget) released in the last two years through the CIPAL project will further increase lentil production in Australia.

In response to epidemics of lentil Ascochyta blight in the Canadian Province of Saskatoon, the Crop Development Center, University of Saskatoon has released the first two resistant Canadian lentil cultivars CDC Redwing (Eston x ILL 5588) and CDC Matador (Indian head (alias ILL 481) x (Eston x PI179310); both of which have ICARDA parentage and the former has resistance from an ICARDA parent (ILL 5588). Further East in Manitoba (Canada), the lentil crop suffers from Anthracnose blight. The only known resistant source to the disease is ICARDA germplasm ILL 481='Indianhead'.

In Lesotho, FLIP 87-21 L and FLIP 84-78L have been released for cultivation in hilly and foot hill areas. Both varieties have been released for higher yield and attractive seed quality.

Portugal has released Beleza (ILL 7711) and Cinderela (ILL 5770) for higher yield, good seed quality.

(National Agricultural Research Systems)

6.2.1.3. International Testing Program

The international testing program on lentil is an instrument for the distribution of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs all over the world. The genetic materials comprise segregating populations, and elite lines with wide or specific adaptation, special phenotypes, and resistance to common biotic and abiotic stresses. A list of nurseries supplied in the 1999/2000 season is given in (Table 6.2.20).

The testing program helps in identification of genotypes with specific and wide adaptation. The performance data permit assessment of genotype x environment interaction and help in targeting breeding efforts for specific agro-ecological conditions.

The salient features of the 1997/98 international nursery results received from cooperators are presented here. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

Table 6.2.20. Distribution of Lentil International Nurseries to cooperators for the 1999/2000 season

International nursery	No. of sets
Elite Nursery, Large-Seed (LIEN-L-00)	46
Elite Nursery, Small-Seed (LIEN-S-00)	43
Elite Nursery, Early (LIEN-E-00)	28
F_5 Nursery, Large Seed (LIF_5N-L-00)	11
F_5 Nursery, Small Seed (LIF_5N-S-00)	13
F_5 Nursery, Early (LIF_5N-E-00)	12
F_5 Nursery, Cold Tolerance (LIF_5N-CT-00)	7
Cold Tolerance Nursery (LICTN-00)	21
Drought Tolerance Nursery (LIDTN-00)	36
Ascochyta Blight Nursery (LIABN-00)	20
Fusarium Wilt Nursery (LIFWN-00)	26
Rust Nursery (LIRN-00)	14
Total	277

The international testing program for lentil yield trial contemplates three kinds of trials: one for large seed (LIYT-L), one for small seed (LIYT-S), and another for southerly latitudes genotypes (LIYT-SL).

The Lentil International Yield Trial-Large (LIYT-L-98) was distributed to 54 locations (27 countries) but field data were reported from 21 locations (10 countries). The grand mean across locations was of 1368 kg/ha. The mean of the local check was 1355 kg/ha. The five highest yielding entries across all the locations were: FLIP 96-13L, 78S26002, FLIP 96-2L, FLIP 96-11L, and FLIP 96-3L, with seed yields of 1467, 1435, 1432, 1432, and 1416 kg/ha, respectively. The location means varied from 155 kg/ha at Zavalla (Argentina) to 3163 kg/ha at Terbol (Lebanon). A number of test entries exceeded the local check by a significant margin ($P \leq 0.05$) at Qazvin (Iran), at Terbol (Lebanon), and at Gelline, Hama, and Izra'a (Syria).

The results of the stability analysis for seed yield (Table 6.2.21) showed that the entries FLIP 96-13L, FLIP 96-3L, and FLIP 96-8L had above average mean, regression coefficient (b) close to one, and deviations from regression equal to zero. Thus these entries were generally adapted across environments. The entry FLIP 96-14L showed above average mean seed yield, regression coefficient exceeding unity, and deviation from regression statistically equal to zero, and was thus responsive to high yielding environments.

The Lentil International Yield Trial-Small (LIYT-S-98) was distributed to 28 locations (15 countries) but field data were reported from 16 locations (six countries). The grand mean across locations was of 1582 kg/ha. The mean of the local check was 1414 kg/ha. The five highest yielding entries across all the locations were: FLIP 95-49L, FLIP 95-39L, FLIP 95-41L, FLIP 96-29L, and FLIP 95-36L, with seed yields of 1830, 1730, 1671, 1666, and 1645 kg/ha, respectively. The location means varied from 499 kg/ha at Qazvin (Iran) to 3110 kg/ha at Terbol (Lebanon). A number of test entries exceeded the local check by a significant margin ($P \leq 0.05$) at Qazvin (Iran), at Tolentino (Italy), at Caracal (Romania), and at Breda, Gelline, Hama and Izra'a (Syria).

The results of the stability analysis for seed yield (Table 6.2.21) showed that the linear portion of GxE interaction was not significant, while the non-linear component was significant.

The Lentil International Yield Trial-Southern Latitudes (LIYT-SL-98) was distributed to 20 locations (14 countries) but field data were reported from 6 locations (five countries). The grand mean across locations was of 764 kg/ha. The mean of the local check was 769 kg/ha. The five highest yielding entries across all the locations were: FLIP 88-34L, FLIP 95-70L, FLIP 87-70L, 87519, and FLIP 86-39L, with seed yields of 1254, 1122, 1119, 1045, and 1019 kg/ha, respectively. However, the overall seed yield differences among the entries were statistically not significant. The location mean varied from 331 kg/ha at Hudeida (Sudan) to 987 kg/ha at Hail (Saudi Arabia). A number of test entries exceeded the local check by a significant margin ($P \leq 0.05$) at New Delhi and Hudeiba.

The results of the stability analysis for seed yield (Table 6.2.21) showed that both the linear and non-linear portion of GxE interaction were not significant.

The entry means over locations for time to flowering varied from 76 to 87 days. The entry FLIP 96-50L and FLIP 92-52L were the earliest to flower (76 days) followed by FLIP 92-54L, and JL-1 (79 days).

Table 6.2.21. ANOVA for stability parameters for seed yield for the entries in LIYT-L-98, LIYT-S-98, and LIYT-SL-98 conducted during 1997/98

	LIYT-L		LIYT-S		LIYT-SL	
Source of variation	df	MS	df	MS	df	MS
Entry	23	78877^{*}	23	125094^{**}	23	$172231^{n.s.}$
Entry x Location (Linear)	23	76394^{*}	23	$33845^{n.s.}$	23	$143597^{n.s.}$
Pooled deviation	456	46948^{**}	336	62401^{**}	48	$88696^{n.s.}$
Pooled error	1008	22485	768	32358	192	63780

*= Significant at $P \leq 0.05$, ** Significant at $P \leq 0.01$
n.s=not significant

For Lentil International Screening Nursery-Large (LISN-L-98), -Small (LISN-S-98), -Drought Tolerance (LISN-DT-98) and -Southern Latitudes (LISN-SL-98), the data for seed yield were analyzed for 9, 8, 8 and 5 locations, respectively. The analyses of data revealed that at two locations in LISN-L-98 (Gachsaran in Iran, and Elvas in Portugal), four locations in LISN-S-98 (Absheron in Azerbaijan, Ardabil and Qazvin in Iran, and Tel Hadya in Syria); two locations in LISN-DT-98 (Breda and Tel Hadya in Syria), and two locations in LISN-SL-98 (Raipur in India, and Khumaltar in Nepal) some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). The five highest yielding entries across locations are given in (Table 6.2.22)

The results of Lentil International F_3-Nursery Large (LIF_3N-L-98), and-Southerly Latitudes (LIF_3N-SL-98) were received from 5, and 2 locations, respectively. As regards the LIF_3N-L-98, all entries were selected in Iran and Jordan, while at Valdivia (Chile) only two entries, namely X96S84 and X96S174 were selected. All LIF_3N-SL-98 entries were selected in Raipur (India), and most entries were selected at Khumaltar (Nepal). As regards the Lentil International F_3-Nursery Small (LIF_3N-S-98), and-Cold Tolerance (LIF_3N-CT-98) field books were returned from two and one locations, respectively, but without data.

The results of Lentil International Cold Tolerance Nursery (LICTN-98) were received from 7 locations (four countries). However, reliable screening was possible only at Caracal (Romania) were the susceptible check was uniformly killed. At this location the best-scored entry was ILL 323 rated at 5 (on a 1-9 scale, where 1=free and 9=plant killed).

The results of Lentil International Ascochyta Blight Nursery (LIABN-98), Fusarium Wilt Nursery (LIFWN-98), and Rust Nursery (LIRN-98) were received from four, four, and two locations, respectively. However, although reported, reliable screening was not possible because of the absence, low incidence, and/or ununiform distribution of the pathogen in the experimental field.

Table 6.2.22. The five highest yielding lines across locations in different lentil screening nurseries during 1997/98

Rank	LISN-L-98	LISN-S-98	LISN-SL-98	LISN-DT-98
1	FLIP 97-8L	FLIP 97-13L	FLIP 97-29L	FLIP 96-53L
2	FLIP 97-7L	FLIP 98-11L	FLIP 96-53L	FLIP 95-64L
3	FLIP 98-9L	FLIP 98-16L	FLIP 97-34L	FLIP 96-59L
4	FLIP 97-5L	FLIP 95-18L	FLIP 97-31L	FLIP 95-61L
5	FLIP 97-1L	FLIP 97-15L	Bari-Masur 4	FLIP 92-48L

(B. Ocampo, A. Sarker, W. Erskine, NARSs Scientists)

6.3. Faba Bean Improvement

6.3.1. Introduction

Faba bean is one of the main pulse crops grown for dry seeds and green pods for human nutrition in developing countries or animal feeding in developed countries. Yield stability and low production are mainly constrained by fungal and virus diseases, parasitic weeds, drought and cold damage. Accordingly, priorities are given to establish a targeted pre-breeding program covering development of improved populations, resistant or with combined resistant to biotic and abiotic stresses, in close cooperation with National Research Systems.

The objectives of faba bean improvement at ICARDA are to develop: high yielding gene pools adapted to WANA, Nile Valley countries and China, developed and delivered to national programs in a decentralized, pre-breeding systems.

The 1998/99 was the fourth of the revised faba bean program.

The work plan of 1998/99 includes:

- Identification of genetic resources for resistance to fungal and virus diseases.
- Development of improved populations for high yielding ability with single and multiple stress resistance for use by national programs.

The Populations are made by 1 Crossing stress resistant sources with locally adapted lines and 2. Building gene pools for particular stresses by recombining resistant sources for resistance to chocolate spot, Ascochyta blight, *Orobanche*, rust and early maturity. The pre-breeding program then distributed new sources of resistance and segregating populations to national programs

With these aims the main results in 1998/99 season includes:

6.3.2. Development of High Yielding Germplasm Accessions with Improved Level for Resistance to Ascochyta Blight and Frost Tolerance

Fifty-six families previously (1996/97) selected for tolerance to heavy frost damage and re-evaluated (1997-98) for tolerance to frost and resistance to Ascochyta blight were grown during 1998/99 to confirm resistance to Ascochyta blight and study their yield performance under heavy disease pressure of Ascochyta blight, compared with four check entries:

a. Ascot: Resistant check.
b. ILB1814: Ascochyta disease-free seed.
c. ILB1814: Heavy infected-seed with Ascochyta.
d. Giza 4:*Highly* susceptible check, used as disease spreader.

The last two checks, (c and d) were sown repeatedly each tested line. A randomized complete block design with three replications was used. Planting was in rows, 3m long with 45cm between rows. Each plot (2.7 m^2) of the tested families and the two checks (a and b) received 30 seeds. However, the other repeated checks (c, d) received 15 seed, to ensure 11.1 plants/m^2 throughout. In order to retain virulence of *Ascochyta fabae*, heavily infected faba bean debris was spread in the field on January 21, 1999 (54 days after planting), and subsequently supported by artificial infection with a spore suspension of Ascochyta blight sprayed when plants were 116 days old. The trial was provided with a misting system to maintain high relative humidity, and increase disease development.

Germination:

Results given in (Table 6.3.1). Revealed highly significant differences in gerermination. The average number of germinated seeds of selected lines, resistant check (Ascot), disease-free check (ILB1814) and Giza 4, ranged from 93.7% to 100% plants/m^2 and all were significantly higher than diseased seed check (ILB1814), which recorded 68.5% plants/m^2.

This finding demonstrates the amount of damage (27-31%) caused by Ascochyta blight on germinability of faba bean seed compared to free-seed (ILB1814), resistant check (Ascot) and selected lines.

Reaction to Ascochyta blight:

The pathogen was highly developed, particularly on the repeated checks. The third disease score reached its maximum values when plants were 147 days old (April 25). The distribution of tested entries into different classes of disease infection is shown in (Table 6.3.2). The susceptible check (Giza 4) rated 8 and occupied the most susceptible class of Ascochyta rating followed by the diseased-seed check (ILB1814) rated 5.8. Disease score of the susceptible check (Giza 4) was highly significantly higher than the other test entries, selected previously for Ascochyta blight resistance.

Table 6.3.1. Average number of plants per square meter and germination %, 54 days after sowing, of faba bean entries tested for resistance to Ascochyta blight at Tel Hadya, 1998/99

	Germination	
No. of tested entries	N. of plant/m2	%
29 (lines)	11.1	100.0
17 (lines)	10.2	098.2
8 (lines)	10.6	095.5
2 (lines)	10.4	093.7
Ascot-Resistant check	11.1	100.0
ILB 1814-Free seed check	10.6	095.5
ILB 1814-Diseased seed check	07.6	068.5
Giza4-Susceptible check	10.9	098.2
LSD 05	00.67	
LSD 01	00.901	
CV%	03.6	

Table 6.3.2. Distribution of faba bean lines into class ranges of ascochyta rating, evaluated at Tel Hadya,1998/99

	4-5	5-6	6-7	7-8	Total	Range	Mean
No. of lines	33	24	2	1	60	4-8	5.1
%	55	40	3.3	1.7			

Plant damage:

The amount of plant damage caused by Ascochyta blight varied from 0.0 to more than 40% (Table 6.3.3). The maximum damage (65%) was recorded on Giza 4 followed by 21.4% on the diseased-seed (ILB1814). The maximum value (100%) of survival plants was recorded on thirteen selected lines, and the disease-free seed compared to 95% recorded on the resistant check (Ascot).

Table 6.3.3. Distribution of faba bean lines into class ranges of plant damage (%)*, evaluated at Tel Hadya, 1998/99

	0-10	10-20	20-30	0-40	<40	Total	Range	Mean
No. of lines	48	9	2	1	1	60	0.65	5.9%
%	80	15	3.3	1.7	1.7			

* Plant damage %=

$$\frac{\text{No. of plants at full germination-No. of plants at harvest X 100}}{\text{No. of plants at full germination}}$$

Number of days to 50% flowering:

The number of days from planting to 50% flowering ranged from 88 to 102, with a mean value of 95 days (Table 6.3.4). Results revealed highly significant differences. Two selected lines: 1862/63 and 1909/12 recorded the maximum number (90-102) of days. However, the susceptible check (Giza 4) recorded the lowest number (88.7) of days with highly significant difference. Flowering of the resistant check and the disease-free check (ILB1814) was significantly later than the susceptible check (Giza 4), however; Giza 4 and the diseased seed check (ILB1814) were not significantly different.

Table 6.3.4. Distribution of faba bean lines into class ranges of number of days to 5o% flowering, evaluated at Tel Hadya, 1998/99

	88-90	90-92	92-94	94-96	96-98	98-100	100-102	Total
No. of lines	1	2	19	33	3	1	1	60
%	1.7	3.3	31.7	55	5	1.7	1.7	

Range:88.7-102, Mean=94.6

100 seed weight:

A wide range of variability (Table 6.2.5) was found between tested lines. The average 100-seed weight ranged from 42 to 145 with an average of 102.4 g/100 seeds. Results of statistical analysis revealed highly significant differences among tested entries. One selected line: 2163/66 ranked first with 100-seed weight of 145.8 g with non-significant increase of 8.8% than the local disease-free check (ILB1814). These two entries along with two selections: 3195/98 and 1862/63 were highly significantly higher than the local diseased-seed check (ILB1814). It could be noticed that the four entries: 2163/66, disease-free check (ILB1814), 3195/98 and 1962/63 recorded 26.9%, 16.6%, 15.9% and 13.4% heavier seed than the local diseased-seed check (ILB1814), respectively. The difference between disease-free and diseased seed of the same local check (ILB1814) (16.6%) could be considered one component of the total yield losses due to infected seed with Ascochyta blight.

Seed yield/plant:

The average seed yield/plant ranged from 7 to 31 with a mean value of 20.5 g (Table 6.2.6). Results of statistical analysis revealed highly significant difference among entries. Four lines: 3195/98, 2241/45, 2427/30, and 1862/63 yielded 84.4%, 75.6%, 69.3% and 69.1% more than the diseased seed check (ILB1814), respectively, with highly significant differences. It was also noticed that the local adapted disease-free check (ILB1814) out-yielded that of (ILB1814) of diseased-seed by 59.6%. Yielding ability of the resistant check (Ascot) and the highly susceptible check (Giza 4) was markedly poor and both occupied the lowest class range of seed yield/plant.

From reviewing the above mentioned results it could be concluded that a considerable yield losses (81%), depending upon comparison between disease free and diseased seed check of ILB1814, is mainly due to relative reduction of: seed germinability: 28%, survival pod bearing plants (stand): 43%, 100-seed weight: 14%, yield/plant: 38%.

Table 6.3.5. Distribution of faba bean lines into class ranges of 100-seed weight, evaluated at Tel Hadya, 1998/99

	42-54	54-66	66-78	78-90	90-102	102-114	114-126	126-138	138-150	Total
No. of lines	4	-	1	5	15	17	14	3	1	60
%	6.7	-	1.7	8.3	25	28.3	23.3	5	1.7	

Table 6.3.6. Distribution of faba bean lines into class ranges of yield(g)/plant, evaluated at Tel Hadya, 1998/ 99

	5-9	9-13	13-17	17-21	21-25	25-29	29-31	Total	range	Mean
No. of lines	4	1	12	15	12	14	2	60	7-31	20.5
%	6.7	1.7	20	25	20	23.3	3.3			

Correlation:

In 1997/98 relationship between the level of frost tolerance (score) and that of resistance to Ascochyta was studied. Results given in (Table 6.3.7) showed highly significantly positive relationship (r=+0.72). Relationship between the infection level (score) on growing plants and seed was positive (r=0.23) but not significant.

Table 6.3.7. Phenotypic correlation coefficients between frost tolerance (1), Ascochyta blight recorded on growing faba bean plants (2), and seeds (3), Tel Hadya, 1997/98

Character	Frost Sc.	Asc. Sc. Plant	Asc. Sc. Seed
1	-	+0.7176**	+0.2131
2		-	+0.2297
3			-

Asc: Ascochyta
Sc.: Score

In 1998/99:
Results given in (Table 6.3.8). indicated that the Ascochyta blight disease development (score 1,2,3), was negatively correlated with: stand, number of pods and seeds/plant, 100-seed weight, seed yield/plant, and yield/plot, with highly significant correlation coefficients. Correlation between disease score and number of days to flowering was negative (r=-0.424) with highly significant relationship. The number of surviving plants/plot (stand), was positive and highly significantly correlated (r=+0.56) with seed yield/plot. Correlation coefficient between yield/plant and yield/plot was the largest (+0.96) followed by those between number of plods/plant and seeds/plant (+0.79) and between 100-seed weight and yield/plant (+0.73).

These findings are of great interest for seed yield improvement through selection. Associations between some yield components (low heritability values) with characteristics with high heritability value, such as seed size, leads to yield improvement

Heritability (H^2):
Heritability values of eleven traits are presented in (Table 6.3.9). Results indicated that the heritability values were generally low, indicating the effect of the environmental conditions on the resistance to Ascochyta blight along with yield and its component, however, heritability of 100-seed weight was the highest value, indicating genetic stability and efficiency of selection for different types of seed size.

New selected promising lines:
Results over the last three year (1997-99) and in the light of the obtained results, ten promising lines combines frost tolerance, resistance to Ascochyta blight and high yielding ability were identified. The pedigree, origin and evaluation period of these lines are given in (Table 6.3.10).

6.3.3. Identification Germplasm Accessions with Combined Resistance to Chocolate Spot and Ascochyta Blight

Three hybrid bulk populations (F_2) were grown under the screen houses at Lattakia, under natural and artificial infection with chocolate spot and Ascochyta blight diseases. The three populations were subjected to individual plant selections:Results are summarized in (Table 6.3.11)

Table 6.3.8. Phenotypic correlation coefficients between eleven characters in faba bean entries tested for resistance to Ascochyta blight at Tel-Hadya, 1998/99

	1	2	3	4	5	6	7	8	9	10	11
Character	Ger.	Flow	Sc.1	Sc.2	Sc.3	Stand	Pod/plant	Seed/plant	100-S. W/t	y./plant	y./plot
1	-	-0.1124	-0.2518	-0.0987	-0.0757	+0.4613**	-0.0126	-0.0006	-0.1204	-0.0165	+0.2020
2		-	-0.1343	-0.3410**	-0.4244**	+0.2835*	+0.2323	0.0009	+0.1556	+0.1940	+0.1860
3				+0.5989**	+0.5685**	-0.5963**	-0.1720	-0.3570**	-0.5802**	-0.5912**	-0.6284**
4				-	+0.8309**	-0.4539**	-0.3960**	-0.5538**	-0.5270**	-0.7153**	-0.7030**
5					-	-0.490**	-0.4720**	-0.5588**	-0.462**	-0.6451**	-0.5264**
6						-	+0.3133*	+0.3688**	+0.3101*	+0.3667**	+0.5577**
7							-	+0.7874**	+0.0272	+0.5189**	+0.5258**
8								-	+0.1089	+0.6992**	+0.7067**
9									-	+0.7317**	+0.6275**
10										-	+0.9584**
11											-

Correlation coefficients exceeded (±) 0.3391 and 0.2616 are considered highly significant and significant, respectively.

Table 6.3.9. Results of statistical analysis of faba bean entries evaluated for Ascochyta resistance and some agronomic characters at Tel Hadya, 1998/99

	Ger.	D.FI.	Sc.1	Sc.2	Sc.3	Stand	Pod/plant	Seed/plant	100-seed Wt.	Yld./plant	Yld./plot
	**	**	**	*	**	**	**	**	**	**	**
Msv.	1.219	9.745	1.321	1.249	1.844	7.556	9.813	49.948	1304.60	93.413	97917.2
Mse.	0.283	5.137	0.44	0.515	0.497	2.095	3.813	15.120	42.365	22.026	19527.3
όg	0.312	1.536	0.2937	0.245	0.449	1.82	2.0	11.609	420.758	23.790	26129.940
όe	0.283	5.137	0.44	0.515	0.497	2.095	3.813	15.120	42.365	45.822	19527.346
όp	0.595	6.673	0.7337	0.760	0.946	3.915	5.815	26.729	463.123	69.618	45657.286
H^2	52.44	23.03	40.03	32.24	47.46	46.49	34.44	43.43	90.85	34.18	57.23

Ger. : Germination
Msv : Mean square of varieties.
Mse : Mean square of error.
ό g : Genotypic variance.
ό e : Environmental variance.
ό p : Phenotypic variance.
D.FL : No.of days to 50 % flowering.
Sc 1 : First score of Ascochyta blight.
Sc 2 : Second score of Ascochyta blight.
Sc 3 : Third score of Ascochyta blight.
Yld. : Yield.
H^2 : Heritability values
**,* : Highly significant and significant at 0.01 and 0.05 level of probability , respectively.

Table 6.3.10. Pedigree, origin, evaluation period and reaction of the most promising faba bean selected lines to frost, Ascochyta blight and some agronomic characters at Tel Hadya 1997-99

			Evaluation period					Results					
			1996/97	1997/98	1998/99	1997/98		1998/99					
Sel No.	Pedigree	Origin	Frost	Frost +Asc.	Asc. +yield	Frost	Asc.	Sc3	Ger./m^2	D.FL	Stand/m^2	100-seed wt.	Yield/ plant
918/21	-	-	IPS	PR	BIPS	2	4	4.3	10.6	95.3	10.6	100.5	25.7
1094/97	90ETA 266	Iraq	IPS	PR	BIPS	1	3	4.3	11.1	93.3	10.6	106.8	24.4
1783/85	90ETA 400	Turkey	IPS	PR	BIPS	2	3	4.3	11.1	92.3	10.9	103.0	27.0
1802/5	90ETA 400	Turkey	IPS	PR	BIPS	2	5	4.0	11.1	94.3	10.9	122.6	24.6
1862/63	90ETA 400	Turkey	IPS	PR	BIPS	3	4	4.3	11.1	102.0	11.1	130.3	28.5
1877/80	90ETA 400	Turkey	IPS	PR	BIPS	1	4	4.0	11.1	96.3	8.1	104.2	18.1
2427/30	90ETA 218	Turkey	IPS	PR	BIPS	3	4	4.0	10.9	95.0	10.6	115.7	28.5
2959/62	90ETA 389	Turkey	IPS	PR	BIPS	1	4	4.0	10.9	95.0	10.6	113.8	25.6
3195/98	ERESENE 87	Turkey	IPS	PR	BIPS	1	4	4.0	10.9	94.7	10.9	133.2	31.0
3457/60	S. Giant	Spain	IPS	PR	BIPS	1	4	4.2	10.9	96.0	10.9	89.8	27.0
Sowing dates			15/10/96	16/10/97	28/11/98								
Mean							3.9	4.1	11.0	95.4	10.5	112.0	26.0
Ascot.		Greec						4.7	11.1	95.3	10.6	44.2	7.1
ILB 1814 F.S.		Syr. Loc.						4.7	10.6	93.3	10.6	134.0	26.9
ILB 1814		Syr. Loc.				4.0	7.0	5.8	7.6	96.7	6.0	114.9	16.8
Giza 4		Egypt				9.0	9.0	8.0	10.9	88.7	3.8	42.3	8.9
Mean						6.5	8.0	5.8	10.0	93.5	7.8	83.9	14.9
L.S.D. 05								1.2	0.67	3.8	1.8	10.9	7.9
L.S.D. 01								1.6	0.89	5.2	2.4	14.8	10.7
C.V. %								13.8	3.6	2.4	10.5	6.3	23.0

IPS: Individual Plant Selection; PR: Progeny Rows; BISP: Bulk of Individual Plant Selection; ASC.: Ascochyta blight; Sc3: Score 3; Ger./m^2: Germinated plant/m^2; YL: Yield/Plant (g); D.FL: No. of days to 50% Flowering

Table 6.3.11. Number of individual selected plants from three hybrid bulk populations (F_2), at Lattakia, 1998/99

Improved population for	Selected plants Field	Lab.+
Resistance to chocolate spot *	121	33
Resistance to chocolate spot +Ascochyta**	109	23
Resistance to Choc. Spot+Asco+Or.**	166	70

* Individual plants, which combined early pod setting and high level of resistance to chocolate spot disease, were selected.

** Individual plants which combine resistance to chocolate spot and Ascochyta were selected.

\+ In both cases seeds of selected plants were investigated, with respect to disease symptoms. All plants with disease symptoms, borne on the seed were discarded.

6.3.4. International Chocolate Spot Nursery 99

One out of 20 International Chocolate spot Nurseries 99, distributed to NARS, was grown at Lattakia. Twenty-six germplasm accessions, compared with one Syrian local check (ILB1814) and susceptible check (R.40) as disease spreader repeated each two lines, were tested in a randomized complete block design with three replicates. The tested entries were planted in rows, 4m long and 45cm in between rows. Each tested entry was represented by one row, which received 20 seeds, to ensure 11.1 plants/m^2. The nursery was artificially inoculated twice with a spore suspension of chocolate spot disease.

Reaction to Chocolate spot and Ascochyta blight was recorded, by using the disease scale 1-9, where 1=highly resistant and 9:highly susceptible.

Results given in (Table 6.3.12). revealed highly significant differences among tested entries. Regarding to reaction to:

Chocolate Spot Diseases: The six entries with the lowest level of disease infection these lines: BPL710, ILB4708, ILB4709, ILB4726, ILB5284 and ILB5288 and all were highly significantly less infected than the susceptible check (R.40).

Reaction to Ascochyta Blight: The germplasm accession ILB4709 ranked first followed by nine tested accessions: ILB368-A, ILB3025, ILB3810-B, ILB4708, ILB4726, ILB5284, ILB5289 ILB5294, and ILB5300, all of which were highly significantly less infected than the susceptible check (R.40).

Three accessions -ILB4708, ILB4709 and ILB5284- showed combined resistance to both diseases (Chocolate spot and Ascochyta blight). The first two accessions: ILB4708 and ILB4709 ranked first and third for yielding ability.

Table 6.3.12. Reaction of faba bean entries to chocolate spot and Ascochyta diseases and days to 50 % flowering,, seed yield and yield ranking tested in Faba Bean International Chocolate Spot Nursery ,Latakya,1998/99

Entry name		Ascochyta	Chocolate spot	Days to flower	Yield g/plant	Yield rank
1-	BPL 710	5	1.33	112	162.2	16
2-	BPL 1179	4.33	2.33	110.7	219.0	11
3-	ILB 368-A	3.66	2	104.3	367.7	2
4-	ILB 2282-59-2	5	4.33	88.3	306.8	4
5-	ILB 2282-60-4	6	4	74.7	250.8	7
6-	ILB 3025	3.66	2.66	104.3	256.0	6
7-	ILB 3743-B	5	4.33	97	81.4	27
8-	ILB 3810-A	4.66	3.66	103	172.0	14
9-	ILB 3810-B	3.66	3.33	104	238.2	9
10-	ILB 4708	3.33	1.66	95.7	474.5	1
11-	ILB 4709	3	1.33	114	346.3	3
12-	ILB 4726	3.33	1.33	87	153.5	20
13-	ILB 5284	3.66	1.66	117	62.1	28
14-	ILB 5285	4.66	2.66	106.7	256.2	5
15-	ILB 5286	5.33	3.66	110	143.8	21
16-	ILB 5288	4	1.66	117	241.7	8
17-	ILB 5289	3.66	3	112	140.4	22
18-	ILB 5290	5	3	110	110.4	23
19-	ILB 5291	5.33	4.33	114	228.8	10
20-	ILB 5292	4	2	109	97.9	24
21-	ILB 5294	3.33	2.66	115	91.2	26
22-	ILB 5295	4.66	3.66	110	158.8	19
23-	ILB 5297	5	2.66	115	161.9	17
24-	ILB 5298	5	4	110	188.8	13
25-	ILB 5300	3.66	2.33	113	95.9	25
26-	ILB 1814	3.66	2.33	86	218.7	12
27-	Local	5	3	87.7	163.9	15
28-	Rebaya 40 (sus. Check)	6.63	6.43	63.2	159.5	18
LSD	0.05	1.37	1.85	2.20	n.s	
	0 01	1.85	.2.5	2.97		
CV	%	18.44	37.7	1.26	70.25	

* Experimental Design : RCB, with three replicates
* Sowing date: Nov. 12, 1998
* Row length : 4 m, Row width : 45 cm, 20 seed/row
* Inoculation dates with chocolate spot disease: Dec.17,1998 and Jan.28, 1999.

6.3.5. Development of Improved Populations

This work aimed at increasing the frequency of favorable genes, lessening the risk of genetic drift, use of epistasis, breaking up genetic linkages, and weakening the sensitivity to inbreeding. Within the population-breeding program the following targeted crosses were made:

Objectives	Single crosses	Double crosses	Total
Combined resistance to Chocolate spot with early maturity	13	22	35
Combined resistance to Ascochyta blight with early maturity	2	52	54
Total	15	74	89

F_1 Crosses:
Six groups of targeted F_1 crosses were grown under the screen houses to be used as genetic base of the improved population for:

a. Early maturity.
b. Resistance to Chocolate spot disease.
c. Resistance to chocolate spot, Ascochyta blight diseases, and *Orobanche*.
d. Resistance to Chocolate spot and Ascochyta.
e. Early maturity and resistance to Chocolate spot.
f. Frost tolerance, resistance to Chocolate spot, Ascochyta and Orobanche.

The F_1 crosses were evaluated compared with their parents where the selfed plants were discarded. Data were recorded with respect to:

- Reaction to Chocolate spot and Ascochyta blight, using 1-9 scale, where 1: highly resistant and 9: highly susceptible.
- Number of seed/plant.
- Seed yield/plant.

Deviation of the actual F_1 mean from the expected F_1 mean (mid-parent) was estimated. Potence Ratio (PR) was estimated and used to determine the degree of dominance of each character.

Lack of dominance was considered when PR equal zero, Partial dominance when PR lies between+1.0 and-1), and complete dominance when PR equals either+1.0 or-1.0, and over-dominance when PR value exceeds either+1.0 or-1.0.

Results:

On the average of each group of the F_1 crosses, the mean values compared with the expected mean of Chocolate spot rating indicated that the degree of dominance was different from group to another (Table 6.3.13). The two groups A and B showed complete dominance of the low rating over high rating for Chocolate spot. The two groups C and D dominance was absent. Group E exhibited over-dominance of low disease infection, but was partial dominant over high disease infection in group F. Reaction to Ascochyta blight indicated that the low infection rate showed completed dominance over the high rate of infection A, and over-dominance in group E. On the other hand the high rate of Ascochyta disease infection showed over dominance (group C) or partial dominance (group D), and dominance was absent in groups B and F. These differences between different F1 crosses may due to closer rating of the parents. The performance of some crosses, which included contrasted reaction (Resistant X Susceptible) of the parents to the pathogen (Table 6.3.14) indicated that low rate of chocolate spot disease infection showed complete dominance over high disease infection. Lack of dominance was found when parents were similarly reacted (Susceptible X Susceptible).

Table 6.3.13. Average reaction of Faba bean F_1 crosses, and their parents to natural infection with chocolate spot and Ascochyta blight grown under screen houses at Tel Hadya, 1998/99

		Reaction to chocolate spot					Reaction to Ascochyta blight				
	No. of	Parents					Parents				
Population*	crosses	♀	♂	F_1	MP	PR	♀	♂	F_1	MP	PR
A	18	5.3	7.7	5.3	6.5	-1.0	5.4	7.7	5.6	6.3	-1.0
B	17	2.1	1.9	1.9	2.0	-1.0	5.3	3.3	3.4	3.4	0.0
C	23	3.5	3.5	3.9	3.4	0.0	5.2	4.9	5.2	5	1.3
D	19	2.3	2.2	2.1	2.2	0.0	4.6	4.2	4.5	4.4	0.5
E	14	5.7	4.9	3.9	5.3	-3.5	6.3	6.1	5.9	6.2	-3.0
F	14	3.0	2.5	2.7	2.8	-0.4	4.9	4.6	4.6	4.6	0.0
Total/mean	105	3.7	3.8	3.3	3.7		5.0	5.1	4.9	5.1	

* A- Early maturity
B- Resistance to chocolate spot disease
c- Combined resistance to chocolate spot, Ascochyta blight and Orobanche.
D- Combined resistance to chocolate spot and Ascochyta
E- Combined early maturity with resistance to chocolate spot disease
F- Combined frost tolerance with chocolate spot, Ascochyta, rust, and Orobanche.
PR: Potence Ratio

Table 6.3.14. Reaction of some faba bean F_1 crosses and parents to natural infection with chocolate spot and Ascochyta blight diseases, grown under screen houses at Tel Hadya, 1998/99

Cross no. (GR-E)	Parents ♀ × ♂	Reaction to chocolate spot: Parents ♀	♂	F_1	MP	PR	Reaction to Ascochyta blight: Parents ♀	♂	F_1	MP	PR
S97089	CS20DK(S) X BPL2282(R)	7	3	3	5	-1.0	7	5	6	6	0.0
S97101	CS20DK(S) X BPL260(R)	7	3	3	5	-1.0	6	6	6	6	0.0
S98009	CS20DK(S) X ILB938(R)	7	2	3	4.5	-0.6	7	5	6	6	0.0
Mean		7	2.7	3	4.8		6.7	5.3	6	6	0.0
S98002	L40/1255/96(S) X STW(S)	7	7	5	7	0.0	7	7	6	7	0.0
S98005	Hud./1231/96(S) X ILB5051(S)	8	8	8	8	0.0	8	8	8	8	0.0
S98006	L40/1255/96(S) X ILB5051(S)	7	8	8	7.5	+1.0	7	8	8	7.5	+1.0
Mean		7.3	7.7	7.0	7.5		7.3	7.7	7.3	7.5	

(R)-resistant
(S)-Susceptible
MP-mid parent
PR-Potence Ratio
GR-E (Group E)

Number of seeds/plant:

All groups of crosses exhibited heterotic effect (Table 6.3.15) on the number of seeds/plant, with a range of 50%-96.0% and mean value of 72.8%, compared to the mid-parent.

Seed yield/plant:

The average seed yield/plant showed a similar (Table 6.3.15.) trend of the number of seeds/plant. Heterosis, expressed as percentage compared to the mid-parent ranged from 54% to 100.9%, with a mean value of 76.3%.

So:

F_2 seed of each of the targeted set of crosses was bulked and planted in an isolated field pilot within forage legumes crops, lentil and B_7 field in Tel Hadya and under screen houses at Lattakia, as genetic bases of the improved populations for:

A. Early maturity — 3 crosses
B. Resistance to Chocolate spot — 19 crosses
C. Resistance to Chocolate spot & Ascochyta — 8 crosses
D. Resistance to Chocolate spot, Ascochyta & Orobanche — 11 crosses
E. Resistance to Orobanche — 23 crosses

a. <u>In Tel Hadya</u>:
At flowering a honey bee hive was introduced in each population plot to induce a high degree of intercrossing. At maturity, each plot was harvested and threshed separately.

b. <u>In Lattakia</u>:
Plant population for early maturity (A), was grown under the screen house, and subjected to random inter-cross pollination by honey bees, however, the three populations B, C and D, were subjected to individual plant selection under artificial and natural infection with Chocolate spot and Ascochyta blight, to select combined resistance (section 6.3.3).

6.3.6. Mass Selection

A total of 255 germplas accessions derived from different genetic resources, were subjected to individual plant selection under natural field infection with Chocolate spot and Ascochyta blight diseases, at Lattakia and Tel Hadya during the two successive seasons, 1996/97 and 1997/98. The criteria for selection was focusing on the association between low level of disease infection and some agronomic characters (pod length, seed size, number of seeds/plant and seed yield/plant). Upon the visual rating in the field and laboratory investigation, plants with inferior seed yield or diseased seeds were discarded. The homogeneous seed of each entry was bulked and stored to be used as genetic stock. In 1998/99 the total entries compared with the Original local check (ILB1814) planted for primary evaluation (observation plots) to estimate the seed yield, flowering date, 100-seed weight). Planting took place in rows, 3 meters long and 45 centimeters in between, 20 seed/row. Each plot ($27m^2$) received 400 seed to ensure 15 plants/m^2. The seed yield was estimated on the plot yield and area. Results showed a wide range of variation (Figure 6.3.1). It was also noticed that 9.4% of the total entries yielded 20% more yield than the original local accession (ILB1814). Response of some entries to mass selection (Table 6.3.16) was clearly expressed in the average increase of 100-seed weight (20%) and seed yield 39%) compared to the original local check (ILB1814). These finding indicates the rapidity which mass selection can effect faba bean improvement.

Table 6.3.15. Average number of seeds and yield/plant of faba bean F_1 crosses, female (♀) and male (♂) parents grown under the screen houses at Tel Hadya, 1998/99

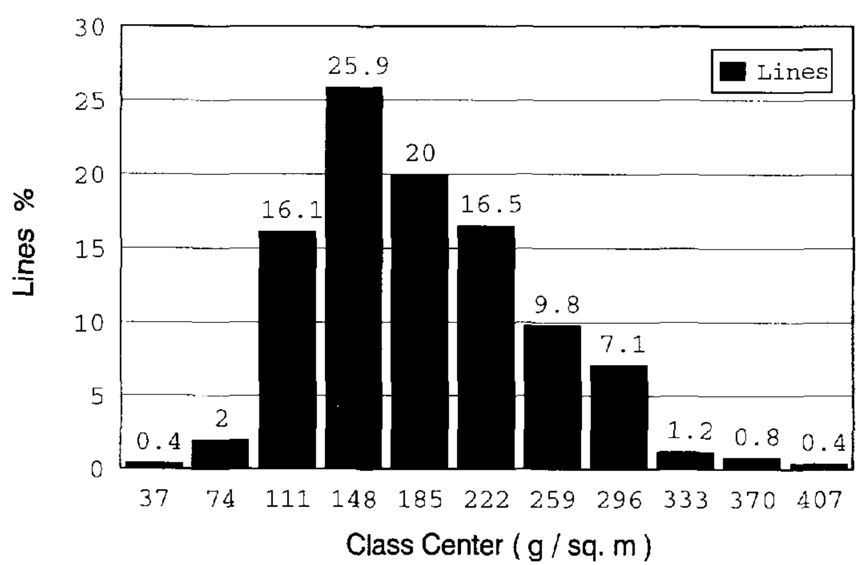
		Number of seeds/plant						Seed yield (g)/plant					
	No. of	Parents						Parents					
Population	crosses	♀	♂	F_1	MP	PR	Het.%	♀	♂	F_1	MP	PR	Het.%
A	18	22.6	20.1	39.6	21.4	14.6	85.0	13.5	4.2	15.4	8.9	1.4	73.0
B	17	16.7	15.3	24.0	16.0	11.4	50.0	10.5	9.8	17.6	10.2	21.1	72.5
C	23	13.5	15.3	26.5	14.4	13.4	84.0	10.7	10.9	21.7	10.8	10.9	100.9
D	19	15.0	17.2	26.8	16.1	9.7	66.5	11.0	11.5	20.4	11.5	35.6	77.4
E	14	17.5	17.4	34.3	17.5	16.8	96.0	12.6	11.4	21.6	12.0	16.0	80.0
F	14	13.4	12.2	19.9	12.8	11.8	55.5	12.2	11.5	18.2	11.9	18.0	54.2
Total/mean	105	16.5	16.3	28.5	16.4	12.9	72.8	11.8	9.9	19.2	10.9	33.5	76.3

PR: potence ratio
Het.: heterosis

Table 6.3.16. Efficiency of mass selection on seed yield of faba bean, Tel Hadya, 1998/99

Entry	Name	Origin	100-seed wt. (g)	Yield t/ha	Relative yield
Giza 402	Fam. 402	Egypt	70.07	3.15	136.96
Giza 429	Selected from Giza402	Egypt	63.47	3.11	135.22
Giza 461	Giza 3 X ILB 938	Egypt	75.17	3.04	132.17
Giza 643	249/801/80 X NA 83	Egypt	74.02	3.70	160.87
Giza 717	503/453/83 X ILB 938	Egypt	78.92	3.04	132.17
1009/596/95	716/725/88 X PGRC	Egypt	67.15	3.04	132.17
1015/672/95	716/724/88 X 75 TA A26026	Egypt	73.22	3.30	143.48
1016/741/95	716/724/88 X 30/18/72	Egypt	84.17	3.00	130.43
1018/754/95	716/724/88 X 74 TA 87	Egypt	72.15	3.18	138.26
Aquadolce	Aquadolce	Spain	134.62	3.74	162.61
L 2 / 96	ILB 1814	Syria	134.95	4.07	176.96
L 47 /96	ILB 1814	Syria	137.85	3.11	135.22
L 62 /96	ILB 1814	Syria	140.47	3.30	143.48
L 73 /96	ILB 1814	Syria	145.07	3.11	135.22
L 82 /96	ILB 1814	Syria	142.13	3.00	130.43
L 86 96	ILB 1814	Syria	128.25	3.11	135.22
Hama 1	Hmah 1	Syria	115.62	2.85	123.91
Agaz	Agaz	Syria	116.62	2.81	122.17
IILB 1814	Ilb 1814 Check	Syria	115.25	2.30	100.00

Planting date :27- 29 November , 1998 , in rows 45 cm in between ,three meters long
Plot area :27 square meters , 20 rows/plot , 20 seeds /row.



Mean value of entries=186.3 g/sq m, Mean of ILB 18 14=229.6 g/sq.m

Figure 6.3.1. Frequency distribution of faba bean entries into classes of yield, g/sq.m, Tel Hadya, 1999

6.3.7. Seed Multiplication

1. Seeds required for the international chocolate spot (41 accessions), Ascochyta blight (12 accessions), and *Orobanche* (16 accessions) were multiplied under the screen houses.
2. Seeds of 255 LIBs, and FILPs along with 123 determinate types were multiplied for distribution to NARS on request.

6.3.8. Cooperation with NARS

6.3.8.1. Two International Faba bean Screening Nurseries

1. International Faba bean Chocolate spot Nursery 99. (28 tested entries) were dispatched to 20 countries in Asia, Europe, Africa and South America.
2. International Faba bean Orobanche Nursery-99 (16 tested entries), was dispatched to 15 countries in Asia, Africa and South America.

7. FORAGE LEGUMES IMPROVEMENT

7.1. Introduction

Livestock are an integral part of farming systems where crop production is limited by large seasonal variations in rainfall. These variations lead to a marked seasonality of feed supply, which is a major constraint to livestock production. Annual forage legumes such as vetches (*Vicia* spp.) *and chicklings* (*lathyrus* spp.) are recognized for their potential to produce extra feed from fallow land, and through the interruption of barley monoculture. These crops can be used for direct grazing during late winter or early spring, harvested for hay in spring either in pure stand or in mixtures with cereals (oat, barley or triticale), or for grain and straw at full maturity. They differ from food legume crops only in the end use. They are mainly used to feed livestock, whereas food legume crops are for human consumption. There is one exceptional case: that is the grasspea (*lathyrus sativus*), which is a popular food and forage crop in Central Asia *and* African *countries* (Bangladesh, China, Ethiopia, India, Nepal, and Pakistan), because of its resistance to drought, water-logging and moderate salinity and because of its low requirement for input. When other crops fail under adverse conditions, grasspea can become the only available food source for the poor in the community and sometimes it is survival food during times of drought-induced famine. Although, its seeds are tasty and protein-rich overconsumption can cause an upper motor neurone disease known as 'neurolathyrism', an irreversible paralysis of the lower limbs. The neurotoxic cause of this disease was identified as β -N-oxalyl-L-α-β -diaminopropionic acid (β -ODAP). Its level in the dry seeds varies widely depending on genetic factors and environmental conditions. Efforts are being made to eliminate this antinutritional factor (ANF) by breeding using the available genetic resources and biotechnology.

Flexibility in forage legume crops to meet different types of utilization in different agro-ecological zones is always of great importance in developing new adapted cultivars. Each crop tends to have an ecological niche. For example, grasspea is suitable to low rainfall areas between 200-300 mm, because of its great drought tolerance; wooly-pod vetch and Hungarian vetch are adapted to high elevation cold areas because of their rapid winter growth and cold tolerance.

The introduction of *Vicia* spp. and *Lathyrus* spp. in rotations also increases the production of feed resources and subsequently the carrying capacity of the land in a sustainable manner. This is because of the maintenance of organic matter and nitrogen status of soil, improved soil physical conditions and better control of diseases and pests compared to continuous cereal monoculture.

Forage legume production is also expected to have a positive effect on rangelands by: (a) reducing overgrazing problem and (b) allowing for adoption of proper grazing systems. At present, livestock move into the range at the beginning of the rainy season, causing great damage to newly emerging vegetation through repeated trampling and defoliation.

7.2. Environmental Adaptation

Although there is a huge diversity of *Vicia* spp. and *lathyrus* spp. in the Mediterranean region, only few have been used as feed (forage) crops and these have received little attention in the past from plant breeders and agronomists. We focus only on those species within the two *genera* which are annual and adapted to areas where rainfall between 250 to 400 mm per annum. In the region, there are at least three species of *lathyrus* and nine species of *Vicia* of potential importance.

In areas where rainfall is less than 300 mm *lathyrus* spp. are common, whereas in higher rainfall areas *Vica* spp. are better adapted. *Vicia narbonensis* is adapted to dry sites, whereas *Vicia ervilia* and *V. sativa* perform better with more moisture. *V. villosa* ssp. *dasycarpa*, and *V. panonica* are better adapted to cold environments in the highlands among other *Vicia* species and *Lathyrus* species. Underground vetch (*Vicia sativa* subsp. *amphicarpa*) and underground chickling (*Lathyrus ciliotatus*) are adapted to areas with marginal lands, hilly rocky non-arable lands and low rainfall.

7.3. Germplasm Enhancement

The general objective of our breeding program is to develop and produce improved lines of feed legume crops, for national programs mainly vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.) and to target these crops to feed livestock in areas with less than 400 mm, rainfall, either in crop rotation in arable land or marginal non-arable lands. It is also highly desirable to have widely adapted cultivars that can be recommended for different locations with similar agro-ecological conditions. While attempting to improve yield potential and adaptation to environment, emphasis is laid on ensuring that the quality components of the end products such as palatability, nutritive value, protein content, intake of herbage, hay, grain and straw are acceptable by animals. This work is being done in close collaboration with animal scientists in Natural Resources Management Program (NRMP).

To achieve this broad objective, two approaches are adopted to develop improved lines of *Vicia* spp. and *lathyrus* spp. (Figure 7.1). In the first approach in wild germplasm accessions are selected to develop improved types for cultivation. This may be seen as domestic approach. In the second, hybridization is done to introgress desirable traits using selection from wild types and landraces. The research is carried out by a multi-disciplinary team involving breeder, pathologist, entomologist, rangelands specialist and animal nutritionist. The research is entirely conducted under rainfed conditions without supplementary irrigation.

As international center with major responsibility to serve National Agricultural Research Systems (NARS), we aim to serve the national forage improvement programs through (1) assembling, classifying, evaluating, maintaining and distributing germplasm, in association with ICARDA Genetic Resource Unit (GRU) (2) developing and supplying NARS with breeding populations with adequate diversity to be used in different environments for different types of end-uses and (3) coordinate international trial to facilitate multi-location testing and identification of adapted genotypes for specific environments.

The forage legumes project emphasizes the need for better understanding of yield limiting factors in different agro-ecological zones, and utilization systems. We cooperate with NRMP in this activity and this information is particularly useful to "tailor", genotypes of each species to fit the targeted environment and farming practices. During the last few years research increasingly turned to less favorable environments, where increased and staple production requires stress tolerant varieties, whose phenology must closely match the temperature and available moisture.

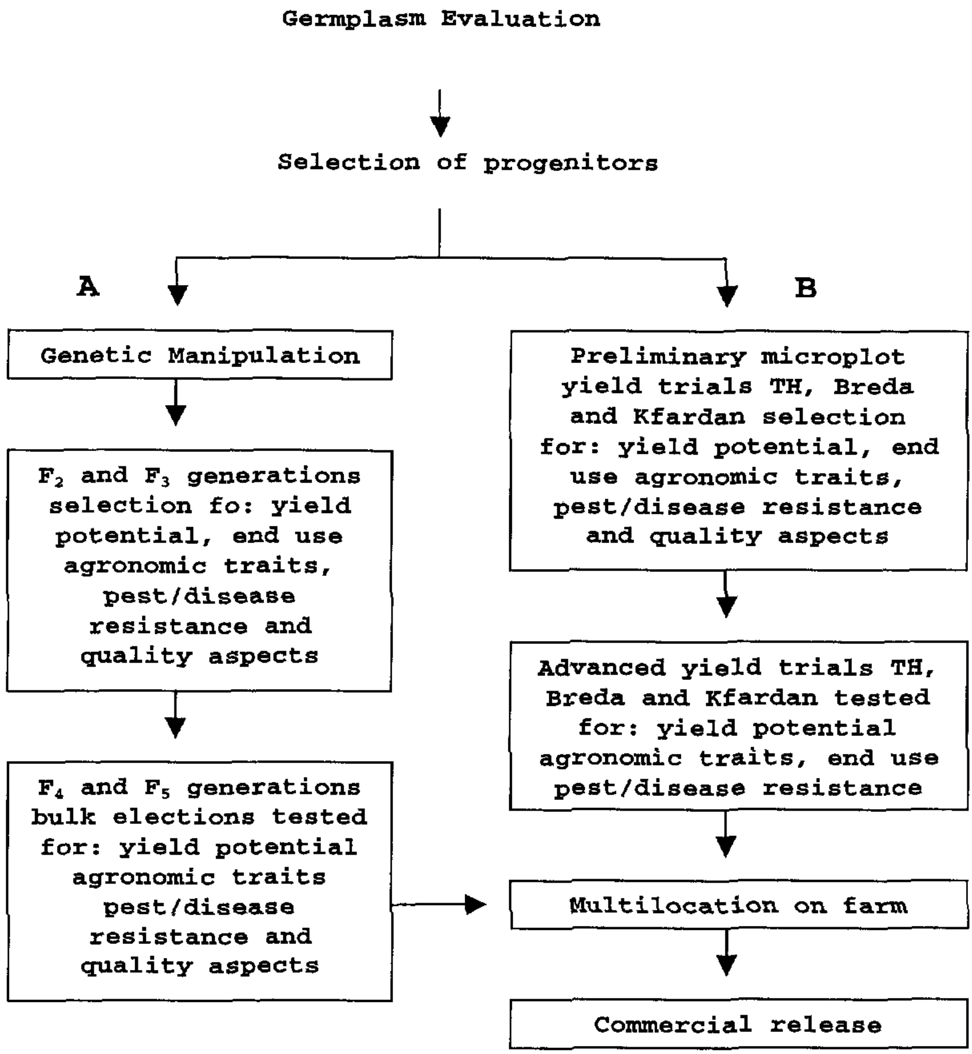


Figure 7.1. Structure of forage legumes breeding program: (A) Hybridization, and (B) Selection

Our forage legumes program was able to gradually adjust its priorities to the changing needs of our clients (Farmers). Over the past five years both as a results of internal assessments, of priorities and of external suggestions a number of activities at Tel Hadya were reduced, such as work on Hungarian vetch and wooly-pod vetch, is now decentralized in Turkey and Central Asia and Caucasian Countries (CAC) in collaboration national programs. Target crosses are being made at Tel Hadya, and the segregated populations are dispatched to Turkey and CAC for selection under low-temperature (cold environment). Some activities were more emphasized, such as improving yield potential and quality of grasspea (*Lathyrus sativus*) which is a dependable source of dietary protein for subsistence farmers in collaboration with Ethiopia, Bengladesh, Nepal and India national programs, to contribute to the alleviation of poverty and malnutrition and the reduction of food shortages, through developing and verify lines of grasspea with high-yield potential under low or zero inputs with low neurotoxin, β-ODAP and improved aminoacids complement using conventional breeding and biotechnology e.g. exploitation of somaclonal variation. More attention is also given to common vetch for its versatility and suitability for different end uses (grazing, hay, grain and straw), specially, the work that is being done in collaboration with M&M Project. Recently, a new activity has been initiated with central Asian and Caucasian Countries (CAC), to test and evaluate promising lines and populations of vetches and chicklings for spring planting. Works on certain species such as *vicia palaestina* and *Lathyrus ochrus* were reduced at the head-quarter and targeted to areas with mild winter and where broomrape is endemic. The results obtained in 1999 are presented on the following pages and are given by species.

7.4. Common Vetch (*Vicia sativa* L.)

7.4.1. Evaluation of Germplasm

During the last three seasons, attention has been paid to the collection and evaluation of native wild types of common vetch. Some showed good cold and drought tolerance as well as early and rapid winter growth, early flowering and maturity. Such genotypes could be of value for developing new cultivars.

In 1998/99, one experiment was conducted to asses 225 accessions originated from different origins of common vetch (*Vicia sativa*) in nursery rows in a cubic lattice design with three replicates (6 rows each). The experiment was fertilized with 40kg/p_2o_5/ha.

In this trial the accessions were visually scored at 1-9 scale (1=poor; and 9=very good) for cold tolerance, winter growth, spring growth, leafiness and pod shattering. The two middle rows were harvested at full maturity to estimate the grain and straw yields. Time to start flowering, and full maturity were recorded.

A broad variation was observed for the characters studied (Table 7.1). The results show that there is a wide range of adaptation, which has been fully documented for reference and future exploitation. Accessions showing good adaptation were identified as good resources for desirable traits for future breeding program.

We believe that Germplasm is the forage breeder's most valuable natural resources. Therefore, we systematically evaluate large numbers of forage germplasm in collaboration with the Genetic Resources Unit (GRU) to identify desirable traits of the species we wish to improve.

Table 7.1. Range, Mean, standard error and coefficient of variation (CV%) for 9 characters of common vetch (*Vicia sativa*)

Character	Range	Mean	SE+	CV%
Cold tolerance*	4-9	7.0	0.7	15.0
Winter growth*	3-9	6.5	0.8	12.0
Spring growth*	4-9	7.0	0.6	15.0
Leafiness*	3-9	7.0	0.7	14.0
Days to flowering	94-122	109	1.2	1.6
Days to maturity	135-162	148	1.5	1.4
Total biological yield (kg/ha)	1630-8300	6930	440	15.0
Grain yield (kg/ha)	443-2600	1550	150	14.0
Harvest index (%)	15-36	24.0	1.9	12.0

On visual score, where 1=poor; 9=very good.

7.4.2. Preliminary Evaluation in Microplot Yield Trials (MYT)

The availability of an appropriate genetic base is an indispensable pre-requisite for our breeding program aiming at the development of improved cultivars. Therefore, special attention is given to the material evaluated in observation rows and to the segregated populations for adaptation for the following agronomically important characters: cold tolerance, rapid winter growth, leafiness, erect types, early in flowering and maturity, high herbage and grain yields and resistance to biotic and abiotic stresses. The study of variation in such agronomic characters is of significant practical value. It helps us to establish a suitable breeding program to develop improved germplasm.

In case of forage crops, to achieve high yield potential for different utilization systems, the end products (herbage, grain and straw) are tested for acceptability by livestock. Therefore, the quality parameters are given great consideration.

Objective selection for desirable traits begins in microplot yield trials following nursery rows evaluation for selected genotypes from the individual plant selections and segregated populations of the target crosses. Selection continues through advanced yield trials, before regional testing of selected promising elite lines by national programs.

In 1998/99, season a microptol field trial of common vetch was grown at Tel Hadya in 3.5m^2 plots arranged in a triple lattice design. The number of entries was 49, seed rate was 100kg/ha and fertilizer was applied at 40kg P_2O_5/ha. This microplot was divided in two sets, one was harvested at 50% flowering to determine the herbage yield (DM) and its quality, while the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

Out of the forty-nine selections which were tested at Tel Hadya, the top 10 selections which combined both high seed and herbage (DM) production were identified for more critical evaluation (Table 7.2). Herbage yield (DM) at 50% flowering varied from 4000 to 5900 kg/ha (mean of 4800 kg/ha), total biological yield from *3400 to 6700 kg/ha* (mean of 5100kg/ha), grain from 460 to 1400 kg/ha (mean of 926) and harvest index from 10 to 25% (mean of 18%).

The moderate and high temperature in winter and spring accompanied with rainfall at Tel-Hadya at vegetative stage facilitated the development of foliar diseases such as downey mildew (*Peronospora viciae*), and chocolate spot/blight (*Botrytis fabae*), which caused a severe damage to certain lines, resulting low herbage and grain yields. Selected entries showed a high level of natural resistance to the above mentioned diseases are shown in (Table 7.2).

There are identified for further tests under artificial infection in the disease nurseries.

Table 7.2. Winter growth (WG), herbage (H) biological (B) and grain (G) yields (kg/ha) harvest index (%) and time (days) to flower and mature of the top 10 selections of common vetch in microplot yield trials at Tel Hadya

IFLVS		Yield kg/ha			HI	Time to	
Sel.#	WG+	H	B	G	(%)	Flower	Mature
2752	9.0	4800	6700	1290	19	96	139
2762	9.0	4500	6300	1350	21	98	138
2748	8.0	5600	6150	1040	17	97	140
2755	7.0	4500	6100	1200	20	101	143
2776	8.0	4500	5900	1150	19	96	135
2775	8.0	4500	5800	1100	19	93	134
2771	9.0	5100	5700	1180	20	96	135
2767	9.0	4000	5000	1000	20	97	134
2761	8.0	4400	5500	1110	22	95	140
2560 (check)	8.0	3800	5000	900	18	97	137
Mean++	7.4	4800	5100	925	18	96	138
S.E.	0.5	351	471	180	3.0	0.9	1.3
CV (%)	12	13	16	25	21	1.7	1.6

+ On a scale 1 to 9, where 1 is slow, and 9 is very rapid growth measured on 21 February 1998

++ Mean of all 49 entries.

7.4.3. Common Vetch Advanced Yield Trials (AYT)

Elite lines from our breeding program are tested over multiple environments (location & years) for yield performance, utilization (grazing, hay, grain & straw) and consistency. Yield of these lines and their relative ranking or consistency in performance form the basis for recommendations to growers.

An experiment was carried out to test elite promising lines of common vetch at Tel Hadya (TH), Terbol (T) and Kfardan (Kfr) where the rainfalls during 1998/99 growing season were 307, 292 and 243mm, which represent 90, 55 and 61% of the total average, respectively. The total number of frost night was 17, 57 and 41 respectively, with absolute minimum temperatures of -3.0, -4.5, and -4.7C^0, respectively. Materials used in this multi-location yield trial are either progenies of single plants (selections or pure lines), selected from the wild types or selected F_3 and F_4 and F_5 families of intra-specific crosses. These lines are selected on the basis of their performance in microplot yield trials for two successive years. This trial was managed in the same way as microplots but had larger plot size (28.0 m^2).

Thirty-six elite lines were tested at Tel Hadya, Kfardan and Terbol. The three locations were chosen to sample the environmental conditions of the cereal zone in Syria and Lebanon. There were large variations between lines within the same location and between locations for winter growth, herbage, biological and grain yields.(Table 7.3).

Table 7.3. Location means of winter growth (WG), herbage (H), biological (B) and grain (G) yields, harvest index (%) and time (days) to flower and mature for 36 elite lines of common vetch in AYT

	Yield kg/ha				HI	Time to	
Location	WG[+]	H	B	G	(%)	Flower	Mature
Tel Hadya	7.0	4200	5400	1500	27	83	125
	±0.6	±289	±318	±122	±1.7	±0.7	±1.0
Kfardan	6.4	2350	3500	800	22.8	80	110
	±0.5	±240	±140	±48	±1.2	±0.7	±0.7
Terbol	5.5	5300	8400	1800	21.0	100	133
	±0.7	±340	±390	±140	±1.1	±1.02	±1.6

[+] On 1 to 9 visual score basis, where 1=poor and 9=excellent growth on 24 February 1998

The total biological yield was greater at Terbol and Tel-Hadya than Kfardan. The harvest index did not follow the same pattern. The large variation in both herbage and biological yields between locations was mainly due to the variation among tested lines in their flowering and maturity times as indicated by the highly significant correlation between days to flowering and maturity and total biological yield of r=-0.462, r=-0.523, r=-667, r=-0.707, and r=-0.55 r=-0.43, at Tel-Hadya, Kfardan and Terbol, respectively. (Table 7.4) shows the most promising and adapted lines at each location. IFLVS # 2717 showed high adaptation and was the most promising and high yielding across the three locations. Its exploitation in the future breeding program in case of high herbage and grain yields would be most desirable. The local check IFLVS # 2560, was adapted at Tel Hadya and Kfardan. The relatively moderate temperatures in winter accompanied with low raifall and high temperature in the spring during the pod forming and filling stages, resulted to high reduction in grain yields, specially at Kfardan. Selected lines in (Table 7.4). Showed a relatively high level of natural resistance to the above mentioned abiotic stresses.

Table 7.4. The most promising and adapted lines of common vetch at Tel Hadya, Kfardan and Terbol

Location	Promising lines IFLVS #							
Tel Hadya	2560	2499	2616	2617	2637	2714	2717*	2639
Kfardan	2484	2494	2505	2506	2567	2717	2627	2560
Terbol	2650	2505	2506	2616	2617	2624	2628	2717

(*) The most adapted lines at the three locations
(**)# 2560 (check local), adapted at Tel Hadya and Kfardan

7.4.4. Improving Seed Retention (Pod-shattering) in Common Vetch (*Vicia sativa*)

Loss of seeds from maturing pods (seed shattering) is common in leguminous forage crops, such as common vetch, and constitutes a serious economic problem, when the crop is used in rotation with cereals. Therefore, an essential character of a grain legume crop and a desirable one in forage legume crop is the ability to retain its seeds long enough to allow mechanical harvesting at full maturity. Pod-shattering in common vetch reduces also its popularity as feed legume crop for fallow replacement. Its seed germinating during the cereal phase of the rotation represent serious "weed problem". Therefore, a breeding program to develop non-shattering cultivars suitable for mechanical harvesting was initiated using natural wild non-shattering mutants IFLVS #1416 and #1361 with undesirable agronomic traits.

The genetic of pod-shattering was studied using parental (P_1,P_2) foliar generations (F_1,F_2) and backcross (BC_1, BC_2, BC_3, BC_4 and BC_5) generations obtained from crosses between wild non-shattering accessions and promising breeding lines with highly desirable agronomic traits, but with high proportion of pod-shattering. The results revealed that non-shattering trait is conditioned by a single recessive gene. Incorporation of this gene into agronomically promising lines was achieved by backcrossing, selfing and selection for non-shattering trait in erect, large and soft-seeded, leafy and early maturity types. After five backcrosses generations twelve superior lines IFLVS # 2558, 2557, 2406, 2556, 2559, 2021, 1715, 1716, 2556, 2728 and 2558 were selected having 97-99% non-shattering pods as compared to 30-40% in the original breeding lines. The grain yields of these lines is above 2.0 and 1.0 tons/ha under Tel Hadya and Kfardan conditions respectively.

Developing non-shattering cultivars in common vetch is continuing with the aim to incorporate the erect growth-habit to facilitate mechanical harvest. IFLVS # 2558 was identified as erect and non-shattering and is also characterized by white flowers, and cylender shape pods which facilitates maintenance selection of the line. Seed multiplication for this line is being done at Tel Hadya and Kfardan stations for distribution to national programs.

The practical benefits of developing non-shattering and erect lines include increased grain yield, reduce problem of volunteers in subsequent cereal crops, improved opportunity for mechanical harvesting and increased flexibility in time of harvest. Increased grain yield results in reducing price of seed and allows farmers to increase the area cultivated with common vetch and so increase livestock production. Until recently, common vetch was not considered a desirable forage legume for use in rotation with cereals because of its pod shattering at maturity. New improved lines are now being used and the popularity of common vetch is substantially increased.

7.4.5. Improving Cold and Drought Tolerance of Common vetch (*Vicia sativa* subsp. *sativa*) and Herbage Production of Under-ground Vetch (*Vicia sativa* subsp. *amphycarpa*)

In our breeding program, special attention is given to the materials collected from its natural habitats. These materials contain genotypes, which appear useful for the improvement of agronomically important characters, as early flowering and maturity, cold tolerance, and high biomas yield under marginal conditions. It is also generally accepted that the availability of basic genetic materials is indispensable pre-requisite for our breeding program aiming at the creation of important cultivars.

Species and subspecies hybridization: hybridization is an important aspect in feed Legumes breeding, to incorporate useful genes carried out by parental species and also to increase variation for selection. Our studies on underground vetch (*Vicia sativa* subsp. *amphicarpa*), which is grown as wild type in central Anatolia region of Turkey revealed that its ability to produce both aerial and underground pods increases its winter hardiness, drought tolerance and persistence under heavy grazing. The disadvantages of underground podding habit, which may limit its utilization, are its low rate of vegetative growth, shattering of above-ground pods and the dependence of amphicarpy on environmental conditions. In contrast, common vetch (*Vicia sativa*) grows well under favorable conditions, but it is not cold and drought tolerance, and there are some improved lines with non-shattering pods.

To enhance the herbage production of underground vetch and improve the drought and cold tolerance of common vetch, crosses between the two subspecies were made to develop a more agriculturally, valuable feed legume crops from both of them, by transferring the desirable genes from the wild to cultivated species and vice-versa. No special difficulties were faced in making the crosses.

The material was derived from crosses of improved lines of common vetch (IFLVS # 715, 2558, 713 and 1448) with two wild accessions of underground vetch (# 2660 originated from central Anatolia, Turkey and # 2614 originated from Gabal Abd El Aziz area, Syria). High vegetative vigor was observed in the F_1 plants carrying few underground pods near the soil surface.

The F_2 population released enormous variability transcending even the limits of the parents in some traits such as number of underground pods, cold tolerance. Leaf: stem ratio and herbage yield.

Selection was done in 1999 in F_3 lines descended from F_2 single plant selections of the eight crosses. Through selection in F_3, ten F_4 and F_5 selected families with average 10 underground pods/plant and more 50% increase over the amphicarpic parents in herbage production were selected as improved lines of underground vetch. Also, twelve families with cold tolerance and maintained vigorous growth of common vetch were selected as improved lines of common vetch.

Seeds of improved lines of underground vetch are being used to rehabilitate the marginal lands in Turkey, in collaboration with NRMP. Also, improved lines of common vetch will be used for winter sowing common vetch in Turkey and other high elevation areas in the region.

7.5. Narbon Vetch (*Vicia Narbonesis*)

7.5.1. Advanced Yield Trials

In 1998/99 season, narbon vetch advanced yield trial was sown at three sites (Tel Hadya, Breda in Syria and Kfardan, in Lebanon). The total number of the tested line was 36 including IFLVN # 2561 (local check).

Winter growth, biological and grain yields and harvest indexes were measured at each location (Table 7.5). There were differences in the performance of the tested lines for all measured traits. Yields were greater at Tel Hadya than Breda and Kafardan, both for biological and grain yields. The harvest index at Breda was greater than Tel Hadya and Kafardan. The relatively low biological and grain yields at Kafardan was mainly due to the relatively low rainfall (243 mm) which represent 60% of long term average, and the early onset of drought and heat stress in the early spring. Promising lines were selected at each site (Table 7.6) based on early maturity, rapid winter and spring growth, high biological and grain yields and drought tolerance. The growing season of 1998/99 was constrained by prolong periods of drought in the spring with intermittent and inadequate rainfall. Narbon vetch (*Vicia narbonensis*), in 1999 season proved to have a great potential as forage legume in dry areas. At Breda where rainfall was 197mm, improved lines of narbon vetch gave yield around 1.5t/ha and 3.5t/ha straw. Under these conditions its yield is more than other legumes. Breeding for greater drought tolerance could increase its adaptation. The resistance to birds damage attribute at seedling stage is a major factor in establishment a good stand. It is easy to establish also because of its large seed. Seeds may be planted deeper than other forage legumes which allows placement in a moist layer, where moisture in the surface soil layer is often the determinant of success of seedings emergence. It is ideal legume for stock pilling forage as straw for sheep. Narbon vetch does not loss its leaves following frost or its seeds at maturity stage. It is a good legume crop in dry areas where others are not successful

Table 7.5. Location means of winter growth (WG), biological (B) and grain (G) yields, harvest index (HI) and time (days) to flower and mature for 36 lines of narbon vetch in AYT

Location	WG(+)	Yield kg/ha B	Yield kg/ha Gr	HI (%)	Time to Flower	Time to Mature
Tel Hadya	7.3	6600	2000	30	80	120
	±0.6	±400	±150	±1.4	±1.0	±2.5
Breda	8.2	4600	1500	32.6	85	132
	±0.5	±320	±190	±2.5	±1.5	±1.0
Kfardan	6.2	3000	750	25.0	70	110
	±0.5	±280	±129	±2.5	±1.4	±1.5

+ On 1 to 9 visual scale basis, where 1=poor and 9=excellent growth on 24 February, 1998.

Table 7.6. Biological and grain yields (kg/ha) of the most promising and adapted lines of narbon vetch at Tel Hadya, Breda and Kfardan.

Tel Hadya Rainfall 307mm			Breda Rainfall 197mm			Kfardan Rainfall 243mm		
IFLVN	Biological yield	Grain yield	IFLVN	Biological yield	Grain yield	IFLVN	Biological yield	Grain yield
2382	7500	2300	2379	4300	1500	2389	3400	1200
2472	7400	2275	2704	4900	1000	2392	3400	1100
2706	7400	2200	2477	5300	2230	2382	3400	1170
2379	7200	2300	2601	5200	1400	2385	3800	1200
2704	7200	2100	2561	5200	1800	2386	3500	1100
2463	7100	2200	2461	5200	1900	2384	3150	1000
2561 (local check)	6500	2000	2392	5100	2000	2561	3000	790
Mean+	6600	2000		4600	1500		3000	750
SE ±	400	150		320	190		280	129
CV(%)	10	12.5		12.0	19		12	16

(+) Mean for all 36 lines.

7.6. Wooly Pod Vetch (*Vicia villosa* subsp. dasycarpa)

7.6.1. Advanced Yield Trials (AYT)

Twenty-five promising lines were tested at Tel Hadya and Kfardan. There were great differences in winter and spring growth, herbage, biological and grain yields, between lines within locations and between locations (Table 7.7). Herbage, biological and grain yields were greater at Tel Hadya than Kafardan. Low grain yield at kfardan was mainly due to delays in the first appearance of floral buds, and the heat stress that occurred when bud development which caused a large propertion of flower and young-pods drops and the buds development were inhibited by high temperature in the spring.

In contrast to other vetches, wooly-pod vetch characterized by a long flowering period, and high herbage yield. These characters make it the most suitable for grazing or haymaking. Early maturity types are needed as it is indicated by the significantly negative correlation between grain yields and days to flowering and maturity (r=-0.640, -0.510 ($p<0.01$) at Tel Hadya and -0.810, -0.601 ($p<0.01$) at Kfardan).

Table 7.7. Location means of herbage (H), biological (B) and grain (G) yields kg/ha and harvest index (HI) and time (days) to flower and mature for 25 lines of wooly pod vetch

	Yield (kg/ha)				Time to	
Location	H	B	G	HI(%)	Flower	Mature
Tel Hadya	4000	4700	850	18	91	126
	±429	±302	±215	±4.3	±0.9	±1.6
Kfardan	2400	3000	450	15	80	112
	±179	±195	±80	±2.3	±0.6	±0.9

(Table 7.8), shows the most promising lines at the two locations. IFLVD # 2562, (the released variety at Quetta, Pakistan under the name of Kuhak 96) was the most promising at the two location. More emphasis has to be given to reduce young pod abortion, pod shattering, high leaf retention and earliness to flowering and maturity with flowering and podding occurring on early formed modes to improve the productivity of wooly pod vetch.

Table 7.8. The most promising and adapted lines of wooly pod vetch at Tel Hadya and Kfardan

Location	Promising lines IFLVD #				
Tel Hadya	2562	2435	2445	2457	2442
Kfardan	2562	2565	2437	2436	2457

7.7. Lathyrus spp. (chicklings)

7.7.1. Advanced Yield Trials of Two Lathyrus spp.

Twenty-five promising lines each of common chickling or grasspea (*Lathyrus sativus* L.) and dwarf chickling (*Lathyrus cicera* L.) were tested at Tel Hadya, Breda and Kfardan. (Table 7.9) shows herbage, biological, and grain yields at the two locations. *Lathyrus cicera* produced the highest herbage yield at Tel Hadya followed by *Lathyrus sativus*; whereas, *L. sativus* produced the highest grain yield at Tel Hadya followed by *Lathyrus cicera*. The relatively low grain yields of *Lathyrus sativus* and *Lathyrus cicera* at kfardan was mainly due to the severe effect of the abiotic stresses of drought and heat stress during the flowering, pod formation and grain filling stage.

Great variability was observed between species and within the same species. The early maturity lines of *Lathyrus sativus* and *Lathyrus cicera* had high grain yields, and the high herbage yield of *L.cicera* was due to its rapid winter growth, during the mild winter 1999.

The results of the advanced yield trials of *Vicia* spp. and *Lathyrus* spp., showed great differences between the tested locations and among entries within the same location for the tested traits. Considerable genetic variation exists within each species for attributes indicative of yield and its components. The variations could be exploited by the appropriate breeding procedures to develop high yielding cultivars. These cultivars can contribute significantly to livestock production in rainfed agriculture. There use in rotation with cereals will increase the sustainability of farming systems by acting as a disease and broomrape break, and by contributing to the nitrogen nutrition of cereals.

The utilization of different species varies between region. Consequently characters for selection vary according to respond to local needs. As forage legumes can be used for direct grazing, hay making, straw and grain, we can begin to see how the various species will meet the farmers needs in the prevailing farming systems. The high grain and straw yields, cold tolerance and early maturity of narbon-vetch make it ideal feed legume for producing winter stocks of grain and straw for feeding sheep during the peak of feed demand in winter. It does not lose its leaves following frost, like many other feed legumes or its seeds at maturity stage. Breeding for greater drought tolerance could increase its adaptation. The resistance to birds damage attribute at seedling stage is a major factor in establishment a good stand of narbon vetch. It is easy to establish because of its large seeds. Seeds can be planted deeper than other vetches, which allows placement in a moisture layer on soil. The long flowering period, prostrate to semi-erect growth habit, rapid winter and spring growth, cold tolerance and high herbage production are the most important attribute to make the wooly pod vetch the most suitable for grazing in the cold areas. It has proved to be well adapted to upland of Balochistan conditions and other highlands areas and a released variety kuhak 96 is in hand. Common vetch is a versatile feed legume crop. The rapid winter growth types can be used for early grazing, the non shattering erect types can be used to produce grain and straw, and the leafy and rapid spring growth types can be used for hay making. For farmers who require hay or grazing dwarf chickling could be another option in dry areas. The grasspea is susceptible to broomrape, but in dry areas it can still be used for grain and straw.

In this report we are reporting the results of 1998/1999 cropping season.

7.8. Improving Nutritional Quality of Grasspea (*Lathyrus sativus*)

ICARDA is placing special emphasis on improving grasspea using the biodiversity available in the genetic resources. The objective in the crop improvement program on this species are to improve its yield potential and nutritional quality through the reduction of the neurotoxine β-N-oxalyl-L-α-β-diaminopropionic acid (β-ODAP) content in its grain. Three approaches are being adopted to achieve objectives: 1) germplasm evaluation, 2) genetic detoxification (hybridization program), 3) Exploitation of somaclonal variation (plant biotechnology) and 4) effect of soil micronutrients, Zn^{++} and Fe^{++}.

In this report we are reporting the results of 1998/1999 cropping season.

Table 7.9. Means and ranges of herbage, biological and grain yields (kg/ha) of two *Lathyrus* spp. in advanced yield trials at Tel Hadya (TH), Breda (Br) and Kfardan (Kfr)

	Herbage Yield (kg/ha)			Biological Yield (kg/ha)			Grain Yield (kg/ha)	
Species	TH	Br	Kfr	TH	Br	Kfr	TH	Br	Kfr
L. sativus									
Mean+	5500	2200	2500	5000	3800	3300	1000	790	600
SE	223	190	137	353	210	193	110	85	50
Range	(4800-6900)	(900-2800)	(2000-2800)	(4300-5600)	(3300-4300)	(2400-3600)	(800-1400)	(400-1100)	(400-800)
L. cicera									
Mean	6600	1900	2400	6100	4200	2700	1600	1117	690
SE	501	190	207	354	246	132	126	82	60
Range	(5700-7500)	(1300-3000)	(1900-3000)	(5000-7400)	(3600-4700)	(2200-3000)	(1092-1930)	(676-1500)	(450-870)

(+) Mean for all 25 entries, each species.

7.8.1. Germplasm Evaluation

The appraisal was carried out of 313 accessions of *Lathyrus sativus* originated from Bangladesh, Ethiopia, Nepal and Pakistan. Four experiments were conducted, in the first and second 100 accessions representing Bangladesh and Ethiopia were planted in a triple lattice design with three replicates (6 rows each), in the third 49 accessions from Nepal and in the fourth 64 accessions from Pakistan were planted in the same design. The experiments were fertilized with 40kg P_2O_5/ha^{-1}.

In these trials the accessions were visually scored at 1-9 scale (1=poor; 9=very good) for seeding vigour, cold tolerance, winter growth, spring growth, leafiness and pod-shattering. Days to start flowering 50% flowering and to physiological maturity, when 95% of the pods had lost their green colour were recorded. The two middle rows were harvested at maturity to estimate the grain and straw yields and the neurotoxin β -ODAP in the grain.

Abroad variation was observed for the characters studied for each group (Table 7.10, 7.11, 7.12 & 7.13). Accessions from Bangladesh have relatively low β -ODAP in the seeds compared with those of Ethiopia, Nepal and Pakistan. The results indicate that non of the tested accessions was <0.2% β -ODAP content in the grains. Accessions showed high yields and early flowering and maturity were identified as a good sources for desirable traits for future breeding program.

Table 10. Range, Mean, standard error and coefficient of variation (CV%) for 10 characters of 100 grasspea (*Lathyrus sativus*) accessions originated from Bangladesh

Character	Range	Mean+		CV%
Seedling vigour	04-09	06.3	0.8	18.6
Cold tolerance	03-08	05.7	0.9	22.0
Winter growth	05-09	06.9	1.0	20.0
Spring growth	05-09	07.5	0.8	14.0
Days to flowering	80-96	86.0	1.2	1.9
Days to maturity	139-154	147	1.8	1.7
Total biological yield(kg/ha)	3700-6600	5200	345	12.0
Grain yield (kg/ha)	1300-2200	1690	190	16.0
Harvest index (%)	24-43	32.7	2.2	10.0
β -ODAP (%) in grains	0.32-0.72	0.44	0.006	-

Table 7.11. Range, mean, standard error and coefficient of variation (CV%) for 10 characters of 100 grasspea (*Lathyrus sativus*) accessions originated from Ethiopia.

Character	Range	Mean±		CV%
Seedling vigour	03- 08	06.8	0.8	17.6
Cold tolerance	04- 08	07.0	0.7	18.0
Winter growth	03- 08	06.6	0.7	16.0
Spring growth	05- 09	07.7	0.9	16.5
Days to flowering	86- 105	97.0	1.2	1.8
Days to maturity	138- 160	152.0	2.0	1.9
Total biological yield(kg/ha)	4600-8000	5900.0	390	10.0
Grain yield (kg/ha)	1000-2500	1650.0	190	16.0
Harvest index (%)	22- 34	27.0	2.3	12.0
β -ODAP (%) in grains	0.33-0.7	00.5	00.004	-

Table 7.12. Range, Mean, standard error and coefficient of variation (CV%) for 10 characters of 100 grasspea (*Lathyrus sativus*) accessions originated from Nepal.

Character	Range	Mean±		CV%
Seedling vigour	03- 09	04.5	00.66	21.0
Cold tolerance	05- 09	07.0	00.69	15.0
Winter growth	03- 09	04.5	00.66	20.0
Spring growth	03- 09	05.0	00.79	21.0
Days to flowering	80- 103	90.0	01.5	2.5
Days to maturity	134- 155	142.0	01.5	1.5
Total biological yield(kg/ha)	1700-6900	3200.0	340.0	15.0
Grain yield (kg/ha)	800-1750	1250.0	163.0	18.0
Harvest index (%)	23- 49	39.0	02.9	10.0
β -ODAP (%) in grains	0.4- 0.8	00.53	00.009	-

Table 7.13. Range, Mean, standard error and coefficient of variation (CV%) for 10 characters of 100 grasspea (*Lathyrus sativus*) accessions originated from Pakistan

Character	Range	Mean±		CV%
Seedling vigour	04- 09	5.5	0.8	22
Cold tolerance	05- 08	7.0	0.9	16
Winter growth	02- 09	5.1	0.8	20
Spring growth	03- 09	6.7	0.8	17
Days to flowering	80- 114	90	1.7	2.6
Days to maturity	139- 157	145	1.5	1.2
Total Biological yield(kg/ha)	2200-5800	3700	280	11.0
Grain yield (kg/ha)	1000-1600	1160	134	16.0
Harvest index (%)	22- 38	31.0	2.8	12.0
β -ODAP (%) in grains	0.29-0.8	0.54	0.014	-

2.5.2. Genetic Improvement (Hybridization)

Genetic improvement work on *Lathyrus sativus* (grasspea) commenced in 1990 at ICARDA, with emphasis being placed on reducing the neurotoxin β -N-oxalyl-L-α- β -diaminopropionic acid (β -ODAP) content in the grains. In the beginning, an intensive screening program was initiated with the possibility of isolating low or toxic free accessions from germplasm collected from different origins. The screening of germplasm continued for four years. Accessions having little as 0.08 to as much as 1.9% were found indicating large variation in β -ODAP content. Five genotypes IFLLS# 523, 578, 536, 519 and 588 were selected as being significantly low in β -ODAP, with less than 0.1%. Along with these five lines, the wild type, *Lathyrus ciliolatus* (underground chickling) was found to be free from the neurotoxin β -ODAP.

β -ODAP (below 0.1) as testers and the 150 hybrid combination were obtained. Gene markers such as seed and flower colours were used to eliminate pods, which might have developed from selfing. Selection from F_2 to F_5 was directed for early maturity, small and large seed size and less than 0.1% β -ODAP. In 1998/99, 110 families were grown under rainfed conditions at Tel Hadya (307 mm) and Breda (197 mm) to assess their yield potential and β -ODAP content. The ten families with lower β -ODAP at Tel Hadya and Breda are shown in (Table 7.14). Yield was generally greater at Tel Hadya than Breda, whereas, the neurotoxin β -ODAP was greater at Breda. Despite an below average growing season rainfall of 10% and 42% at Tel Hadya and Breda, respectively, the ten selected lines produced grain yields above 1.0 t/ha at Tel Hadya and around 0.8 t/ha at Breda. IFLLS 722 was the only line having high grain yield and β -ODAP content below 0.1%.

From these studies it is apparent that the neurotoxin β -ODAP is much lower than the landraces. Further it is interesting to note than the yield potential of these lines is relatively high when rainfall at Breda was 197 mm. The result reported here appear to be highly encouraging to overcome the problem of toxicity of this drought tolerance hardy crop.

Table 7.14. Grain yield (kg/ha), crude protein (CP%) and β-ODAP content (%) of 10 promising F_5 families of grasspea at Tel Hadya and Breda 1998/1999

Tel Hadya (rainfall 307mm)				Breda (rainfall 197mm)			
IFLLS#	Grain yield (kg/ha)	CP (%)	β-ODAP (%)	IFLLS #	Grain yield (kg/ha)	CP (%)	β-ODAP (%)
716	1400	27.5	0.077	722	1050	26.9	0.090
736	1027	26.4	0.075	706	830	27.0	0.091
722	1300	27.5	0.085	735	900	26.9	0.096
717	1510	28.6	0.090	676	800	26.7	0.105
726	1360	28.0	0.092	707	950	27.9	0.105
453	800	28.2	0.092	683	770	27.4	0.107
680	1100	27.0	0.092	729	700	27.2	0.107
704	1400	27.7	0.092	672	890	27.4	0.110
727	1500	27.0	0.092	681	1000	26.0	0.110
720	1350	28.0	0.080	695	1100	26.2	0.110
Mean+	1270	27.5	0.22		700	26.9	0.367
SE +	186	0.92	0.028		90	0.07	0.05

(+) Mean of the all 110 tested lines.

7.8.3. Use of Somaclonal Variation in *Lathyrus Sativus* (grasspea) to Select Variants with low β-ODAP Concentration

Explants of internodes and shoots were taken from 15 day old seedlings (grown *in vitro*) from the Ethiopian landraces (Eth.1-Eth.17 lines) and improved lines Fam 85 (flat, white coated seeds), IFLLS# 482, Sel 520, 521 and 588. These explants were cultured on B5L (root, leaves and internodes) or B5L2 (shoots) medium. Explants developed into callogenic tissue after a few days of culturing and were subcultured on fresh medium every 6 weeks. Explants that developed roots were transferred to B5L2; explants with shoots but no roots were cultured on MSL++ (Murashige&Scoog, Lathyrus, supplemented with growth regulators). Plants (R1) with well-developed roots and shoots were hardened and transferred to the plastic house, where seeds were harvested. Seedlings of the regenerated plants showed high variation for morphological traits (leaf shape, etc) as compared to the original lines. Even the flower color differed in some R2 plants as compared to the original selection. Seeds of the first R3 plants have been analysed for their β-ODAP concentration. Results of these tests show that the level of β-ODAP has reduced substantially compared to that of the original line see (Table 7.15).

Table 7.15. Number and origin of explants cultured and their regeneration

IFLL Selection no.	Explants (no.)	Plantlets (no.)*	Plants (no.)	Seeds	Regeneration percentage**
Fam.85	470	5	15	Yes	3.2
Sel.482	253	3	22	Yes	8.7
Sel.520	180	3	15	Yes	8.3
Sel.521	196	3	9	Yes	4.6
Sel.588	296	1	27	Yes	9.1
Eth.1	200	10	30	Yes	15.0
Eth.2	195	15	20	Yes	10.3
Eth.3	212	10	24	Yes	11.3
Eth.4	187	9	12	No	6.4
Eth.5	221	7	21	No	9.5
Eth.6	159	11	14	No	8.8
Eth.7	151	5	13	No	8.6
Eth.8	152	7	8	No	5.3
Eth.9	157	6	20	Yes	12.7
Eth.10	127	5	4	No	3.1
Eth.11	54	5	2	No	3.7
Eth.12	57	6	0	No	0.0
Eth.13	55	1	1	No	1.8
Eth.14	52	0	0	No	0.0
Eth.15	53	3	0	No	0.0
Eth.16	54	0	0	No	0.0
Eth.17	57	2	0	No	0.0
Totol	3538	117	257		7.3

* Plants still *in vitro*.

** Based on plants planted in the conviron

From 3538 cultured explants 257 plants have been so far planted in soil (7.3 %), another 117 plants are currently developing *in vitro*. Plants can be regenerated from cultures even more than 18 month old, therefore if the current cultures are kept aliv a continuous number of regenerated plants can be expected. Explants of Eth 13-

Eth17 have been cultured less than 4 months and have therefore not regenerated plants. Regeneration of the explants into plants is varying from 3.1 to 15 % which shows clearly differences in regeneration capacity between the various lines (Table 7.15). To increase the regeneration, a variety of media is currently being tested.

7.8.4. Zinc and Phosphorus Effect on β-ODAP Content on *Lathyrus sativus*

In this second-year pot experiment, a number of modifications were made from the previous year. First, the *Lathyrus sativus* lines were different. This time, we included two high-toxin lines from Ethiopia and a low toxin one from ICARDA (LS 288): previously, three ICARDA lines with a range of toxin concentration were used: LS 512, LS 566, and LS 562. This time Zn, which increased yield and reduced the toxin concentration in the previous year, was again included at 0, 5, 10, 25 and 50 ppm. As P is known to interact with Zn, a range of P fertilizer was applied to give O, 10ppm (low) and 50 ppm P (high).

The amount of soil used in each pot was the same as before, i.e., 3.5kg per pot. Nitrogen was applied as a blankettreatment to all pots as ammonium nitrate at 20 ppm. The design was a split-split plot with lathyrus lines the main plots, Zn the sub-plots, and P the sub-sub plots. The seeds were planted (5 per pot) in the potted soil to a depth of 1cm; the pots were then watered to field capacity as required. At full maturity the plants were harvested and threshed to separate the grain from straw, and β-ODAP content was measered in both strow and grain.

The resulting data from the trial are presented in (Table 7.16) as none of the lines showed a significant yield increase with either Zn or P, the data are not presented. The major observation was that added Zn consistently reduced the β-ODAP concentration in the seeds, i.e., decreases from 0.794 to 0.637% for Ehtiopian I, from 0.772 to 0.655% for Ethiopian 2, and from 0.335 to 0.252 for the low-toxin ICARDA line.

These trends were similar, with the 10ppm applied P level. However, when the high P level was applied (50 ppm), there was an apparent interaction between Zn and P. The high P rate tended to revert the downward trend in β-ODAP with added Zn. For example, in Ethiopian I, β -ODAP decreased from 0.800 with no added Zn to 0.609 with 10 ppm Zn. However, at the same rate of P, β -ODAP values increased again at the 25 and 50 ppm Zn. Thus, P was interfering with the capacity of the Zn to reduce β -ODAP.

Table 7.16. Phosphorus and Zinc fertilization: β -ODAP calculation in grain and straw of three *L. sativus* lines

		β -ODAP%					
		Grain			Straw		
Phosphorus	Zinc	Ethiopian 1	Ethiopian 2	LS 288	Ethiopian 1	Ethiopian 2	LS 288
00	00	0.794	0.772	0.335	0.754	0.970	0.665
00	50	0.790	0.692	0.297	0.809	0.963	0.825
00	10	0.760	0.667	0.292	0.686	0.988	0.736
00	25	0.677	0.664	0.270	0.782	1.191	0.868
00	50	0.637	0.655	0.252	0.803	0.948	1.017
Mean		0.731	0.687	0.290	0.756	1.012	0.853
SE±		0.030	0.023	0.014	0.024	0.045	0.087
10	00	0.769	0.880	0.430	0.788	0.889	0.677
10	05	0.707	0.778	0.300	0.779	0.902	0.729
10	10	0.683	0.695	0.290	0.757	0.893	0.914
10	25	0.660	0.34	0.286	0.723	0.984	0.908
10	50	0.618	0.624	0.257	0.760	0.883	0.913
Mean		0.689	0.722	0.316	0.761	0.883	0.808
SE±		0.025	0.048	0.030	0.011	0.011	0.011
50	00	0.800	0.815	0.489	0.966	1.046	0.845
50	05	0.778	0.680	0.232	0.917	0.828	1.093
50	10	0.609	0.617	0.233	0.806	0.939	0.791
50	25	0.667	0.646	0.202	0.846	1.117	0.846
50	50	0.674	0.757	0.383	0.890	1.170	0.868
Mean		0.706	0.703	0.308	0.885	1.020	0.889
SE±		0.004	0.037	0.055	0.019	0.069	0.052

There was a tendency for β -ODAP concentrations to be higher in the lathyrus straw than again. Indeed, in the non-P fertilized pots, there was a clear trend for β -ODAP in straw to increase with added Zn. From this it can be deduced that the effect of Zn lay in an influence on the translocation from straw to increase with added Zn. From this, it can be deduced that the effect of Zn lay in an influence on the translocation from straw to grain.

This current year, the influence of Zn and P is being experimented in a field trial allowing for more comprehensive conclusion on the role of Zn in relation to the neurotoxin in lathyrus.

7.9. Nutritional Quality

Improved forage quality is an important objective in our breeding program. Also achieving high yield potential and adaptation to different niches, agroecological zones and utilization needs to be complemented by ensuring that the end products are acceptable by livestock. Therefore, quality of hay, straw and grain are gives great consideration.

7.9.1. Hay and Straw Quality of two *Vicia* spp.and Two *Lathyrus* spp.

The quality parameters utilized in forage breeding program are crude protein (CP%), neutral detergent fibers (NDF%), acid detergent fibers (ADF%) and dry matter organic matter digestibility (DMOM%).

Large differences were observed both between and within species hays of *Vicia sativa* and *Vicia dasycarpa* having higher protein content than straws (Table 7.17). Hay of *Vicia dasycarpa* has higher protein content than *Vicia sativa*. Because of the high proportion of fibers in *Vicia dasycarpa* hay and straw its digestibility is lower than *Vicia sativa*.

Hays and straws of *Lathyrus sativus* and *Lathyrus cicera* are higher in protein content and digestibility than those of *Vicia sativa* and *Vicia dasycarpa* (Table 7.18). This is mainly due to high Leaf: stem ratio and high degree of leaf retention at harvest.

Table 7.17. Mean and range of protein content % NDF %, ADF %, and DOMD (%) for hays and straws of three *Vicia* spp. promising lines in advanced yield trials at Tel Hadya 1998/1999

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
V. sativa								
Mean	18.3	35	24	70	8.7	46	35	55
SE .	0.139	0.274	0.192	0.210	0.1312	0.29	0.130	0.467
Range	16-20	32-43	24-30	71-77	7-11	44-54	34-39	49-62
Vicia dasycarpa								
Mean	21	38	30	69	14	50	32	59
SE .	0.16	0.353	0.198	0.307	0.141	0.25	0.163	0.469
Range	20-23	34-41	24-28	66-73	12-16	44-49	20-23	54-64
Vicia narbonensis								
Mean	-	-	-	-	10.5	47	34	53
SE .	-	-	-	-	1.061	2.34	1.25	3.049
Range	-	-	-	-	9-13	40-51	31-36	48-60

Table 7.18. Mean and range of protein content % *NDF* %, ADF %, and DOMD (%) for hays and straws of two *Lathyrus* spp. elite lines in advanced yield trials at Tel Hadya 1998/1999

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
Lathyrus sativus								
Mean	20.0	40	26	73	12.5	46	27	60
SE .	0.143	0.539	0.252	0.143	0.063	0.882	0.426	0.59
Range	19-22	35-46	22-29	69-80	14-16	37-53	23-26	54-65
Lathyrus cicera								
Mean	21.2	36	23.3	77	17.0	42	25	60
SE .	0.14	0.26	0.119	0.214	0.099	0.301	0.301	0.099
Range	19-23	34-38	22-24	75-79	16-18	35-37	22-28	56-68

7.9.2. Protein and Neurotoxin β -(N-Oxalyl)-L-α-β -Diamino-Propionic acid (β -ODAP) in two *Lathyrus* spp. Grain at Tel Hadya and Breda

Protein and neurotoxin β -ODAP for promising lines of *Lathyrus sativus* and *L. Cicera* were estimated by a Near-Infrared Reflectance (NIR) spectroscopy Model NEOTEC 5000, with a wave length setting between 1100 and 2500 mm. Every fifth sample was verified by Micro-Kjeldahl method for crude protein and classical spectrophotometic analysis for β -ODAP. Which gave a correlation of r=0.92 and 95 for β -

ODAP and crude protein, respectively. (Table 7.19) summarizes the results of crude protein% and β -ODAP% for 25 promising lines each of *L. sativus and L. cicera* grown at Tel Hadya and Breda with rainfall of 307 and 197mm, respectively. The results indicate that none of the tested lines was β -ODAP free, although some lines were very low below 0.1% (The threshold is 0.2%). Large variation was found between species and between lines within the same species. *Lathyrus cicera* had the highest protein and β -ODAP contents at the two locations. The presence of such variation in protein and β -ODAP suggests that there is a good potential for developing lines of the three tested species with low β -ODAP and high protein contents.

Table 7.19. Mean and range of protein content % and β -ODAP% of grains of promising lines of two *Lathyrus* spp. at Tel Hadya and Breda

	T.Hadya		Breda
Species	β -ODAP%	Protein %	B -ODAP%
L. sativus			
Mean	0.18	31.0	0.22
SE .	0.03	1.6	0.05
Range	0.07-0.2	25-33	0.1-0.3
L. cicera			
Mean	0.12	29	0.19
SE .	0.04	0.9	0.13
Range	0.04-0.16	31-33	0.16-0.23

7.9.3. Variation in Tannins and Protein Contents of Narbon Vetch (*Vicia narbonensis*) Seed

In small ruminates, tannins in narbon vetch seeds have a negative effect as an antipalatability factor and a positive effect as a protein out-flow from rumen.

Tannins and protein contents in the grains of the thirty-six lines of narbon vetch grown at Tel Hadya and Breda were estimated.

Non of the thirty-six lines of narbon vetch were tannin-free. Tannin contents of the whole seed varied from 0.22,in Sel#2378 to 0.39 in Sel#2468, whereas, protein content varied from 29.0 in sel#2393 to 33.6% in Sel#2379. Tannins and protein contents were higher at Breda than Tel Hadya (Table 7.20). At both locations Tannin content was negatively correlated with 100 seed weight (r = -0.27 and -0.28) at Tel Hadya and Breda, respectively. Lines with very low tannin content were susceptible to downy mildew (*Peronospora viciae*), aphis (*Aphis craccivora*) and pod-borer (*Helicovera* sp.). The presence of moderate levels of tannins in narbon vetch may be a beneficial as a defense against insects and diseases and on animal by reducing the risk of bloat.

In conclusion, the improvement of vetches and chicklings quality is of a paramount importance to the performance of ruminant animals (sheep & goats). A modest increase in protein and digestibility from the development of new elite lines can increase animal performance. Both quantity and quality of the forage consumed contribute to response of the animal. Therefore, progress in breeding for high yield potential is supplemented by improving the quality of the herbage, grain and straw. Forage vetches and chicklings improved in quality were developed by breeding for (a) greater nutritional value, (b) increasing intake and digestibility (c) lower contents of toxic properties which reduce the feed intake and are injurious to animal health. The most useful selection criteria in our breeding program for voluntary intake is the leafiness. Thus, leafiness appears to be an important attribute at the morphological level in the early stage of our breeding program and could help in the improvement of nutritive value of the herbage and straw. Leafness has also been found to be positively correlated with protein content and digestibility.

Table 7.20. Mean and range of protein content (%) Tannins content (%) and 100 seed weight (gr) for 36 elite lines of narbon vetch, at Tel Hadya and Breda

	Tel Hadya			Breda		
	GP (%)	Tannins (%)	100 seed weight (gr)	GP (%)	Tannins (%)	100 Seed weight (gr.)
Mean	29.48	0.307	16.66	32.20	0.339	18.7
SE±	0.28	0.009	0.43	0.21	0.007	0.47
Range	27.9-33.6	0.22-0.39	10.7-20.8	30.0-34.7	0.24-0.4	9.8-23.4

7.10. Forage Legume Pathology

Even though diseases are not presently a major problem on forage legumes in the WANA region, their importance is location-specific and sporadic epidemics can occur under favorable conditions. Screening and selecting for resistance to the main stem and leaf diseases of forage legumes is therefore an important selection criteria for developing productive forage legumes suitable for the dry and marginal areas of the WANA region. The main diseases that have been identified through routine monitoring in the region are: Downy mildew (*Peronospora trifoliorum*), Ascochyta blight (*Ascochyta pisi* f. sp. *lathyri*) and Botrytis grey mold (*Botrytis cinerea*). The forage legume enhancement project continues to identify several promising lines of *Vicia* and *Lathyrus* spp. for yield and adaptation in the region. Their reactions to these major diseases need to be continuously assessed.

The objectives of the forage legume pathology component research in the project are to: 1) Monitor the relative importance of these diseases on selected genotypes in on-farm trials, and through periodic collaborative disease surveys in the region. 2) Evaluate selected genotypes and accessions for resistance to the major diseases under control and natural conditions to obtain information on sources of resistance to individual and multiple diseases from new genetic resources.

7.10.1. Screening for disease resistance

7.10.1.1. Screening of Narbon Vetch Lines for Resistance to Downy Mildew

In continuation of the evaluation of narbon vetch (*Vicia narbonensis*) for resistance to downy mildew started during the 1997/98 season, a set of 36 genotypes were promoted from the 1997/98 microplot yield trials and screened under artificial conditions in field plots in 1998/99. They were planted in two replications in a randomized complete block design in a screening nursery at Tel Hadya. Each genotype was planted in two row plots of 2.5 m length and 0.30 m width. After every five genotypes, a susceptible genotype was planted as a check and spreader row. In order to maximize disease development, infected narbon vetch debris from the previous season was spread in the plots four weeks after planting. Disease severity was assessed after flowering on a 5 point rating scale where 1=highly resistant and 5=highly susceptible.

The weather conditions during the 1998/99 cropping season were not very favorable for downy mildew development at Tel Hadya. Although none of the narbon vetch genotypes screened was immune to the disease, infection levels were generally low with the susceptible check receiving an average rating score of only 3. The average scores of the selections ranged from 1.5 to 3.5 (Table 7.21) summarizes the distribution of the mean rating scores by number of genotypes in each category. A total of 13 genotypes were highly resistant with a rating of 2 or less, while 20 genotypes were moderately resistant with a rating of above 2 but less than 3. Only 3 genotypes showed a clearly susceptible reaction with ratings above 3.

7.10.1.2. Screening of *Lathyrus Sativus* Accessions for Resistance to Ascochyta Blight

One hundred accessions of *Lathyrus sativus* were obtained from the gene bank of GRU to be screened for resistance to Ascochyta blight in field plots. Each accession was planted in two row plots of 2.5 m length and 0.30 m width. After every five accessions, a susceptible genotype was planted as a check and spreader row. The accessions were spray-inoculated with a spore suspension of *Ascochyta pisi* f.sp. *lathyri* just before flowering and monitored for disease development.

Unfavorable weather conditions for disease development resulted in a screening failure of the *Lathyrus sativus* accessions. No disease developed on the accessions even with the artificial spore spray inoculations. This was mainly due to high temperatures and dry conditions that prevailed during the developmental stage of the accessions. Humidity, which is an essential factor for Ascochyta blight development, was very low throughout most of the season to favor infection. Sprinkler source irrigation may need to be considered for future screenings, to ensure that humidity is increased for infection.

7.10.1.3. Evaluation of Narbon Vetch Elite Lines for Resistance to Downy Mildew

Thirty six advanced genotypes selected for adaptation and other agronomic characteristics were planted for yield evaluation in the breeding block. Downy mildew infection scores were taken when environmental conditions were optimal for natural disease occurrence and spread. The disease severity scale used was based on 1-5; where 1=no infection and 5=severe infection. The ratings were based mostly on the percentage of leaf infections.

Significant ($p<0.05$) differences were observed among genotypes in affecting disease severity. Among the genotypes, the following were resistant: IFLVN 2704-98, 2463-98, 2382-98, 2398-98, 2469-98, 2472-98, 2706-98, 2377-98, 2389-98 and 2392-98. The most resistant genotype was IFLVN-2704-98 which had a resistant level comparable only with the local check, 2561-98 Local. This genotype could be used in the crossing block to develop mildew resistant gene pools. The reaction groups and mean number of entries in each are also summarized in (Table 7.21).

Table 7.21. Number of entries of vetches in different disease reaction categories, Tel Hadya, 1998/99 cropping season

	Number of entries in each disease reaction category[1]					
Nursery	1	2	3	4	5	Total
Narbon vetch nursery	0	23	12	1	0	36
Narbon vetch elite lines	3	21	10	2	0	36

[1] 1- 5 rating scale where 1= resistant and 5=susceptible.

7.11. Forage Legume Entomology

Six *Lathyrus ochrus* and 4 *L. cicera* lines were evaluated for resistance to *Sitona* spp. under artificial infestation in the plastichouse and natural infestation in the field. In the plastichouse, the 10 lines were sown (3 seeds of each one) in a circular manner around the edges of pots (15 x 16cm) containing mixture soil (1: 2: 4) (sand: soil: peat moss). The experimental design used was a randomized complete block with 10 replications. Seedlings were infested when they were about 10 cm in height. Prior to infestation, seedlings were thinned to one/accession; each pot was infested with 12 weevils and was covered by a well-aerated plastic cage (15x30cm). Three days after the infestation, the cages were removed and the number of notches in the leaves was counted. In the filed, each accession was planted in a 2 m long row using an RCBD with 4 reps. A 1-9 scale was used to assess leaflet damage around mid-February (1, no damage; 2, 1-10% leaflets damage; 3, 20-11% leaflets damage; 4, 21-30% leaflets damage; 5, 31-40% leaflets damage; 6, 41-50% leaflets damage; 7, 51-70% leaflets damage; 8, 71-90% leaflets damage; 9, more than 90% leaflets damage. Nodule damage was assessed from samples taken at flowering time (mid-April). Five plants were randomly selected from each plot, uprooted with soil to recover most of the root system and then washed in the laboratory. The total number of damaged nodules was counted.

The results showed that all the 6 lines of *L. ochrus* had less leaflet damage and nodule damage than the four accessions of *L. cicera*. The best lines of *L. ochrus* was IFLLO # 549, which had the least visual damage score (1.75) and nodule damage (23.2%) (Table 7.22). Resistance of *L. ochrus* to *Sitona* may be related to its neurotoxin, β -ODAP content in the grain and seedling. To test this hypothesis, several lines of *L. ochrus, L. sativus* & *L. Cicera* with different neurotoxin concentrations will be tested next season for *Sitona* resistance.

Table 7.22. Visual damage score and nodule damage caused by *Sitona* spp. on some *Lathyrus ochrus* and *L. cicera* lines, under artificial infestation in the plastichouse and natural infestation in the field, Tel Hadya, 1999

		In plastic house		In field		
Lathyrus sp.	IFLL #	% of notched		VDS*		%ND**
L .ochrus	537	15.00	b	2.5	bcd	23.50
L .ochrus	540	13.25	b	2.25	cde	28.50
L .ochrus	547	11.00	b	2.50	bcd	24.50
L .ochrus	549	11.00	b	1.75	e	23.25
L .ochrus	550	13.50	b	2ed		32.25
L .ochrus	762	15.50	b	2ed		25.50
L. cicera	88	44.33	a	3.000	a	26.50
L. cicera	487	38.25	a	3.000	a	29.00
L. cicera	488	38.50	a	3.000	a	39.75
L. cicera	489	41.00	a	3.000	a	29.25
LSD		11.85		0.55		12.55

Means followed by same letter are not significantly different *(P<0.05)*.

* Visual damage score based on a 1-9 scale.

** Percentage of nodule damage.

7.12. International Testing Program

The international testing program on feed legumes is an instrument for the diffusion of genetic materials and improved production practices, in the form of international trials, to the national programs in and outside the WANA region. The genetic materials in forage legume trials comprise elite lines with wide or specific adaptation, special morphological or quality traits, and resistance to common biotic and abiotic stresses. Nurseries are only sent on request and often include germplasm specifically developed for a particular region or a national program. A list of trials supplied in the 1999/2000 season is given in (Table 7.23).

The testing program helps in identification of genotypes with specific and wide adaptation and help in targeting breeding efforts for specific agro-ecological conditions.

We supplied 124 sets of 4 different types of trials (Table 7.23) to various cooperating scientists in 21 countries for conduct during the 1999/2000 season.

The main features of the 1997/98 international nursery results received from cooperators are presented here. The stability analyses of the trials were done using Eberhart and Russell (1966) model. The lines mentioned as having a general or specific adaptation showed above average yield performance.

Table 7.23. Distribution of forage legume international trials to cooperators for the 1999/2000 season

International Trial	No. of sets
Lathyrus Adaptation Trial (ILAT)	
- *Lathyrus sativus* (ILAT-LS-00)	38
Vetch Adaptation Trial (IVAT)	
- *Vicia sativa* (IVAT-VS-00)	36
- *Vicia narbonensis* (IVAT-VN-00)	29
- *Vicia ervilia* (IVAT-VE-00)	21
Total	124

Three International *Lathyrus* Adaptation Trials (ILAT) namely, *L. sativus* (ILAT-LS), *L. cicera* (ILAT-LC), and *L. ochrus* (ILAT-LO); and three International Vetch Adaptation Trials (IVAT) namely, *Vicia sativa* (IVAT-VS), *V. narbonensis* (IVAT-VN), and *V. ervilia* (IVAT-VE) were supplied to cooperators during 1997/98. In each of these trials there were 15 test entries and one local check. The results of these trials are discussed as below.

The ILAT-LS were distributed to 49 locations in 19 countries but field data were received from 15 locations of 5 countries. The mean seed yield of entries across locations varied between 812 and 1372 kg/ha with an average of 1144 kg/ha. The lowest location mean (438 kg/ha) was recorded in Sanandaj (Iran) and the highest (2974 kg/ha) in Tolentino (Italy). The five best entries across all locations were in the order #564, #555, #565, #559 and #560. The deviations from regression were very high. The mean biological yield of *L. sativus* selections across locations varied between 2984 and 5148 kg/ha with an average of 3995 kg/ha. The lowest location mean (1045 kg/ha) was recorded in Sanandaj (Iran) and the highest (7870 kg/ha) in Mushagar (Jordan). The five best entries across all locations were #555, #564, #463, #535 and #560. The deviations from regression were very high.

The ILAT-LC were distributed to 32 locations in 14 countries but field data were received from only 6 locations in 2 countries. The mean seed yield of entries across locations ranged between 602 and 810 kg/ha with an overall mean of 707 kg/ha. However, this differences were statistically not significant. The lowest location mean (235 kg/ha) was recorded in Ardabil (Iran) and the highest (1479 kg/ha) in Gachsaran (Iran). The variance due to genotype x environmental interaction was not significant. The biological yield of *L. cicera* selections across locations varied between 2137 and 2584 kg/ha with an average of 2388 kg/ha. However, the observed differences were statistically not significant. The lowest location mean (938 kg/ha) was recorded in Ardabil (Iran) and the highest (5970 kg/ha) in Caracal (Romania).

The selections #500 and #574 showed general adaptation. The selection #575 was particularly adapted to favorable environments, whilst #501 to poor environments.

The ILAT-LO were distributed to 25 locations in 11 countries but field data were reported from 2 locations in 2 countries. The mean seed yield of entries across locations ranged between 350 and 650 kg/ha with an overall mean of 534 kg/ha. The five best entries across all locations were in the order #551, #542, #104, #386 and #385. The biological yield of *L. ochrus* selections varied between 2562 and 3443 kg/ha with an average of 2929 kg/ha. The five best entries across all locations were #551, #385, #540, #104 and #547.

The results of IVAT-VS, IVAT-VN, IVAT-VE and IVAT-VD were reported from 13, 7, 7, and 11 locations, respectively.

The IVAT-VS were distributed to 58 locations in 23 countries but field data were reported from 13 locations in 5 countries. The mean seed yield of entries across locations ranged between 369 to 621 kg/ha with an average of 492 kg/ha. The lowest location mean (123 kg/ha) was recorded in Sanandaj (Iran) and the highest (1513 kg/ha) in Mushagar (Jordan). The five best entries across all locations were in the order #2496, #2505, #2742, #2556 and #2624. The selection #2560 showed general adaptation. The selection #2624 was the best adapted to high yielding environments.

The biological yield of *V. sativa* selections across locations varied between 1711 and 2531 kg/ha with an average of 2012 kg/ha. The lowest location mean (382 kg/ha) was recorded in Sanandaj (Iran) and the highest (6778 kg/ha) in Mushagar (Jordan). The five best entries across all locations were #2640, #2556, #2639, #2496 and #2560. The selection #2496 showed the best adaptation to high yielding environments.

The IVAT-VN were distributed to 44 locations in 21 countries but field data were reported from seven environments in three countries. The mean seed yield of entries across locations varied between 557 and 711 kg/ha with an average of 641 kg/ha. However, the observed seed yield differences were statistically not significant. The lowest location mean (191 kg/ha) was recorded in Sanandaj (Iran) and the highest (1412 kg/ha) in Gachsaran (Iran). The selection #2384 showed general adaptation. The selection #2388 was the best adapted to high yielding environments. The biological yield of *V. narbonensis* selections across locations varied between 2328 and 2949 kg/ha with an average mean of 2600 kg/ha. However, the observed biological yield differences were statistically not significant. The lowest location mean (572 kg/ha) was recorded in Sanandaj (Iran) and the highest (6147 kg/ha) in Caracal (Romania). Selections #2382 and #2461 showed general adaptation. Selection #2388 showed the best adaptation to high yielding environments.

The IVAT-VE were distributed to 35 locations in 14 countries but field data were reported from seven environments in three countries. The mean seed yield of entries across locations varied between 692 and 855 kg/ha with an average seed yield of 757 kg/ha. However, the observed seed yield differences were statistically not significant. The lowest location mean (426 kg/ha) was recorded in Maragheh (Iran) and the highest (1364 kg/ha) in Gachsaran (Iran). The selection #2646 showed general adaptation. The selection #2516 showed specifically adaptation to high yielding environments. The biological yield of *V. ervilia* selections across locations varied between 1639 and 2235 kg/ha with an average of 1874 kg/ha. However, the observed differences were statistically not significant. The lowest location mean (882 kg/ha) was recorded in Shirvan (Iran) and the highest (3594 kg/ha) in Rabba (Jordan). The selection #2511 showed general adaptation. The selections #2510 and #2516 were the best adapted to high yielding environments, whereas selection #2646 was the best adapted to low yielding environments.

The IVAT-VD were distributed to 41 locations in 16 countries but field data were reported from 11 environments in five countries. The mean seed yield of entries across locations varied between 539 and 690 kg/ha with average seed yield of 625 kg/ha. The observed seed yield differences were statistically not significant. The lowest location mean (177 kg/ha) was recorded in Sanandaj (Iran) and the highest (1148 kg/ha) in Rodat (Qatar). The variance due to genotype X environmental interaction was not significant. The biological yield of *V. dasycarpa* selections across locations varied between 3179 and 3974 kg/ha with an average of 3605 kg/ha. However, the observed differences were statistically not significant. The lowest location mean (673 kg/ha) was recorded in Sanandaj (Iran) and the highest (10570 kg/ha) in Rodat (Qatar). The selection #2457 showed general adaptation. The selections #2440 and #2445 were the best adapted to high yielding environments. Forage legume cultivars released by national programs (NARS) in collaboration with ICARDA are shown in (Table 7.24).

Table 7.24. Forage legume cultivars released by national programs (NARS) in collaboration with ICARDA

Country	Year	Name	Parentage	Special features
Australia	1998	(*Lathyrus cicera*) Chalus	IFLLC-1279	High yield, low neurotoxin β -ODAP
Cyprus	1998	(*V. narbonensis*) 568	IFLVN-568	Drylands
Jordan	1994	(*L. ochrus*) IFLLO-185	IFLLO-185	High yield and resistant to Orobanche
Jordan	1994	(*V. villosa ssp. dasycarpa*) IFLVD 683	IFLVD-683	Tolerant to Orobanche and high biomass
Jordan	1994	(*V. sativa*) IFLVS-715	IFLVS-715	High yield and resistant to Orobanche
Lebanon	1997	(*L. cicera*) Jaboulah	IFLLC-492	High yield, drought tolerant
Lebanon	1997	(*V. ervillia*) Amara	IFLVE-2520	High yield and cold tolerant
Lebanon	1997	(*V. sativa*) Baraka	IFLVS-715	High yield, cold tolerant and non-shattering
Morocco	1990	(*V. sativa*) ILFVS-1812	ILFVS-1812	High yield, erect, tolerance to Orobanche and early
Morocco	1992	(*V. villosa ssp. dasycarpa*) IVLVD-2053	IVLVD-2053	High yield, cold tolerant and resistant to Orobanche
Morocco	1994	(*V. narbonensis*) IFLVN-2387	IFLVN-2387	High yield and early maturing
Morocco	1994	(*V. narbonensis*) IFLVN-2391	IFLVN-2391	High yield and early maturing
Morocco	1994	(*V. sativa*) IFLVS-709	IFLVS-709	High yield and non-shattering
Pakistan	1997	(*V. villosa ssp. dasycarpa*) Kuhak-96	IFLVD-683	High yield and cold tolerant

7.13. Use of Forage Legume by NARS

The Mashreq Countries, Iraq, Jordan, Lebanon and Syria have an extensive work on farmer's fields to demonstrate the potential of forage legumes, as the best option in rotation with barley and durum wheat in the fallow-cereal rotation or continuous barley rotation.

Increasing feed production could be achieved through the promotion of rotations that include alternative feed legumes such as vetchs and chicklings, for different utilization (direct grazing, hay making, grain & strow).Results from Iraq, Jordan and Syria showed an average daily life weight grains of lambs grazing *Vicia sativa* Var. Baraka of 185 grams without supplementary feeding. Results from Iraq showed an average increase in milk production from ewes grazing common vetch variety Baraka (IFLVS # 715) of 175 gm/ewe/day. In Lebanon, the released variety *Lathyrus cicera* (Jaboula) is widely grown in El-Kasr where rainfall is below 200mm. Using common vetch in cereal-vetch rotation continues to be better than a monoculture cereal or cereal-fallow rotation and enhanced the integration between crop and livestock production.

At Deir-Tanaeil, Lebanon, *Vicia narbonensis* # 67 produced 1770 kg/ha grain and 6700 kg/ha straw and significantly increased milk production from lactating cows.

In Saudi Arabia, at experimental station of King Saud University at Deirab (24-42 N^{c}-44-46 E^{0}) near Ryadh, seventeen lines of *Vicia sativa* and six lines of *Vicia narbonensis* supplied from ICARDA were tested. The best two lines of *Vicia sativa* were IFLVS # 2019 and 715 (Baraka) whereas, the best lines of *V. narbonensis* were IFLVN # 2380 and 2383. They are adapted to the central region of Saudi Arabia.

In Griz Alta, Brazil, improved lines of *Vicia sativa*, *V. dasycarpa* and *V. ervilia* were tested and adapted lines were selected from materials supplied by ICARDA. The most promising adapted lines were IFLVS # 370, 371, 1895 and 3625, IFLVD #839, 3684, 4139 and IFLVE 589, 225 and 199.

In Cyprus after 5 years of testing breeding lines of *Vicia narbonensis* (narbon vetch), the national program released IFLVN # 568 (named Velox) as a variety for cultivation in dry areas as a livestock feed.

In Turkey, an extensive program for developing feed legumes for highlands of Turkey is conducted in collaboration with ICARDA. *Vicia panonica*, *V. sativa*, *V. villisa* spp. *dasycarpa*, and *Lathyrus sativus*, *L. cicera* and

L. ochrus were tested. Selection has been made for improved cold tolerance hungarian vetch at Haymana and Ulas locations. Underground vetch (*Vicis amphicarpa*) improved lines and used in rotation of marginal non-arable lands at Polatli.

The growing season of 1998/99 was the first testing season for testing forage vetches and chicklings in Central Asia and Coucasus Countries (CAC).

In Kazakhstan, 16 lines of common vetch and 13 lines of grasspea were tested at Almalybak v. Karasay district, Almaty, region. The grain yield of common vetch lines varied from 1.4 to 2.0 t/ha, and highly adapted lines were selected for further tests and seed multiplication for distribution to farmers. *Lathyrus sativus* showed more adaptation and higher yields. Grain yield up to 3.6t/ha was obtained and selection was made for the most adapted lines for seed multiplication and on farm trials tests.

In Armenia, common vetch and grasspea lines were tested at Armavir Province (Ararat Plain), herbage yield varied from 1.12 to 2.02t/ha, whereas, grain yield from 0.51 to 1.3t/ha. Selection was made for adapted lines for further tests and seed multiplication.

7.14. Evaluation of Annual Forage Legumes Introduced from ICARDA Under Alpine Grassland Conditions in China

Alpine grassland occupied about one third of total grassland areas in China. One of the limiting factors of grassland livestock production in the region is shortage of forage legumes for improving grazing land and for supplementary feedings due to harsh environments. Therefore, a project entitled "Evaluation and selection of forage legumes for alpine grasslands" begun in 1997 with support of Gansu provincial government.

Ten lines each of five annual forage legume species were provided by ICARDA, in 1997. The species included *Vicia sativa*, *V. villosa*, *V. narbonensis*, *Lathyrus sativa* and *L.cicer*. The experimental site is located at Xiahe county, Gansu province, China, which is typical alpine grassland, 250 km south-east of Lanzhou city. The elevation at the experimental site is 3000 m asl, the annual rainfall is varied from 350 to 450 mm and the mean annual temperature is from 3.5 to 4.0 °C.

The experiment was a randomised complete block design with 3 replicates. Blocks were 50 cm apart and each was divided into 1x2 m plots spaced 50 cm apart. Each plot was further divided into 5 rows with 20 cm distance and seeds were then sown. All of 50 lines were tested in 1998, while only the varieties produced seeds were tested again in 1999. The trials were conducted during the period mid May to end of September each year. Plots were hand weeded as necessary.

Herbage yields: Results obtained in 1998 indicated that *V. villosa* produced the highest herbage yield which was followed by *L. cicer*, whereas *V. narbonensis* had the lowest herbage production among the five tested species. The mean herbage yield (DM kg/ha) for was 9881 for *V. villosa*, 7417 for *L. cicer*, 6470 for *V. sativa*, 5685 for *L. sativa*, and 3623 for *V. narbonensis*.

Seed yields: All lines of *V. villosa* tested did not produce any seed under the experimental conditions. Sixteen lines from the other 4 species produced seeds. Among them 9 were *V. sativa*, 4 were *V. narbonensis*, 2 were *L. cicer* and 1 was *L.sativa*. Those 16 varieties were tested again in 1999. The results indicated that all of 9 lines of *V. sativa* grew well under the experimental conditions, the mean seed yield was 1040 kg/ha with the range of 892 to 1392 kg. *V. narbonensis*, in average, produced 1075 kg seeds/ha which was slightly higher than that of *V. sativa*. However, seed yields varied considerably among the 4 varieties tested with the highest yield of 1341.0 kg and the lowest one of 342.0 kg. Seed yield of 2 *L. cicer* varieties was 807.0 and 762.0 kg/ha, respectively. The only line of *L. sativa* tested grew poorly and produced as little as 10.0 kg seed/ha.

Based on the two year's results varieties of *V. narbonensis*, *V. sativa* and *L. cicer* showed great potential of herbage and seed production under the alpine grassland conditions in China.

(Nan Zib, China & Ali Abd El Moneim)

7.15. Project Staff and Collaborators

7.15.1. Project Staff

Dr. Ali Abd El Moneim	Research Project Manager (Breeder)
Dr. Chris Akem	Pathologist
Dr. Mustapha El Bouhssini	Entomologist
Dr. Michael Baum	Biotechnologist
Dr. Bruno Ocampo	International Nurseries
Mr. George Zakko	Research Assistant
Mr. Hani Nakkoul	Research Assistant (Quality)
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7.15.2. Natural Resources Management Contributing Staff

Dr. John Ryan	Soil Fertility Specialist
Dr. Michael Zöbisch	Soil Conservation and Land Management Specialist
Dr. Mustapha Bounejmate	Feed Legumes Production
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8. INTEGRATED PEST MANAGEMENT IN CEREAL AND LEGUME-BASED CROPPING SYSTEMS IN DRY AREAS

Executive Summary

Surveys in CWANA indicated that diseases represent a major threat to cereal production in Uzbekistan (yellow rust), Kyrgyzistan (tan spot), Kazakhstan (Septoria) and Eritrea (Nile Valley)(leaf rust). Insect pests survey in Uzbekistan, Kyrgyzstan and Kazakhstan showed that cereal leaf beetle and sunn pest are important pests of wheat and barley. A preliminary survey of legume viruses was initiated in Iraq and Iran, and a more extensive survey is planned for 2000.

Virulence of the yellow rust pathogen was studied in a number of countries. Virulence on Yr_1 and Yr_3 was observed only in Tajikistan. Virulence on YrSD and YrSU was observed only in Syria. Virulence on Yr_{15}, Yr_{3N}, Yr_{sp} and Yr_{17} was observed only in Lebanon. No virulence on Yr_{15}, Yr_{3N}, , Yr_{sp}, and Yr_4 was detected in CWANA. The gene combination "MIa9, MIak" conferred resistance against all wheat powdery mildew isolates tested from Morocco, Tunisia and Syria.

Components for the integrated management for lentil broomrape, lentil vascular wilt and chikpea ascochyta blight were identified. IPM options for these pests will be evaluated in collaboration with NARS partners during 2000.

New sources of resistance to faba bean necrotic yellows virus (FBNYV) and bean leaf roll virus (BLRV) were identified in faba bean germplasm. Lentil genotypes with combined resistance to FBNYV and BLRV were also identified. A quantitative glasshouse assay to predict BYDV resistance in bread wheat was found to be promising.

Water extract from *Melia azedarach* dry fruits (15g/1) reduced significantly *Sitona* adult feeding on lentil plants. An integrated pest management package comprising winter-sown plating date, a moderately resistant cultivar (Ghab 3) and neem oil reduced chickpea leafminer damage and at the same time conserved natural enemies, as there was little effect on parasitoids. Bioassays conducted at ICARDA showed that four isolates of *Beauveria bassiana* and one isolate of *Paecilomyces farinosus* gave a high mortality (>95%) on Sunn pest adults. These promising isolates will be tested further next season by spraying plants and litter with fungal suspensions from these five isolates. Thirty-

five additional entomopathogenic fungi were collected from Uzbekistan.

8.1. Pest Surveys

8.1.1. Cereal Diseases Survey in Syria

8.1.1.1. Incidence of Foliar Diseases

Two field surveys were conducted in the major cereal growing areas in two agroecological zones in northern Syria. In Aleppo district, 15 fields were surveyed. Low incidence levels of powdery mildew, scald, net blotch, and loose smut were observed on barley. There was no foliar disease development on wheat. In Idleb, 14 fields were assessed for disease incidence. Low incidence levels of powdery mildew, scald, and net blotch were observed on barley, and sporadic incidence of septoria on wheat was observed in Al Ghab area. The continuous drought during the crop season hindered disease development in the region surveyed.

8.1.1.2. Incidence of Root Diseases

Assessment of root rot diseases was also carried out based on culturing in the laboratory of random samples collected from wheat and barley fields in Aleppo and Idleb. Isolation results showed that *Cochliobolus sativus* and *Fusarium* sp. were frequently isolated from crown and sub-crown internodes of randomly collected durum wheat and barley samples. (Figure 8.1) shows the incidence level of root pathogens recorded in Aleppo and Idleb. Incidence due to *Cochliobolus sativus* was 50% and that of *Fusarium* sp. 60%. In Idleb district, root rot incidence on barley was relatively higher than on durum wheat. It was 83 and 64% in Aleppo and Idleb surveyed fields respectively, (Figure 8.2). Root rot incidence on barley was relatively high in Aleppo district (Figure 8.3). Preliminary assessment showed that the pathogenic fungi associated with the root rot complex were mostly species of *Fusarium* and *Helminthosporium* genera.

(A. Yahyaoui, Z. Alamdar, M. Naimi, R. El-Naeb)

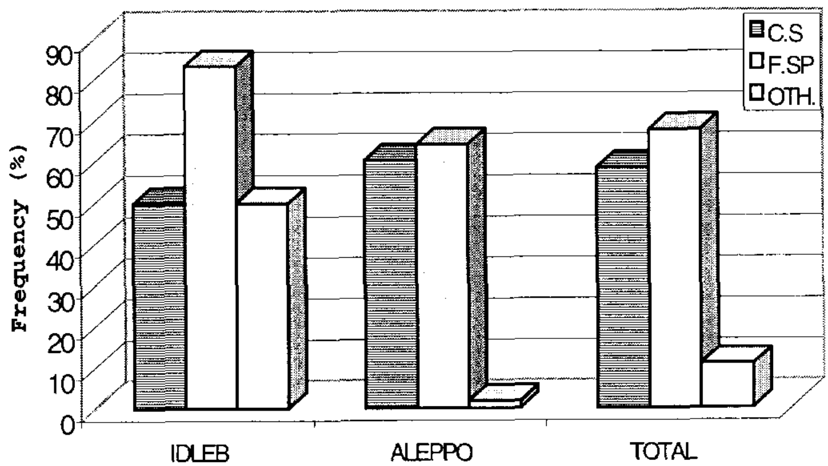

Figure 8.1. Incidence of root rot pathogens in Aleppo and Idleb regions

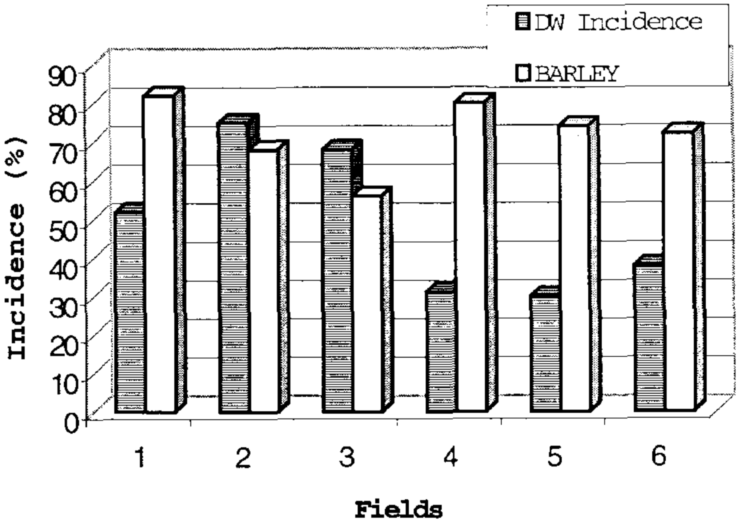

Figure 8.2. Root rot incidence on barley and durum wheat in Idleb

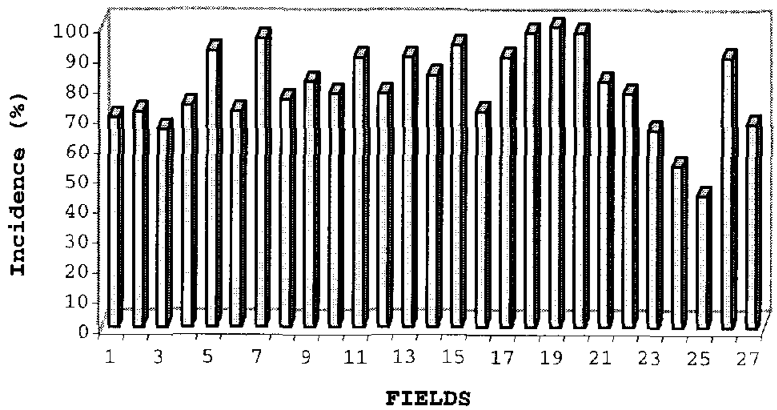

Figure 8.3. Root rot incidence on barley in Aleppo district

8.1.2. Cereal Disease Surveys in CAC

Disease surveys conducted in Uzbekistan, Kyrgyzstan, and Kazakhstan covered 65 farmer fields under both rainfed and irrigated conditions in different cereal growing areas. In each country, farmer fields surveyed were 30 to 50 km apart. The major cereal experimental stations were also visited and relevant breeding nurseries were evaluated for disease resistance. In Uzbekistan 15 farmer fields were evaluated and four experimental stations were visited. In Kyrgyzstan, 26 farmer fields were surveyed and three experimental stations were visited. In Kazakhstan, 28 farmer fields were surveyed and five major experimental stations were visited.

8.1.2.1. Disease Survey in Uzbekistan

Leaf rust, Septoria, tan spot, and powdery mildew in addition to yellow rust were observed in some fields. In most cereal growing area, epidemic levels were reached and yield losses are expected particularly in late-planted fields. Most yellow rust damage was recorded at Tashkent and Sardarya regions. Hangaron and Namangan regions (Table 8.1) were the least affected cereal areas. The epidemic level of yellow rust recored in Uzbekistan can be attributed to prevelance of climatic conditions that were conducive to yellow rust development and to the fact that over 60% of cereal growing area was planted to the susceptible variety "Yuna". At the experiment station, different levels of disease resistnace were recorded. Among the breeding material evaluated, advanced lines in the facultative winter wheat nurseries showed high level of resistance to yellow rust. New varieties such as Ulugved, Stepa, Polovchanka can progressively replace the variety Yuna. In Uzbekistan, yellow rust presents a clear danger to winter wheat production and sustainability. Common diseases observed on winter barley in most of the area surveyed were powdery mildew and scald. High incidence of net blotch was recorded in Samarkand and Andijon regions. Loose and covered smuts were also common but at a lower incidence level.

(A. Yahyaoui, M. El Bouhssini, and Z. Khalikulov)

Table 8.1. Yellow rust incidence and severity in seven cereal growing areas in Uzbekistan

Region	Incidence	Severity	Expected yield loss (%)*
Tashkent	100	60 S	20-30 %
Sardarya	100	70 S	10-40 %
Dzhizak	100	60 S	15-25 %
Samarkand	100	40 S	10-20 %
Hangaron	100	40 S	10-15 %
Namangan	30	20 S	00-05 %
Andijon	100	20 S	05-10 %

* (Expected yield loss based on growth stage of the crop would be lower range for varieties at hard dough growth stage and higher range of yield loss would be for varieties at soft dough stage)

8.1.2.2. Disease Survey in Kyrgyzstan

The cereal growing area surveyed in Kyrgyzstan was relatively limited (853 km) and covered mostly the area between Tashkent and Bishkek, and the area around Bishkek. At the experimental stations, yellow rust, leaf rust, powdery mildew, tan spot, and *Septoria nodorum* were present on winter wheat. Net blotch, scald, powdery mildew and loose smut were observed on barley. Good screening for rusts, tan spot, powdery mildew, and scald can be conducted at the "JAL" experimental station. Farmers wheat fields surveyed showed constant high incidence of tan spot and possibly *Septoria nodorum*, but different infection levels of yellow rust, leaf rust, and loose smut. High incidence of Fusarium head blight was observed on durum wheat at the Kyrgyzstan Experimental Station in Sokuluk region. Incidence levels of Helminthosporium diseases on winter wheat were relatively high particularly on the variety Intensivnya that occupies over 4% of the cereal growing area. Powdery mildew was also present at different levels of infection in almost all wheat areas. Scald and powdery mildew were relatively high on winter barley and severe incidence of net blotch were observed on spring barley and is expected to reach epidemic levels if favorable weather conditions prevail.

(A. Yahyaoui, M. El Bouhssini, M. Djunusova, and V. Isaeva)

8.1.2.3. Disease Survey in Kazakhstan

Cereal fields surveyed in kazakhistan are grown under rainfed conditions with prevalence of spring barley north of Kyrgistan border. Most common barley diseases observed were scald and net blotch on winter and spring barley, respectively. Powdery mildew and barley stripe were also widely distributed. Prevalent wheat diseases were tan spot, *Septoria nodorum*, powdery mildew, yellow rust and leaf rust (higher incidence). In the area around Almaty, incidence of *Septoria nodorum* ranged from 30 to 100%. Incidence of tan spot was higher in the area near mountain range. Low incidence traces of yellow rust was observed. In the region between Almaty and Taldykorgan that used to be a large wheat growing and is actually exclusively a range area, sporadic fields of winter wheat and spring barley were encountered almost 100 km apart. No major disease incidence was observed in this region and at the Taldykorgan branch Institute of Agriculture. However, at Kapal (40 km northeast Taldykorgan), incidence of root rots on spring barley exceeded 40% in two large fields, net blotch was also observed but at a lower incidence level.

(A. Yahyaoui, M. El Bouhssini)

8.1.2.4. Disease Assessment in Eritrea

In Eritrea, wheat and barley development during this crop season was less than optimal due to the delay and insufficient rainfall. Cereals were stressed at early growth stages, hence poor stand was observed in farmers' fields and at the experimental station. The late rains associated with relatively high temperatures favored foliar disease development at the main station as well as in farmers' fields. High level of leaf rust (*Puccinia recondita*) incidence on wheat was observed. On barley, scald (*Rhyncosporium secalis*) and Helminthosporium diseases were well developed particularly barley net blotch (net and spot forms) caused by *Pyrenophora teres*. Incidence of bacterial disease and septoria was observed on barley, at Halhale and Embalerho, respectively. At Halhale, local barley land race population showed more tolerance to the spot form than to the net form of *Pyrenophora teres*, and high level of sensibility to spot blotch caused by *Bipolaris sorakiniana*. The symptoms of these diseases are relatively difficult to recognize. The development of the spot blotch disease is usually favored by warm wet conditions. High bacterial infections were recorded in some fields. The bacterial disease observed was caused by bacteria stripe *Xanthomonas transluscens*.

(A. Yahyaoui and Y. Tewelde)

8.1.3. Survey of Viruses Affecting Forage Crops in Syria

A survey was conducted, in collaboration with the University of Aleppo during April-May, 1999, in different governorates in Syria to identify viruses which affect different forage species (*Medicago* sp., *Triforlium* sp., *Lathyrus sp.*, *Pisum* sp., *Vicia* sp.). Both, symptomatic and random samples were collected form all the fields surveyed. The most commonly encountered viruses were pea enation mosaic virus, broad bean mottle virus, pea seed-borne mosaic virus, alfalfa mosaic virus and cucumber mosaic virus. The overall virus incidence, estimated from testing the randomly collected samples, was 17%. The total virus incidence range among the forage species surveyed was from 7.5% (*Vicia ervilia*) to 44% (*Lathyrus*. sp). Around 75% of the samples were infected with a single virus and 25% had a mixed infection. Most of the above detected viruses are seed-borne in one or more forage legume species, suggesting that seed quality could be an important factor in forage production in Syria. This, however, requires further investigation.

(K.M. Makkouk, N. Attar (ICARDA) and A. Haj Kasem (Aleppo University))

8.1.4. Preliminary Survey for Chickpea Viruses in Iran

A preliminary survey to identify virus diseases affecting chickpea in Iran was conducted during June, 1999. The survey covered five chickpea fields; three at 20 km south of Shiraz and two at 60 km north of Shiraz. A total of 106 samples, with symptoms suggestive of virus infection, were collected and tested for the presence of any of seven viruses. The results obtained indicated that three viruses, namely, chickpea chlorotic dwarf virus (CCDV), bean leaf roll virus (BLRV) and beet western yellows virus (BWYV) were the most commonly encountered (Table 8.2). This could be the first record of CCDV in Iran. Based on the results of this limited survey, a more extensive survey for legume viruses in Iran is planned for 2000.

(K.M. Makkouk)

8.1.5. Preliminary Survey for Legume Viruses in Iraq

A limited survey of legume viruses, at two locations in northern Iraq, was conducted during May, 1999. Chickpea chlorotic dwarf virus was the most commonly encountered virus, followed by beet western yellows virus and pea enation mosaic virus (Table 8.3). Faba bean necrotic yellows virus was also detected in chickpea and lentil, but at a lower incidence. Since northern Iraq was hit with a very severe drought during 1998/1999 growing season, most legume fields during the survey showed an extremely poor growth. Accordingly, a more extensive survey for legume viruses in Iraq is planned for 2000.

(K.M. Makkouk)

Table 8.2. Results of serological testing of chickpea samples collected during June 1999 from Fares province in Iran, for the presence of viruses using the tissue-blot immunoassay (TBIA)

Location	No. of samples tested	No. of samples reacted positively with antisera *					
		AMV	CMV	CCDV	BWYV	BLRV	Unidentified luteovirus
20 km south of Shiraz							
Field 1	34	2	0	12	0	1	0
Field 2	14	0	1	2	0	0	1
Field 3	11	0	0	1	5	6	1
60 km north of Shiraz							
Field 1	27	0	0	1	1	5	5
Field 2	20	0	0	0	0	0	1
Total	106	2	1	16	6	12	9

- All viruses were negative to antisera for FBNYV

AMV=	Alfalfa mosaic virus	BWYV =	Beet western yellows virus
CMV=	Cucumber mosaic virus	CCDV =	Chickpea chlorotic dwarf virus
BLRV=	Bean leaf roll virus	FBNYV =	Faba bean necrotic yellows virus

Table 8.3. Identification of viruses affecting legume crops at two locations in northern Iraq during May 1999

Location Crop	No. of samples tested	No. of samples reacted positively with antisera						
		PEMV	FBNYV	CCDV	BWYV	SbDV	BLRV	General Luteovirus
Rabiaa Res. Sta.								
Chickpea	32	NT	2	10	10	1	0	1
Lentil	16	10	2	2	0	0	1	0
Pea	7	NT	0	3	2	0	2	0
Batnaya (Mosul)								
Chickpea	14	NT	0	4	1	0	0	0
Lentil	2	0	0	0	0	0	0	0
Total	71	10	4	19	13	1	3	1

* NT=Not tested
PEMV=Pea enation mosaic virus; FBNYV=Faba bean necrotic yellows nanovirus; CCDV=Chickpea chlorotic dwarf virus; BWYV=Beet western yellows virus; SbDV=Soybean dwarf virus; BLRV=Bean leaf roll virus; General luteovirus=Based on the reaction with 5G4 monoclonal antibody, which react positively with most legume luteoviruses.

8.1.6. Survey of Cereal Insects in Central Asia

Survey of cereal insects was carried out in Uzbekistan, Kyrgyzstan and Kazakhistan between 24 May and 18 June, 1999. A total of 69 farmer fields (15 in Uzbekistan, 26 in

Kyrgyzstan, and 28 in Kazakhstan) in different growing areas under rainfed and irrigated conditions were sampled. In each country, farmer fields surveyed were 30 to 50 km apart.

In Uzbekistan two insect pests (Sunn pest (SP) and cereal leaf beetle (CLB)) seem to be important and would require some attention. SP was found in Tashkent, Serdaria, Gizak, Samarkand and Ahangaran regions. On average, Sunn pest population was about 1 adult/5 m^2 and/or 1 nymph/1 m^2. Even though this level of infestation is low, it does show the potential of Sunn pest becoming an economical pest, taking into consideration that the wheat is almost a new crop in the country. CLB was found in all the regions surveyed. However, high infestation levels were recorded in Gizak, Galaral and Andijan regions. The level of infestation varied from 20-40% on both barley and wheat. Russian Wheat aphid (RWA) was also found, but at very low incidence level. The highest infestation level recoded for this aphid was 10% in Ertson, a high elevation area in Angerin district.

In Kyrgyzstan, SP and CLB were present in all the fields surveyed. However, the infestation levels varied among regions. The percent spikes damaged by SP ranged from 5-30%; the highest level of damage was observed in the plains bordered by mountains. Both *Eurygaster* spp. and *Aelia* spp. were found in the country. In the area surveyed, the level of damage caused by CLB was low and varied between 5-20%. However, a very high infestation level was observed in the "Jal" Research Station. RWA was found mostly on spring-sown barley and the infestation level was about 10%. On some spring-sown wheat fields, there was a quite high level of Hessian fly (HF) infestation (30%).

In Kazakhstan, aphids seem to be important insect pests of wheat in the south between Athamekan and Taras as about 20-50% of the spikes had high number of aphids. A similar level of infestation was also observed in Taldykorgan region in the East. SP was found from Taras to the border of Kyrgyzstan. The damage on spikes caused by this pest was around 10-15%, and the population density was about 1 adult/10 m^2. SP was also present in the other areas surveyed (South and South-East) and its damage was higher (30%) in the plains bordered by mountains, as it was the case in the other countries. The damage caused by CLB ranged from 10-100%. The highest level of damage was observed at the experimental station of the Institute of Agricultural Research for Science and Marketing. Spring barley breeding material was sprayed with protectant insecticides in order to be saved. Severe damage was also observed on oat. RWA was also found on spring barley. The level of infestation in some fields was about 25% at the tillering stage. This level of damage could increase at a later stage. It would be very useful to conduct a survey on spring barley around the end of June in order to assess RWA damage.

(M. El Bouhssini (ICARDA), Z. Pulatov (Plant Protection Research Institute, Teshkent), M. Djunusova (Scientific Research Institute of Agriculture, Kyrgyzstan) and A. Yahyaoui (ICARDA))

8.2. Studies on Pest Biology and Variability

8.2.1. *Phoma* and *Ascochyta* spp. Interactions

During the 1998/99 cropping season, an experiment was initiated under controlled plastic house conditions to understand the interactions of *Phoma* and *Ascochyta* pathogens in disease symptom development and spread. This was necessitated by the likelihood that this interaction does occur in nature and may be responsible for blight epidemics in some fields in the region. This hypothesis was based on the frequency of isolation of both pathogens from blighted plants in previous epidemic years.

The experiment was carried out to determine the disease reactions on a set of chickpea cultivars inoculated with single and different pathogen combinations. The following 5 treatments were evaluated and compared: Inoculations with *Aschochyta rabiei* only, *Phoma* sp. only, *Ascochyta* and *Phoma* mixture, *Ascochyta* then followed by *Phoma* 7 days later, *Phoma* then followed by *Ascochyta* 7 days later. Four chickpea cultivars (Ghab 1, Ghab 3, FLIP 94-90 and S 95345) were gown in plastic pots. The experiment was a split plot design in 3 replications with inoculation treatments as main plots and cultivars as sub-plots,. At 6 weeks old, plants were spray-inoculated with a spore suspension of the pathogen or pathogen combination. Following each inoculation, pots were covered with polyethylene sheets for 48 hrs to stimulate infection. The challenge inoculated treatments were done 5 days after removing the covers when infection symptoms could be observed. All plants were rated for disease severity on a 1-9 scale both at flowering and podding growth stages.

Maximum disease severity for all the cultivars was recorded in the treatment where *A. rabiei* was first inoculated and then challenged with *Phoma*, while the least was with *Phoma* alone or *Phoma* challenged with *A. rabiei* (Table 8.4). There was thus an apparent synergistic reaction when *Ascochyta* inoculations were followed by *Phoma*. When the order was reversed, where *Phoma* was inoculated first then followed by *Ascochyta*, there was apparently some cross-protection, resulted in low disease severity. This protection was apparent for all cultivars except the most susceptible one in the last rating (Table 8.4). The disease severties from spraying suspension mixtures were comparable to those sprayed with *Ascochyta* followed by *Phoma*. From this study, it is clear that when these 2 related pathogens occur together, their interactions can accelerate the development of blight epidemics. This also depends on which of the pathogens infects first. The mechanism of these interactions needs to be further investigated.

(C. Akem and S. Kabbabeh)

Table 8.4. Possible interactions between *Ascochyta rabiei* and *Phoma* spp in blight severity

	Disease symptom severity (1-9)* at flower iniation				
Treatment	Ghab 1	Ghab 3	F 94-90	S 95345	ILC 1929
Phoma only	2.0	1.7	2.3	2.3	2.7
Ascochyta only	4.7	4.0	4.0	5.3	7.7
Phoma/Ascochyta mixture	5.3	5.0	5.3	5.7	7.3
Phoma then *Ascochyta*	3.0	2.7	2.7	2.3	2.7
Ascochyta then *Phoma*	6.3	6.0	6.7	5.0	7.7
Mean	4.3	3.9	4.2	4.1	5.6
LSD (0.05)	1.6	2.2	1.2	2.2	1.4
SE	0.7	0.9	0.5	0.6	0.4
	Disease symptom severity (1-9)* at pod initiation				
Phoma only	2.3	2.3	4.3	3.3	2.7
Ascochyta only	6.0	5.3	6.7	6.0	8.0
Phoma/Ascochyta mixture	7.0	6.7	6.3	7.0	8.7
Phoma then *Ascochyta*	5.3	3.7	3.7	4.0	8.0
Ascochyta then *Phoma*	7.3	7.0	7.3	6.7	8.7
Mean	5.6	5.0	5.7	5.4	7.2
LSD (0.05)	1.6	1.3	1.9	1.8	1.5
SE	0.7	0.5	0.8	0.8	0.6

* On a scale of 1-9 where 1=no infection and 9=severe infection resulting in death of plants.

8.2.2. Reaction of Lentil Cultivars to Different Isolates of *Sclerotinia sclerotiorum*.

The frequent observations of Sclerotinia stem blight on lentil in field trials in the region and on-going research to identify sources of resistance to the causal organism necessitated this interaction study involving a number of isolates collected from different locations in Syria. The main aim of the study was to establish whether resistance among different cultivars is the same to different isolates. This is useful for deciding whether resistance identification should be focused on location specific isolates or a broad range of isolates.

Four out of 10 isolates of *Sclerotinia sclerotiorum* collected from different locations in Syria were characterized in the lab. and used to determine the differential reactions on a set of lentil genotypes based on growth and sporulation.

Intact stems of lentil grown in greenhouse pots and detached stems in trays were inoculated with actively growing mycelia of each isolate. The rates of lesion expansion on the genotypes were compared.

Isolate number 36, collected from Research station Hama was the most virulent isolate as it was the only one pathogenic to all the 10 lentil genotypes in both tests. In the intact stem test, the other 3 isolates were pathogenic to most but not all the lentil genotypes (Table 8.5). In the detached shoots test, all the isolates were pathogenic to the genotypes tested with little variation in the rate of lesion expansion. Significant variation was shown by genotype ILL 7012 and 6994 on some of the isolates (Table 8.5). This tends to suggest the existence of some variability in the *S. sclerotiorum* isolate populations on lentil. However, this may need further investigation for this to be useful in the resistance screening research.

(C. Akem and S. Kabbabeh)

8.2.3. Virulence Studies in Cereal Disease

Comprehensive information on pathogen virulence and variation, and the epidemiological information on pathogen movements, provides a basis for the development of an early warning system to farmers growing potentially susceptible cultivars. Thus, an important ongoing activity at ICARDA HQ is the study of disease incidence, virulence patterns and shifts of most common diseases through surveys, trap nurseries, and pathogenicity studies under controlled environment, and under artificial inoculation in the field.

Only Syrian isolates are used in artificial inoculation for screening under field and controlled environment conditions. The relative virulence of these isolates is, for some diseases, similar to the common virulence types in WANA. Evaluation for disease resistance, under artificial inoculation, to stripe rust, septoria, scald, barley stripe, common bunt, loose and covered smut is conducted under field conditions. Screening for wheat leaf rust, stem rust, and barley powdery mildew is conducted in plastic houses.

Table 8.5. Daily rate of lesion expansion on lentil stems inoculated with isolates of *Sclerotinia sclerotiorum*

	Rate of lesion expansion (cm/day)* on intact stems of lentil grown pots				
Lentil entry	Isolate#14	Isolate#17	Isolate#20	Isolate#36	Mean
ILL 7012	1.7	2.0	1.3	0.1	1.2
ILL 7005	0.4	0.1	0.0	0.6	0.3
ILL 5588	0.0	0.0	0.7	2.0	0.7
ILL 7009	0.9	1.5	2.0	1.0	1.3
ILL 6819	1.9	1.7	0.0	1.4	1.3
ILL 4400	1.3	0.0	2.0	1.6	1.2
ILL 5883	1.3	0.0	0.0	1.4	0.7
ILL 5722	0.7	2.2	2.8	1.6	1.8
ILL 2130	0.3	0.6	2.3	1.5	1.2
ILL 6994	0.5	0.4	1.1	1.2	0.8
Mean	0.9	0.8	1.2	1.2	
LSD (0.05)	0.8	0.7	0.6	0.8	
SE	0.4	0.4	0.3	0.4	
	Rate of lesion expansion (cm/day) on detached shoots				
ILL 7012	2.4	1.5	1.6	1.4	1.7
ILL 7005	2.5	3.0	2.2	2.4	2.5
ILL 5588	2.9	2.8	2.3	2.8	2.7
ILL 7009	2.8	3.2	2.6	2.7	2.8
ILL 6819	2.7	2.4	1.9	2.2	2.3
ILL 4400	2.4	2.7	2.1	2.7	2.5
ILL 5883	2.9	2.8	2.3	2.8	2.7
ILL 5722	2.5	2.9	2.6	2.4	2.6
ILL 2130	2.7	2.3	1.9	2.2	2.3
ILL 6994	1.4	2.4	2.0	2.8	2.1
Mean	2.5	2.7	2.1	2.5	
LSD (0.05)	0.8	0.6	0.8	0.7	
SE	0.3	0.2	0.3	0.2	

* Determined by measuring the lesion expansion of each genotype over a 7 day period.
Each value is the mean of 5 stem replications.

8.2.3.1. Cereal Rusts in Syria

Cereal rust differential genotypes were used to identify the prevailing pathotypes and races for yellow rust, leaf and stem rust of wheat in Syria. Each genotype in the yellow rust differential nursery was planted in the field in 2 rows, each of 0.5 m long. Genotypes in the leaf and stem rust differential nurseries were planted in hill plots under plastic house conditions. The plants were evaluated under artificial infection. Two inoculations were carried out at early and late tillering growth stages using a mixture of uredospores. The inoculum was collected in the previous season from naturally infected fields at different locations in Syria. Severity of infection was assessed at seedling and heading stages. The stripe rust differentials included new accessions (Avocet series) being tested as potential differentials in the CWANA region. Four new Syrian yellow rust isolates were tested for their virulence on the yellow rust differential set (Table 8.6). The isolates were bulk spores (THb), and single spore isolates (TH1, TH2, TH3) representing different virulence types. The conventional differential entries (number 1-21) were evaluated for resistance against all isolates in the growth chamber, and in the field at seedling (Sd) and adult (Ad) growth stages. The comprehensive differential set included the new avocet differentials (entry 17-26), cultivars with known resistance genes, universal susceptible cultivars, and check cultivars. Yellow rust bulk isolate (THb) was the most virulent. Yellow rust resistance genes that showed only adult plant resistance, under field conditions, were Yr_8, Yr_{10}. The adult plant resistance associated with Yr_{18} was not observed. Resistance genes that expressed resistance only at the seedling growth stage were: Yr_{sw}, and Yr_{9+}. Virulence was recorded, under field conditions on the following genes: Yr_7, Yr_{6+}, Yr_8, Yr_9, Yr_{2+}, Yr6+Yr_7, and Yr_{A+}, (Table 8.6). Virulence of leaf rust (*Puccinia recondita*) was also studied using a bulk isolate. Artificial inoculation was carried out in the plastic house. The adult and seedling reactions were evaluated (Table 8.7). Virulence on the following leaf rust resistance genes (Lr 22b, Lr11, Lr2c, Lr3, Lr3ka, Lr3Bg, Lr 14a, Lr14b, and Lr36) was observed. Reported resistance genes from Egypt, Ethiopia, Sudan, and Yemen are also listed (Table 8.7). A bulk of Syrian stem rust isolates (Syr) was tested against stem rust differentials under artificial inoculation realized in plastic house. The isolate was virulent (S) to intermediate (I) on all stem rust resistance genes, except Sr27 (Table 8.8). A virulence reaction (R) from Egypt, Ethiopia, Sudan and Yemen.

Table 8.6. Pathotype identification and virulence analysis of wheat stripe rust isolates

Differential genotypes	R.Genes	Ad	Sd	TH1	TH2	TH3	THb
Chinese 166(W)	Yr1	R	R	R	R	R	R
Lee(S)	Yr7	S	S	S	S	S	S
Heines Kolben(S)	Yr6+	S	S	S	S	S	S
Vilmorin 23(W)	Yr3a,4a,+	R	R	R	R	R	R
Moro(W)	Yr10	MR	R	R	R	R	R
Strubes Dickopf(W)	Yr2+	S	R/S	R	S	R	S
Suwon 92 x Omar(W)	SO	S	R	R	R	R	R
Clement(W)	Yr9+	S	R/S	R	R	S	R
Hybrid 46 (W)	Yr3b,4b	R	R	R	R	R	R
Reichersberg 42(W)	Yr7+	MS	S	S	S	S	S
Heines peko(S)	Yr6+	MS	S	R	S	S	S
Nord Despres(W)	Yr3a,4a,+	R	R	R	R	R	R
Compare (S)	Yr8	R	S	S	R	R	S
Carstens V(W)	CV	R	R	R	R	R	R
Spaldings prolific(W)	SP	R	R	R	R	R	R
Heines VII(W)	Yr2+	MS	S	R	R	S	S
Anza	A+	S	S	S	R	S	S
Sonalika	-	S	R/S	R	R	S	S
Triticum spelta	Yr5	R	R	R	R	R	R
Gereck 79	-	S	R/S	R	R	S	S
Cham 1	-	MR	R	R	R	R	R
Yr1*Avocet(S)	Yr1	R	R	-	-	-	R
Yr5*Avocet(S)	Yr5	R	R	-	-	-	R
Yr7*Avocet(S)	Yr7	S	-	-	-	-	-
Yr8*Avocet(S)	Yr8	S	S	-	-	-	S
Yr9*Avocet(S)	Yr9	S	S	-	-	-	S
Yr10*Avocet(S)	Yr10	R	S	-	-	-	S
Yr15*Avocet(S)	Yr15	R	R	-	-	-	R
Yr17*Avocet(S)	Yr17	S	S	-	-	-	S
Avocet S	-	S	S	-	-	-	S
Avocet R		S	R	-	-	-	R
Jupateco R	Yr18	S	S	-	-	-	S
Jupateco S		S	S	-	-	-	S
Kalyansona	Yr2+	S	S	-	-	-	S
Federation		S	S	-	-	-	S
Fed.4/Kavkaz	Yr9	S	S	R	S	S	S
Cranbrook	Yr7	S	S	-	-	-	S
Corella	Yr6+Yr7	S	S	-	-	-	S
Oxley	Yr6+APR	S	S-	-	-	-	R
Cook		S	R	-	-	-	R
Seri 82		S	S	S	S	S	S

R: resistant, S: susceptible. - not evaluated, + additional gene (unknown), MR=moderately resistance, MS=moderately susceptible, TH1, TH2, TH3=single isolates collected from Tel Hadya, THb=bluk of isolates collected from Tel Hadya, Ad: field adult plant reaction, Sd: field seedling reaction.

Table 8.7. Pathotype identification and virulence analysis of wheat leaf rust isolates

Name	R.Gene	Sd	Ad	Egy	Eth	Sud	Yem
Thatcher	Lr22b	S	S	R	-	-	-
TC*6/Centenatrio (RL6003)	Lr1	R	R	R	R	-	-
TC*6/Webster (RL6016)	Lr2a	R	R	-	-	-	-
TC*6/Carina (RL6019)	Lr2b	R	S	-	-	-	-
TC*6/Loros (RL6047)	Lr2c	S	S	-	-	-	-
TC*6/Democrat (RL6002)	Lr3	S	S	-	-	-	-
TC*6/Aniversario (RL6007)	Lr3Ka	S	S	-	R	-	R
Bage/8*TC (RL6042)	Lr3Bg	S	S	-	-	-	-
Transfer/6*TC (RL6010)	Lr9	R/S	MR	-	-	R	R
TC*6/Exchange (RL6004)	Lr10	S/R	S	-	-	-	-
Kussar (W976)	Lr11	S	S	-	R	-	-
Exchange/6*TC (RL6011)	Lr12	S	R	-	-	-	-
Manituou	Lr13	S	R	-	-	-	-
Selkirk/6*TC (RL6013)	Lr14a	S	S	-	-	-	-
TC*6/Maria Escobar (RL6006)	Lr14b	S	S	-	-	-	-
TC*6/Kenta1483 (RL6052)	Lr15	R/S	R	-	-	-	-
TC*6/Exchange (RL6005)	Lr16	S	R	-	-	-	-
Klein Lucero/6*TC (RL6008)	Lr17	S	R	-	R	R	R-
TC*7/Africa 43 (RL6009)	Lr18	S	MR	R	-	-	-
TC*7/Tr (RL6040)	Lr19	R/S	R	-	-	-	-
Thew (W203)	Lr20	S/R	S	-	-	-	-
TC*6/RL5406 (RL6043)	Lr21	S	R	R	R	R	R
TC*6/RL5404 (RL6044)	Lr22a	S	R	-	-	-	-
Lee 310/6*TC (RL6012)	Lr23	S	MS	-	-	-	R
TC*6/Agent (RL6064)	Lr24	R/S	R	-	-	R	-
Transec (Awned)	Lr25	R	R	-	-	-	-
TC*6/ST-1-25 (RL6078)	Lr26	R	R	R	-	R	-
Gatcher (W3201)	Lr27+Lr31	R/S	R	-	-	-	-
CS2D-2M	Lr28	R/S	R	-	-	-	-
TC*6/CS7AG#11 (RL6080)	Lr29	R	R	-	-	-	-
TC*6/Terenzio (RL6049)	Lr30	S/R	MS	-	-	R	R
TCLR32 (RL5497)	Lr32	S/R	MS	-	-	-	-
TC*6/PI58548 (RL 6057)	Lr33	S	M	-	-	-	-
TC*6/PI58548 (RL 6058	Lr34	S	MR	-	-	-	-
RL5711	Lr35	S	R	-	-	-	-
E84018	Lr36	S	S	-	-	-	-
WL711	Lr13	R/S	R	-	-	-	-

Sd: seedling, Ad: Adult, Egy: Egypt, Sud: Sudan, Eth: Ethiopia, Yem: Yemen

Table 8.8. Pathotype identification and virulence analysis of wheat stem rust isolates

Name	Gene	Syr	Egy	EtH	Sud	Yem
Isr5Ra	Sr5	S	-	R	R	R
W2691Sr6	Sr6	S	-	-	-	-
Line	Sr7a	S	-	-	-	-
ISr7BrGa	Sr7b	S	R	R	R	R
ISr8Ara	Sr8a	S	R	-	R	R
Barleta Benvuto	Sr8b	S	-	-	-	-
ISr9Ara	Sr9a	S	-	-	-	-
W2691Sr9B	Sr9b	S	-	-	-	-
ISr9Dra	Sr9d	S	-	-	-	-
Vernstein	Sr9e	I	-	R	-	R
ISr5SB	Sr9f	S	-	-	-	-
CNS (TC2B)/Line E	Sr9g	S	-	-	-	-
W2691Sr10	Sr10	S	-	-	-	-
TSr11Ra	Sr11	I	-	-	-	-
CH-SP-(TC3B)	Sr12	S	-	-	-	-
W2691Sr13	Sr13	S	-	-	-	-
Line A Seln.	Sr14	S	-	-	-	-
W2691Sr15NK	Sr15	S	-	-	-	-
ISr16Ra	Sr16	I	-	-	-	-
LC/Kenya Hunter	Sr17	S	-	-	-	-
LCSr19Mg	Sr19	S	-	-	-	-
LCSr20Mg	Sr20	I	-	-	-	-
T.Monococcum Deriv.	Sr21	S	-	-	-	-
SWSr22T.3.	Sr22	I	-	-	-	-
Exchange	Sr23	S	-	-	-	-
BT Sr 24 A9	Sr24	I	-	-	-	-
LC Sr 25 Ars	Sr25	S	-	-	-	-
Eagle	Sr26+Sr9g	S	R	-	-	-
Coorong Triticale	Sr27	R	-	-	-	-
W2691Sr2Bkt	Sr28	S	-	-	-	-
Pusa/Edch	Sr29	S	-	-	R	-
BtSr3oWst	Sr30	I	R	R	-	-
Line E/Kvz	Sr31	I	-	-	-	-
C77-19	Sr32	I	-	-	-	-
Tetra Canthatch/AE-Sguarrosa (RL5045)	Sr33+Sr5	I	-	-	-	-
Compare	Sr34	I	-	-	-	-
W3763	Sr35	I	-	-	-	-
W2691 SrTt1	Sr36	I	-	-	-	-
W2691 SrTt2	Sr37	S	-	-	-	-
Fed.*2/SrTt3	SrTt3+Sr10	S	-	-	-	-
Medea AP9D	SrDp2	S	-	-	-	-
BTSrGamut	SrGt	I	R	R	R	R
Peliss	SrPl	S	-	-	-	-
BT/Wld	SrWld	S	-	-	-	-

Syr: Syria, Egy: Egypt, ET: Ethiopia, Sud: Sudan, Yem: Yemen, R: Resistant, S: Susceptible I: Intermediate

8.2.3.2. Wheat Yellow Rust in CWANA

Yellow rust pathogenic variation is the underlying cause of the elusive rust resistance. During the last decade, several yellow rust epidemics have occurred in most *countries in the region* and resulted in severe losses in wheat production. Yellow rust epidemics and significant yield losses in 1996 and in 1999 have been observed in Azerbaijan. During a survey in May 1999, yellow rust was considered a major wheat disease in other CWA countries where yellow rust continues to incur wheat crop losses. Known resistant to yellow rust ("Yr" genes) were evaluated for their effectiveness against stripe rust (*Puccinia striiformis*) in Syria, Lebanon, Turkey, Tajikistan, Iran, Ethiopia, and Yemen (Table 8.9). Virulence on Yr1 and Yr3 was observed only in Tajikistan. Virulence on Yr SD and Yr Su was observed only in Syria. Virulence on Yr 8 and Yr 17 was observed only in Lebanon. Virulence on Yr 18 was observed at all sites. *No virulence on* Yr15, Yr 3N, Yr Sp, and Yr 4 was detected in Central and Western Asia.

Table 8.9. Virulence spectrum of yellow rust in Central and Western Asia (CWA)

Cultivar (W/S)	Yr Gene	SYR	LEB	TUR	TAJK	IRAN	ETH	YEM
Chinese 166 (W)	Yr1	8R-0S	3R-0S	5R-0S	0R-1S	9R-0S		
Lee (S)	Yr7	1R-7S	0R-3S	0R-5S	0R-1S	7R-2S	2R-2S	0R-1S
Heines Kolben (S)	Yr6	6R-2S	0R-3S	0R-5S	0R-1S	8R-1S	3R-1S	1R-0S
Vilmorin 23 (W)	Yr3 V	8R-0S	3R-0S	5R-0S	0R-1S	9R-0S		
Moro (W)	Yr10	5R-2S	3R-0S	5R-0S	0R-1S	9R-0S		
Strubes Dickkopf (W)	SD	6R-2S	3R-0S	5R-0S	1R-0S	10R-0S		
Suwon 92xOmar (W)	SU	2R-6S	3R-0S	5R-0S	1R-0S	10R-0S		
Clement (W)	Yr9	1R-7S	2R-1S	5R-0S	1R-0S	8R-1S		
Hybrid 46 (W)	Yr4	8R-0S	3R-0S	5R-0S	1R-0S	9R-0S		
Reichersberg 42 (W)	Yr7	3R-5S	1R-2S	5R-0S	1R-0S	10R-0S		
Heines Peko (S)	Yr6	3R-5S	2R-1S	4R-1S	1R-0S	10R-0S	4R-0S	1R-0S
Nord Desprez (W)	3N	8R-0S	3R-0S	5R-0S	1R-0S	9R-0S		
Compare (S)	Yr8	8R-0S	2R-1S	5R-0S	1R-0S	9R-0S	4R-0S	1R-0S
Carstens V (W)	CV	8R-0S	3R-0S	5R-0S	1R-0S	10R-0S		
Spaldings Prolific W)	SP	8R-0S	3R-0S	5R-0S	1R-0S	9R-0S		
Heines VII (W)	Yr2*	1R-7S	2R-1S	5R-0S	1R-0S	10R-0S		
Yr 15/ 6* Avocet S	Yr 15	8R-0S	3R-0S	2R-0S			4R-0S	1R-0S
Yr 17/ 4* Avocet S	Yr 17	8R-0S	0R-1S	2R-0S				
Jupateco R (Yr 18)S	Yr18	2R-6S	1R-2S	0R-2S	0R-1S	9R-1S	2R-2S	0R-1S
Avocet R (YrA)	YrA	4R-4S	2R-1S	0R-2S	1R-0S		1R-3S	0R-1S
Kalyansona (Yr2) S	Yr2	1R-7S	0R-3S	0R-4S	0R-1S	5R-5S	2R-2S	0R-1S
Federation S	Yr9*	1R-7S	0R-3S	0R-1S	1R-0S	6R-4S	1R-3S	0R-1S
Fed.4/Kavkaz (Yr9)	Yr9	1R-7S	0R-3S	0R-4S	0R-1S		1R-3S	0R-1S
Cranbrook (Yr7) S	Yr7	1R-7S	1R-2S	0R-4S	0R-1S		0R-4S	0R-1S
Corella (Yr6+Yr7) S	Yr6+Yr7	1R-7S	0R-3S	0R-1S	0R-1S		2R-2S	0R-1S
Oxley (Yr6+APR) S	Yr6+APR	1R-7S	2R-1S	0R-1S	0R-1S	1R-0S	2R-2S	0R-1S
Cook (S)	APR	5R-2S	1R-2S	1R-0S	0R-1S	10R-0S	4R-0S	0R-1S
Anza (A+) S	18+A	1R-7S	0R-3S	0R-5S	0R-1S	8R-2S	2R-2S	0R-1S
Seri 82	Yr9	1R-7S	0R-3S	0R-1S	0R-1S		2R-2S	0R-1S

SYR=Syria, LEB=Lebanon, TUR=Turkey, TAJK=Tajikistan, ETH=Ethiopia and YEM=Yemen

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8.2.3.3. Barley Powdery Mildew in Syria

Powdery mildew could become very important in barley growing areas in Syria. During this crop season, thirty powdery mildew isolates were purified and multiplied on the barley cultivar "Martin". For the virulence studies, six isolates were maintained from each of the following barley growing areas: Tel Hadya, Al Ghab, Messiaf, Al Bab, Lattakia, and Idleb. Six powdery mildew isolates (five from Tel Hadya and one from Lattakia) were studied for their differential virulence on pallas near isogenic lines (Table 8.10).

Table 8.10. Powdery mildew differential genotypes: Pallas near isogenic lines

Differential number	Name	Origin	Designation
P-01	Iso 1R	CI 16137 Algerian	Mla, + ?
P-02	Ricardo	CI 6306 (Ricardo)	Mla3
P-03	Iso 20R	CI 16151 Franger	Mla6. Ml-a14
P-04A	Nordal	Carlsberg Heine 4808	Mla7. Ml-k, + ?
P-04B	Nordal	Carlsberg Haine 4808	Mla7. + ?
P-06	Iso 10R	CI 16147 Multan	Mla7. Ml-(LG2)
P-07	Mona	Svalof Monte Cristo	Mla9. Ml-k
P-08A	Senat	Svalof Triple Awn Lemma	Mla9. Ml-k
P-08B	Senat	Svalof Triple Awn Lemma	Mla9
P-09	Iso 12R	CI 16149 Durani	Mla10. Ml-Du2)
P-10	Emir	Cebeco Arabische	Mla12
P-11	Rupal	Svalof Rupee	Mla13. Ml-Ru3)
P-12	HOR 1657	HOR 1657 (HOR 1657)	Mlc
P-13	HOR 1402	HOR 1402 (HOR 1402)	Ml(1402)
P-14	W.41\145	Weihenstephan (41\145)	Ml(41/145)
P-15	Rupee gene 2	Svalof Rupee	Ml(Ru2)
P-17	MC gene 2	Svalof Monte Cristo	Mlk
P-18	nigrinudum	CI 11549 (Nigrinudum)	Mlnn
P-19	Iso 5R	CI 16145 Psaknon	Mlp
P-20	Atlas	CI 4118 Coast	Mlat
P-21	Deba	Abed Weihenstephan MR II	Mlg, Ml-(CP)
P-22	Riso 5678	CI 15219 Mut.in Carlsberg II	Ml05
P-23	Lofa	Abed H.laevigatum	Ml(La)
P-24	Iso 3R	CI 16141 Hanna	Mlh
PALLAS	PALLAS	Svalof MUT. IN BONUS	Mla8

The virulence/Avirulence reaction of these isolates is shown in Table 11. The six isolates showed three distinct pathotypes:

Pathotype SYR1 represented by powdery mildew isolate from Lattakia (Lat-1)

Pathotype SYR 2 represented by powdery mildew isolate from Tel Hadya (TH-1)

Pathotype SYR 3 represented by powdery mildew isolate from *Tel Hadya (TH-2)*

Pathotype SYR 3 represents virulence types of three isolates from Tel Hadya (TH-2; TH-3; TH-4; and TH-5). Within Tel Hadya two pathotypes were identified among the isolates tested (Table 8.11).

Table 8.12 shows the relative virulence of the three pathotypes on the universal differential genes.

(Table 8.13) shows the three pathotypes described above and the respective differential genes. The pathotypes differed on three differential genes. Pathotype SYR1 and SYR 2 were more virulent than SYR 3 (Table 8.12).

Table 8.11. Reaction of known resistance genes to six powdery mildew isolates from Syria

	Powdery mildew isolate					
Gene designation	Lat-1	TH-1	TH-2	TH-3	TH-4	TH-5
Ml-a,+?	R	R	R	R	R	R
Ml-a3	R	*S*	R	R	R	R
Ml-a6. Ml-a14	S	I	S	I	S	S
Ml-a7. Ml-k,+?	R	R	R	R	I	R
Ml-a7. + ?	R	R	R	R	R	R
Ml-a7. Ml-(LG2)	R	R	R	R	R	R
Ml-a9. Ml-k	R	R	R	R	R	R
Ml-a9. Ml-k	R	R	R	R	R	R
Ml-a9	R	R	R	R	R	R
Ml-a10. Ml-Du2)	S	S	S	S	S	S
Ml-a12	R	R	R	R	R	R
Ml-a13. Ml-Ru3)	R	R	R	R	R	R
Ml-c	S	I	S	I	I	S
Ml-(1402)	S	S	S	S	S	S
Ml-(41/145)	S	S	S	I	S	S
Ml-(Ru2)	S	S	R	R	R	I
Ml-k	S	S	S	S	S	S
Ml-nn	S	S	S	S	S	I
Ml-p	I	S	S	S	I	I
Ml-at	S	S	S	S	S	S
Ml-g, Ml-(CP)	S	R	S	S	S	S
Ml-05	R	R	I	R	R	R
Ml-(La)	S	S	S	S	I	S
Ml-h	S	S	S	S	S	S
Ml-a8	S	S	S	S	S	S

Table 8.12. Virulence/Avirulence reaction of three Syrian powdery mildew pathotypes on Pallas near isogenic lines (Pallas differentials)

Resistance genes and gene combinations	Powdery mildew isolates		
	Pathotype		
	SYR1	SYR2	SYR3
R. GENE(S)	Lat-1	TH-1	TH-2
Ml-a3	A	V	A
Ml-a6. Ml-a14	V	A/V?	V
Ml-a10. Ml-Du2)	V	V	V
Ml-c	V	A/V?	V
Ml-(1402)	V	V	V
Ml-(41/145)	V	V	V
Ml-(Ru2)	V	V	A
Ml-k	V	V	V
Ml-nn	V	V	V
Ml-p	A/V?	V	V
Ml-at	V	V	V
Ml-g, Ml-(CP)	V	A	V
Ml-(La)	V	V	V
Ml-h	V	V	V
Ml-a8	V	V	V

Table 8.13. Powdery mildew pathotypes from two locations in Syria

Resistance gene/isolate Identification	Pathotype		
	SYR1	SYR2	SYR3
	Lat-1	TH-1	TH-2
Ml-a3	R	S	R
Ml-(Ru2)	S	S	R
Ml-g, Ml-(CP)	S	R	S

Lat: Lattakia; TH: Tel Hadya; SYR: Syria

8.2.3.4. Barley Powdery Mildew in WANA

Virulence analysis of barley powdery mildew in WANA (Table 8.14) showed that, the gene combination "Mla9, Mlak" conferred resistance against all mildew isolates tested from Morocco, Tunisia, and Syria. The following near isogenic lines names showed resistance in WANA from (Table 8.15).

Table 8.14. Virulence/Avirulence frequency of powdery mildew isolates from Tunisia, Morocco, and Syria on pallas near isogenic lines

NIL	Resistance gene designation	WANA %R	Tunisia (19 Isolates) VIR/AVIR	%R	Morocco (38 Isolates) VIR/AVIR	% R	Syria (30 Isolates) VIR/AVIR	%R
Pallas	Mla 8	18	15/4	21	30/8	21	26/10	33
P-01	Mla1,+?	63	4/15	79	28/10	26	0/30	100
P-02	Mla3	71	10/9	48	12/26	68	3/27	71
P-03	Mla6, Mla14	42	9/10	53	26/11	28	14/16	53
P- 04A	Mla7 , Mlak,+	96	2/17	90	0/37	97	0/30	100
P- 04B	Mla7, +	90	8/11	52	0/38	100	0/30	100
P-06	Mla7, ML(LG2)	96	2/17	90	1/37	97	0/30	100
P- 07	Mla9, MLk	96	1/18	95	2/36	95	0/30	100
P- 08A	Mla9,MLk	96	0/19	100	3/35	92	0/30	100
P- 08B	Mla9	97	2/17	90	0/38	100	0/30	100
P-09	Mla10, ML(DU)	32	13/6	22	29/9	23	17/13	43
P-10	Mla12	58	16/3	16	18/20	52	2/28	93
P-11	Mla1,+?	92	4/15	79	2/36	95	1/29	96
P-12	MLc	54	11/8	43	15/23	60	14/16	53
P-13	ML(1402)	55	7/12	64	8/30	79	24/6	20
P-14	ML(41/145)	24	13/6	32	30/8	21	23/7	23
P-15	ML (Ru2)	52	10/9	48	19/17	44	10/20	66
P-17	MLk	29	10/9	48	26/12	31	25/5	16
P-18	MLnn	28	10/9	48	30/8	21	22/8	26
P-19	MLp	56	3/16	85	19/19	50	16/14	46
P-20	Mlat	17	10/9	48	36/2	5	26/4	13
P-21	MLg, ML(CP)	46	13/6	32	16/22	57	18/12	40
P-22	Mlo	92	0/19	100	3/35	92	4/26	86
P-23	ML(La)	27	13/6	32	23/15	39	27/3	10
P-24	MLh	10	14/5	27	36/2	5	28/2	6

Table 8.15. Virulence/Avirulence frequency of 87 powdery mildew isolates from Tunisia, Morocco, and Syria

NIL	Res. gene designation		Tunisia (19 Isoltes)		Morocco (38 Isolates)		Syria (30 Isolates)	
P-04A	Mla7 , Mlak,+	96	2/17	90	0/37	97	0/30	100
P-04B	Mla7,+	90	8/11	52	0/38	100	0/30	100
P-06	Mla7,ML(LG2)	96	2/17	90	1/37	97	0/30	100
P-07	Mla9,MLk	96	1/18	95	2/36	95	0/30	100
P-08A	Mla9,MLk	96	0/19	100	3/35	92	0/30	100
P-08B	Mla9	97	2/17	90	0/38	100	0/30	100
P-11	Mla1,+?	92	4/15	79	2/36	95	1/29	96
P-22	Mlo	92	0/19	100	3/35	92	4/26	86

8.2.3.5. Scald

Virulence of scald isolate mixtures was evaluated under field conditions at three experimental stations in Syria at Tel Hadya (TH), Lebanon at Terbol (TR)), and in Turkey at Haymana (HY). Seven virulence groups were identified (Table 8.16). The groups V, VI and VII do not show distinctive differences between the scald isolates at the respective stations. The differentials in group I-IV showed different reaction types. Scald isolates were avirulent on group I that has six differential varieties. Syrian isolate was virulent on group II and IV, the Lebanese and the Turkish were virulent only on group II and group IV, respectively. Scald isolates from Syria were more virulent on the differential genotypes than those from the other sites. Screening of barley germplasm for scald resistance at these three sites will give more reliable information on the effectiveness of resistance sources to be deployed in WANA region.

(A. Yahyaoui and Z. Alamdar)

Table 8.16. Reaction of scald differential genotypes to different mixtures of scald evaluated under field conditions at three experimental stations

	Scald Isolates & Testing Sites		
Differentials Group	Syria (TH)	Lebanon (TR)	Turkey (HY)
I. Armelle, Astrix, Atlas 46, Athene, Osiris, Forrajera	R	R	R
II. Kitchin Digger Osiris Igri Rihane-03	S	R	R
III. Trebi	R	S	R
IV. La Mesita	S	R	S
V. Bey , Abyssinin, La Mesita	MR	R	R
VI. Jet, Modoc	R	MR	R
VII. Steudelli, Pirate	MS	R	R

8.2.4. Variability in Feeding Preference of *Sitona crinitus* on Legume Seedlings

Sitona crinitus Herbst is the major insect pest of lentil in West Asia and North Africa. The larvae feeding in the nodules causes the main damage. In Morocco and in Syria, grain yield losses due to *Sitona* larvae were estimated at 25% and 20%, respectively.

Ten legume species were evaluated for their feeding preference to Sitona adults. The experiment was carried out in the greenhouse at Tel Hadya using an RCBD with 10 reps. In each pot, the 10 entries were planted in a circular manner, three seeds of each legume species. About 10 days later, and prior to infestation, the seedlings were thinned to one per entry and each pot was infested with 12 Sitona adults. These latter were collected from the field and starved for two days prior to their release in the pots.

The pots were covered by well-aerated plastic cages (15x30 cm) with a fine mesh on the top and four screened ventilation holes on the sides. Three days after the infestation, the number of notches on the leaves was counted.

The most preferred legume species for *Sitona* adults were *Vicia sativa*, *Lens culinaris*, and *Vicia ervilia*, and the least preferred were *Lathyrus* spp. However, and on the contrary to what was reported earlier in the literature, *Vicia faba* and *Cicer arietinum* are not hosts as Sitona adults did not feed on them at all (Table 8.17).

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8.2.5. Hessian Fly Biotypes in Morocco

Hessian fly, *Mayetiola destructor* (Say), is the most important insect pest of wheat (*Triticum* species) in Morocco. The most practical control method for Hessian fly has been the use of resistant cultivars. In Morocco, four resistant bread wheat cultivars have been released. Hessian fly resistance in wheat is conditioned mostly by dominant alleles at one or pair of loci, and virulence against each resistance wheat allele is conditioned by recessive alleles at a single locus in the Hessian fly. Most resistance genes confer larval antibiosis, whereby first instar larvae die soon after they begin feeding on plants. The deployment of wheat cultivars with high levels of antibiosis to first instars exerts a strong selection pressure on Hessian fly populations that favors biotypes capable of surviving on resistant wheat. The objective of this study was to estimate the frequency of virulence to three resistance genes, H5, H13 and H22 in the Hessian fly populations in the major wheat growing areas of Morocco.

Hessian fly populations were obtained from bread wheat fields (about 300 plants per location) collected in five locations (Chaouia, Fez, Abda, Marchouch, and Beni Mellal). Infested wheat plants were taken to the laboratory at INRA, (Settat, Morocco) and increased on susceptible wheat cultivar 'Nama'.

Table 8.17. Number of leaf notches on seedlings of 10 legume species caused by adult *Sitona* feeding under artificial infestation in the plastic house, ICARDA, 1999

Species	Mean number of leaf notches
Lens culinaris (accession ILL:4401)	A 40
Vicia sativa (accession Asel. 2541-2560	A 45.7
Vicia ervilia (accession Asel. 2542-2563)	AB 37.9
Trifolium angustifolium	ABC 26.7
Medicago polymorpha	BC 24
Lathyrus cicera (accession 495)	CD 16.5
Lathyrus sativus (accession 533)	CD 14.9
Lathyrus ochrus (accession 762)	D 1.1
Vicia faba (accession ILB 1811)	D 0
Cicer arietinum (Ghab 3)	D 0
LSD (5%)	14.6

Means followed by the same letters are not significantly different ($P<0.05$).

Seeds of each of the three wheat differentials containing the resistance genes H5, H13, H22 and the susceptible check Nasma were planted in a pot containing soil and divided into four sections. When seedling were at one leaf stage, the number of plants per entry was thinned to three. A single mated female from each population was released in the pot, which was covered by a cheesecloth cage. The pots were uncovered about three days after the infestation, when females died. Two hundred females per population were used to estimate the level of Hessian fly virulence to the three resistance genes in each of the five locations in Morocco.

The experiment was conducted in a growth chamber set at 20°C and 12: 12 (L: D) h photoperiod throughout the test. The evaluation was made three weeks after the infestation. Resistant plants were light green, whereas susceptible plants were stunted and dark green. Plants showing resistance symptoms were dissected under microscope and checked for the presence of larvae to confirm infestation. Percentage data were transformed by arcsin and analyzed by using SAS. Means were separated by LSD at $p=0.05$.

The mean percent susceptible plants of three genes varied across locations. The lowest level of virulence was found in Fes, Marchouch and Abda. The highest level of virulence to H13 and H22 genes was in Beni Mellal with 6.4

and 7.3%, respectively. H5 gene showed similar and low level of susceptibility across all the locations (Table 8.18). These data show the existence of biotypic variation in Hessian fly populations across the five locations. The data also show the potential of biotype development as cultivars carrying these resistance genes will be grown in large scale; they will be exerting high selection pressure on Hessian fly populations. Biotype development should be closely and continually monitored using differentials in the field and in the growth chamber.

(N. Najat (University Shouaib Doukkali), El Jadida, Morocco), S. Lhaloui (INRA, Morocco) and M. El Bouhssini (ICARDA))

Table 8.18. Percentage of wheat plants showing susceptibility to infestation by five *M. destructor* populations in three cultivars carrying resistance genes H5, H13, and H22, growth chamber test, Settat, Morocco

	Origin of M. destructor population				
Genotype	Chaouia	Fes	Abda	Marchouch	Beni Mellal
H13	Aa	Ab	Aa	Ab	Ac
	3,7	1,8	2,6	1,5	6,4
H22	Aa	Ab	Ab	Ab	Aa
	4,2	1,9	1,5	2	7,3
Nesma	Ba	Ba	Ba	Ba	Ba
	99,1	99,5	99,8	99,9	99,4
H5	Aa	Aa	Aa	Aa	Ca
	2,1	1,7	2,3	1,0	1,9

Means followed by the same letters in horizontal rows (lower case) and in vertical rows (upper case) are not significantly different (P=0,05), LSD test.

8.3. Sources of Resistance

8.3.1. Effective Resistance Genes to Wheat Rusts

8.3.1.1. Effective Resistance Genes to Wheat Yellow Rust

Known resistant genes to yellow rust ("Yr" genes) were evaluated for their effectiveness against yellow rust (Puccinia striiformis) in Syria, Lebanon, Turkey, Tajikistan, Iran, Ethiopia, and Yemen (Table 8.19). Resistance genes Yr. (8, CV, 15, and 17) were effective in all the testing sites in the countries mentioned above. Yr"SD" and Yr"SU" were effective at all sites but Syria. Yr7 and Yr 2+ were effective at all sites but Syria and Lebanon. The latter genes could be still used in central Asia and should be avoided in Syria and Lebanon. A combination of the resistance genes such (Yr15 and Yr1), (Yr17 and Yr3N), (Yr'CV', Yr'Sp', and Yr8), and (Yr18 and Yr1) could offer a durable resistance to yellow rust in CWANA region.

Table 8.19. Effective yellow rust resistance genes in Central Western Asia

Cultivar	Yr Gene	Syria	Lebanon	Turkey	Tajekistan	IRAN
Chinese 166	Yr 1	+	+	+	+	+
Vilmorin 23 (W)	Yr 3 V	+	+	+	-	+
Hybrid 46 (W)	Yr 4+	+	+	+	+	+
Nord Desprez (W)	Yr 3N	+	+	+	+	+
Compare (S)	Yr 8	+	+-	+	+	+
Carstens V (W)	Yr CV	+	+	+	+	+
Spaldings Prolific (W)	Yr SP	+	+	+	+	+
Yr 15 Avocet S	Yr 15	+	+	+		
Yr 17 Avocet S	Yr 17	+	-	+		
Suwon 92xOmar (W)	Yr SU	-	+	+	+	+
Strubes Dickkopf (W)	Yr SD	+-	+	+	+	+
Reichersberg 42 (W)	Yr 7+	-	+	+	+	+
Heines VII (W)	Yr 2+	-	-	+	+	+

+ Effective resistance gene
- Ineffective resistance gene

8.3.1.2. Effective Resistance Genes to Wheat Leaf Rust

Leaf rust resistance genes were evaluated for their effectiveness against a bulk of rust isolates, collected in Syria from durum wheat, and bread wheat in 1998 (Table 8.20). The resistance genes showed differential reaction to the isolates tested. Six resistance genes (Lr1, Lr2a, Lr25, Lr26, Lr28, and Lr29) were resistant against all isolates, the resistance genes Lr 12, lr13, Lr17, and Lr22 were effective against the bulk isolate but not against the isolates originating from durum and bread wheat. Two resistance genes (Lr2b and Lr20) were effective against durum and bread wheat isolates but not against the bulk (Table 8.20).

Table 8.20. Effective leaf rust resistance genes, against leaf rust bulk isolates, durum wheat and bread wheat isolates from Syria

Cultivar	Lr Gene	Bulk isolate	Durum wheat isolate	Bread wheat isolate
Tc*6/Centenario	Lr1	+	+	+
Tc*6/Webster	Lr2a	+	+	+
TC*6/Webster (RL6016)	Lr2b	-	+	+
Transfer/Tc*6	Lr9	+	-	+
Exchange/Tc*6 adult plant res.	Lr12	+	-	-
Tc*6/Frontana	Lr13	+	-	-
Tc*6/w1483	Lr15	+	-	+
Klein Lucero/Tc*6	Lr17	+	-	-
Tc*7/translocation 4-Agropyron elongatum	Lr19	+	-	+
Thew (W203)	Lr20	-	+	+
Tc*6/RL 5404 Tetra Canthatch X Ae.squarrosa Var.strangulata-RL 5271	Lr22	+	-	-
Tc*6/Agent	Lr24	+	-	+
Tc*6/Transec	Lr25	+	+	+
Tc*6/St-1-25	Lr26	+	+	+
Tc*6/CS7D-Ag#11	Lr29	+	+	+
Tc*8/VPM	Lr37	+		
Tc*6/TMR-514-12-24	Lr38	+		
Tc*6/V336	Lr W	+		
TC	Tc	+		
Tc*6/C-77-1	Lr28	+	+	+

+ Effective resistance gene
- Ineffective resistance gene

8.3.1.3. Effective Resistance Genes to Wheat Stem Rust

Table 8.21 shows the effective resistance genes to wheat stem rust. The stem rust resistance genes Sr23, Sr24, Sr27, Sr31, Sr32, SrGt, and Sr26+Sr9g gave an immune reaction when tested against a bulk of Syrian Stem rust isolates. These genes were considered as highly effective resistance genes.

8.3.2. Effective Resistance to Durum Wheat Diseases

8.3.2.1. Common Bunt

Effective resistance to common bunt in durum wheat is still very low. In 1999, only two durum wheat fixed lines were classified as highly resistant to common bunt(Table 22).

Table 8.21. Effective resistance genes to wheat stem rust

Cultivar	Gene	Reaction
Exchange	Sr23	++
BT Sr 24 A9	Sr24	++
Eagle	Sr26+Sr9g	++
Coorong Triticale	Sr27	++
Line E/Kvz	Sr31	++
C77-19	Sr32	++
BTSrGamut	SrGt	++
ISr7BrGa	Sr7b	+
Vernstein	Sr9e	+
Tetra Canthatch/AE-Sguarrosa (RL5045)	Sr33+Sr5	+
W3763	Sr35	+

++ Highly effective resistance, + effective resistance

Table 8.22. Effective resistance to common bunt

Mrb5/Mgr-4	ICD91-0828-AB-13AP-0AP-2AP-0AP
Mrb5/Albit1	ICD92-1006-CABL-0AP-8AP-0TR

8.3.3. Effective Resistance to *Septoria tritici*

A set of wheat differential cultivars for *Septoria tritici* was evaluated using a bulk of Syrian isolates. Seventeen genotypes showed effective resistance under artificial inoculation in the field. Durum wheat and triticale resistance sources in the differential set were ineffective against the Syrian septoria isolates (Table 8.23).

(A. Yahyaoui, M. Naimi, and I. Maaz)

8.3.4. Effective Resistance Genes to Barley Powdery Mildew in Morocco, Syria, and Tunisia.

The gene combination "Mla9, Mlak" conferred resistance against all mildew isolates tested from Morocco, Tunisia, and Syria. The resistance gene 'mlo' and the gene combination 'Mla9, Mlak' are highly effective in Tunisia (Table 8.24), whereas 'Mla12', 'Mla9', and 'Mla7, Mlak' are highly effective in Morocco (Table 8.25). In Syria, in addition to the effective genes in both Tunisia and Morocco, the gene combination 'Mla7, Ml (LG2)', "Mla1+' and 'Mla7+' are also effective against endemic mildew virulence types (Table 8.26). An adequate control for barley powdery mildew can be achieved by incorporating these genes in adapted barley material to be released in the respective countries.

Table 8.23. Effective/Ineffective resistance in wheat cultivars to *Septoria tritici* in Syria

Differential cultivars	Effectiveness
Spring Bread Wheat	
Anza(I 15284)	+
Bobwhite(CM33203-K-9M-2Y-1M-1Y-1M-0Y)	+
Colotana CI 13556	+
Fortuna CI 13596	+
Forntana CI 12470	+
H574-1-2-6 (PurdueUniv.selection)	+
KV217C SWM4064-6Y-4M-3Y-1M-1Y-3M-0Y-0pt2-0Y-0pt2	+
Miriam chapingo 53//Norin 10/Brevor/3/Yaqui 5412 Meru	+
MTN 72-10-9(Nainari 60/PI 3416140	+
DQ-12 (Yamhill/Hyslop sel.)	+
EA-7(Ac.ventricosa/T.persicum//38marneVPM 1.1.1.2.R4	+
Jcr 979 CI 16906	+
Kavkaz (Lutescens 314 H 147/Bezostaya 1)	+
MTN 71-8-11 (CI 12752/CI 13554)	+
Red chief CI 12109	+
Yamhill CI 14563	+
81 UWWMN 2024) Palmaress/TF 1035) favereav/141Martin/K3/Hohen 77/ora/2/capelle/magdelena) sel.1	+
81 UNWWMN 2095 (Maris Huntsman//VPM/Moisson)bulk PV63-3	+
Rolette CI 15326	+
Mapache M2Ax2802-F-12M-1N-1M-0Y	+
Olaf CI 15930	+/-
Pat 19 (512/VS-IWRN 60-218/2/Deb)	+/-
ZN-157 (ISWRN 1970 No. 56,70M-1018-19)	+/-
Winter Bread Wheat	
Aurora PI 167407	+/-
Bezostaya 1 PI 345685	+/-
Zenati Bouteille	+/-
Siete Cerros (7C) CI 14493	-
Durum Wheat	-
Etit 38 (Land variety)	
Triticale	-
Beagle UM "S"-TCL Bulk X 1530A-12M-SN-1M-0Y	
DU-75 (M2A2x8266-8-6Y-1M-2Y-0Y)	-
Ward CI 15892	-
VOC 447 LD 393/2Langdon/ND58-322	-
Lakhish yaktana/Norin 10/Brevor/3/Florence Aurore	-

\+ Effective resistance
\- Ineffective resistance

Table 8.24. Effective resistance genes to barley powdery mildew in Tunisia

Ref.	R.Gene	Eff.	Ref	R.Gene	Eff.
P-08A	Mla9, MLk	++	P-04A	Mla7, Mlak, +	+
P-22	Mlo	++	P-06	Mla7, ML(LG2)	+
P-07	Mla9, MLk	++	P-08B	Mla9	+
			P-19	MLp	+
			P-01	Mla1, + ?	+
			P-11	Mla13,ML(Ru3)	+

++ Highly effective, + Effective resistance

Table 8.25. Effective resistance genes to barley powdery mildew in Morocco

Ref.	R.Gene	Eff.	Ref	R.Gene	Eff.
P-04B	Mla7, +	++	P-08A	Mla9, MLk	+
P-08B	Mla9	++	P-22	Mlo	+
P-04A	Mla7, Mlak, +	++	P-13	ML(1402)	+
P-06	Mla7, ML (LG2)	++			
P-07	Mla9, MLk	++			
P-11	Mla13,ML(Ru3)	++			

Table 8.26. effective resistance genes to barley powdery mildew in Syria

Ref.	R.Gene	Eff.	Ref.	R.Gene	Eff
P-01	Mla1, + ?	++	P-11	Mla13,ML(Ru3)	+
P-04A	Mla7, Mlak, +	++	P-10	Mla12	+
P-04B	Mla7, +	++	P-22	Mlo	+
P-06	Mla7, ML(LG2)	++	P-02	Mla3	+
P-07	Mla9, MLk	++			
P-08A	Mla9,MLk	++			
P-08B	Mla9	++			

(A. Yahyaoui, Z. Alamdar, A. Amri, and S. Grando)

8.3.5. Resistance Sources

Selected fixed lines for a single disease are designated for use in crossing programs or to be introduced in the area where the disease is the most prevalent. Fixed genotypes from advanced breeding material that confer resistance to specific diseases are assembled in nurseries called "germplasm pools" and dispatched to collaborators for testing at target disease sites under natural infection. At ICARDA, the germplasm pools are continuously tested against different virulence types, under artificial inoculation, using disease isolate from Syria. Targeted wheat diseases are stripe rust, septoria, and common bunt. Barley diseases are scald, barley stripe, loose smut, powdery mildew, and covered smut. Screening for wheat leaf rust, stem rust, and barley powdery mildew is conducted in plastic houses. Lines included in germplasm pools also confer resistance or at least moderate resistance levels to other diseases.

8.3.5.1. Barley Germplasm Pools

The selected germplasm pools were screened for other diseases and highly susceptible lines were eliminated. Barley genotypes in the different germplasm pools (Tables 8.27-8.31) that are considered as sources of resistance to specific disease are distributed to NARS collaborators for exploitation in their breeding programs. Sources of resistance to covered smut (Table 8.27) to loose smut (Table 8.28), powdery mildew (Table 8.29), scald (Table 8.30), and barley stripe (Table 8.31) are continuously tested against different virulence types under artificial inoculation at three sites in the region that are Syria (Tel Hadya), Lebanon (Terbol), and Turkey (Haymana). Testing under artificial inoculation will be initiated with other NARS programs in CWANA.

Table 8.27. Sources of resistance to barley covered smut

Name	Pedigree
Line 9-26 F27	IPA-Iraq
Arabi Abiad//WI2197/CI 13520/5/Arabi Abiad/4/Bc//Aw White/Aths/3/Kv/Mazurka/6/Arabi Aswad//WI2291/WI2269	ICB87-0938-0AP-13AP-0AP
WI2291/WI2269/3/Atem/Roho//Katade	ICB89-0816-2AP-0AP-0AP
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-3APH-0AP
Apm/11012-2//Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP-6APH-0AP
Api/CM67//Harma03/4/Cq/Cm//Apm/3/RM1508/5/ Attiki/6/Aths/7/SP(6H)/Apro//Cal.Mr/3/ROD5 86/Apm/4/Aths	ICB90-0288-0AP
Belts.600807/ Henry//Sussex/3/2*Barsoy	AV 92-42-52
Antares/Ky63-1294/3/Roho//Alger/Ceres 362-1-1	ICB90-0148-0AP-1AP-0AP-3AP-0AP
Roho//Alger/Ceres.363-1-1/3/Tipper	ICB89H-0157-0AP-0AP-4AP-0AP
Rihane/lignee 640//ICB-107766	ICBH88-0088-0AP-12AP-1AP-0AP
Wieselburger/Ahor 1303-61/3/Arr/Esp//Alger/Ceres,362-1-1	ICBH89-0136-0AP-0AP-3AP-0AP
Roho//Alger/Ceres,362-1-1/3/CWB117-77-9-7	ICBH89-0156-0AP-0AP-3AP-0AP
Wieselburger/Ahor 1303-61//ICB-103351	ICBH88-0111-11AP-1AP-0AP
Rihane/Lignee 640//ICB-107766	ICBH88-0088-0AP-18AP-0AP

Table 8.28. Sources of resistance to barley loose smut

Name	Pedigree
ICB-102998/3/Alger/Ceres,362-1-//Emir	ICBH88-0034-0AP-2AP-2AP-0AP
Bkf/Magnelone 1604//Alouette	ICB-HA81-0072-1AP-1AP-0AP
Zarjon/80-5151	ICBH88-0083-0AP-8AP-1AP-0AP
Roho/Masurka//ICB-103020	ICBH88-0132-0AP-12AP-1AP-0AP
CWB22-6-13/ICB-102893	ICBH88-0176-0AP-8AP-0AP
RUSS94-1	

Table 8.29. Sources of resistance to barley powdery mildew

Name	Pedigree
Api/CM67//Mona/3/DI/Asse/CM65-IW-B/4/Assala-02	ICB85-0225-2AP-3AP-0TR-1AP-0TR-0AP
WI2291/WI2269//Arta	ICB88-1596-24AP-0AP
Atem/Roho//Katade/3/Aramir/Arabi Abiad	ICB89-0908-6AP-0AP-0AP
Belts. 600807/Henry//Sussex/3/2*Barsoy	AV 92-42-52
Alpha/Durra//Antares/Ky63-1294	ICB90H-0042-0AP-1AP-0AP-5AP-0AP
Tipper/ICB-102854	ICB90-0032-0AP-5AP-0AP-2AP-0AP
Bkf/Magnelone 1604//Alouette	ICB-HA81-0072-1AP-1AP-0AP

Table 8.30. Sources of resistance to scald

Name	Pedigree
Line 9-26 F27	IPA-Iraq
Anca/2469//Toji'S'/3/Shyri	CMB87-0628-AL-2Y-2B-1Y-1M-0B-1M-0Y-0AP
Mammut//Gloria'S'/Come'S'	CMSWB92A-0141-0AP
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-6AP-0AP
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-8AP-0AP
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-3AP-0AP
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-1AP-0AP
Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-2AP-0AP
GLoria'S'/Copal'S'	CMB81-0295-30B-4Y-1M-1Y-1M-0Y-0AP
Estate/4/MCU33/Fza//Tib/3/PI 356456/5/Lignee 527/6/ Arar/Rhn-03	ICB93-0217-0AP-0AP
Alpha/Durra//Antares/Ky63-1294	ICB90H-0042-0AP-1AP-0AP-5AP-0AP

Table 8.31. Sources of resistance to barley stripe

Name	Pedigree
ArabiAbiad//WI2197/CI13520/5/ArabiAbiad/4/Bc//AwWhite/Aths /3/Kv/Mazurka/6/Arabi Aswad//WI2291/WI2269	ICB87-0938-0AP-13AP-0AP
SLB 39-67/3/Arr/Esp//Alger/Ceres,362-1-1	ICB88-1986-20AP-0AP
WI2291/WI2269//Arta	ICB88-1596-24AP-0AP
WI2291/WI2269/3/Atem/Roho//Katade	ICB89-0816-2AP-0AP-0AP
Atem/Roho//Katade/3/Aramir/Arabi Abiad	ICB89-0908-6AP-0AP-0AP
Mo.B1337/WI2291//JLB 37-74	ICB89-0168-11AP-0AP-0AP
RUSS94-1	

(A. Yahyaoui, Z. Alamdar, S. Grando, and S. Ceccarelli)

8.3.5.2. Wheat Germplasm Pools

In 1999, sources of resistance in bread wheat to yellow rust (Table 8.32), leaf rust (Table 8.33), stem rust (Table 8.34), and to septoria (Table 8.35) were assembled as germplasm pools and dispatched to NARS cooperators for further testing under natural infection and exploitation as advanced breeding lines or as sources of resistance in the crossing programs. The genotypes included in the disease germplasm pools (Tables 8.32-8.35) have been tested, in the breeding nurseries, in many countries in WANA.

Table 8.32. Sources of resistance to yellow rust in bread wheat

Name	Pedigree
CHAM 4//Vee'S'/Snb'S'	ICW91-0008-5AP-0TS-2AP-0TS-2AP-0L
F//68.44/Nzt/3/Cuc'S'/4/Algeria.M 28	ICW89-0293-2AP-0AP-2AP-0TS-0AP
KAUZ'S'/4/Car853/Coc//Vee#5'S'/3/Ures	ICW91-0497-0TS-6AP-0TS-1AP-0L-0AP
NS732/Her//Ures/Bow'S'	ICW91-0255-0TS-1AP-0TS-2AP-0L
Ns732/Her//71St2959/Crow'S'	ICW91-0205-0Br-2AP-1AP-0L
SUNBRI	-
Shi#4414/Crow'S'//Vee'S'/Snb'S'	ICW90-0196-0AP-1AP-0TS-1AP
Snb'S'//Shi#4414/Crow'S'	ICW91-0048-2AP-0TS-3AP-0TS-1AP-0L
Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/Mn72252/5/RmnF12-71/Jup'S'	ICW92-0012-0AP-4AP-0L-0AP
Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/Mn72252/5/Shi#4414/Crow'S'	ICW91-0273-4AP-0TS-1AP-0TS-2AP-0L-0AP
Vee'S'//Bow'S'/Crow'S'	ICW91-0243-2AP-0TS-4AP-2AP-0L

Table 8.33. Sources of resistance to leaf rust in bread wheat

Name	Pedigree
KAUZ'S'/Kauz'S'	ICW91-0493-0TS-5AP-0TS-1AP-0AP
KAVZ'S'//Kea'S'/Tan'S'	ICW90-0335-0AP-1AP-0TS-2AP-0L
Mon'S'/Ald'S'//Tow'S'/Pew'S'	ICW89-0237-1AP-0L-3AP-0AP-0Br-3AP-0AP
NS732/Her//Shi#4414/Crow'S'	ICW91-0182-0Br-2AP-1AP-0AP
NS732/Her//Shi#4414/Crow'S'	ICW91-0157-0Br-12AP-0TS-0AP
Opata/Bow//Bau/3/Opata/Bow	CMBW89Y00819-0TOPM-0AP-0TS-2AP-0TS-3AP
SKH8/4/Rrv/Wwi5/3/Bj'S'//On*2/Bon/5/Rbs/AnZA/3/kVZ/Hys//Ymh/Tob/4/Bow'	ICW88-0209-3AP-0L-5AP-0L-0AP
Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/Mn72252/5/RmnF12-71/Jup'S'	ICW92-0012-0AP-4AP-0L-0AP
Ures*2/Prl'S'//Tow'S'/Pew'S'	ICW91-0533-0TS-1AP-0TS-1AP-0AP

Table 8.34. Sources of resistance to stem rust in bread wheat

Name	Pedigree
F//68.44/Nzt/3/Cuc'S'/4/Algeria.M 28	ICW89-0293-2AP-0AP-2AP-0TS-0AP
KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	ICW91-0310-0Br-8AP-5AP-0L-0AP
KAVZ'S'//Kea'S'/Tan'S'	ICW90-0335-0AP-1AP-0TS-2AP-0L
Opata/Bow//Bau/3/Opata/Bow	CMBW89Y00819-0TOPM-0AP-0TS-2AP-0TS-AP
Tsi/Vee#5'S'//KAUZ'S'	ICW91-0295-5AP-0TS-2AP-4AP-0L-0AP
Vee#7/Kauz'S'	ICW91-0197-0TS-12AP-0TS-3AP-0L

Table 8.35. Sources of resistance to septoria in bread wheat

Name	Pedigree
Bau'S'/6/Atl66/H567.71//Atl66/5 /Pmn5//S948/4*Cno'S'/3/Pmn5	CM 03259-0AP-0L-1AP-0AP-0Br-1AP
COLOTANA	-
IAS58/4/KAL/BB//CJ"S"/3/ALD"S"/5/BOW"S"	CM81812-12Y-06PZ-6Y-4M-1Y-0M-0PZ
KAUZ'S'//Bow'S'/Nkt'S'	ICW90-0505-0AP-4AP-0TS-3AP-0L-0AP
KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	ICW91-0310-0Br-8AP-1AP-0L
KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	ICW91-0310-0Br-8AP-1AP
Psn'S'/Bow'S'//Kauz'S'	CM-0AP101432-0AP-0L-7AP-0AP-0Br-2AP-0AP
Sn64/Hn4//Rex/3/Edch/Mex/4/Sls's'/5/Bow's'	ICW85-0721-300L-300AP-300L-1AP-0L-0AP
Snb'S'/KAUZ'S'	ICW91-0038-0Br-3AP-0TS-1AP-0L

(A. Yahyaoui, M. Naimi, and O. Abdallah)

8.3.5.3. Resistance to rusts in Aegilops species

Aegilops accessions comprising different species or same species but collected from different regions in WANA were tested under artificial inoculation for resistance to yellow rust, leaf rust, and stem rust. Accession that showed resistance (R) or moderately resistance (MR) levels were selected for further testing using different rust virulence levels. The Aegilops accessions tested included 16 species. (Table 8.36). The Aegilops accessions tested showed good levels of resistance to yellow rust. Combined resistance to the rusts was relatively low. Accessions within each Aegilops species varied in their reaction to yellow and stem rust (Figure 8.4). Ae. ovata showed better levels of resistance compared to Aegilops trinucialis (Figure 5). All Ae. spletoides and Ae. triaristata accessions were completely resistant to both rusts (Table 8.36).

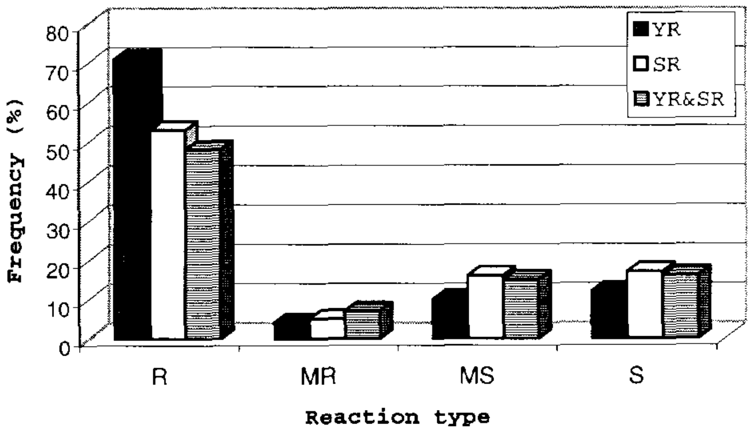

Figure 8.5. Resistance level to yellow and stem rust in two Aegilops
YR: Yellow Rust, SR: Stem Rust, R: Resistant, MR: moderately Resistant, MS: moderately Susceptible, S; Susceptible

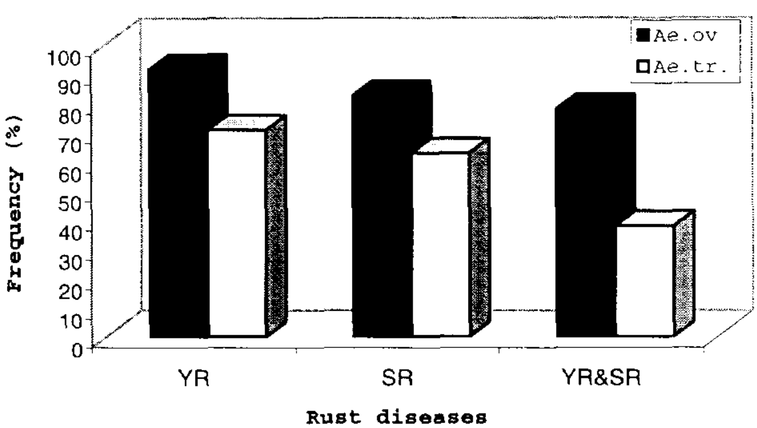

Figure 8.5. Resistance level to yellow and stem rust in two Aegilops species
Ae. ov; *Aegilops ovata*, Ae.tr; *Aegilops triuncialis*, YR: yellow rust, SR: stem rust, SY&SR: yellow and stem rusts.

Table 8.36. Reaction levels of sixteen *Aegilops* species to yellow rust and stem rust

	Number of accessions & Rust diseases		Number of *Aegilops* accessions within disease reaction types			
Aegiops species		Disease	Res.	Int. Res.	Int. Susc.	Susc.
Aegilops ovata	47	Yellow rust	42	1	0	4
		Stem rust	36	1	0	8
Aegilops triuncialis	17	Yellow rust	12	0	0	5
		Stem rust	7	3	0	6
Aegilops ventricosa	06	Yellow rust	0	2	2	2
		Stem rust	2	0	3	1
Aegilops speltoides	03	Yellow rust	4	0	0	0
		Stem rust	4	0	0	0
Aegilops biuncialis	03	Yellow rust	2	0	0	1
		Stem rust	0	0	0	1
Aegilops triaristata	02	Yellow rust	2	0	0	0
		Stem rust	2	0	0	0
Aegilops geniculata	02	Yellow rust	2	0	0	0
		Stem rust	1	0	0	0
Aegilops caudate	02	Yellow rust	1	0	0	1
		Stem rust	0	1	0	1
Aegilops species	07	Yellow rust	6	0	1	0
		Stem rust	2	0	0	5

(A. Yahyaoui, M. Naimi, and J. Valkoun)

8.3.6. BYDV Resistance in Wheat x *Thynopyrum ponticum* Derived Lines

A total of 3705 seeds obtained from 140 mature wheat plants regenerated from the callus obtained from culturing immature embryos of a number of wheat x *Thynopyrum ponticum* derived lines were planted in Giffy 7 pots, vernalized and then transplanted in the field. All plants were BYDV-inoculated at the seedling stage. Resistant individual plants were identified on the basis of no BYDV symptoms and no or low detectable virus by using the TBIA. Seeds from the best performing lines were harvested, and cytological studies are in progress to see whether or not the BYDV resistance genes, assumed to be located on one of both of the two telocentric chromosomes (described previously), have been introgressed into the 42 wheat chromosomes.

(K.M. Makkouk and W. Ghulam)

8.3.7. Selection of BYDV Resistant Barley Plants in F2 Population of 68 Crosses

The F2 population of 68 barley crosses, with one of the parents being BYDV resistant (QB 813, 2) and the other parent being different genotypes adapted to different agroecologies in WANA, were monitored weekly during the 1998/1999 growing season following artificial inoculation with the virus. All plants with clear BYDV symptoms were eliminated and seeds were harvested only from resistant, good looking plants. Two single plant selections from each cross were made on the basis of no symptoms and low BYDV concentration. The seeds from the rest of the good looking plants for each cross were bulked and BYDV resistance in the F3 populations will be monitored during the coming growing season.

(K.M. Makkouk, S. Ceccarelli, S. Grando and W. Ghulam)

8.3.8. Evaluation of Wheat Hessian Fly Nursery in Lattakia, Syria

Hessian fly is not an economical pest in Syria. However, it does exist in the coastal areas and causes damage on late-planted wheat. The objective of the present study was to test the efficacy of the known sources of resistance in wheat (bread and durum wheat) to the Syrian Hessian fly.

Five durum wheat and 19 bread wheat lines were tested in the field at Lattakia, Syria using an RCBD with four replications. Nasma, a Moroccan susceptible cultivar was included as a susceptible check. Each entry was planted in one-meter long row, and 30 cm apart from the next one. The material was planted very late (early January) to allow high infestation level. The evaluation, which was made in April, was based on the reaction of the total number of plants/ row. All the plants were pulled and taken to the lab at ICARDA for examination. Susceptible plants were stunted and had live larvae (flaxseeds).

The reaction of both durum wheat (Table 8.37) and bread wheat (Table 8.38) to Hessian fly in Lattakia indicates that the virulence of fly populations in Syria is quite different from that of Morocco. Of the 10 genes that are effective against Hessian fly in Morocco, only H5, H21, and to a lesser extent H7H8 are effective against Hessian fly in Syria. Four other bread wheat lines and two durum wheat lines also showed a good level of resistance (<30% susceptibility) to Hessian fly (Tables 8.37 & 8.38).

The American Uniform Hessian fly nursery with all the known genes (27) for resistance to Hessian fly will be tested next season in Syria, both under field and plastic house conditions, to confirm 1999 results and to determine the efficacy of the rest of the genes. Because this nursery consists of fixed bread wheat lines, its reaction to Hessian fly in Syrian will give a better picture of biotype difference among the fly populations in Syria, Morocco and USA.

Table 8.37. Reaction of some durum wheat lines to Hessian fly in Syria, field test, Lattakia

Entry/Pedigree	Crop species	Resistance gene	Percent infested plants
CI112	D. wheat	Unknown	29.8
CI113	D. wheat	Unknown	35.9
CI115	D. wheat	Unknown	22.8
CM829	D. wheat	Unknown	52.8
BD-DHFN#47	D. wheat	H5	4.8
Nasma (susceptible check)	B. wheat	None	80.1

Table 8.38. Reaction of some bread wheat lines to Hessian fly in Syria, field test, Lattakia 1999

Entry/Pedigree	Crop species	Resistance gene	Percent infested plants
SHI4414/CROW'S'	B.wheat	Unknown	39.9
BUC'S'/MN72253-	B.wheat	Unknown	54.9
IAS20/H567-1/4*IAS20/3/BOW'S'	B.wheat	Unknown	22.3
Jouda/Saada	B.wheat	H5	47.8
Jouda/KS811261-5	B.wheat	H13	59.9
Nasma*2/14-2	B.wheat	H22	49.7
Nasma*2/261-9	B.wheat	H13	55.4
Potam*3/KS811261-5	B.wheat	H13	42.2
Sais*2/14-2	B.wheat	H22	39.2
BUK"S"/CHIRC"S"/PRL"S"PVN	B.wheat	Unknown	28.5
BUK"S"/PRL"S"/PRL"S"/VEE	B.wheat	Unknown	51.1
Massira	B.wheat	Unknown	40.9
SBW18	B.wheat	Unknown	25.9
ADC14	B.wheat	Unknown	21.4
Seneca	B.wheat	H7H8	16.7
Kay	B.wheat	H11	80.1
BT82104B1-3-2	B.wheat	H14H15	72.1
Hamlet	B.wheat	H21	0.0
??	B.wheat	H23	43.8
Nasma (susceptible check)	B.wheat	None	80.2

8.3.9. Evaluation of a Collection of Wild Lentil Species for Resistance to *Sitona crinitus*

One hundred accessions of wild lentil species from ICARDA collection were screened for resistance to *S. crinitus* in the greenhouse. Ten accessions were sown in a pot (16×15cm) filled with soil mixture (peat moss: sand: soil) using a randomized complete block design with 10 replications. Seeds were sown in a circular manner around the edge of the pot. Plants were infested when they were about 10 cm in height. Twelve Sitona adults were used to infest the 10 plants/pot. Pots were covered by well-aerated plastic cages (15x30 cm). Three days after infestation, the cages were removed, and individual plants were scored for leaflet damage using a visual damage scale from 1-9 (1, no damage; 2, 1-10% leaflets damage; 3, 20-11% leaflets damage; 4, 21-30% leaflets damage; 5, 31-40% leaflets damage; 6, 41-50% leaflets damage; 7, 51-70% leaflets damage; 8, 71-90% leaflets damage; 9, more than 90% leaflets damage). The 8 promising accessions, which showed low level of leaflet damage were re-tested using the same procedure. The two accessions that showed the highest leaflet damage (4 and 11) in the first test were included as susceptible checks.

(Table 8.39) summarizes the final screening results. Only one accession 359 showed a significantly lower leaflet damage (score of 3, in the 1-9 scale). This finding is the first report of resistance to *S. crinitus* H. However, and even if there is a strong correlation between leaflet damage and nodule damage, this promising accession will also be tested for nodule damage under artificial infestation in the greenhouse and in the field.

(M. El-Demir (ARC, Aleppo), M. El Bouhssini, S. Sarker (ICARDA), N. Al-Salti (University of Aleppo))

8.3.10. Evaluation of a Wheat Collection for Resistance to Cereal Leaf Beetle in Kyrgyzstan

During the 1999 CAC cereal insect survey, cereal leaf beetle was found to be an important pest in Kyrgyzstan, mostly in Bishkek region. At the experimental Research Station 'Jal', there was a wheat collection of 3550 lines from different origins. This collection was heavily infested by cereal leaf beetle; the level of leaf damage by this insect varied from almost 0 to 100. This big variation in reaction encouraged us to evaluate visually this collection for resistance to CLB based on the amount of leaf defoliation caused by the larvae.

Table 8.39. Visual Damage Score on wild lentil accessions caused by *Sitona crinitus* H. adult feeding under artificial infestation in the greenhouse, Tel Hadya, ICARDA, 1999

Accession number	Visual damage score
4	7b
11	7b
71	9a
84	7b
87	6bc
90	5c
91	5c
93	6bc
239	6bc
359	3d
LSD 5%	1.8

Means followed by the same letter are non-significantly different, Duncan's multiple range test at 5% level.

Some 206 lines that showed a very low level of damage were selected. Another 6 highly susceptible lines were selected and will be included in future screening tests for comparison. The selected lines (promising and the six susceptible checks) will be planted next season in the same location (rows of 1 m long each and 4 replications). Late planted (mid-November) material was much more infested by cereal leaf beetle than the early planting (early October), we recommend that the material be planted after mid-November. As cereal leaf beetle is recognized to be a major insect pest of wheat in Kyrgyzstan, we recommend to start using this station as a hot spot location to screen for resistance to this pest. Other Integrated Pest Management components (cultural practices, biological control) should also be investigated.

(M. El Bouhssini (ICARDA), M. Djunusova and V. Isaeva (Scientific Research Institute of Agriculture, Kyrgyzstan))

8.4. New Developments in Screening Methodology

8.4.1. Comparison of Field Inoculation Methods to Screen for Chickpea Ascochyta Blight Resistance

Following a 2-year study (Annual Reports 1997 and 98), to determine the best time for debris spreading to increase the infection and development of Ascochyta blight in the screening nursery, it was concluded that the best time to inoculate with debris for optimum infection was in early January. Other alternatives to debris inoculations have been the use of spore suspension sprays and the use of infected susceptible checks to act as spreaders. During the 1998/99 cropping season a trial was initiated to further refine the field inoculation techniques by comparing all the possible alternatives of inoculation for optimum field infection. Five different methods of inoculation were compared with the non-inoculated control. These were: the use of infected seed of a susceptible cultivar as border rows or checks, the use of clean seed of the susceptible check, debris inoculation at planting, debris inoculation after germination, and spore suspension spray at the vegetative growth stage. The experiment was a split plot design with inoculation methods as the main plots and chickpea cultivars as the sub plots, in 3 replications.

The development of Ascochyta blight severity on 4 chickpea cultivars (ILC 263, Ghab 1, Ghab 3, and FLIP 88-85), using these different methods of inoculation was compared. (Table 8.40) summarizes the mean disease severity ratings on a scale of 1-9, on each cultivar, with the different inoculation methods as compared to the non-inoculated control. The results confirm earlier findings of the complete killing of the cultivars when inoculated with infected debris at planting. The most efficient method to inoculate field plots for optimum infection and disease development was to spread infected debris 4 weeks after germination (Table 8.40). This method of inoculation gave optimum infection on the susceptible cultivar and also produced a significantly higher level of infection on the moderately resistant ones as compared to the non-inoculated control. The method also clearly differentiated cultivar reactions to Ascochyta blight, with ILC 263 showing its high susceptibility and the other 3, their moderate resistance.

Conditions were generally favorable for the development and spread of Ascochyta blight during the early phase of the 1998/99 season. Infection from the infected debris spread in the nursery in January produced good initial infection. Due to a dry spell that pervailed during the vegetative phase of crop growth, disease spread was not adequate. By the end of April, spore suspensions with *A. rabiei* were spray-inoculated on the entries in the nursery and a mist irrigation system was turned on to increase humidity and facilitate disease spread. Following these spray inoculations, good disease development occurred as could be observed by the severe infection of check mixtures and death of the highly susceptible checks. Thus, it was possible to distinguish different levels of reactions to *A. rabiei* within the entries in the nursery.

(C. Akem and R.S. Malhotra)

Table 8.40. Severity of Ascochyta blight on chickpea cultivars using different inoculation methods

	Disease severity rating				
Inoculation methods	ILC 263	Ghab1	Ghab3	F88-85	Mean
Infected check-lanting	8.2	6.5	5.5	5.6	6.4
Clean check-planting	7.8	5.0	4.3	4.0	5.3
Infected debris-planting	9.0	9.0	9.0	9.0	9.0
Infected debris-germination	8.2	5.8	5.8	5.2	6.3
Spore spray	8.5	6.2	4.2	4.8	5.9
Control-No inoculation	7.8	4.5	3.5	4.5	5.1
Mean	8.3	6.2	5.4	5.5	-
LSD (0.05)	0.47	2.2	3.0	1.1	-
S.E	0.2	1.0	1.3	0.5	-

* Disease severity rating on a scale of 1-9; where 1=no infection, and 9=plants killed from high susceptibility.

8.4.2. Comparison of Field Inoculation Methods to Screen for Ascochyta Blight Resistance in Faba Bean

Field inoculations to screen faba bean lines for resistance to Ascochyta blight have often relied on spore suspension sprays. In chickpea, infected debris with *Ascochyta rabiei* has been established to be a better source of inoculum. Its effect has also been shown to depend on the time of spread. To explore the potential of using infected debris for inoculation of faba bean lines to screen for resistance to Ascochyta blight, different alternative methods of inoculation were compared with the non-inoculated control to determine the most efficient method for screening. These were: use of infected seed of a susceptible cultivar as border rows or checks, use of clean seed of the susceptible check, debris inoculation at planting, debris inoculation after germination, and spore suspension spray at vegetative growth stage. Four faba bean cultivars (ILB 1814, ICARUS, Giza 4, and Ascott), with known variable reactions to Ascochyta blight were used to compare the efficacy of the different methods of inoculation in causing disease severity. The experiment was a split design trial with inoculation methods as main plots and cultivars as sub plots in 3 replications. Two Ascochyta blight disease severity ratings, on the 1-9 rating scale, were taken at flowering and at podding to compare the efficacy of the different inoculation methods on the initiation and spread of the disease.

(Table 8.41) summarizes the mean disease severity of the second rating at podding, on each cultivar with the different inoculation methods as compared to the non-inoculated control. The results show a high level of infection of the susceptible cultivar, Giza 4, when inoculated with infected debris at planting. Since there was no complete kill of the cultivars with this method of inoculation, it appears to be the best method to inoculate faba bean lines for optimum infection to differentiate between reactions. The method also differentiates cultivar reactions to Ascochyta blight with Giza 4 and ICARUS showing their high susceptibility and the others their moderate resistance. Next in efficiency is the inoculation with infected debris after germination. Clean seed used as checks, even of a susceptible line, produced the same infection as the non-inoculated check (Table 8.41). This may not be a suitable method to increase disease initiation and spread. These results will need to be confirmed before being adopted for use in Ascochyta blight resistance screening in faba bean.

(C. Akem and S. Khalil)

8.4.3. Monitoring Virus Movement and Concentration in F2 Barley Populations

In an attempt to find a way in identifying BYDV resistant plants in barley F2 populations, to eliminate susceptible segregants early in the season, BYDV was monitored on the basis of symptoms produced and virus concentration in the stem at three and four weeks after inoculation. At three weeks after virus inoculation, no virus was detected in around 25-50% of the plants of the different F2 populations (Table 8.42). The regression coefficient between percentage of symptomless plants and percentage of plants with no detectable virus was slightly higher at 3 weeks as compared with four weeks after inoculation (Figure 8.6). Accordingly, it might be better to eliminate barley plants with detectable virus three weeks rather than four weeks after inoculation. This topic will be investigated further during the next growing season.

(K.M. Makkouk and W. Ghulam)

Table 8.41. Severity of Ascochyta blight on faba bean cultivars using different inoculation methods

Inoculation Method	*Disease severity (1-9)* on faba bean cultivars*					
	ILB 1814 Dis.Seed	ILB 1814 Clean seed	ICARUS	GIZA 4	ASCOTT	Mean
Infected check-at planting	4.0	3.0	4.0	7.0	2.7	4.1
Clean check-at planting	3.5	2.3	2.8	6.3	2.7	3.5
Infected debris-planting	5.3	4.0	7.7	8.5	4.7	6.0
Infected debris at germination	5.2	3.0	5.3	7.2	3.0	4.7
Spore spray on susceptible checks	3.7	2.7	2.5	5.5	2.2	3.3
Control- No inoculation	4.0	2.3	3.0	6.7	2.8	3.8
Mean	4.3	2.9	4.2	6.9	3.0	
LSD (0.05)	1.5	0.6	1.4	1.6	0.9	
S.E	0.6	0.3	0.6	0.7	0.4	

* Based on a disease rating scale of 1-9; where 1=no infection and 9=severe infection resulting in plant death.

8.4.4. Quantitative Glasshouse Assay for BYDV Resistance in Bread Wheat

In an effort to develop a simple plastic house test which could be used as a reliable guide for field performance, 23 bread wheat lines were planted in pots in the glasshouse, 3 plants/pot, 1 tiller/plant and 3 pots per genotype. The same bread wheat genotypes were planted in the field in 4x1 m rows. Both, plants in the plastic house and in the open field were artificially inoculated with BYDV at the seedling stage and before tillering. There was a correlation between the head weight in the glasshouse and grain yield in the open field (Figure 8.7). The predictability of open field yield under BYDV pressure from the plastic house head weight was low (R^2=0.123). Further refinement on this assay will be made during the next growing season.

(K.M. Makkouk and W. Ghulam)

Table 8.42. Monitoring symptoms appearance and relative virus concentration in F2 population of different barley crosses at three and four weeks following artificial inoculation with barley yellow dwarf virus

F2 population	Period after virus inoculation	% Symptomless plants	% of plants with different levels of virus concentration		
			High	Low	No virus
35	3 Weeks	23	49	23	28
36		41	38	22	40
38		35	38	23	39
39		48	27	34	39
40		45	25	34	41
42		41	25	30	45
45		47	27	25	48
47		49	14	29	57
49		41	26	25	49
52		47	20	22	58
33	4 Weeks	36	79	8	13
34		36	84	8	8
37		37	62	14	23
41		45	42	18	40
43		55	40	24	36
44		50	37	31	32
46		52	37	18	45
48		47	48	23	29
50		51	38	23	39
51		44	38	27	35

Number of plants used for each population ranged (119-188).

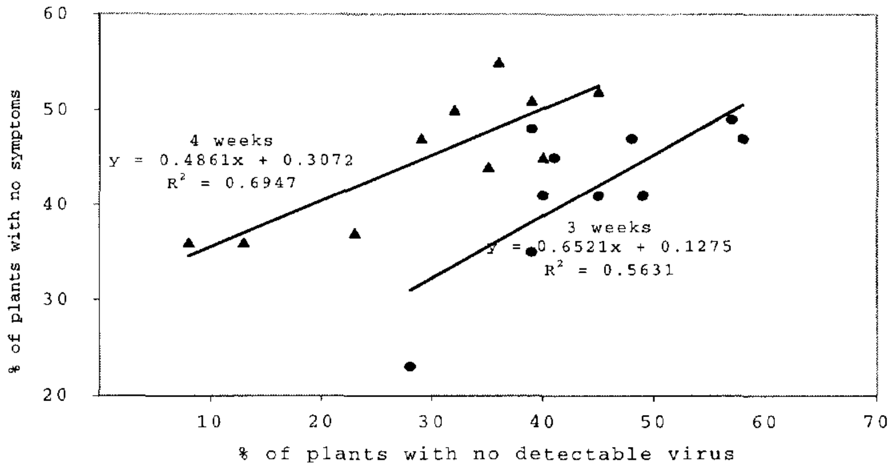

Figure 8.6. Correlation between % of plants with BYDV symptoms and % plants with no detectable virus in different barley F2 populations at three and four weeks after artificial virus inoculation.

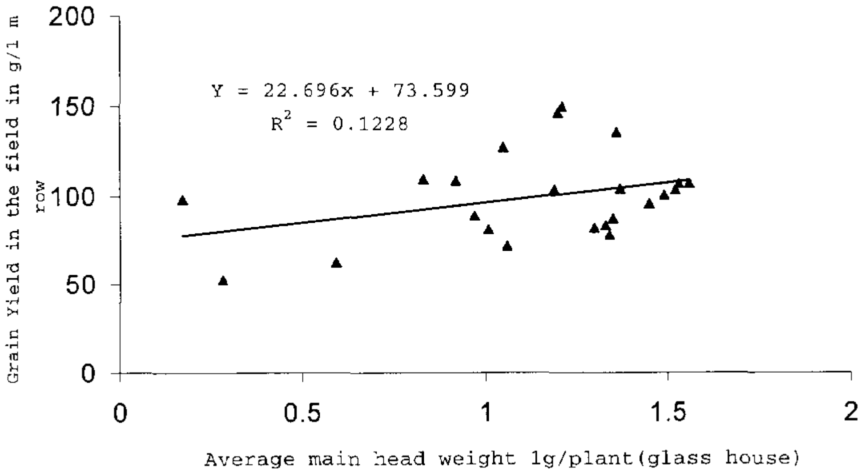

Figure 8.7. Correlation between grain yield in the field in grams and the average main head weight 1g/plant in the glasshouse for 23 bread wheat genotypes, when all plants were artificially inoculated with BYDV during the 1998-1999 growing season.

8.5. Integrated Pest Management

8.5.1. Ascochyta Blight of Chickpea

Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. Is the most important disease of chickpea in the West Asia and North African (WANA) region. It is particularly severe when the crop is planted during winter. Moderate temperatures of 15-25°C and high humidity of up to 100% prevailing during this period favor disease initiation and spread. Annual epidemics of the disease are thus usually weather-dependent. A good season for the chickpea crop is often favorable for Ascochyta blight epidemics. With the promotion of winter chickpea in the region, the risks of frequent Ascochyta blight epidemics are also increasing. Major emphasis is being given to the identification of sources of resistance to the disease for farmer use. Because this resistance is often non-durable due partly to the variability of the pathogen, emphasis is recently being shifted to the evaluation of other methods of containing the disease through an integrated disease management approach. This approach integrates host resistance with minimal chemical use as seed treatments and timed foliar sprays, and the modification of agronomic practices.

During the 1998/99 cropping season, a set of experiments initiated during the 1996/97 cropping season to evaluate the effect of different control components in integrated packages for the management of Ascochyta blight on winter chickpea cultivars was continued. The following 4 cultivars, FLIP 88-85, FLIP 90-96, Ghab 1 and Ghab 3, with different levels of reaction to the disease were evaluated in all the packages. In addition, seeds were treated with fungicides, and for each package there was the variation of one agronomic practice. Inoculum source for all the plots was from infected chickpea debris spread on the soil surface in the plots 4 weeks after crop germination. The experimental design for all the trials was a split-split plot with cultivars as main plots, seed treatments as sub plots and a cultural practice (sowing date, row spacing and fungicide timing) as sub-sub plots. The different packages were evaluated at 3 different on-station locations (Tel Hadya, Hemo and Al-Ghab) in Syria, in collaboration with NARS scientists.

8.5.1.1. Timing of Fungicide Applications to Manage Ascochyta Blight of Chickpea

The fungicide Bravo (Chlorothalonil) has been found to be effective as a foliar spray to control Ascochyta blight of chickpea. It was used to determine the optimum time for minimal foliar sprays to control Ascochyta blight on chickpea cultivars. The fungicide was applied once at 4 different growth stages (seedling, vegetative, flowering and podding) on the 4 chickpea cultivars tested. Seeds of all cultivars were treated with the fungicide Tecto (Thiabendazol) except for the seeds in control treatment which were not treated and plants emerged received no foliar spray. Ascochyta blight severity was evaluated on a 1-9 disease rating scale (1=no disease and 9=severe disease) after podding, to determine the effects of the fungicide seed treatments and foliar applications on disease severity of the chickpea cultivars. The best disease control on all the 4 cultivars was obtained with a single fungicide spray made either at the seedling or vegetative growth stage. The disease reactions at these stages were significantly lower than the non-sprayed control for all the cultivars at all the 3 locations (Table 8.43). Generally, single foliar sprays made after the flowering growth stage did not significantly reduce Ascochyta blight severity on most of the cultivars and locations. The drought conditions that prevailed in the later part of the cropping season did not allow for consistent crop growth, and so yields within and between locations could not be compared.

8.5.1.2. Integrating Planting Dates with Seed Treatments and Host Resistance to Manage Ascochyta Blight

Continuing with a comparison of the different planting dates that was initiated during the 1996/97 cropping season, 5 different planting dates in November, December, January, February and March, were used to evaluate treated and untreated seed of the 4 chickpea cultivars for reaction to Ascochyta blight at the 3 trial locations. Ascochyta blight disease severity ratings were taken at podding for the 3 winter dates and at flowering for the 2 spring dates. Plot seed yields could not be determined because of the highly variable growth between plots due to the prevailing drought conditions during the season. The lowest disease ratings on both treated and untreated seed were recorded with the March spring plantings for all the locations. These were significantly lower than the early winter plantings of all the cultivars (Table 8.44).

The highest disease severity ratings were obtained with untreated seeds of the first three plantings at the Al-Ghab and Tel Hadya locations. At the Hemo location, only the first two plantings of untreated seed had such significant high ratings. Overall, January plantings with treated seed gave the best results in terms of lower disease reactions at all the locations when compared with the earlier November or December plantings. Fungicide treated seeds only significantly reduced Ascochyta blight severity on the early plantings, when compared with the untreated seed, at the Hemo location.

Table 8.43. Effect of timing of a single fungicide spray on Ascochyta blight severity of chickpea genotypes during 1998/99 season

		Disease severity rating [a]				
		Chickpea genotype				
Location	Growth stage of fungicide spray	FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	Seedling	3.0	3.0	4.0	3.6	3.4
	Vegetative	4.0	3.7	4.0	4.0	3.9
	Flowering	5.6	4.6	5.3	4.6	5.0
	Podding	6.0	4.3	6.3	5.3	5.5
	No spray control	6.0	5.3	7.2	5.8	6.1
	LSD (0.05)	0.6	0.7	0.7	-	-
Heimo	Seedling	2.0	1.6	2.0	2.0	1.9
	Vegetative	2.0	2.0	2.0	2.0	2.0
	Flowering	2.6	2.0	2.0	2.0	2.1
	Podding	3.0	2.6	3.6	3.3	3.1
	No spray control	4.5	3.3	5.7	4.9	4.6
	LSD (0.05)	0.6	0.8	0.7	0.5	-
Al-Ghab	Seedling	2.6	2.3	3.7	3.0	2.9
	Vegetative	3.3	3.0	4.0	3.0	3.3
	Flowering	4.3	4.0	5.0	4.0	4.3
	Podding	4.7	4.3	5.3	4.3	4.7
	No spray control	5.7	5.0	6.7	5.3	5.7
	LSD (0.05)	1.1	1.0	1.3	1.1	-

[a]Based on a rating scale of 1-9 where 1=no infection and 9=plants killed

Table 8.44. Influence of planting date and fungicide seed treatment on Ascochyta blight severity of chickpea genotypes during 1998/99 season

Location	Planting date	Seed treatment	Disease severity rating [a] Chickpea genotype F 88-85	F 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	17 Nov	T	6.0	4.3	5.0	4.0	4.8
		NT	6.3	4.0	6.0	5.0	5.3
	19 Dec	T	5.7	4.7	5.0	4.6	5.0
		NT	6.0	4.3	6.0	4.6	5.2
	15 Jan	T	4.6	4.0	4.3	4.3	4.3
		NT	5.3	4.3	5.6	5.3	5.1
	16 Feb	T	4.3	3.6	4.3	3.3	3.9
		NT	4.6	4.0	5.3	4.0	4.5
	14 Mar.	T	3.0	3.0	3.0	3.0	3.0
		NT	3.0	3.0	3.3	3.0	3.1
	LSD (0.05)	T	1.0	1.1	1.1	0.7	
		NT	0.7	0.7	0.9	1.1	
Hemo	15 Nov	T	2.6	2.3	3.6	2.3	2.7
		NT	5.6	4.0	6.6	4.0	5.1
	17 Dec	T	3.0	2.0	3.3	2.3	2.7
		NT	5.0	3.3	6.0	5.0	4.8
	15 Jan	T	1.3	2.0	2.6	2.3	2.1
		NT	3.0	2.6	3.3	4.0	3.2
	18 Feb	T	1.6	2.0	1.6	1.3	1.6
		NT	2.6	2.6	2.6	2.0	2.5
	15 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	2.0	1.6	2.0	2.0	1.9
	LSD (0.05)	T	1.1	0.6	1.0	1.0	
		NT	1.3	1.0	1.2	1.5	
Al-Ghab	17 Nov	T	5.7	4.6	6.7	5.3	5.8
		NT	5.7	5.7	7.0	6.0	6.1
	15 Dec	T	5.3	4.6	6.3	5.0	5.3
		NT	5.7	5.7	6.0	6.3	5.9
	16 Jan	T	4.0	3.0	5.0	4.7	4.2
		NT	5.3	4.0	5.3	4.7	4.8
	14 Feb	T	3.0	3.3	3.0	2.7	3.0
		NT	3.3	3.0	3.3	3.0	3.2
	14 Mar.	T	1.3	1.3	1.3	1.3	1.3
		NT	1.3	1.3	1.3	1.3	1.3
	LSD (0.05)	T	1.0	1.2	1.2	0.7	
		NT	1.1	0.7	0.8	1.1	

[a]Disease severity based on a scale of 1-9 modified from Singh et al., (1981) ; where 1=no infection and 9=plants killed. T=Treated seed with the fungicide, Tecto at rate of 3g/kg; NT=non-treated seed.

8.5.1.3. Integrating Row Spacings with Seed Treatments and Host Resistance to Manage Ascochyta Blight

Temperature and relative humidity are the main environmental factors that greatly influence the development and spread of Ascochyta blight on chickpea. Both parameters, but especially the latter, can be influenced by plant density. Plant density between and within rows can be adjusted to reduce the canopy closure and thus lower rapid humidity build up during winter months. Adjustments however, have to be made such that optimum populations are maintained to achieve adequate yields in the absence of the disease. This can be obtained through inter-row rather than intra-row spacing. In the third integrated experiment, 4 row spacings (30, 45 cm, 60, and 75 cm) were used to determine the effect of plant populations integrated with seed treatments on the severity of ascochyta blight of the same 4 chickpea cultivars used in the other trials. Disease severity ratings were recorded as in the other trials. The plant populations ranged from 60 seeds/m^2 in the closer spacings to 24 seeds/m^2 in the wider spacings. There were generally no significant differences in disease severity between the treated and untreated seeds of the same spacings for all the locations (Table 8.45 & 8.46). Within the treated seeds, significant differences were recorded between the closest (30 cm) and widest (75 cm) spacings for the susceptible cultivars only (Table 8.45). With the untreated seeds, there were no significant differences in disease severity between the narrow and wide row spacings for all the cultivars at all the locations (Table 8.46).

8.5.1.4. Use of Systemic Activated Resistance to Manage Ascochyta Blight on Chickpea

The experiments, initiated during 1998 with the compound acibenzolar-S-methyl (CGA 245704), supplied by Novartis Ag Chemical Company and marketed as BION, on Ascochyta blight management were continued during 1999. This compound has been shown to be effective in activating systemic resistance in plants to a number of diseases. Because of limited success with a field trial in the first season, only the plastic house trial was repeated in 1999. Seven out of the 10 chickpea lines with varying levels of reaction to Ascochyta blight as in 1998 were grown in green house pots. At four weeks old, when the plants were fully at the vegetative growth stage, they were sprayed with the BION solution and covered for 24 or 48 hrs. Two BION concentrations were used, a high and a low at each covering period. The BION-sprayed plants were then challenge-inoculated with an aggressive isolate of *Ascochyta rabiei* and covered for 24 hrs. The experiment was a split plot design in 3 replications, with BION treatments as main plots and cultivars as sub-plots. Plants were observed for disease symptom development and rated on the 1-9 disease severity scale at 3 weeks after inoculations and again 3 weeks later just before podding.

BION sprays at both concentrations significantly reduced the severity of Ascochyta blight on only some of the 7 chickpea genotypes (Table 8.47). On some genotypes, the effect was more dramatic with the high concentration while on others it was with the lower concentration. The results were not consistent with the known cultivar reactions and may thus need further reconfirmation. To be of practical use, it will still be important to test and confirm the results under field conditions.

Table 8.45. Effect of row spacing on Ascochyta blight severity of treated chickpea genotypes at different locations in Syria during 1998/99 season

		Disease severity rating [a]				
	Row spacing	Chickpea genotype				
Location	(cm)	FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	5.7	5.3	6.3	5.3	5.7
	45	6.0	4.6	5.7	4.7	5.2
	60	5.5	4.3	5.0	4.3	4.8
	75	4.6	4.3	5.0	4.0	4.5
	LSD(0.05)	0.7	1.1	1.2	1.1	
Hemo	30	3.0	3.0	5.0	3.6	3.7
	45	2.3	2.0	4.0	3.3	2.9
	60	2.3	2.0	3.3	2.3	2.5
	75	2.3	2.0	3.0	2.3	2.4
	LSD(0.05)	0.9	0.9	0.6	1.2	
Al-Ghab	30	4.6	5.3	5.7	5.0	5.2
	45	5.0	4.3	6.0	4.3	4.9
	60	4.3	4.3	4.3	4.3	4.3
	75	4.0	4.3	4.3	4.0	4.1
	LSD(0.05)	0.7	0.9	1.1	0.8	

[a]Disease severity on a scale of 1-9; where 1=no disease and 9=plants killed

Table 8.46. Effect of row spacing on Ascochyta blight severity of untreated chickpea genotypes at different locations in Syria during 1998/99 season

		Disease severity rating [a]				
	Row spacing	Chickpea genotype				
Location	(cm)	FLIP 88-85	FLIP 90-96	Ghab 1	Ghab 3	Mean
Tel Hadya	30	6.0	5.3	6.7	6.0	6.0
	45	6.3	5.0	6.7	4.3	5.6
	60	5.8	4.3	6.3	4.3	5.2
	75	5.6	4.3	6.3	4.3	5.1
	LSD (0.05)	1.3	1.1	1.2	0.9	
Heimo	30	4.0	3.0	4.3	4.0	3.8
	45	4.7	2.7	5.3	4.0	4.2
	60	3.3	3.0	4.3	3.3	3.5
	75	3.3	2.7	4.0	3.0	3.2
	LSD (0.05)	1.3	0.8	1.1	1.3	
Al-Ghab	30	4.7	5.3	6.3	5.3	5.4
	45	5.3	5.0	6.7	5.0	5.5
	60	4.7	4.3	5.3	4.7	4.7
	75	4.3	4.3	5.0	4.3	4.5
	LSD (0.05)	1.2	1.3	1.3	0.9	

[a]Disease severity on a scale of 1-9; where 1=no disease and 9=plants killed.

Table 8.47. Effect of BION spray on Ascochyta blight severity of chickpea cultivars in the greenhouse;1999

BION	Ascochyta blight disease severity (1-9) on different cultivars							
Treatment	Ghab 1	Ghab 3	F88-85	F90-96	ILC190	F 93-210	ILC 1929	Mean
H 24 hrs	5.0	4.5	3.3	3.0	4.0	2.3	5.5	3.9
L 48 hrs	5.0	4.7	3.7	3.3	4.5	3.0	3.8	4.0
H 48 hrs	5.7	4.0	4.6	4.3	2.3	2.3	4.5	3.9
Control	7.0	6.3	6.7	5.0	5.0	5.0	7.0	6.0
LSD (0.05)	1.2	1.1	1.5	1.2	1.2	1.3	1.5	
SE	0.7	0.9	0.9	0.8	0.7	0.9	0.8	

H 24=High dosage of 0.08g/l covered for 24 hrs before pathogen inoculation. L 48=Low dosage of 0.04g/l covered for 48 hrs before pathogen inoculation.

8.5.1.5. Use of Cultivar Mixtures to Manage Ascochyta Blight

Farmers in the WANA region often plant seeds of a mixture of varieties rather than pure seeds, especially in crops where they have different varieties with different characteristics at their disposal. The mixture of cultivars with different reactions to diseases has been shown to be effective as a management tool for several foliar diseases. These include ascochyta blights in other leguminous crops, and thus cultivar mixtures could also play a role in the integrated management of chickpea Ascochyta blight.

To confirm promising results with cultivar mixtures obtained during the 1998 season, this trial was repeated using 2 chickpea cultivars, ILC 263 (susceptible), and Ghab 3 (resistant). The cultivars were mixed in different proportions (25:75; 50:50; 75:25) to test the reactions of the mixtures in comparison to the pure cultivars. The three mixture combinations were evaluated in field plots planted in a randomized block design in 3 replications. Disease development depended on infected chickpea debris-spread in the plots at the vegetative stages of plant growth. Disease was controlled in some of the pure cultivar plots with 2 foliar fungicide sprays to differentiate the effects of the mixtures on disease development. Two disease severity and incidence ratings were taken, the first just before flowering and the second at podding.

The two test cultivars maintained their susceptible and resistant reaction in the trial as indicated by significant differences in disease reactions in the pure unsprayed plots. The best mixture combination was one with a higher proportion of the resistant to the susceptible component (S25/R75). It gave a significantly lower disease reaction than the unsprayed susceptible control (Table 8.48). Other mixture combinations also gave better disease reactions than the unsprayed susceptible control.

(C. Akem, and S. Kabbabeh)

Table 8.48. Effect of cultivar mixtures on Ascochyta blight severity and incidence of chickpea

Mixture treatment	First disease rating at Flowering		Second disease rating at Podding	
	DS (1-9)*	DI (%)	DS (1-9)	DI (%)
ILC 263/Ghab 3 50/50	4.7	53	5.8	63
ILC 263/Ghab 3 75/25	5.7	63	7.0	70
ILC 263/Ghab 3 25/75	4.3	50	5	60
Ghab 3 with 2 sprays	3.2	45	4.2	53
ILC 263 with 2 prays	5.7	70	6.8	80
Ghab 3 nonspray	4.0	63	4.3	70
ILC 263 nonspray	7.3	85	8.3	90
Mean	4.9	61	5.9	69
LSD (0.05)	1.0	25.3	1.1	24.0
SE	0.4	11.6	0.5	11.0

* Based on a disease severity rating scale of 1-9 where 1=no infection and 9=severe infection.

8.5.2. Integrated Management of Fusarium Wilt of Lentil

8.5.2.1. Integration of Soil Solarization, Genetic Resistance, Sowing Dates and Fungicide Seed Treatment to Manage Fusarium Wilt of Lentil

8.5.2.1.1. Field experiments

The integration of four components (solarization, cultivars, sowing dates and fungicide seed treatment) for the management of lentil vascular wilt was evaluated under field conditions, in the lentil fusarium wilt sick plot. A strip of the plot was solarized with polyethylene covering for 70 days after irrigating to field capacity; another strip of similar acreage was left as control.

Four genotypes, differing in their reactions to wilt (ILL 2130, moderately susceptible; ILL 5748 and ILL 5722 moderately resistant and ILL 5883 highly resistant) were tested. Benlate-T (Benomyl-Thiram) was used for seed treatments at 1g ai/kg of seed. Three sowing dates investigated were Mid November, Mid December 1998 and Mid January 1999. The seeding rate was 250 seeds m^{-2}. The experiment was a split-split plot design in three replications with solarization as main plots, sowing dates as sub plots and genotypes with seeds treated or non-treated with the fungicide, as sub sub plots. Disease evaluations were taken, by visually estimating the percent of wilted/killed plants, three times at 15 days intervals, starting from 20 April and ending on 13 May 1999. The middle row of each sub-sub plot unit was harvested at maturity (24/5/99), and only biological yield was determined. Seeds, although obtained, were lost due to a burning in the fumigation chamber. Data were subjected to analyses of variance to determine least significance differences (first experiment).

The strip, which has been solarized in 1997, was also planted this year to study the residual effect of solarization on wilt incidence and yield component. Treatments in this experiment were similar to the above-mentioned except for sowing dates, where only 2 sowing dates were investigated, mid December 98 and mid January 99 (second experiment).

Seed treatments with fungicide, in both experiments, did not have any effect on the severity of lentil vascular wilt and may not be useful in the integrated management of the disease.

Overall means indicate that percent terminal wilt increased and biological yield (BY) decreased, when sowing was delayed from mid Nov. to mid Jan. in both solarized and non-solarized treatments. The differences were significant for BYD and non-significant for % terminal wilt (Table 8.49).

Overall means for % terminal wilt for the four genotypes tested confirmed their earlier ranking for wilt susceptibility with ILL 5883 being the most resistant and ILL 2130 the most susceptible (Table 8.50).

Interactions between genotypes and sowing dates were significantly different for BYD but not for % terminal wilt. However, the later was consistently higher when sowing was delayed from mid November to mid January (Table 8.51)

Table 8.49. Effect of sowing dates on percent terminal wilt (% term. wilt) and biological yield g m^{-2} in the 1st. experiment (solarized and non-solarized strips)

Sowing	sowing 1		sowing 2		sowing 3	
Parameters	% term. wilt	BYD	% term. wilt	BYD	% term. wilt	BY
	11 a	505 c	13 a	428 b	16 a	337 a
LSD	11	59	-	-	-	-

Table 8.50. Means of % terminal wilt and biological yield for the 4 cultivars tested

Genotypes	ILL 2130		ILL 5722		ILL 5748		ILL 5883	
Parameters	%wilt	BYD	%wilt	BYD	%wilt	BYD	%wilt	BY
	23 b	448 b	15 b	368 a	12 ab	424 b	4 a	455 b
LSD	9	50	-	-	-	-	-	-

Table 8.51. Means of % terminal wilt and biological yield for the 4 cultivars tested in different sowing dates

Genotypes	sowing 1		sowing 2		sowing 3	
	% term. wilt	BYD	% term. wilt	BYD	% term. wilt	BYD
ILL 2130	19 b	540 b (b)	22 b	463 b(b)	30 b	339 ab(a)
ILL 5722	10 ab	463 ab (c)	19 ab	375 a(b)	15 ab	264 a (a)
ILL 5748	11 ab	448 a (a)	8 ab	438 ab(a)	18 ab	386 b (a)
ILL 5883	3 a	570 b (b)	4 a	436 ab(ab)	4 a	360 b (a)
LSD Bs	15	86	-	-	-	-
Ss	15	86	-	-	-	-

* Ss=LSD value for same solarization, Bs=LSD value between solarization treatments.

Figures between brackets followed by similar letter (s) are not significantly different between sowing treatments.

Figures outside brackets followed by similar letter (s) are not significantly different within same sowing treatment.

BYD was significantly higher and % terminal wilt was significantly lower, for all genotypes, in solarized treatment compared with the non-solarized one (Table 8.52). The increase in BYD in the solarized treatment might be partly explained by the effect of solarization on % terminal wilt. Other factors such as the quantity of water available to the plants in the different sowing dates as well as the effect of solarization on nutrient availability could also play a part.

Table 8.52. Interactions between genotypes and solarization

Genotypes	sol-		sol+	
	% term. wilt	BY	% term. Wilt	BY
ILL 2130	40 c (b)	264 ab (a)	7 a (a)	631 b (b)
ILL 5722	25 b (b)	217 a (a)	5 a (a)	518 a (b)
ILL 5748	20 b (b)	285 ab (a)	4 a (a)	564 ab(b)
ILL 5883	5 a (a)	318 b (a)	2 a (a)	593 b (b)
LSD Bs	34	81		
Ss	13	70		

* Ss=LSD value for same solarization, Bs=LSD value between solarization treatments.

Figures between brackets followed by similar letter(s)are not significantly different between sol treatment.
Figures outside brackets followed by similar letter(s) are not significantly different within same sol treatment.

Table 53 summarizes the effect of interactions between solarization x sowing dates x genotypes on % terminal wilt and BYD of lentil. Differences in % terminal wilt, for the four genotypes tested, were significantly different in the non-solarized treatment, but disappeared in the solarized one. Differences, in this parameter, between solarization treatments were also significant, especially for the susceptible ILL 2130, in December and January sowings. The highest % wilt values were recorded in January sowing for all genotypes, except for ILL 5722 where the highest value was recorded in December sowing. BYD, for all genotypes, peaked in November sowing. This can be explained by the fact that the crop received more water, and was least affected by wilt. BYD were consistently higher in the solarized treatment. However, differences between solarization treatments were not significant. It is worth-mentioning that ILL 5883 gave the best BYD in the non-solarizesd treatment and equaled ILL 2130 in the solarized one (Table 8.53).

Table 8.53. Summary of statistical analysis for 1st. experiment

Gentypes	Sowing date	% Terminal wilt		BY	
		Sol-	Sol+	Sol-	S01+
ILL 2130	DATE 1	31.0 ab(a)	6.3 a(a)	340 b	740 c
	DATE 2	38.0 b(b)	6.0 a(a)	288 b	638 bc
	DATE 3	51.0 b(b)	8.0 a(a)	163 a	516 b
ILL 5722	DATE 1	15.0 ab(a)	5.5 a(a)	289 b	646 bc
	DATE 2	37.0 b(b)	3.5 a(a)	191 a	559 b
	DATE 3	23.0 ab(a)	6.0 a(a)	181 a	348 a
ILL 5748	DATE 1	16.0 ab(a)	6.0 a(a)	255 a	642 bc
	DATE 2	12.0 ab(a)	4.5 a(a)	338 b	540 b
	DATE 3	33.0 ab(a)	3.0 a(a)	261 a	511 b
ILL 5883	DATE 1	4.6 a(a)	2.3 a(a)	395 b	745 c
	DATE 2	4.5 a(a)	2.5 a(a)	318 b	554 b
	DATE 3	5.8 a(a)	2.0 a(a)	239 a	481 b

LSD 5% for % terminal wilt=22 for within same solarization, 28.9 between solarization

LSD 5% for biological yield=122 for within same solarization, 488 between solarization

Figures between brackets followed by similar letter (s) are not significantly different between sol treatment.

Figures outside brackets followed by similar letter(s) are not significantly different within same sol treatment

Results of the three-solarization treatments are summarized in (Table 8.54) % terminal wilt values were less and BYD were higher in the strips solarized in 1997 compared to the non-solarized one, indicating a residual effect of solarization on both parameters. However, differences were only significant between the current year solarization treatment (sol 98) and the two others.

Table 8.54. Summary of statistical analysis for 2nd. Experiment

	Non-solarized		Solarized 97		Solarized 98	
Genotypes	%terminal wilt	BYD	%terminal wilt	BY	%termina l wilt	BY
ILL 2130	44 b (b)	226 ab (a)	28 b (ab)	296 a (a)	7 a (a)	577 b (b)
ILL 5722	30 b (b)	186 a (a)	8 ab (ab)	314 a (ab)	5 a (a)	453 a (b)
ILL 5847	22 ab(a)	300 b (a)	15 ab (a)	323 a (a)	4 a (a)	525ab (b)
ILL 5883	5 a (a)	279 b (a)	5 a (a)	316 a (a)	2 a (a)	518ab (b)
LSD Bs*	24	192				
Ss	18	86				

* Ss=LSD value for same solarization, Bs=SD value between solarization treatments.

Figures between brackets followed by similar letter (s) are not significantly different between sol. treatment.

Figures outside brackets followed by similar letter (s) are not significantly different within same sol. treatment

8.5.2.1.2. Plastic House Experiment

Wilt management through soil solarization (non-solarized (sol-), solarized in the previous season (sol 97) and solarized this season (sol 98), seed treatment (+/-) and genetic resistance was also investigated under plastic house conditions. Four lentil genotypes, as in the field trials, differing in resistance levels to vascular wilt were used. Seeds were also dressed with Benomyl-T @ 1 g a.i /kg seed. Seeds were sown in pots in soil collected from non-solarized strips and from strips solarized in 97 and 98 from the sick plot. The experiment was in split-split design with solarization as main plots, genotypes as sub-plots and fungicides as sub-sub plots with 3 replications. Pots were arranged on aluminum table in plastic house kept at 20/15 ^{o}C day/night, and irrigated as needed. Wilt severity scores were recorded at two weeks intervals, starting two months after sowing until plant maturity, using 1-9 scale where 1=plants healthy and 9=completely wilted plants. Biological and seed yields were also recorded. Analysis of variance was performed for all parameters recorded. Similar to field experiments, seed treatment with benomyl-T had no effect on wilt incidence and severity.

Results revealed high significant differences among lines tested for their reaction to lentil wilt in the three solarization treatments, with ILL5883 being the most resistant. Both solarization treatments (sol 97 & sol 98) of fusarium infested soil significantly decreased wilt severity and increased BYD and SYD for the four genotypes tested as compared to the control treatment (sol-). The decrease in wilt severity and the increase in BYD and SYD were more pronounced in sol 98 compared to sol 97 (Table 8.55).

From the above investigation, it can be concluded that an integrated management of lentil vascular wilt is possible with the integration of moderately resistant accessions, solarization and adjustment of sowing dates. Special attention needs to be given to the control of weeds which are generally more severe in early sowings.

(B. Bayaa, S. Kemal, C. Akem A. Sarker and W. Erskine)

Table 8.55. Summary of statistical analysis of plastic house experiment.

	Sol-			Sol 97			Sol 98		
Genotypes	Wilt score	BY	SY	Wilt score	BY	SY	Wilt score	BY	SY
ILL 2130	8b(c)	132b(a)	32b(a)	4.9b(b)	344c(b)	103b(b)	2.6b(a)	467c(c)	117a(b)
ILL 4605	9b(a)	0 a(a)	0a(a)	7.8d(a)	100a(b)	48a(b)	7.8c(a)	223a(c)	77a(b)
ILL 5722	86b(c)	11a(a)	2a(a)	6.4c(b)	192b(b)	66ab(b)	1.9ab(a)	384b(c)	141b(c)
ILL 5883	1.5a(a)	182b(a)	40b(a)	2a(a)	288c(b)	102b(b)	1a(a)	377b(c)	116a(b)
LSD Ss*	1.2	83	42						
Bs	1.4	76	39						

* Ss=LSD value for same solarization, Bs=LSD value between solarization treatments.

Figures between brackets followed by similar letter (s) are not significantly different between sol. treatment.
Figures outside brackets followed by similar letter(s) are not significantly different within same sol. treatment

8.5.3. Integrated Disease Management

8.5.3.1. Scald Management

Scald is frequent in many counties in CWANA, particularly in areas with cool winter temperatures. Resistance break down is common for scald disease. The variety Rihane, released in North Africa in 1986, occupies more than 40% of the barley areas in Morocco, and up to 80% of the barley area in Tunisia. Rihane is also a popular variety in Iraq, Algeria, and many other countries. The resistance in Rihane is no longer effective against most diseases, scald in particular. The barley line WI 2291 has been used in many crosses and varieties have been released. WI 2291 is highly susceptible to scald in Syria.

The objective of the scald management experiment is to test the changes in disease severity and performance of barley cultivars in mixtures. The mixture included a resistant variety (V1), a moderately resistant (V2) and a susceptible variety (V3) to scald in different mixtures as follows:

Treatment	Variety resistance to scald and mixture proportions
V1-	Resistant variety
V2-	Moderately resistant variety
V3-	Susceptible variety
V4-	1/3V1: 1/3V2: 1/3V3 Mixture
V5-	1/4V1: 1/4V2: 1/2V3 Mixture
V6-	1/4V1: 1/2V2: 1/4V3 Mixture
V7-	1/2V1: 1/4V2: 1/4V3 Mixture

The severity of scald was evaluated, in the inoculated and the protected treatments. Difference in severity was apparent in all the varieties. The highest reduction was observed in V7 treatment (Figure 8.8), where the resistant variety represented 50% of the mixture, followed by V4 treatment where equal proportion of the three varieties was used.

The effect of varietal mixture was on the biomass and straw yield also significant (Figure 8.9). The highest biomass and straw yield were recorded in treatment V5 where the susceptible cultivars represented 50% of the mixture. The biomass and straw yield obtained in the mixture were higher than that of the individual varieties. Slight increase in grain yield was also observed in the mixture of varieties. The varietal mixture resulted in slight increase in yield and significantly higher straw yield than grain the pure varieties. The lower incidence of scald in the mixtures will allow reduction in the inoculum concentration for the following season, and hence less disease pressure.

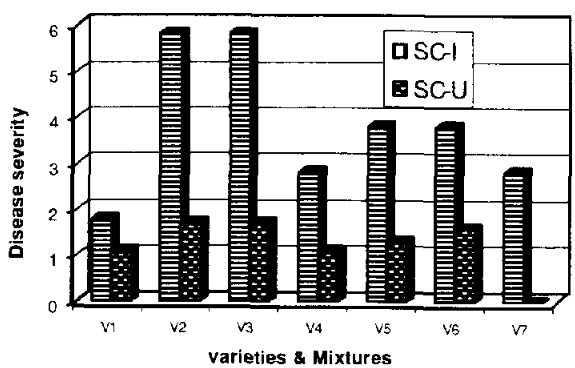

Figure. 8.8. Scald Management: Disease severity

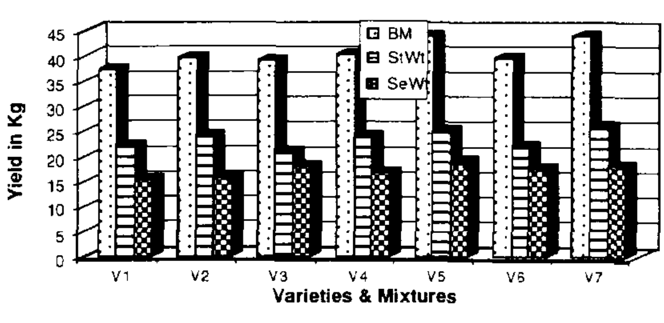

Figure 8.9. Effect of varietal mixture on yield

8.5.4. Integrated Management of Virus Diseases

8.5.4.1. Effect of Seed Dressing Insecticide Treatment Imidacloprid (Gaucho®) on BLRV and SbDV Spread in Different Lentil Genotypes after Artificial Virus Inoculation with Aphids

The usefulness of seed-dressing with Imidacloprid (Gaucho®) a nitroguanidine group insecticide to reduce spread of the aphid vectored bean leaf roll virus (BLRV) and Soybean dwarf virus (SbDV) was investigated in a field experiment conducted at Tel Hadya, Aleppo, Syria, using seven lentil genotypes: ILL 74 (resistant to BLRV and moderately resistant to SbDV); ILL 75 (resistant to BLRV & SbDV); ILL 2581, ILL 4401 (moderately resistant to BLRV and susceptible to SbDV); ILL 6015, ILL 7212, ILL 7949 (susceptible to BLRV & SbDV).

Lentil seeds were treated with Gaucho® at the rate of 0.5, 1 and 2 g/kg of seeds and compared with untreated seeds (control). The experiments were carried out in a randomized complete block design (RCB) with two replicates for both the inoculated and non-inoculated treatments. Each replicate plot consisted of 2 rows (2 m long), 30 cm apart, with 3 cm between plants within the row. Seventy days after sowing, all plants were artificially inoculated with the virus by using the aphid vector *Acyrthosiphon pisum*.
Results obtained showed that Gaucho treatment significantly improved lentil yields of moderately resistant and susceptible lentil genotypes, whereas the effect on the yield of resistant genotypes was not significant. In addition, Gaucho seed treatment was more effective in increasing seed yield of BLRV-inoculated plots as compared to SbDV-inoculated plots. In other words, the seed treatment was more effective in reducing BLRV spread than SbDV spread (Table 8.56).

(K.M. Makkouk and S.G. Kumari)

8.5.5. Effect of *Melia azederach* Seed Water Extract on Sitona Feeding

Sitona crinitus H. is an important pest of lentil in West Asia and North Africa. *Sitona* adults feed on leaflets, but it is the larvae that feed on nodules that cause most damage. Insecticides effective against this pest have been identified, but their use in farmer fields is very limited because of the high cost. The environmental hazards associated with them is another consideration. ICARDA and its partner organizations in the region have been evaluating alternatives to the use of conventional insecticides.

Table 8.56. Effect of seed dressing insecticide treatment Gaucho® on the yield of lentil genotypes artificially inoculated with bean leaf roll virus (BLRV) and soybean dwarf virus (SbDV)

		Yield (gram)			
		Gaucho concentration (g/ Kg seeds)			
Lentil Genotype	Inoculum	0	0.5	1	2
ILL 74	Control (no virus)	132 a	125 a	122 a	120 a
	SbDV	98 a	99 a	113 a	117 a
	BLRV	120 a	121 a	119 a	119 a
ILL 75	Control (no virus)	119 a	120 a	114 a	116 a
	SbDV	99 a	106 a	109 a	115 a
	BLRV	110 a	114 a	112 a	115 a
ILL 2581	Control (no virus)	100 a	96 a	105 a	107 a
	SbDV	14 a	35 ab	52 bc	67 c
	BLRV	49 a	68 ab	80 bc	91 c
ILL 4401	Control (no virus)	220 a	227 a	230 a	220 a
	SbDV	14 a	35 ab	51 b	74 c
	BLRV	139 a	183 b	206 c	204 c
ILL 6015	Control (no virus)	178 a	185 a	182 a	184 a
	SbDV	32 a	37 a	53 a	81 b
	BLRV	72 a	132 b	134 b	143 b
ILL 7212	Control (no virus)	185 a	192 a	197 a	192 a
	SbDV	29 a	41 a	74 b	91 b
	BLRV	64 a	96 b	102 b	170 c
ILL 7949	Control (no virus)	234 a	239 a	249 a	244 a
	SbDV	75 a	91 a	133 b	149 b
	BLRV	52 a	120 b	157 c	195 d

LSD=22.1, Average values followed with the same letters in the same horizontal row were not significant.

Powder from *M. azedarach* dry fruits was soaked in tap-water for 24 hours; three concentrations were prepared, 15, 25 and 50 g/l. Deltamethrin (0.1 %) and water were used as checks. Ten seedlings of lentil/pot at about 10 cm height were infested with six pairs of Sitona adults. The infestation was made 30 minutes after the plants have been sprayed. The percentage of leaflet damage was assessed 3 days after infestation.

Feeding activity was significantly reduced on plants treated with the three concentrations (15, 25 and 50 g/l); leaflet damage for the three concentrations was 24.8, 24.2, and 14.7%, respectively, whereas that of the unsprayed check was 98%. The 50 g/l concentration gave a significantly less leaflet damage than the other two (Figure 8.10)

Since *M. azedarach* is a widely distributed tree in WANA, the use of water extracts from *Melia* fruits could provide a cheap and environment-friendly means of controlling this lentil pest. Because of these promising results, further studies are being carried out to determine whether there is any residual effect from *Melia* fruit extracts on seeds of treated plants and any side-effect on beneficial insects.

(M. El-Demir (ARC, Aleppo), M. El Bouhssini (ICARDA) and N. Al-Salty (University of Aleppo))

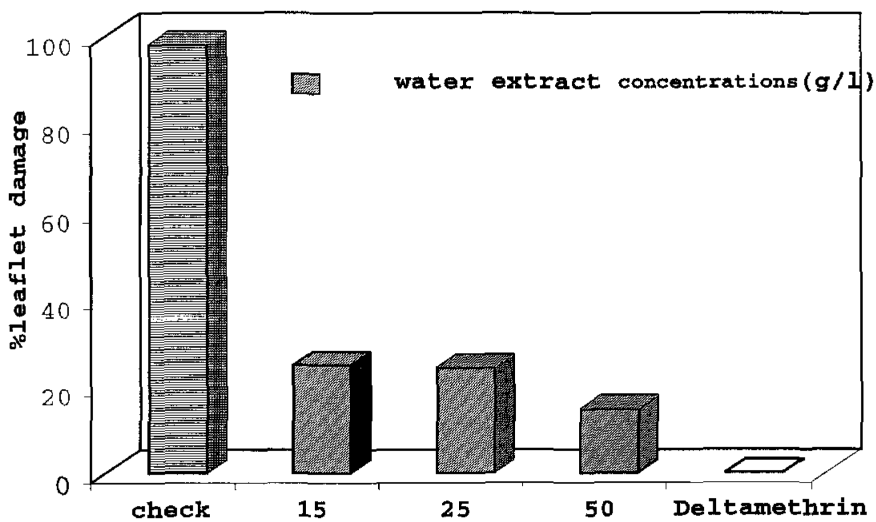

Figure 8.10. Effect of three concentrations of water extracts dry fruits of *Melia azedarach* on *Sitona crinitus* adult feeding

8.5.6. Screening of Bt Toxins Against Adults and Larvae of *S. Crinitus*

Seventy-five Bt toxins obtained from the Centre for Rhizobium Studies (CRS, Australia) were evaluated for their efficacy against adults of *S. crinitus*. The bioassay was conducted in the entomology lab at ICARDA. Two lentil leaflets were soaked in the toxin and allowed to dry, and then placed in a small plastic container to which one *Sitona* adult was added. The test was repeated five times, and water was used as the test control. The adults used in the test were starved for 24 h prior to their use for infestation. The evaluation of leaflet damage was done 24 h after infestation.

Fifteen toxins gave 100% protection against adult feeding; there was no leaflet damage (no feeding), where as the control (water) had leaflet damage ranging between 80-100%.

The remaining quantities of the 15 promising toxins were used against adults to screen against *Sitona* larvae. We used second instar larvae extracted from field soil samples at Tel Hadya. One nodule was soaked in the toxin and placed in a small plastic container (a little bit bigger in size than the Elisa test tubes) along with one *Sitona* larva. The control was also water, and the test was replicated 10 times. The evaluation of the test was based on larval mortality after 72 h.

All the 15 toxins did not show any efficacy against *Sitona* larvae. However, the 15 toxins will be re-tested next season against larvae, as their efficacy might have been affected during the handling process. The same material was screened against adults, and only remaining quantities, which were stored for few weeks in a regular freezer, were screened against larvae.

(M. El Bouhssini (ICARDA), W. Reeve (CRS, Australia), R.A. Fadel, M. El-Demir (ARC, Aleppo) and A. Joubi (ICARDA))

8.5.7. IPM of Chickpea Leafminer

Chickpea leafminer, *Liriomyza cicerina* Rond. is an important insect pest of chickpea in WANA. Yield losses caused by this pest could go as high as 30%. Efforts are put on developing an IPM package based on host plant resistance, planting date and safe chemicals.

An experiment comparing the effect of planting date (winter vs spring), varieties (local vs improved) and a safe chemical (Neem oil vs deltamithrin) was carried out in the field at Tel Hadya. The experimental design used was a split plot with planting date as the whole plot and variety by insecticide application as the sub plot; 4 replications were used in this experiment. The chickpea cultivars used were a Syrian local and Ghab3, and the treatments used were Neem oil (2ml/l) and deltamithrin) (0.25cc/l). Neem oil was sprayed three times tarting from the insect appearance at ten days intervals. Deltamethrin was sprayed just one time when the insect appeared in the field. A random sample of 30 leaves from each plot was taken twice a week. The leaves were put in small plastic cages covered with a cheesecloth and placed in the rearing room (22°C, 16:H light). The following measurements were taken: number of mining (damaged leaflets), number of pupae, number of adults and number of adult parasitoid, *Opius monilicornis*.

The results showed that winter-sown chickpea had significantly less mining than the spring-sown chickpea (Figure 8.11). The cultivar Ghab3 and neem oil also reduced significantly the number of chickpea leafminer and the minning (Figures 8.12 & 8.13).

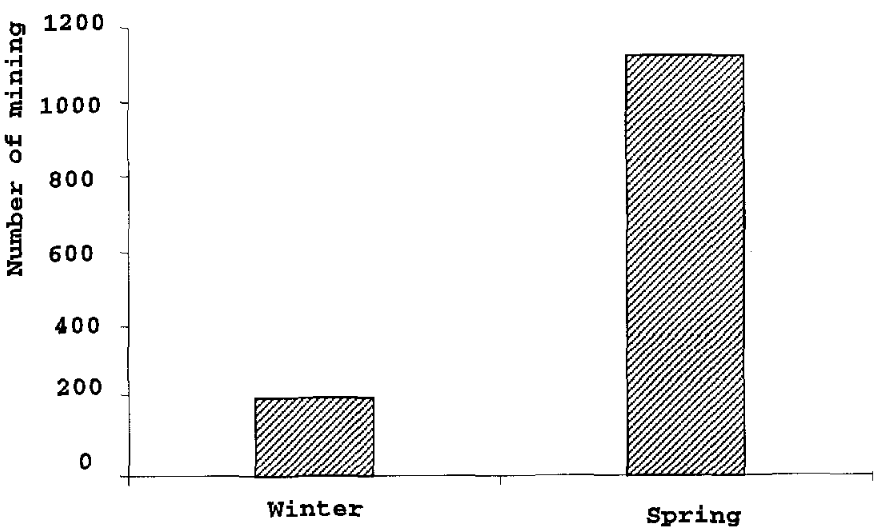

Figure 8.11. Effect of planting dates on number of mining caused by leafminer, Tel Hadya

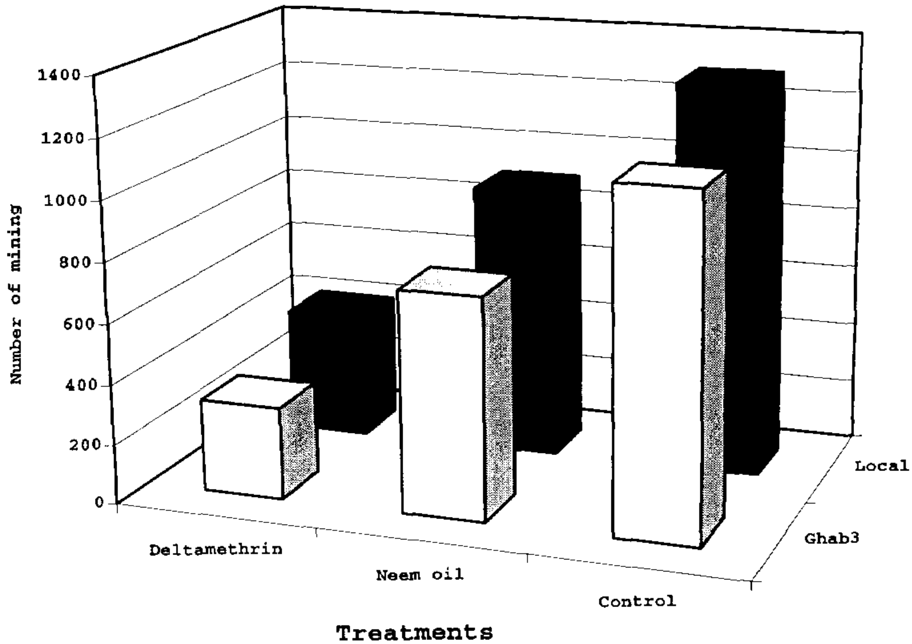

Figure 8.12. Effect of neem oil, deltamethrin and varieties on number of mining caused by leafminer

The use of Deltamithrin reduced significantly the number of parasitoids, by about 70%, compared to the unsprayed check. Neem oil had a relatively lower effect on parasitoid (Figure 8.14). These results corroborate those of last year. An IPM package comprising a resistant cultivar, Neem oil and winter planting date should reduce leafminer damage and at the same time conserve natural enemies.

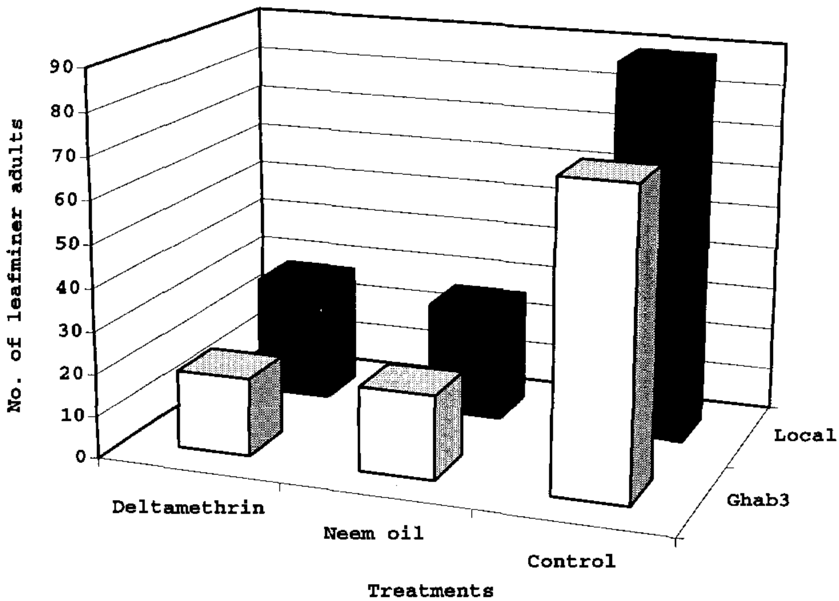

Figure 8.13. Effect of neem oil, deltamethrin and varieties on number of leafminer adults, Tel Hadya

8.5.8. Larval Parasitoids of Chickpea Leafminer

The level of parasitism of chickpea leafminer by the two larval parasitoids, *Opius monilicornis* and *Diglyphus isaea* was assessed at Azaz and Tel Hadya. The experiment was a RCBD with 10 reps. A random sample of three plants was taken from each rep., and leaves were put in small plastic containers and placed in a rearing room (22±2°C, 16 H light, 75% RH). Samples were taken three times during the season.

The level of parasitism of *O. monilicornis* at the two locations was significantly higher than that of *D. isaea*, and reached about 70% on the third generation of the leafminer. At this time, the level of parasitism of *D. isaea* was about 5% (Figures 8.15 & 8.16). The larval parasitoid *O. monilicornis* seems to be playing an important role in regulating the chickpea leaf miner populations and should be conserved in nature.

(M. El Bouhssini, A. Joubi (ICARDA), K. Mardini (ARC, Aleppo) and A. Babi (University of Aleppo))

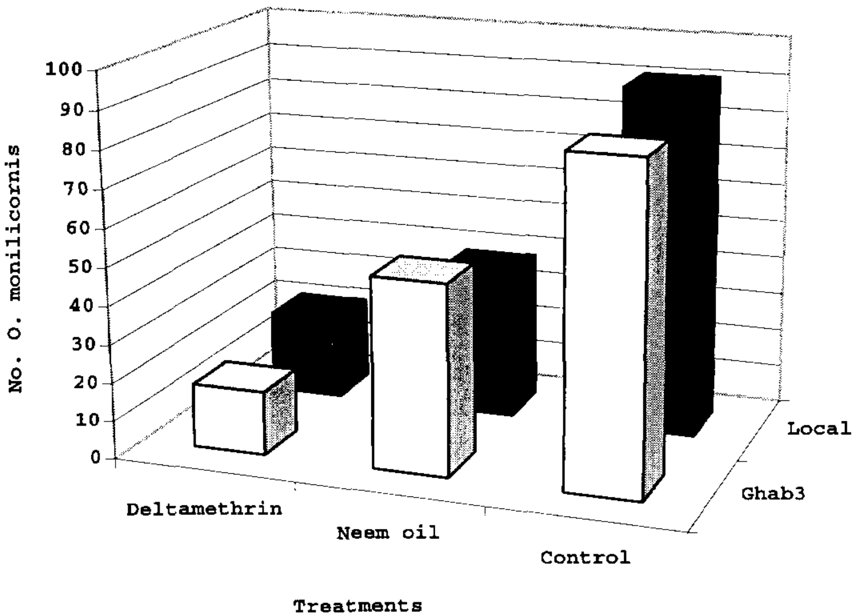

Figure 8.14. Effect of neem oil, deltamethrin on leafminer parasitoid, *O. monilicornis*, Tel Hadya

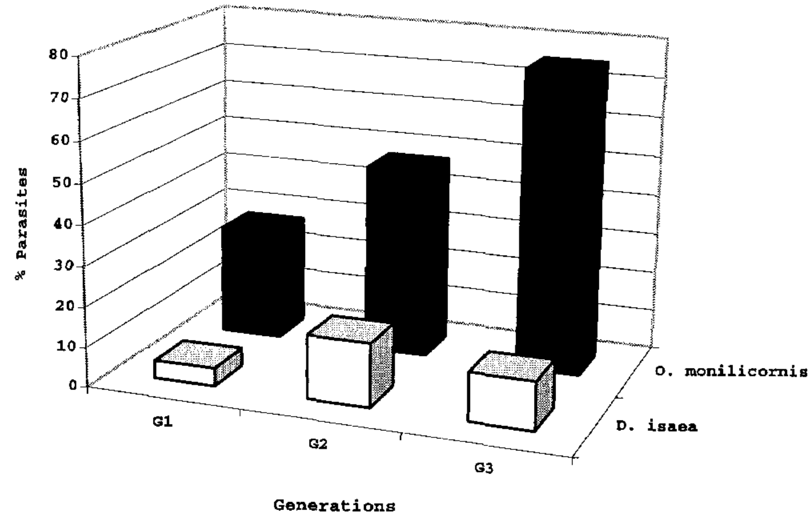

Figure. 8.15. Evolution of level of parasitism on the three generations of leafminer, Tel Hadya

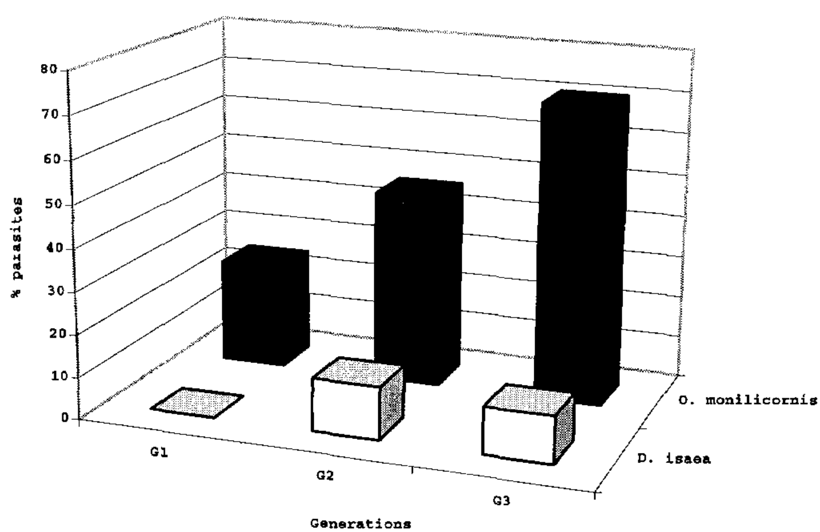

Figure. 8.16. Evolution of level of parasitism on the three generations of lefminer, Azaz

8.5.9. Pathogenicity Test of Some Fungal Isolates Collected from Syria and Turkey on Sunn Pest Adults

Sunn pest (*Eurygaster integriceps* Puton) is one of the most damaging pests of wheat and barley in West Asia, where over US $42 million is spent annually for its control. Yield loss incured by this pest is commonly estimated at 20-30% in barley and 50-90% in wheat. Efforts are being put on developing an integrated pest management package based on entomopathogenic fungi to replace the existing chemical control strategy.

Twenty fungal isolates recovered from the collections made in Syria and Turkey were tested at ICARDA against field collected Sunn pest adults. The fungal dosage used was $5x10^7$. We had 20 Sunn pests/test, 5 per bioassay container. The adults were immersed in fungal suspension for 5 sec. Mortality reading was taken 12 days after treatment. Two bioassays per strain were conducted.

The results showed that the mortality ranged from 30 to 100% among the 28 test strains. Four isolates of *Beauveria* bassiana and one isolate of *Paecilomyces farinosus* gave a high mortality (>95%), which was 10% higher than that of a commercialized strain of *Beauveria bassiana* used as a check. These 5 isolates will be tested further this season. Bioassays will be conducted on plants and litter sprayed with fungal suspensions from the 5 promising isolates.

(B. Parker, M. Skinner (University of Vermont) and M. El Bouhssini (ICARDA))

8.5.10. Collection of Entomopathogenic Fungi Associated with Sunn Pest in Uzbekistan

Exploratory activities to collect Sunn pest from their overwintering sites in Uzbekistan were conducted in January 1999.

Sunn pest adults were collected from overwintering sites around all major wheat growing areas. The adults collected were placed in plastic bags and held in cool dry conditions and kept in the lab for further processing. Specimens were handled under sterile conditions and transferred to a sterile moist environment. Fungal outgrowths were observed at 4xmagnification and transferred to PDA and ¼ strength SDAY media, which is semi-selective for *Beauveria* spp. All media was supplemented with 0.001g/l pencillin G and 0.005 g/l streptomycin sulfate.

Out of the 425 symptomatic specimens that were processed from the Uzbekistan collection, 35 entomopathogenic fungi were isolated. Eighty percent of these isolates were Beauveria bassiana and the remaining isoates were members of the genus *Paecilomyces*. Pathogenicity tests of these isolates will be done in the immediate future at ICARDA against field-collected Sunn pest.

(M. El Bouhssini (ICARDA), B. Parker and M. Skinner (University of Vermont), K. Asaov, P. Zarib (UZNIIR) and M. Nasyrov (Samarkand State University))

8.5.11. Two New Egg Parasitoids Species of Sunn Pest in Syria

Field collections of parasitized eggs of Sunn pest were carried out during April of 1999 in several wheat producing areas, Hassaka, Ghab, Azaz and Aleppo. Each parasitized egg mass was put in a plastic tube (1.5x12 cm) with a drop of honey for the emerging aduts to feed on and placed in a rearing room set at 23± 2° C, 70% RH and 16 H light. The emerged adults were increased on Sunn pest eggs in the laboratory. Once enough adult parasitoids were produced, 20 from each group were put in 70% alcohol with glycerin and sent to INRA Lyon (France) for identification.

The results showed that one of the egg masses collected from Aleppo region was parasitized by *Ooencyrtus fecundus* Ferriere & Voegele (Hymenoptera: Enyrtidae). This is the first report of this species on Sunn pest eggs in Syria. The other new reported species of Sunn pest egg was found in Hassaka and belongs to *Gryon fasciatus* Priener (Hymenoptera: Scelionidae).

(M. Abdel Hay (ARC, Aleppo), M. El Bouhssini (ICARDA) and A. Babi (University of Aleppo))

8.5.12. Study of Sunn Pest Oviposition and Egg Parasitism

This study was carried out at Azaz region where weekly field inspections were made to assess the evolution of egg laying of Sunn pest and the development of parasitism using a unit area of 5 m^2. The wheat field used in this study was sampled using a metal frame (0.25 m^2), which was randomly thrown, in the field 20 times at each sampling. The number of egg masses, healthy or parasitized, found in the framed area was recorded.

In 1999, the beginning of egg laying was delayed due to the low temerature in the second half of March; the mean temperature during this period was 9.8°C. The first Sunn pest egg mass was found in wheat field on 21 April, and the first parasitized eggs were recorded on the 28^{th} of the same month (Figure 8.17) The level of egg parasitissm reached 100% by the 12^{th} of May, where *Trissolcus simoni* accounted for 50% and *T. grandis* and *T. vassilievi* each for 25%.

(M. Abdel Hay (ARC, Aleppo), M. El Bouhssini (ICARDA) and A. Babi (University of Aleppo))

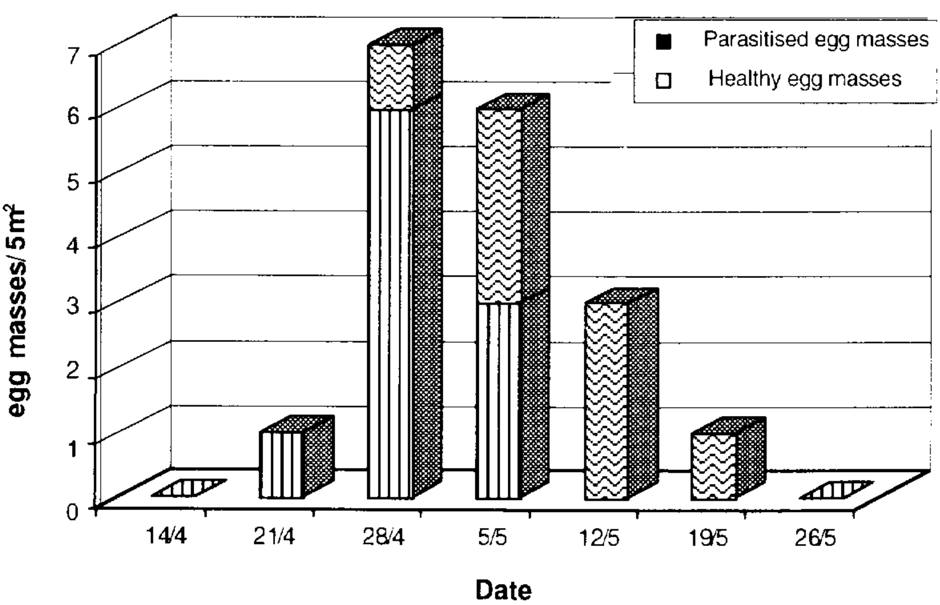

Figure. 8.17. Evolution of oviposition and egg parasitism of sunn pest, Azaz.

8.5.13. Integration of Sowing Dates Early Maturing Variety and Chemical Sprays to Manage Broomrapes in Lentil.

Broomrape (*Orobanche* spp.) is a major problem of lentil in the Mediterranean basin, especially in early sowings, and is difficult to control. The integration of some previously tested control measures was made this year, in collaboration with the Syrian Directorate of Agricultural Research, in two sites Idlib (wet) and Tel Hadya (relatively dry) to confirm earlier results.

The IDM package included using two sowing dates: early (5/12/1998) and normal (15 /1/1999); and three cultivars: Hourani (ILL 2130), Syrian local large (ILL 4400) and an early maturing cultivar adapted to late sowing (ILL 5582). These were integrated with three chemicals: imazethapyr, applied either as pre-emergence treatment, at a rate of 30 ml ai/h (T3) on 22/12/1998 & 28/1/1999 for the first and second sowings, respectively or as two post emergence treatments, each at a rate of 15 ml ai/h (T4) on 223/2/1999 for the first sowing and on 25/3/99 for the second sowings; imazaquin as two post-emergence treatments, each at a rate of 7.5 ml ai/h (T5) on 23/2/1999 & 25/3/ 1999 for the first and the second sowings respectively; or imazapic as two post-emergence treatments, each at a rate of 5 ml ai/h (T6)on 23/2/1999 for the first sowing and on 25/3/99 for the second sowings. Controls were not treated (T1) or hand weeded twice (T2) on 27/4 & 2/5/1999. Evaluation of orobanche shoots was done on 17/5/1997 and the crop was harvested the same day.

Each experimental plot consisted of 6 rows, each of 4 m long distanced by 30 cm. The plant density was 250 seed m^{-2}. The experimental design was a split-split design with three replications. Dates of sowing were the main plots, genotypes as sub plots and chemicals as sub-sub plots. Results were taken from the four median rows only.

Broomrape infestation at Idlib site was higher than at Tel Hadya. This is essentially attributable to a higher precipitation being received at the former site (Table 8.57 & 8.58). The mean number of orobanche shoots and BYD were significantly higher at sowing 1 at both sites, thus confirming earlier report. However, mean seed yield was significantly higher at sowing 2, indicating that the higher broomrape shoots number adversely affects SYD (Table 8.59). This may due to the fact that orobanche shoots appear late in the season, at a time the plant has completed its vegetative growth and start the pod filling stage.

All chemical treatments performed significantly better than the two non-treated controls (Table 8.60). Imazathapyr and Imazapic, applied as post-emergence treatments, gave the best control of orobanche and increased both SYD and BYD. Reduction in No ranged between 82-93 %. Increase in BYD ranged between 24-45% and that of SYD between 139-460%. Imazathapyr, applied as pre-emergence treatment, gave the lowest SYD as compared with other chemical treatment. However, the differences were not significant.

The interactions between sowings and treatments, in affecting the parameters studied are summarized in (Table 8.61). Data show pronounced superiority of the two above-mentione treatments in reducing the orobanche shoots and increasing both SYD and BYD. BYD were, in general, Higher in sowing 1, While SYD were Higher In sowing 2. Differences in SYD between the two sowings were only significant for the early maturing line. Imazathapyr, applied as pre-emergence treatment, gave the lowest SYD in sowing 2.

Interactions between Sowing dates and genotypes are summarized in (Table 8.62) All genotypes had higher number of orobanche shoots and better BYD in sowing 1, whereas seed yield, for all of them, was better in sowing 2. ILL5882 was the best performing genotypes, In both sowings, for All parameters tested.

The interactions between all treatments tested (Table 8.57) enabled us to make the following statements:

- In general, orobanche infestation was higher in Idlib (wetter site) as compared to Tel Hadya (drier site)
- Imazapic and imazathapyr (post emergence) gave best results:

- Reduced number of orobanche shoots by 80% for imazapic and 84% for imazathapyr in first sowing and by 99 and 100% for the second sowing, respectively.
- Increased biological yield by 52% for imazapic and 39% for imazathapyr in first sowing and by 32% and 38% for the second sowing, respectively.
- Increased seed yield by 113% for imazapic and 224% for imazathapyr in first sowing and by 181% and 113% for the second sowing, respectively.
- Increased 100 seed weight by 68% for imazapic and 92% for imazathapyr in first sowing and by 2.7% and 4% for the second sowing, respectively.
- Varietal responses for the two herbicides have also been observed.

- The results from Tel Hadya were less consistent (Table 8.58).

The results obtained are already being validated under larger field plot conditions. The effectiveness of imazapic as a component of IDM of broomrape, as established from the two locations during the 1997/98 cropping season, was confirmed. The entire package will be validated in on-farm trials with farmer participation to prepare for adoption in lentil production areas where broomrape is a major problem.

(B. Bayaa(ICARDA), N. El-Hussein (Aleppo University) and W. Erskine (ICARDA))

8.6. Adapt, Develop and Improve Diagnostic Kits for Pathogen Detection and Identification

8.6.1. Production of Faba Bean Necrotic Yellows Virus Antiserum Against Bacterially Expressed Viral Coat Protein.

Faba bean necrotic yellows virus (FBNYV) is an economically important virus affecting food legumes in a number of West Asian and North African countries. The DNA genome has been reported to be composed of at least seven circular ssDNA components of 1 kb each. The capsid protein (CP) gene located on component 5 was cloned in an expression vector pQE-9 (Qiagen). Expression of the CP with an N-terminal hexahistidine tag in *Escherichia coli* M15 cells was induced by adding IPTG to a final concentration of 1 mM. About 1 mg of expressed CP was purified from 500 ml of bacterial liquid culture using a Ni-NTA resin column (Qiagen). The expressed CP which migrated as a protein of ≈ 22 kDa in SDS-PAGE was identified by its strong reaction with polyclonal antibodies to FBNYV in western blots. A total of 1 mg of expressed CP, extracted from the SDS-PAGE 22 kDa band, was administered into a white rabbit using seven intramuscularl injections at weekly intervals. The antiserum produced was evaluated for FBNYV detection in tissue-blot immunoassay. Antiserum diluted 1:1000 gave a strong virus-specific reaction, with almost no background, similar to the reaction produced by monoclonal antibodies and far better than the polyclonal antibodies raised against virion preparation, purified from FBNYV-infected faba bean.

(K.M. Makkouk and S.G. Kumari)

Table 8.57. Summary statistical analysis for the experiment of IPM of broomrape on lentil at Idlib research station during 1998/99 cropping season

Genotypes	Parameters	Sowing 1 (***)						Sowing 2						LSD
		T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	For same sowing
	No	97(d)b	74(c)b	65(c)b	10(a)a	37(b)b	16(a)a	52.5(c)a	44(b)a	7.6(a)a	0(a)a	1.1(a)a	1.1(a)a	20.3
ILL2130	BYD	402(a)a	455(a)a	601(a)a	549(a)a	506(a)a	613(a)a	520(ab)a	320(a)a	442(ab)a	545(ab)a	492(ab)a	537(b)a	219
	SYD	17(a)a	28(a)a	51(a)a	57(a)a	39(a)a	34(a)a	34(ab)a	43(ab)a	6.5(a)a	72(ab)a	49(ab)a	95(b)a	74
	100SW	1.2(a)a	3(a)a	1(a)a	3.4(a)a	3.4(a)a	2.8(a)a	3(a)a	2.4(a)a	2.2(a)a	3(a)a	2.2(a)a	2.8(a)a	2.5
	No	91(c)b	79(c)b	46(b)b	19(a)a	24(a)b	26(a)b	59(b)a	43(b)a	4.4(a)a	0(a)a	2.5(a)a	0.3(a)a	
ILL4400	BYD	342(a)a	389(a)a	517(ab)a	581(b)a	396(a)a	547(ab)a	386(a)a	326(a)a	367(a)a	504(a)a	408(a)a	510(a)a	
	SYD	7.8(a)a	21(ab)a	51(ab)a	91(b)a	26(ab)a	50(ab)a	18(a)a	37(ab)a	12(a)a	46(ab)a	43(ab)a	96(b)a	
	100SW	1.1(a)a	3.8(ab)a	3.3(ab)a	4.3(b)a	3.5(ab)a	3.2(ab)a	4.6(b)b	3.7(a)a	1.5(a)a	4.7(b)a	4.6(b)a	4.5(b)a	Between sowings
	No	88(c)b	69(c)b	31(ab)b	16(ab)a	34(b)b	13(a)a	51(b)a	41(b)a	10(a)a	0(a)a	1(a)a	0.4(a)a	20.3
ILL5582	BYD	470(a)a	462(a)a	574(ab)a	556(ab)a	596(ab)a	691(b)a	514(a)a	394(a)a	578(a)a	671(a)a	510(a)a	601(a)a	216
	SYD	14.5(a)a	30(a)a	51(a)a	85(a)a	47(a)a	63(a)a	67(b)a	69(ab)a	55(a)a	127(ab)a	97 (ab)a	133(b)a	73.5
	100SW	3.6(a)a	4.4(b)a	1.3(a)a	3.8(ab)a	3.9(b)a	4(a)a	3.3(ab)a	3.6(a)a	2.2(a)a	3.6(ab)a	3.3(ab)a	3.9(ab)a	2.4

(*) T1=control; T2=hand weeding), T3=Imazathapyr (pre-emergence), T4=Imazathapyr (post-emergence), T5=imazaquin (post-emergence), T6=imazapic (post-emergence).

(**) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}; 100 SW=100 seed weight g.

(***) 1st sowing date (5/12/1998); 2nd sowing date (15 /1/1999).

Figures followed by similar letter (outside brackets) are not significantly different for the same parameter within same sowing. Figures followed by similar letter (in brackets) are not significantly different for the same parameter between different sowings.

Table 8.58. Summary statistical analysis for the experiment of IPM of broomrape on lentil at Tel *Hadya research station during* 1998/99 *cropping season*

Genotypes	Parameters	Sowing 1***						Sowing 2						LSD	
		T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	Ss	Bs
	No**	19.7a(b)	67.2b(b)	2	1	8.3	0	0	0	0	0	0	0	18	19
ILL 2130	BYD	222	204	255	227	195	343(a)	213	134	157	93	107	236(a)	165	173
	SYD	29	37	27	30	35	29	8	18	20	47b	9	36	32	33
	100 SW	3.2	3.2	2.6	3.1	3.1	3.8	2.4	2.8	1.8a	2.8	3.2	2.9	2	2.2
	No	64.3b(b)	33.3a(b)	7.7	0.7	5.3	0.3	0	0	0	0	0	0		
ILL 4400	BYD	167	292	282	176	222	204(a)	93	184	144	130	116	199(a)		
	SYD	43	30	42	22	39	26	18	25	15	11 a	13	9		
	100 SW	2.3	3.5	4	2.9	4	3.8	2.4	3.2	3.6ab	3.8	2	3.5		
	No	35.3a(b)	43.3a(b)	4	0.3	8.3	0	0	0	0	0	0	0		
ILL 5582	BYD	171	255	167	153	264	287(b)	148	125	165	157	153	90(a)		
	SYD	38	28	30	34	25	54	14	12	21	18ab	19	22		
	100 SW	4.2	3.7	3.6	3.7	3.3	4.5	2.8	3.18	3.8b	2.2	2.2	3.5		

(*) T1=control; T2=hand weeding), T3=Imazathapyr (pre-emergence), T4=Imazathapyr (post-emergence), T5=imazaquin (post-emergence), T6=imazapic (post-emergence).
(**) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD= Seed yield g m^{-2}; 100 SW=100 seed weight g.
(***) 1st sowing date (5/12/1998); 2nd sowing date (15 /1/1999).
Figures followed by similar letter (outside brackets) are not significantly different for the same parameter within same sowing.
Figures followed by similar letter (in brackets) are not significantly different for the same parameter between different sowings.
Figures not followed by letters are not significantly different for the same parameter within and between different sowings.

Table 8.59. Effect of dates of sowing on mean number of orobanche shoots m^{-2} (No) and both mean biological (BYD) and seed yield (SYD) g m^{-2} of lentil at Idlib Research Station during 1998/99 cropping season

Sowing	Sowing 1**			Sowing 2		
parameters	No*	BYD	SYD	No	BYD	SYD
	47 b	514 b	42 a	18 a	479 a	61 b
LSD	7	22	36			

(*) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}.

Figures followed by similar letter for the same parameter are not significantly different between sowings.
(**) 1st sowing date (5/12/1998);2nd sowing date (15/1/1999).

Table 8.60. Effect of different treatments x genotypes on number of orobanche shoots m^{-2} (No) and both biological (BYD) and seed yield (SYD) g m^{-2} of lentil at Idlib Research Station during 1998/99 gropping season

Treatments		T1***	T2	T3	T4	T5	T6	LSD St*	LSD Bt
	NO**	75d	59c	36b(b)	5a	19a	8a	15	14
ILL 2130	BYD	461a	388a	522ab	547ab	499ab	575b	162	155
	SYD	25a	36a	29a	64a	44a	65a	54	52
	NO	75b	61b	25b(ab)	10a	13a	13a		
ILL 4400	BYD	364a	357a	442ab	542b	402ab	528b		
	SYD	13a	30ab	31ab	68b	35ab	73b		
	NO	69c	55b	20a(a)	8a	18a	7a		
ILL 5582	BYD	492ab	428a	576ab	614 b	553ab	646b		
	SYD	41a	50ab	53ab	106 b	72ab	98b		

(*) St=LSD value for similar treatment;Bt=LSD value between different treatments.
(**) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}.
(***) T1=control; T2=hand weeding), T3=Imazathapyr (pre-emergence), T4=Imazathapyr (post-emergence), T5=imazaquin (post-emergence), T6=imazapic (post-emergence).

Figures followed by similar letter (outside brackets) are not significantly different for the same parameter between different treatments.
Figures followed by similar letter (in brackets) are not significantly different for the same parameter within same treatment.

Table 8.61. Effect of different treatments x sowings on number of orobanche shoots m^{-2} (No) and both biological (BYD) and seed yield (SYD) g m^{-2} of lentil at Idlib Research Station during 1998/99 gropping season

Sowing	Sowing 1***			Sowing 2		
Parameter	No**	BYD	SYD	No	BYD	SYD
T 1****	92(b)	405a	13a	54b(a)	473b	39a
T 2	74d(b)	435a	27a	43b(a)	347a	50ab
T 3	47c(b)	564ab	51ab	7a(a)	462b	24a
T 4	15a(b)	562ab	78b	0a(a)	573b	81b
T 5	32b(b)	499ab	37a	2a(a)	470b	63ab
T 6	18a(b)	617b	49a(a)	1a(a)	549b	108b(b)
LSD Ss*	12	132	44			
Bs	11.8	121	44			

(*) Ss=LSD value for similar sowing; Bs=LSD value between different sowings.

(**) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}; 100 SW=100 seed weight g.

(***) 1st sowing date (5/12/1998);2nd sowing date(15 /1/1999).

(****) T1=control; T2=hand weeding), T3=Imazathapyr (pre-emergence), T4=Imazathapyr (post-emergence), T5=imazaquin (post-emergence), T6=imazapic (post-emergence).

Figures followed by similar letter (outside brackets) are not significantly different for the same parameter within same sowing.

Figures followed by similar letter (in brackets) are not significantly different for the same parameter between different sowings.

Table 8.62. Effect of interactions between sowing dates and genotypes on number of orobanche shoots m^{-2} (No) and both biological (BYD) and seed yield (SYD) g m^{-2} of lentil at Idlib Research Station during 1998/99 gropping season

Sowing	Sowing 1			Sowing 2		
Parameters	No	BYD	SYD	No	BYD	SYD
ILL 2130	50b(b)	521ab	38a	18a(a)	476ab	50a
ILL 4400	48b(b)	462a	41a	18a(a)	417a	42a
ILL 5582	42a(b)	558b	49a(a)	17a(a)	545b	91b(b)
LSD Ss*	6	77	27			
Bs*	6	63	30			

(*) Ss=LSD value for similar sowing; Bs=LSD value between different sowings.

(**) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}; 100 SW=100 seed weight g.

(***) 1st sowing date (5/12/1998);2nd sowing date(15 /1/1999).

Figures followed by similar letter (outside brackets) are not significantly different for the same parameter within same sowing.
Figures followed by similar letter (in brackets) are not significantly different for the same parameter between different sowings.

Table 8.63. Effect of genotypes on mean number of orobanche shoots m^{-2} (No) and both mean biological (BYD) and seed yield (SYD) g m^{-2} of lentil at Idlib Research Station during 1998/99 cropping season

Genotypes	ILL 2130			ILL4400			ILL 5582		
Parameters	No*	BYD	SYD	No	BYD	SYD	No	BYD	SYD
	34b	498b	44a	33ab	439a	42a	29.5a	551b	70b
LSD	4.2	55	20						

(*) No=Number of orobanche shoot m^{-2}, BYD=Biological yield g m^{-2}; SYD=Seed yield g m^{-2}.
Figures followed by similar letter for the same parameter are not significantly different between genotypes.

8.6.2. Distribution of ELISA Kits

ELISA kits or antisera for any of 14 legume viruses and four cereal viruses available at the Virology Laboratory were sent to collaborators in Algeria, Egypt, Ethiopia, India, Iraq, Syria and Tunisia.

(K.M. Makkouk and S.G. Kumari)

8.7. Monitoring Seed-Borne Viruses

8.7.1. Testing for Seed-borne Viruses

8.7.1.1. Cleaning Gene Bank Accessions from Seed-borne Viruses

About 313 lentil accessions planted in the field for multiplication were tested for the presence of seed-borne virus infection, in an effort to eliminate all infected plants during the late flowering stage (April-May), and only seeds from healthy plants were harvested and stored.

54 peas accessions were tested as dry seeds for the presence of pea enation mosaic virus (PEMV) and pea early

browning virus (PEBV) in February and five accessions were possibly infected, and will be cleaned later.

2592 accessions of barley dry seeds were tested for the presence of barley stripe mosaic virus (BSMV) and 66 accessions were found infected. The virus-free accessions will be stored in the gene bank, and accessions with virus-infected seeds will be cleaned later.

8.7.1.2. Testing for International Nurseries

During August, about 123 faba bean accessions (100 seeds per accession) were tested for the presence of BBSV, BYMV and PSbMV, 3 accessions were found to be infected with either one of these viruses.

490 lentil accessions were tested during July and August for the presence of seed-borne viruses, about 500 seeds were tested per accession and 71 accessions were found to contain one or more seed-borne infections and were disqualified for dispatch.

80 lentil and 24 pea accessions were tested for tomato spotted wilt virus (TSWV), and all were virus-free.

About 280 faba bean accessions to be sent to Australia were tested for the presence of six viruses BBSV, BYMV, PSbMV, BBTMV, BBMV and PEMV, and all were virus-free.

8.7.1.3. Testing for Seed Unit

In August, 22 lentil accessions from the Seed Unit were tested for BBSV, BYMV and PSbMV and all were virus-free.

A summary of all the work on testing for seed-borne viruses is summarized in (Table 8.64)

(K.M. Makkouk and N. Attar)

Table 8.64. Testing for seed-borne viruses of legume and cereal crops at the Virology Laboratory during 1999.

Source /Crop	No. of accessions tested	No. of accessions found infected	No.of seeds tested per accession	Period of testing	Seed-borne viruses checked
Gene Bank					
Lentil	313	261	1200	April-May	BBSV, BYMV, PSbMV
Peas	54	5	5	February	PEMV, PEBV
Barley	2592	66	200	January-July	BSMV
International Nurseries					
Faba bean	123	3	100	August	BBSV, BYMV, PSbMV
Lentil	490	71	500	April-August	BBSV, BYMV, PSbMV
Lentil	80	0	10	August	TSWV
Peas	24	0	5	August	TSWV
Faba bean	280	0	10	October	BBSV, BYMV, PSbMV, PEMV, BBMV, BBTMV
Seed Unit					
Lentil	22	0	200	September	BBSV, BYMV, PSbMV

8.8. Training and Networking

8.1. Individual Non-degree Training

Eight students / researchers from Egypt, Ethiopia, Iran, Tunisia and Syria spent short-term (1-3 weeks) training periods in the pathology Laboratory, working on different aspects of legume diseases.

(Chrys Akem, B. Bayaa and S. Kababeh)

Nine students from Algeria, Tunisia and Syria spent short-term (1-3 weeks) training periods in the Virology Laboratory, working on different aspects of virus research.

(K.M. Makkouk and S.G. Kumari)

Five people were trained in the entomology lab., 2 from Libya, and 1 from each of Ethiopia, Syria and Iran.

(M. El Bouhssini)

Three junior researchers from Douma, Syria were trained in cereal disease evaluation for a period of (1-3 weeks)

Two junior scientists from Syria and Iran were trained in IPM approaches in cereal pathology for 1 month

One scientist from Ethiopia was trained in cereal rusts for a period of 3 months

Visiting scientist from Morocco, work review of net blotch for 10 days.

(A. Yahyaoui)

8.8.2. Individual Degree Training

Three graduate students from Aleppo University are carrying out their research works in legume pathology. One for Ph. D degree and the other two for MSc. degree.

One graduate student from the University of Aleppo has completed his M.Sc. thesis research on "Study of Septoriosis in Syria: Distribution and Importance, Etiology, Biology and Sources of Resistance"

(B. Bayaa)

Two graduate students carried out their thesis research on virus diseases. One from the University of Jordan who has completed her M.Sc. thesis research on Ecology and Screening for Resistance to Faba Bean Necrotic Yellows Virus in Cool Season Legumes, and another from Aleppo University, Syria who also completed her M.Sc. thesis research on Viruses Affecting Legume Crops in El-Ghab region of Syria.

(K.M. Makkouk)

Three graduate (MSc.) students from the University of Aleppo are carrying their MSc. Thesis on the following topics:

- Biological control of aphids.
- Biology of Sunn pest and its parasitoids.
- IPM of chickpea leafminer

A forth student completed his MSc. Thesis on *Sitona* of lentil, biology and control (thesis defended).

(M. El Bouhssini)

One graduate student (MSc.) from the University of Aleppo started thesis work on dryland cereal root rots.

(A. Yahyaoui)

9. TRAINING AND VISITS

Training activities in Germplasm Program aim to assist researchers in NARS to develop their abilities in recognizing the problems facing cereals and legumes and applying modern techniques to solve these problems. The training in Germplasm Program focus on providing technical training to individual non-degree trainees, conduct and support the research of graduate students and conduct short-term training courses at ICARDA headquarters and regional, sub-regional and in-country courses. The trainees are trained to design and manage conventional experiments in various disciplines such as breeding, hybridization, note taking, disease scoring, selection, analysis and interpretation of experimental data and preparation of short technical reports; the trainees mainly are familiarized with practical application in the field and in the laboratory as well as some lectures. Round table discussions take place in specialized short-term group training courses. A method for evaluating progress is used to measure the performance of trainees and the impact of their training on agricultural research in their countries. The following training activities were conducted during 1999.

9.1. Short-Term Courses

9.1.1. Short-Term Courses at ICARDA Headquarters

9.1.1.1. Breeding Field Crops for Stress Tolerance

The course was organized at ICARDA headquarters in Tel Hadya in collaboration with CAC (Central Asia and Caucasus countries) during the period between 5-15 April 1999; it was sponsored by ICARDA/CAC Project. Nine scientists attended the course; they were from Armenia, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. The main objective of the course was to update the participants on advanced methods and improved techniques to increase efficiency of breeding for resistance to different stresses in their respective countries. The participants evaluated the course as highly successful and useful.

9.1.1.2. Integrated Management of Cereal and Legume Pests in the West Asia and North Africa

The course was organized during April 25-May 6 1999 and sponsored by ICARDA. Twelve participants from seven countries attended the course. The main subjects of the course were to identify major pests affecting cereals and legumes in WANA, get acquainted with new tools to identify and control pests, assess pests infestation/infection and damage, sampling and monitoring pest populations and select and use the available control measures, singly and in combinations in an integrated approach. The course was very successful and useful as reflect by the participants' evaluations.

9.1.1.3. DNA Molecular Marker Techniques for Crop Improvement

This course was organized between 12-23 September 1999, jointly sponsored by ICARDA and the Arab Fund for Economic and Social Development (AFESD). Sixteen participants from 10 countries attended the course (Table 9.1). The main subjects of the course were to introduce participants to theoretical aspects of DNA work, provide practical experience in some aspects of DNA marker techniques (RFLP, PCR-RAPD), Microsatellite, AFLP and to discuss the current and potential uses of DNA molecular marker techniques in germplasm evaluation and plant breeding. The course was well received by the trainees and some of the trainees.

Table 9.1. Attendance at DNA Molecular Marker Techniques for Crop Improvement Course.

Country	No. of participants
Egypt	2
Eritrea	1
Jordan	2
Kazakhstan	1
Palestine	2
Sudan	1
Syria	5
UAE	1
Yemen	1
Total	16

9.1.2. Regional/Sub-Regional Short-Term Training Courses

9.1.2.1. English Language

Two courses were held in Uzbekistan and Kyrgystan during January to March and February to April 1999 respectively, jointly organized by ICARDA and CIMMYT. A total of seventeen participants from three countries, namely Kazakhstan, Uzbekistan and Kyrgystan attended the courses. The participants benefited from these courses to improve their communication skills, helping them to communicate and exchange ideas and experiences with other international scientists.

9.1.2.2. Application of Computers in Wheat Breeding

Two courses on "Application of Computers in Wheat Breeding" were held in Uzbekistan and Kazakhstan during 8-17 and 18-26 February 1999 respectively. The courses were jointly organized by ICARDA and CIMMYT. A total of 15 participants from Kazakhstan, Uzbekistan and Kyrgystan attended the courses. The aim of the courses was to introduce the participants to using computer applications on designing and management of wheat breeding trials and how to apply these applications in their respective national programs.

9.1.3 In-Country Short-Term Training Courses

9.1.3.1. DNA Molecular Marker Techniques for Crop Improvement, (IPA, Baghdad-Iraq)

A training course on DNA molecular marker techniques for crop improvement was held at Agricultural Research Center (IPA), Baghdad, Iraq from 8-18 June 1999. Ten participants mainly M.Sc. and Ph.D. students participated in this course and they represented several research organizations in Iraq. Additional staff of IPA was present in the lectures and practicals as observers. The major aim of the course was to ensure that all DNA marker technologies could now routinely be used at IPA. The practical sessions gave a comprehensive overview of DNA marker technology used for genetic diversity analysis and mapping for plant breeding.

9.1.3.2. DNA Molecular Marker Techniques for Crop Improvement, (Rabat, Morocco)

The course was held in Rabat, Morocco in collaboration between ICARDA, INRA (Institut National de la Recherche Agronomique) and DPVCTRF-SCSP (Direction de la Protection des Végétaux, du Contrôle Technique et de la Répression des Fraudes-Service de Contrôle de Semences et Plants) during 19-30 July 1999. A total of 19 participants from twelve institutions/faculties in Morocco participated in the course. The selected participants were mainly M.Sc., Ph.D. students and professors. The course was divided into two parts: A theoretical and practical parts covering the most used molecular marker techniques RAPD, STMS and AFLP. All participants successfully completed the course. Long discussions were held during and after the practical, theoretical sessions reflecting the interest of participants in these new molecular tools. At the end of the course, the participants expressed their satisfactions.

9.2. Individual Training

9.2.1. Individual Non-Degree Training

Individual training in specific areas in Germplasm Program was provided to 43 researchers from 12 countries (Figure 9.1). Participants spent periods ranging between 1 week to 8 months in different research activities of the program (Table 9.2). Individual training is most suitable for scientists who have undertaken research for a reasonable period of time, so their training programs are tailored to meet the specific need of NARSs.

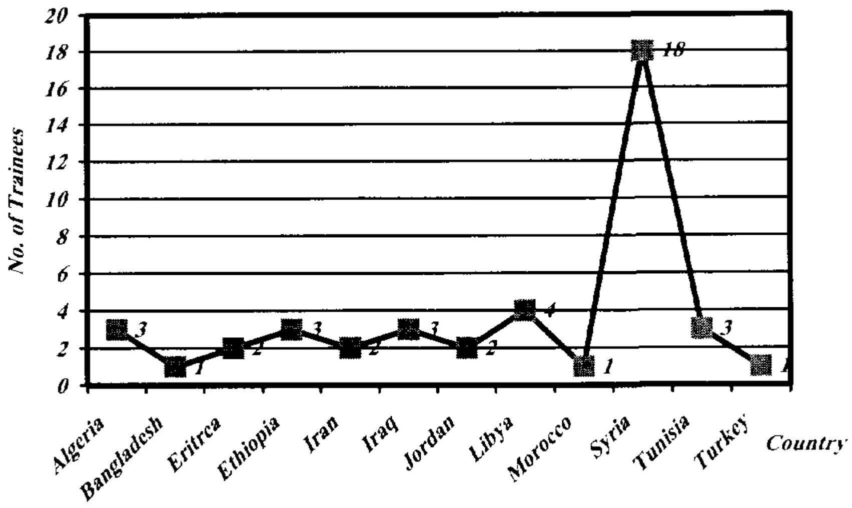

Figure 9.1. Individual Non-Degree Trainees to the Germplasm Program in 1999

Table 9.2. Training subjects provided to individual non-degree trainees in the Germplasm Program during 1999

Topic	No. of Trainees
Integrated Pest Management	15
Food Legumes Breeding	9
Cereal Breeding	9
Forage Legume Breeding	4
Biotechnology	4
Grain Quality	2
Total	43

9.3. Graduate Research Training

An important aspects of ICARDA's training is participation in post-graduates. The Germplasm Program has a total of 36 post-graduate students (17 M.Sc. and 19 Ph.D. students). During 1999, a total of eleven students (three Ph.D. and eight M.Sc. students) graduated or completed their thesis research and three new applicants started their thesis research work at ICARDA (Table 9.3).

Table 9.3. Graduate Research Students at the Germplasm Program during 1999

Country	M.Sc. Students		Ph.D.Students	
	Total	Graduated in 1999	Total	Graduated in 1999
Algeria	-	-	2	1
Australia	-	-	1	-
Egypt	-	-	1	-
Eritrea	1	1	-	-
Finland	1	1	-	-
Germany	-	-	2	-
Jordan	1	-	-	2
Morocco	-	-	2	-
Netherlands	-	-	1	-
Somalia	1	-	-	-
Sudan	1	1	-	-
Syria	12	5	7	-
Turkey	-	-	2	-
UAE	-	-	1	-
Total	17	8	19	3

9.4. Visitors and Scientific Visits

Visits between the Germplasm Program and NARS are an effective tool for transferring scientific information and research experiences. In 1999, sixty eight visitors from twenty four countries (Algeria, Australia, Azerbaijan, Belgium, Denmark, Egypt, Ethiopia, France, Germany, India, Iran, Iraq, Kazakhstan, Libya, Morocco, Pakistan, Russia, Spain, Sudan, Syria, Tunisia, Turkey, USA and Uzbekistan) visited the Germplasm Program. Most of the visitors were invited for a short periods from one week to one month to have an overview of breeding activities on the improvement of ICARDA mandate crops, discuss joint projects, select germplasm, lecture in training courses, discuss graduate student research, or gather information on Germplasm Program activities and research findings. In addition, about 150 farmers and more than 60 students from Syrian and Lebanese Universities visited the program for one day visit.

(Fadel Afandi & GP scientists)

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11. VARIETIES RELEASED BY NATIONAL PROGRAMS

Crop	Country	Year of release	Variety
Barley	Algeria	1987	Harmal
Barley	Algeria	1992	Badia
Barley	Algeria	1993	Rihane-03
Barley	Australia	1989	Yagan
Barley	Australia	1991	High
Barley	Australia	1993	Kaputar
Barley	Australia	1993	Namoi
Barley	Bolivia	1991	Kantuta
Barley	Bolivia	1993	Kolla
Barley	Bolivia	1994	San Lorenzo
Barley	Brazil	1989	Acumai
Barley	Canada	1992	Seebe
Barley	Canada	1993	Falcon
Barley	Canada	1994	Tukwa
Barley	Canada	1995	Kasota
Barley	Chile	1989	Centauro
Barley	Chile	1989	Leo/Inia/Ccu
Barley	China	1988	Zhenmai 1
Barley	China	1989	Api/CM67//B1
Barley	China	1989	CT-16
Barley	China	1989	V-24
Barley	China	1998	S500
Barley	China	1998	V06
Barley	Cyprus	1980	Kantara
Barley	Cyprus	1989	Mari/Aths*2
Barley	Cyprus	1994	Achera
Barley	Cyprus	1994	Mia Milia
Barley	Cyprus	1995	Lefkonoiko
Barley	Cyprus	1995	Lysi
Barley	Cyprus	1995	Sanokrithi-79
Barley	Ecuador	1989	Shyri
Barley	Ecuador	1992	Atahualpa-92
Barley	Ecuador	1992	Calicuchima-92
Barley	Egypt	1993	Giza 125
Barley	Egypt	1993	Giza 126
Barley	Egypt	1993	Giza 127
Barley	Egypt	1994	Giza 128
Barley	Ethiopia	1973	Beka
Barley	Ethiopia	1975	IAR/H/485
Barley	Ethiopia	1979	Holkr
Barley	Ethiopia	1980	Ardu 12-60B
Barley	Ethiopia	1985	HB-42
Barley	Ethiopia	1986	HB-120
Barley	Ethiopia	1994	Shege
Barley	Ethiopia	1996	Misratch
Barley	Ethiopia	1998	Abay
Barley	Iran	1986	Aras
Barley	Iran	1990	Kavir
Barley	Iran	1990	Star (Makui)
Barley	Iran	1996	Ezeh
Barley	Iran	1997	Ganub
Barley	Iran	1997	Sahand=Tokak
Barley	Iraq	1993	Rihane-03
Barley	Iraq	1994	IPA 265
Barley	Iraq	1994	IPA 7
Barley	Iraq	1994	IPA 9

Crop	Country	Year of release	Variety
Barley	Italy	1992	Digersano
Barley	Italy	1992	Salus
Barley	Jordan	1984	Rum
Barley	Kenya	1984	Bima
Barley	Kenya	1993	Ngao
Barley	Lebanon	1989	Rihane-03
Barley	Lebanon	1997	Assy
Barley	Lebanon	1997	ER/Apm
Barley	Libya	1992	Wadi Gattara
Barley	Libya	1992	Wadi Kuf
Barley	Libya	1997	Ariel
Barley	Libya	1997	Borjouj
Barley	Libya	1997	Irawen
Barley	Libya	1997	Maknosa
Barley	Mexico	1986	Mona/Mzq/DL71
Barley	Mexico	1998	Capuchona
Barley	Morocco	1984	Asni
Barley	Morocco	1984	Tamelalt
Barley	Morocco	1988	Aglou
Barley	Morocco	1988	Armal
Barley	Morocco	1988	Tiddas
Barley	Morocco	1991	Laannaceur
Barley	Morocco	1997	Igrane
Barley	Morocco	1997	Safia
Barley	Nepal	1987	Bonus
Barley	Pakistan	1985	Jau-83
Barley	Pakistan	1987	Frontier 87
Barley	Pakistan	1987	Jau-87
Barley	Pakistan	1993	Jau-93
Barley	Pakistan	1995	AZRI-95
Barley	Pakistan	1996	Sanober-96
Barley	Pakistan	1996	Soorab-96
Barley	Peru	1987	Nana 87
Barley	Peru	1987	Una-87
Barley	Peru	1989	Buenavista
Barley	Peru	1994	Una-94
Barley	Peru	1996	Una-96
Barley	Portugal	1982	Campones
Barley	Portugal	1982	Enxara
Barley	Portugal	1982	Sereia
Barley	Portugal	1983	CE 8302
Barley	Portugal	1990	Ancora
Barley	Qatar	1982	Gulf
Barley	Qatar	1983	Harma
Barley	Qatar	1989	Harma 88
Barley	Saudi Arabia	1985	Gustoe
Barley	Spain	1990	Resana
Barley	Syria	1987	Furat 1113
Barley	Syria	1991	Furat 2
Barley	Syria	1994	Arta
Barley	Tanzania	1991	Kibo
Barley	Thailand	1987	BRB-8
Barley	Thailand	1987	Semang 1
Barley	Thailand	1987	Semang 2
Barley	Tunisia	1985	Faiz
Barley	Tunisia	1985	Roho
Barley	Tunisia	1987	Rihane-03

Crop	Country	Year of release	Variety
Barley	Tunisia	1992	Manel 92
Barley	Turkey	1993	Tarm 92
Barley	Turkey	1993	Yesevi
Barley	Turkey	1995	Orza
Barley	USA	n.a.	Micah
Barley	USA	n.a.	Poco
Barley	Vietnam	1989	Api/CM67//B1
Barley	Yemen	1986	Arafat
Barley	Yemen	1986	Beecher
Bread Wheat	Algeria	1982	HD 1220
Bread Wheat	Algeria	1982	Setif 82
Bread Wheat	Algeria	1989	Zidane 89
Bread Wheat	Algeria	1992	ACSAD 59=40DNA
Bread Wheat	Algeria	1992	Alondra=21AD
Bread Wheat	Algeria	1992	Nesser=Cham 6
Bread Wheat	Algeria	1992	Rhumel=Siete Cerros
Bread Wheat	Algeria	1992	Sidi Okba=Cham 4
Bread Wheat	Algeria	1992	Soummam=DouggaXBJ
Bread Wheat	Algeria	1994	Ain Abid
Bread Wheat	Algeria	1994	Mimouni
Bread Wheat	Egypt	1982	Giza 160
Bread Wheat	Egypt	1988	Giza 162
Bread Wheat	Egypt	1988	Giza 163
Bread Wheat	Egypt	1988	Giza 164
Bread Wheat	Egypt	1988	Sakha 92
Bread Wheat	Egypt	1991	Gammeiza 1
Bread Wheat	Egypt	1991	Giza 165
Bread Wheat	Egypt	1993	Sahel 1
Bread Wheat	Egypt	1994	Giza 166
Bread Wheat	Egypt	1994	Giza 167
Bread Wheat	Egypt	1994	Sids 1
Bread Wheat	Egypt	1994	Sids 2
Bread Wheat	Egypt	1994	Sids 3
Bread Wheat	Egypt	1995	Sids 4
Bread Wheat	Egypt	1995	Sids 5
Bread Wheat	Egypt	1995	Sids 7
Bread Wheat	Egypt	1995	Sids 8
Bread Wheat	Greece	1983	Arachthos
Bread Wheat	Greece	1983	Louros
Bread Wheat	Greece	1983	Pinios
Bread Wheat	Iran	1986	Azadi
Bread Wheat	Iran	1986	Golestan
Bread Wheat	Iran	1988	Darab
Bread Wheat	Iran	1988	Quds
Bread Wheat	Iran	1988	Sabalan
Bread Wheat	Iran	1990	Falat
Bread Wheat	Iran	1995	Darab 2
Bread Wheat	Iran	1995	Mahdabi
Bread Wheat	Iran	1995	Tajan
Bread Wheat	Iran	1996	Gaher
Bread Wheat	Iran	1996	Nicknejad
Bread Wheat	Iran	1996	Zagross
Bread Wheat	Iran	1997	Alement
Bread Wheat	Iran	1997	Alrand
Bread Wheat	Iran	1997	Atrak
Bread Wheat	Iran	1997	Chamran
Bread Wheat	Iran	1997	Zareen

Crop	Country	Year of release	Variety
Bread Wheat	Iran	1998	Azar 2
Bread Wheat	Iraq	1989	Es14
Bread Wheat	Iraq	1994	Abu Ghraib
Bread Wheat	Iraq	1994	Adnanya
Bread Wheat	Iraq	1994	Hamra
Bread Wheat	Iraq	1998	Vee 'S'
Bread Wheat	Italy	1996	Sibilla
Bread Wheat	Jordan	1988	L88=Rabba
Bread Wheat	Jordan	1988	Nasma=Jubeiha
Bread Wheat	Jordan	1988	Petra
Bread Wheat	Jordan	1990	Nesser
Bread Wheat	Lebanon	1990	Seri
Bread Wheat	Lebanon	1991	Nesser=Cham 6
Bread Wheat	Lebanon	1999	Towpe
Bread Wheat	Libya	1985	Germa
Bread Wheat	Libya	1985	Zellaf
Bread Wheat	Morocco	1984	Jouda
Bread Wheat	Morocco	1984	Merchouch
Bread Wheat	Morocco	1989	Kanz
Bread Wheat	Morocco	1989	Saba
Bread Wheat	Morocco	1996	Massira
Bread Wheat	Morocco	1998	Aguilal
Bread Wheat	Morocco	1998	Arrihane
Bread Wheat	Oman	1987	Wadi Quriyat 151
Bread Wheat	Oman	1987	Wadi Quriyat 160
Bread Wheat	Pakistan	1986	Sutlej 86
Bread Wheat	Pakistan	1996	AZRI-96
Bread Wheat	Pakistan	1996	Sariab-96
Bread Wheat	Portugal	1986	LIZ 1
Bread Wheat	Portugal	1986	LIZ 2
Bread Wheat	Qatar	1988	Doha 88
Bread Wheat	Sudan	1982	Debeira
Bread Wheat	Sudan	1987	Wadi El Neel
Bread Wheat	Sudan	1990	Elnielain
Bread Wheat	Sudan	1992	Sasaraib
Bread Wheat	Sudan	1996	Nessr
Bread Wheat	Syria	1984	Bohouth 2
Bread Wheat	Syria	1984	Cham 2
Bread Wheat	Syria	1986	Cham 4
Bread Wheat	Syria	1987	Bohouth 4
Bread Wheat	Syria	1991	Bohouth 6
Bread Wheat	Syria	1991	Cham 6
Bread Wheat	Tunisia	1983	T-DUMA-D6811-INRAT
Bread Wheat	Tunisia	1987	Byrsa
Bread Wheat	Tunisia	1987	Salambo
Bread Wheat	Tunisia	1992	Vaga 92
Bread Wheat	Tunisia	1996	Tebica 96
Bread Wheat	Tunisia	1996	Utique
Bread Wheat	Turkey	1979	Gerek 79
Bread Wheat	Turkey	1985	Atay 85
Bread Wheat	Turkey	1986	Dogankent-1 (Cham 4)
Bread Wheat	Turkey	1988	Dogu 88
Bread Wheat	Turkey	1988	Genç-88
Bread Wheat	Turkey	1988	Kop
Bread Wheat	Turkey	1989	Es14
Bread Wheat	Turkey	1990	Katia 1
Bread Wheat	Turkey	1990	Yuregir

Crop	Country	Year of release	Variety
Bread Wheat	Turkey	1990	Karasu 90
Bread Wheat	Turkey	1991	Gun 91
Bread Wheat	Turkey	1994	Dagdas 94
Bread Wheat	Turkey	1994	Kutluk 94
Bread Wheat	Turkey	1995	Basribey 95
Bread Wheat	Turkey	1995	F//68.44NZT/3/CUC'5'
Bread Wheat	Turkey	1995	Kasifbey 95
Bread Wheat	Turkey	1995	Kirgiz 95
Bread Wheat	Turkey	1995	Sultan 95
Bread Wheat	Turkey	1996	Ikizce 96
Bread Wheat	Turkey	1996	Pehlivan 96
Bread Wheat	Turkey	1997	Kinaci 97
Bread Wheat	Turkey	1997	Palandoken 97
Bread Wheat	Turkey	1997	Suzen 97
Bread Wheat	Turkey	1998	Aytin 98
Bread Wheat	Turkey	1998	Mizrak 98
Bread Wheat	Turkey	1998	Turkmen 98
Bread Wheat	Turkey	1998	Uzunyayla 98
Bread Wheat	Turkey	1998	Yildiz 98
Bread Wheat	UAE	1995	Cham 2
Bread Wheat	UAE	1995	Kirgiz 95
Bread Wheat	UAE	1995	Seyhan 95
Bread Wheat	Yemen	1981	Ahgaf
Bread Wheat	Yemen	1983	Marib 1
Bread Wheat	Yemen	1988	Aziz
Bread Wheat	Yemen	1988	Dhumran
Bread Wheat	Yemen	1988	Mukhtar
Bread Wheat	Yemen	1992	Alswiri
Bread Wheat	Yemen	1995	Radfan
Bread Wheat	Yemen	1998	Seiyun
Durum Wheat	Algeria	1982	ZB//Fg/Loukos
Durum Wheat	Algeria	1984	Timgad
Durum Wheat	Algeria	1986	Sahl
Durum Wheat	Algeria	1986	Waha
Durum Wheat	Algeria	1992	Om Rabi 6
Durum Wheat	Algeria	1993	Belikh 2
Durum Wheat	Algeria	1993	Heider
Durum Wheat	Algeria	1993	Kabir-1
Durum Wheat	Algeria	1993	Om Rabi 9
Durum Wheat	Cyprus	1982	Mesaoria
Durum Wheat	Cyprus	1984	Karpasia
Durum Wheat	Cyprus	1994	Macedonia
Durum Wheat	Egypt	1994	Benesuef-3
Durum Wheat	Egypt	1979	Sohag 1
Durum Wheat	Egypt	1988	Beni suef
Durum Wheat	Egypt	1988	Sohag 2
Durum Wheat	Egypt	1990	Sohag 3
Durum Wheat	Greece	1982	Selas
Durum Wheat	Greece	1983	Sapfo
Durum Wheat	Greece	1984	Skiti
Durum Wheat	Greece	1985	Samos
Durum Wheat	Greece	1985	Syros
Durum Wheat	Iran	1996	Seimareh=Om Rabi 5
Durum Wheat	Iran	1997	Heider
Durum Wheat	Iran	1997	Korifla
Durum Wheat	Iraq	1994	Waha Iraq
Durum Wheat	Iraq	1997	Korifla

Crop	Country	Year of release	Variety
Durum Wheat	Jordan	1988	Cham 1
Durum Wheat	Jordan	1988	ACSAD 65=STK
Durum Wheat	Jordan	1988	Amra=N-432
Durum Wheat	Jordan	1988	Maru=Cham 1
Durum Wheat	Jordan	1988	Petra=KRF
Durum Wheat	Lebanon	1987	Belikh 2
Durum Wheat	Lebanon	1989	Sebou
Durum Wheat	Lebanon	1993	Waha=Cham 1
Durum Wheat	Libya	1985	Baraka
Durum Wheat	Libya	1985	Fazan
Durum Wheat	Libya	1985	Ghuodwa
Durum Wheat	Libya	1985	Marjawi
Durum Wheat	Libya	1985	Qara
Durum Wheat	Libya	1985	Zorda
Durum Wheat	Libya	1991	Zahra 1
Durum Wheat	Libya	1992	Khiar 92
Durum Wheat	Libya	1993	Zahra 3
Durum Wheat	Libya	1993	Zahra 5=Korifla
Durum Wheat	Libya	1995	Zahra 9
Durum Wheat	Morocco	1984	Marzak
Durum Wheat	Morocco	1989	Om Rabi 1
Durum Wheat	Morocco	1989	Sebou
Durum Wheat	Morocco	1991	Tensift
Durum Wheat	Morocco	1992	Brachoua
Durum Wheat	Morocco	1992	Om Rabi 5
Durum Wheat	Morocco	1994	Anouar
Durum Wheat	Morocco	1994	Jawhar
Durum Wheat	Morocco	1997	Telset
Durum Wheat	Pakistan	1985	Wadhanak
Durum Wheat	Portugal	1983	Celta
Durum Wheat	Portugal	1983	Timpanas
Durum Wheat	Portugal	1984	Castico
Durum Wheat	Portugal	1985	Helvio
Durum Wheat	Portugal	n.a.	Te 9204
Durum Wheat	Saudi Arabia	1987	Cham 1
Durum Wheat	Spain	1983	Mexa
Durum Wheat	Spain	1985	Nuna
Durum Wheat	Spain	1989	Jabato
Durum Wheat	Spain	1991	Anton
Durum Wheat	Spain	1991	Roqueno
Durum Wheat	Spain	1997	Polux=Syrian-2
Durum Wheat	Spain	1998	Altair=Syrian-3
Durum Wheat	Spain	1998	S. Froilan
Durum Wheat	Spain	1998	Alicante=Azeghar-1
Durum Wheat	Spain	1999	Gaviola
Durum Wheat	Sudan	1996	Cham 1
Durum Wheat	Sudan	1997	Waha
Durum Wheat	Syria	1984	Cham 1=Waba
Durum Wheat	Syria	1987	Bohouth 5
Durum Wheat	Syria	1987	Cham 3=Korifla
Durum Wheat	Syria	1994	Cham 5=Om Rabi 3
Durum Wheat	Tunisia	1987	Razzak
Durum Wheat	Tunisia	1993	Khiar
Durum Wheat	Tunisia	1993	Om Rabi 3
Durum Wheat	Turkey	1984	Susf bird
Durum Wheat	Turkey	1985	Balcali
Durum Wheat	Turkey	1988	EGE 88

Crop	Country	Year of release	Variety	Other name
Durum Wheat	Turkey	1990	Cham 1	-
Durum Wheat	Turkey	1991	Kiziltan	-
Durum Wheat	Turkey	1994	Aydin 93	-
Durum Wheat	Turkey	1997	Haran=Om Rabi 5	-
Durum Wheat	Turkey	1998	Altin 98	-
Durum Wheat	Turkey	1998	Ankara 98	-
Faba Bean	Egypt	1994	Gizablanca	Selected from Reina Blanca
Faba Bean	Egypt	1995	Giza 429	Selected from Giza 402
Faba Bean	Egypt	1995	Giza 461	Giza 3 x ILB 938
Faba Bean	Egypt	1995	Giza 643	249/801/80 x NA 83
Faba Bean	Egypt	1995	Giza 674	Giza 402 x BPL 582
Faba Bean	Egypt	1995	Giza 714	462/908 B/83 x 503/453/83
Faba Bean	Egypt	1995	Giza 716	461/842/83 x 503/453/83
Faba Bean	Egypt	1995	Giza 717	503/453/83 x ILB 938
Faba Bean	Egypt	1997	Giza 2	n.a.
Faba Bean	Egypt	1997	Giza 3	n.a.
Faba Bean	Egypt	1998	Giza 40	Landrace, selected from local variety
Faba Bean	Egypt	1998	Giza 843	461/845/83 x 561/2076/85
Faba Bean	Iran	1986	Barkat	ILB 1269
Faba Bean	Portugal	1992	Favel	80S 43977
Faba Bean	Sudan	1990	Sellaim-ML	n.a.
Faba Bean	Sudan	1991	Shambat 104	n.a.
Faba Bean	Sudan	1991	Shambat 75	n.a.
Faba Bean	Sudan	1993	Basabeer	BB7
Faba Bean	Sudan	1993	Hudeiba 93	Bulk1/3
Faba Bean	Sudan	1993	Shambat 616	616
Faba Bean	Syria	1991	Hama 1	Selection from Aquadulce
Faba Bean	Turkey	1998	Yilmaz 98	n.a.
Forage Legumes	Australia	1998	(Lathyrus cicera) Chalus	IFLLC-1279
Forage Legumes	Cyprus	1998	(V. narbonensis) acc. 568	IFLVN-2383.
Forage Legumes	Jordan	1994	(L. ochrus) IFLLO-185	IFLLO-185
Forage Legumes	Jordan	1994	(V. villosa ssp. dasycarpa) IFLVD 683	IFLVD 683
Forage Legumes	Jordan	1994	(V. sativa) IFLVS-715	IFLVS-715
Forage Legumes	Lebanon	1997	(L. cicera) Jaboulah	IFLLC-492
Forage Legumes	Lebanon	1997	(V. sativa) Baraka	IFLVS-715
Forage Legumes	Morocco	1990	(V. sativa) ILFVS-1812	ILFVS-1812
Forage Legumes	Morocco	1992	(V. villosa ssp. dasycarpa) IVLVD-2053	IVLVD-2053

Crop	Country	Year of release	Variety	Other name
Forage Legumes	Morocco	1994	(V. narbonensis) IFLVN-2387	IFLVN-2387
Forage Legumes	Morocco	1994	(V.narbonensis) IFLVN-2391	IFLVN-2391
Forage Legumes	Morocco	1994	(V. sativa) IFLVS-709	IFLVS-709
Forage Legumes	Pakistan	1997	(V. villosa ssp. dasycarpa) Kuhak-96	IFLVD-683
Kabuli Chickpea	Algeria	1988	ILC 3279	ILC 3279
Kabuli Chickpea	Algeria	1988	ILC 482	ILC 482
Kabuli Chickpea	Algeria	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Algeria	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	China	1988	ILC 202	ILC 202
Kabuli Chickpea	China	1988	ILC 411	ILC 411
Kabuli Chickpea	China	1993	FLIP 81-40WC	FLIP 81-40WC
Kabuli Chickpea	China	1993	FLIP 81-71C	FLIP 81-71C
Kabuli Chickpea	China	1996	ILC 3279	ILC 3279
Kabuli Chickpea	Cyprus	1984	Yialousa	ILC 3279
Kabuli Chickpea	Cyprus	1987	Kyrenia	ILC 464
Kabuli Chickpea	Egypt	1994	Giza 88	n.a.
Kabuli Chickpea	Egypt	1995	Line 195	ILC 195
Kabuli Chickpea	France	1988	TS1009	ILC 482
Kabuli Chickpea	France	1988	TS1502	FLIP 81-293C
Kabuli Chickpea	France	1992	Roye Rene	F 84-188C
Kabuli Chickpea	India	1996	Pant G88-6	n.a.
Kabuli Chickpea	Iran	1995	FLIP 84-48C	FLIP 84-48C
Kabuli Chickpea	Iran	1995	ILC 3279	ILC 3279
Kabuli Chickpea	Iran	1995	ILC 482	ILC 482
Kabuli Chickpea	Iraq	1991	Dijla	ILC 3279
Kabuli Chickpea	Iraq	1991	Rafidain	ILC 482
Kabuli Chickpea	Italy	1987	Califfo	ILC 72
Kabuli Chickpea	Italy	1987	Sultano	ILC 3279
Kabuli Chickpea	Italy	1995	Pascia	FLIP 86-5C
Kabuli Chickpea	Jordan	1990	Jubeiha 2	ILC 482
Kabuli Chickpea	Jordan	1990	Jubeiha 3	ILC 3279
Kabuli Chickpea	Lebanon	1989	Janta 2	ILC 482
Kabuli Chickpea	Lebanon	1993	Baleela	FLIP 85-5C
Kabuli Chickpea	Lebanon	1998	Al-Wady	FLIP 86-6
Kabuli Chickpea	Libya	1993	ILC 484	ILC 484
Kabuli Chickpea	Morocco	1987	ILC 195	ILC 195
Kabuli Chickpea	Morocco	1987	ILC 482	ILC 482
Kabuli Chickpea	Morocco	1992	Douyet	FLIP 84-92C
Kabuli Chickpea	Morocco	1992	Rizki	FLIP 83-48C
Kabuli Chickpea	Morocco	1995	Farihane	FLIP 84-79C
Kabuli Chickpea	Morocco	1995	Moubarak	FLIP 84-145C
Kabuli Chickpea	Morocco	1995	Zahor	FLIP 84-182C
Kabuli Chickpea	Oman	1988	ILC 237	ILC 237
Kabuli Chickpea	Oman	1995	FLIP 87-45C	FLIP 87-45C
Kabuli Chickpea	Oman	1995	FLIP 89-130C	FLIP 89-130C
Kabuli Chickpea	Pakistan	1992	Noor 91	FLIP 81-293C
Kabuli Chickpea	Portugal	1992	Elmo	ICC 6304
Kabuli Chickpea	Portugal	1992	Elvar	FLIP 85-17C
Kabuli Chickpea	Portugal	1998	Elite	ICC 5035
Kabuli Chickpea	Spain	1985	Alcazaba	ILC 2555

Crop	Country	Year of release	Variety	Other name
Kabuli Chickpea	Spain	1985	Almena	ILC 2548
Kabuli Chickpea	Spain	1985	Atalaya	ILC 200
Kabuli Chickpea	Spain	1985	Fardan	ILC 72
Kabuli Chickpea	Spain	1985	Zegri	ILC 200
Kabuli Chickpea	Spain	1995	Athenas	ILC 72 x CA2156
Kabuli Chickpea	Spain	1995	Bagda	ILC 72 x CA 2156
Kabuli Chickpea	Spain	1995	Kairo	ILC 72 x CA 2156
Kabuli Chickpea	Sudan	1987	Shendi	ILC 1335
Kabuli Chickpea	Sudan	1994	Jebel Marra-1	ILC 915
Kabuli Chickpea	Sudan	1996	Atmor	ICCV 89509
Kabuli Chickpea	Sudan	1998	Matama-1	FLIP 91-770
Kabuli Chickpea	Sudan	1998	Salawa	ICCV-2
Kabuli Chickpea	Sudan	1998	Wad Hamid	FLIP 89-826
Kabuli Chickpea	Syria	1986	Ghab 1	ILC 482
Kabuli Chickpea	Syria	1986	Ghab 2	ILC 3279
Kabuli Chickpea	Tunisia	1986	Amdoun 1	Be-sel-81-48
Kabuli Chickpea	Tunisia	1987	Chetoui	ILC 3279
Kabuli Chickpea	Tunisia	1987	Kassab	FLIP 83-46C
Kabuli Chickpea	Tunisia	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Tunisia	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	Turkey	1986	Guney Sarisi 482	n.a.
Kabuli Chickpea	Turkey	1986	ILC 195	ILC 195
Kabuli Chickpea	Turkey	1991	Akcin	87AK81115
Kabuli Chickpea	Turkey	1992	Aydin 92	FLIP 82-259C
Kabuli Chickpea	Turkey	1992	Izmir 92	FLIP 85-60C
Kabuli Chickpea	Turkey	1992	Menemen 92	FLIP 85-14C
Kabuli Chickpea	Turkey	1994	Aziziye	FLIP 84-15C
Kabuli Chickpea	Turkey	1994	Damla	FLIP 85-7C
Kabuli Chickpea	Turkey	1997	Gokce	FLIP 87-8C
Kabuli Chickpea	USA	1994	Dwelley	Surutato x FLIP 85-58C
Kabuli Chickpea	USA	1994	Sanford	Surutato x FLIP 85-58C
Lentil	Algeria	1987	Syrie 229	n.a.
Lentil	Algeria	1988	Balkan 755	n.a.
Lentil	Algeria	1988	ILL 4400	ILL 4400
Lentil	Argentina	1991	Arbolito	ILL 4650x-4349
Lentil	Australia	1989	Aldinga	FLIP 84-80L
Lentil	Australia	1993	Cobber	FLIP 84-58L
Lentil	Australia	1993	Digger	FLIP 84-51L
Lentil	Australia	1993	Matilda	FLIP 84-154L
Lentil	Australia	1995	Northfield	78S 26013
Lentil	Australia	1998	Cassab	FLIP 92-35L
Lentil	Australia	1998	Cumra	ILL 590
Lentil	Bangladesh	1993	Barimasur-2	Sel. from ILL 4353xILL 353
Lentil	Bangladesh	1995	Barimasur-4	Sel. from L5 x FLIP84-112L
Lentil	Canada	1989	Indian head	ILL 481
Lentil	Canada	1994	CDC Matador	((Indian head x (Eston x PI 179310))
Lentil	Canada	1994	CDC Redwing	Eston x ILL 5588
Lentil	Chile	1989	Centinela	74TA 470
Lentil	China	1988	FLIP 87-53L	FLIP 87-53L
Lentil	China	1998	C 87	ILL 6980
Lentil	Egypt	1990	Precoz	ILL 4605

Crop	Country	Year of release	Variety	Other name
Lentil	Egypt	1998	Giza 370	Bulk selection from Egyptian land race 370
Lentil	Egypt	1998	Giza 4	n.a.
Lentil	Egypt	1998	Giza 51	ILL 883 (Iran) x ILL 470 (Syria)
Lentil	Egypt	1998	Sinai 1	Bulk selection from Argentinean variety Precoz
Lentil	Ethiopia	1980	R 186	R 186
Lentil	Ethiopia	1984	Chalew	LL 358
Lentil	Ethiopia	1984	Chikol	NEL 2704
Lentil	Ethiopia	1993	FLIP 84-7L	FLIP 84-7L
Lentil	Ethiopia	1995	Ada'a	FLIP 86-41L
Lentil	Ethiopia	1995	Gudo	FLIP 84-78L
Lentil	Iraq	1994	Baraka	78S 26002
Lentil	Jordan	1990	Jordan 3	78S 26002
Lentil	Lebanon	1988	Talya 2	78S 26013
Lentil	Lebanon	1995	Toula	FLIP 86-2L
Lentil	Lesotho	1998	FLIP 87-21L	FLIP 87-21L
Lentil	Libya	1993	El Safsaf 3	78S26002
Lentil	Morocco	1990	Bakria (Precoz)	ILL 4605
Lentil	Nepal	1989	Sikhar	ILL 4402
Lentil	New Zealand	1992	Rajah	FLIP 87-53L
Lentil	Pakistan	1990	Manserha 89	ILL 4605
Lentil	Pakistan	1995	Masur 95	18-12xILL 4400
Lentil	Pakistan	1996	Shiraz-96	ILL 5865
Lentil	Sudan	1993	Aribo 1	ILL 818
Lentil	Sudan	1993	Rubatab 1 (ILL 813)	ILL 813
Lentil	Sudan	1998	Nedi	ILL 6467
Lentil	Syria	1987	Idleb 1	78S 26002
Lentil	Tunisia	1986	Nefza	ILL 4606
Lentil	Tunisia	1986	Neir	ILL 4400
Lentil	Turkey	1987	Firat 87	75Kf 36062
Lentil	Turkey	1990	Erzurum 89	ILL 942
Lentil	Turkey	1990	Malazgirt 89	ILL1384
Lentil	Turkey	1991	Sazak 91	NEL 854
Lentil	Turkey	1996	Sayran 96	ILL 784
Peas	Cyprus	1994	Kontemenos	PS 210713
Peas	Ethiopia	1994	061K-2P-2192	n.a.
Peas	Lesotho	1997	Local Sel 1690	n.a.
Peas	Lesotho	1997	Mg 102469	n.a.
Peas	Lesotho	1997	Syrian Aleppo	n.a.
Peas	Oman	1995	A 0149 Dry Pea	n.a.
Peas	Oman	1995	Collegian Dry Pea	n.a.
Peas	Oman	1995	MG 102703 Dry Pea	n.a.
Peas	Oman	1995	Syrian Local Dry Pea	n.a.
Peas	Sudan	1989	Krema-1	n.a.
Peas	Sudan	1994	Ballet	n.a.

GERMPLASM PROGRAM
Staff List 1999

1.	Dr William Erskine	Program Leader
2.	Dr Salvatore Ceccarelli	Barley Breeder
3.	Dr Khaled Makkouk	Plant Virologist
4.	Dr Hugo Vivar	Regional Coordinator Latin America & Barley Breeder (based in Mexico)
5.	Dr Miloudi Nachit	Durum Breeder (CIMMYT) & Regional Representative (WANA)
6.	Dr Osman Abdallah	Bread Wheat Breeder
7.	Dr Ali Abd El Moneim	Forage/Legume Breeder
8.	Dr Michael Baum	Biotechnologist
9.	Dr Habib Ketata	Acting Regional Coordinator Highlands Program & Winter Wheat Breeder
10.	Dr Abderrezak Belaid	Socioeconomist (based in Tunisia)
11.	Dr Rajinder S. Malhotra	Senior Chickpea Breeder
12.	Dr Victor Shevtsov	Barley Breeder (based in Uzbekistan)
13.	Dr Amor Yahyaoui	Senior Cereal Pathologist
14.	Dr Mustapha El Bouhssini	Entomologist
15.	Dr Chrys Akem	Legume Pathologist
16.	Dr Stefania Grando	Barley Breeder
17.	Dr Ashutosh Sarker	Lentil Breeder
18.	Dr Sripada Udupa	Associate Scientist
19.	Dr Bruno Ocampo	Acting International Trials Scientist & Research Associate
20.	Mr Fadel Afandi	Research Associate
21.	Dr Imad Eujayl	PDF-Biotechnology
22.	Mr Bruno Schill	PDF-Faba Been Breeder
23.	Mrs Bianca Van Dorrestein	Research Fellow (Visiting)
24.	Mr Gaby Khalaf	Research Associate
25.	Mr Michael Michael	Research Associate
26.	Mr Antoine P. Asbati	Research Associate
27.	Mr Munzer Naimi	Research Associate
28.	Mr Fouad Jaby El Haramein	Research Associate
29.	Mr Samir Hajjar	Research Associate

30. Mr Adonis Kourieh	Research Assistant
31. Mr Henry Pashayani	Research Assistant
32. Mr Nicholas Rbeiz	Research Assistant (based in Terbol)
33. Mr Abdallah Joubi	Research Assistant
34. Mr Pierre Kiwan	Research Assistant (based in Terbol)
35. Mrs Siham Kabbabeh	Research Assistant
36. Mr Mazen Jarrah	Research Assistant
37. Mr Hani Nakkoul	Research Assistant
38. Mr George Zakko	Research Assistant
39. Ms Suheila Arslan	Research Assistant
40. Mr Hasan El Hasan	Research Assistant
41. Mr George Kashour	Research Assistant
42. Mr Alaa Yaljarouka	Research Assistant
43. Ms Safaa Kumari	Research Assistant
44. Mr Mahmoud Hamzeh	Research Assistant
45. Mr Ziad Alamdar	Senior Research Technician
46. Mr Mohamed Azrak	Senior Research Technician
47. Mr Riad Ammaneh	Senior Research Technician
48. Mr Adnan Ayyan	Senior Research Technician
49. Mrs Widad Ghoulam	Senior Research Technician
50. Mr Omar Labban	Senior Research Technician
51. Mr Nidal Kadah	Senior Research Technician
52. Mr Raafat Azzo	Research Technician
53. Mr Mohamed K. Issa	Research Technician
54. Mr Ahmad El Saleh	Research Technician
55. Mr Mohamed El Jasem	Research Technician
56. Mr Bounian Abdel Karim	Research Technician
57. Ms Setta Ungi	Research Technician
58. Ms Nadia Fadel	Research Technician
59. Ms Sawsan Tawkaz	Research Technician
60. Mr Hani Hazzam	Research Technician
61. Ms Aman Sabbagh	Research Technician
62. Ms Iman Maaz	Research Technician
63. Mrs Mouna Baalbaki	Research Technician
64. Mr Mohamed El Karim	Research Technician
65. Mrs Nouran Attar	Research Technician
66. Mr Noaman Ajanji	Driver/Store Keeper
67. Mr Obeid El Jasem	Labourer-Farm
68. Mr Fawaz El Abdallah	Labourer
69. Mr Joseph Karaki	Assistant Research Technician (based in Terbol)

70. Mr Ghazi Khatib	Assistant Research Technician (based in Terbol)
71. Ms Rita Nalbandian	Executive Secretary
72. Mrs Sossi Toutounji	Secretary
73. Ms Hazar Sabbagh	Secretary
74. Mrs Tamar Varvarian	Secretary

Consultants

1. Dr Shaaban Khalil	Faba Bean Breeder
2. Dr Bassam Bayaa	Legume Pathologist
3. Dr Mohamed Shafik Hakim	Cereal Pathologist
4. Dr Wafa Choumane	Legume Biotechnologist
5. Mrs Maisoun Hamameh	Cereal Biotechnologist
6. Mr Haitham Sayed	Cereal Biotechnologist

ARGP-12

المركز الدولي للبحوث الزراعية في المناطق الجافة
ايكاردا
ص. ب. 5466 حلب ، سورية

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