GERMPLASM PROGRAM LEGUMES

Annual Report for 1997

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1. INTRODUCTION

The crop improvement research on cereals and legumes at the International Center for Agricultural Research in the Dry Areas (ICARDA) is done by the Germplasm Improvement Program. Among the cereals, it covers barley, durum wheat and bread wheat, while amongst the legumes it covers lentil, chickpea, faba bean, forage legumes and pea. 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 pea 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 mandate for this crop.

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 the headquarters. In the case of chickpea, ICRISAT posted a chickpea breeder at ICARDA to address the needs of the crop in WANA.

The overall objective of the Germplasm Improvement 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, Russia, 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 1996/97 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 higher than the long term average in Bouider and Tel Hadya, and lower in Breda and Terbol. The deviation in precipitation from the long term average were considerable in descending order at Tel Hadya, Terbol, Bouider and Breda, in this order.

In Bouider, the total precipitation exceeded the long term average by approximately 50 % (348 mm versus 226 mm). The highest monthly precipitation deviations from the average were positive and occurred in December, March and April (more than 40 mm above average). The mean maximum temperature during the cropping season was 1°C below the long term average, whereas the mean minimum temperature was 2°C above the average.

In Breda, the total precipitation was 15 % lower than average (231 mm versus 266 mm). The highest monthly precipitation deviations from the average were negative and occurred in January and February (26 mm below the average), whereas in March the precipitation was 25 mm above average. Minimum and maximum temperatures were about 2.5°C below the average from January to April.

In Tel Hadya, the total precipitation exceeded the long term average by 25 % (434 mm versus 348 mm). The highest monthly precipitation deviations from the average were positive and occurred in December, March, and above all in April (80 mm above average). During November and February, the precipitation was less than half of the average. Though the minimum and maximum temperatures during the cropping season were average, they were 2°C below average from February to April.

In Terbol, the total precipitation was 12 % lower than average (496 mm versus 565 mm). The highest monthly precipitation deviations from the average were negative and occurred in November and January (54 mm and 67 mm below average). Precipitation in April was the double of average. The minimum and maximum temperatures followed the average, however between February and April the maximum was 3°C and the minimum 2°C below the average.

One of the major events in 1997 was the Center Commissioned External Review (CCER) of cereal projects and integrated pest management, held in Aleppo in early February 1997. Overall, the CCER produced an excellent, well-balanced report which showed a depth of understanding of our research on cereals and integrated pest management (IPM) and gave constructive ideas for change. The CCER made the following key recommendations regarding cereal and IPM research:

1. ICARDA should define clearly its long-term strategy to carry out its global mandate on barley
2. Durum program should receive strong support to maintain its lead as a world center of excellence for durum wheat
3. ICARDA should develop a systematic, multi-disciplinary, smooth flowing approach to germplasm evaluation, identification of traits; and pre-breeding centered on its cereal germplasm collections
4. Planning to enlarge the storage facilities should be initiated, including the possibility of storing duplicate samples for important crops of the area that have been collected by NARS
5. Increased level of staffing for the Integrated Pest Management Program should be made available
6. Biotechnological activities should be conducted within a well-defined, multidisciplinary experimental framework, and that ICARDA's biotechnology laboratories should focus on the application of molecular markers to tackle clearly defined problems in phenotypically and agronomically well-characterized material (germplasm)
7. The guiding scientific vision of the biotechnology/GRU/germplasm enhancement collaborative effort should be an emphasis on characterization of germplasm using appropriate molecular biology techniques, and this approach should be integral to the Center's research thrusts; further, molecular biology and biotechnology methods of partnerships between molecular biologists, breeders and supporting disciplines should permeate and underpin all germplasm enhancement programs at ICARDA
8. ICARDA should examine how best to serve the Central Asian Republics and Trans-Caucasus Republics through research partnerships, training and exchanges of germplasm

The program accepted these recommendations and has started to make the necessary changes during 1997 within available budgetary limitations.

During the year the following changes in senior staff occurred:

a. Dr Guillermo Ortiz-Ferrara (CIMMYT) Spring bread wheat breeder *left and was replaced by* Dr *Osman* Abdalla
b. Dr Mustafa El-Bouhssini joined as Entomologist in the program
c. Dr Habib Ketata was transferred to Ankara as Wheat breeder in the CIMMYT/ICARDA/Turkey program
d. Dr Abderrezak Belaid (Socio-economist) was transferred to ICARDA Tunis.
   Dr. Omar Mamluk (Cereal Pathologist) retired
c. Dr. Franz Weigand (Biotechnologist) resigned
d. Dr. S. K. Yau (Cereal International Trials Scientist) resigned
e. Mr Suren Jurgensen joined as a Junior Professional Officer from Denmark in barley breeding

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 1997:

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 (person 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 (person in charge, F. Weigand)

3. **Improving Yield and Yield Stability of Barley in Stress Environments**, supported by the Government of Italy (person 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 (person 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) (person in charge S. Ceccarelli)
6. **Resistance to nematodes in lentil and chickpea,** in collaboration with the Institute of Nematology of Bari, (persons 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 (person in charge R.S. Malhotra)
8. **Fusarium Wilt in Chickpea**, supported by the Government of Spain and in collaboration with INIA (person in charge R.S. Malhotra)
9. **Wheat Adaptation Studies for Wheat in WANA and Australia**, supported by Grains Research Development Council (GRDC) Australia, in collaboration with the University of Sydney (person in charge G. Ortiz-Ferrara)
10. **International Durum Wheat Improvement**, supported by Grains Research Development Council (GRDC) Australia, in collaboration with the New South Wales Department of Agriculture (person in charge M. Nachit)

11. **Coordinated Improvement Program for Australian Lentils**, supported by Grains Research Development Council (GRDC) (person in charge W. Erskine)
12. **Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia**, supported by the Australian Centre for International Agricultural Research (ACIAR) (person in charge W. Erskine)
13. **Central and West Asia Rusts Network-enhanced Regional Food Security Through the Development of Wheat Varieties with Durable Resistance to Yellow Rust** (person in charge O. Mamluk)
14. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN)** supported by IFAD (person in charge M. Machit)
15. **Faba Bean in China**, supported by the Australian Centre for International Agricultural Research (ACIAR) and in collaboration with the Genetic resources Unit (person in charge L. Robertson)
16. **Integrated Management of Pest and Diseases**, supported by BMZ (person in charge K. Makkouk)
17. **Durum Wheat Improvement** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge M. Nachit)
18. **Kabuli Chickpea** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge R.S. Malhotra)
19. Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants (person in charge: S. Ceccarelli) (supported by the Australian Centre for International Agricultural Research-ACIAR).
20. Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality (person in charge: M. Nachit) (supported by Agricultural Technology, Utilization and Transfer

Project-ATUT).

21. Development of high yielding, long spike bread wheat cultivars possessing high tiller, number, rust resistance and heat tolerance facilitated by microsatellite DNA markers (person in charge: Dr O. Abdalla) (supported by Agricultural Technology, Utilization and Transfer Project-ATUT).
22. Genetic transformation of barley for improved stress resistance (person in charge: Dr M. Baum) (supported by CGIAR).
23. Adaptation of barley to drought and temperature stress using molecular markers (person in charge (Dr S. Ceccarelli) (supported by USDA, Texas Tech University, U.S.A.)
24. Inheritance and linkage of winter hardiness in lentil (person in charge: Dr W. Erskine) (supported by USDA, Washington State University, U.S.A.)
25. Use of entomopathogenic fungi for the control of Sunn pest (person in charge: Dr M. El Bouhssini) (supported by USDA, University of Vermont, U.S.A.)

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 two sections, one with the results of cereal crops improvement work and one with results of the legume crops improvement work.

Most of the results reported in the two sections were obtained during the 1996-97 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.

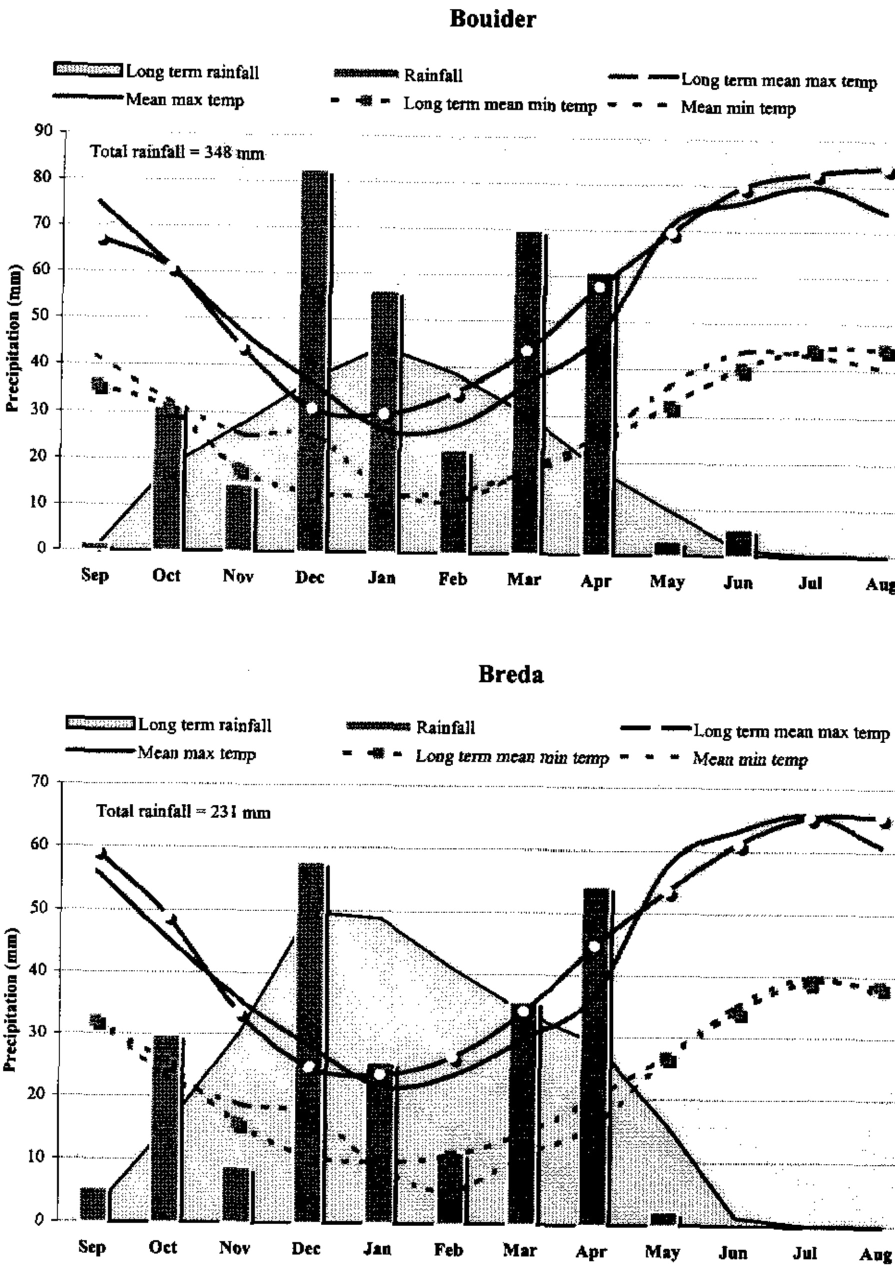
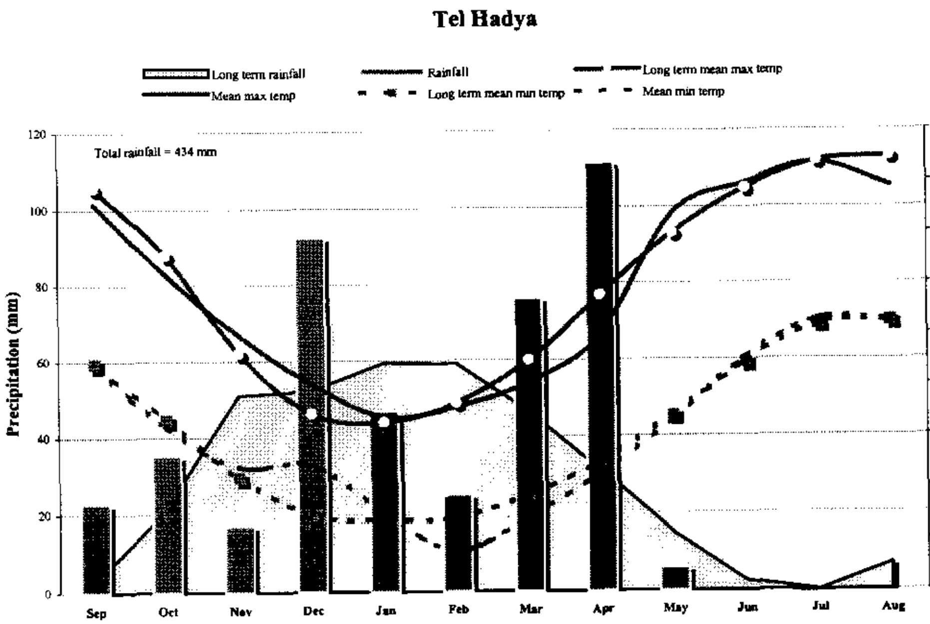


Fig. 1.1. Weather conditions at Bouider and Breda during 1996-97.



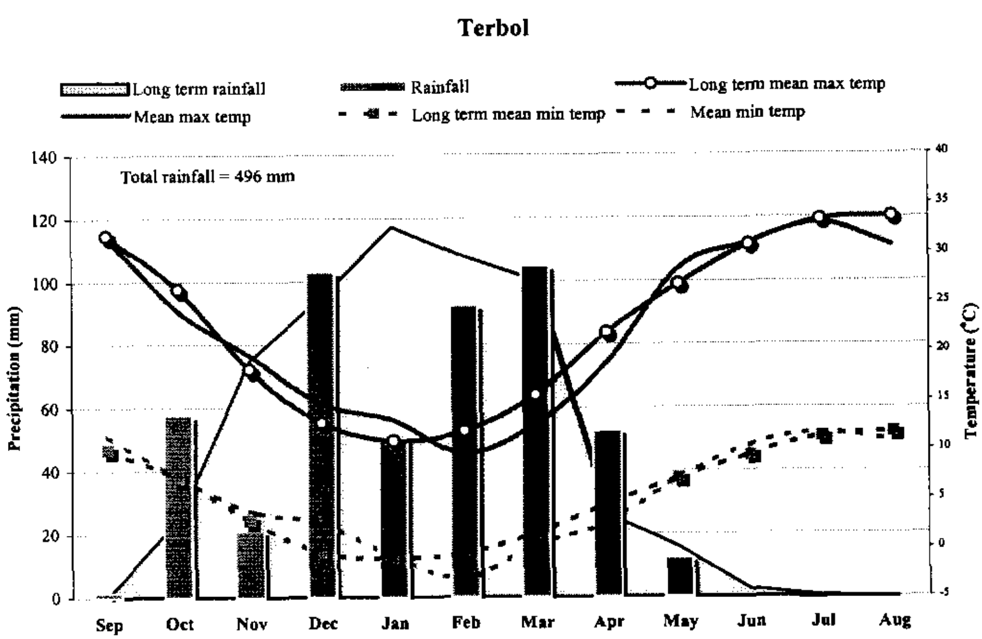


Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1996-97.

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.

2.1. Lentil Breeding

2.1.1. Base Program

2.1.1.1. Lentil Adaptation and Breeding Scheme

The lentil is an under-exploited and under-researched annual legume. From the onset 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 and E. Africa 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. The target areas/regions and key traits for selection/recombination are tabulated in Table 2.1.

The breeding strategies used for this annual, diploid, self-pollinated food legume have changed 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 (Figure 2.1), illustrating the value of direct exploitation of landraces.

Table 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 and wilt resistance
2. < 300 mm ann. Rainfall:	Biomass, drought escape through' earliness
3. Morocco:	Biomass, attributes for mechanical harvest and rust resistance
4. Egypt:	Seed yield, response to irrigation, earliness and wilt resistance
High elevation	
1. Anatolian highlands:	Biomass and winter hardiness
2. N. African highlands:	Seed yield and low level of winter hardiness
South Asia and E. Africa	
1. India, Pakistan, Nepal:	Seed yield, early maturity, resistance & Ethiopia to rust, ascochyta and wilt
2. Bangladesh:	Seed yield, extra earliness & rust resistance

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 were made at ICARDA to produce Stage-2 material. These 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

(Figure 2.1).

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. For other 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. Approximately 200 crosses are made annually at ICARDA. 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.

2.1.1.2. 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 2.1.1.3) to ensure that only high-yielding, wilt resistant lines are advanced in the breeding program.

The 1996/97 season was drier than average at Breda and Terbol with rainfall totals of 231 mm received in the growing season at Breda and 496 mm at Terbol. Tel Hadya location was wetter than long-term average with a total rainfall of 434 mm. The winter cold was average in Syria with 39 frost days at Breda and 41 days at Tel Hadya in the 1996/97 season, where the long-term averages are 43 days at Breda and 37 days at Tel Hadya. By contrast, the winter was cooler and longer than average at Terbol in Lebanon, where 60 frost events were recorded in the 1996/97 cropping season.

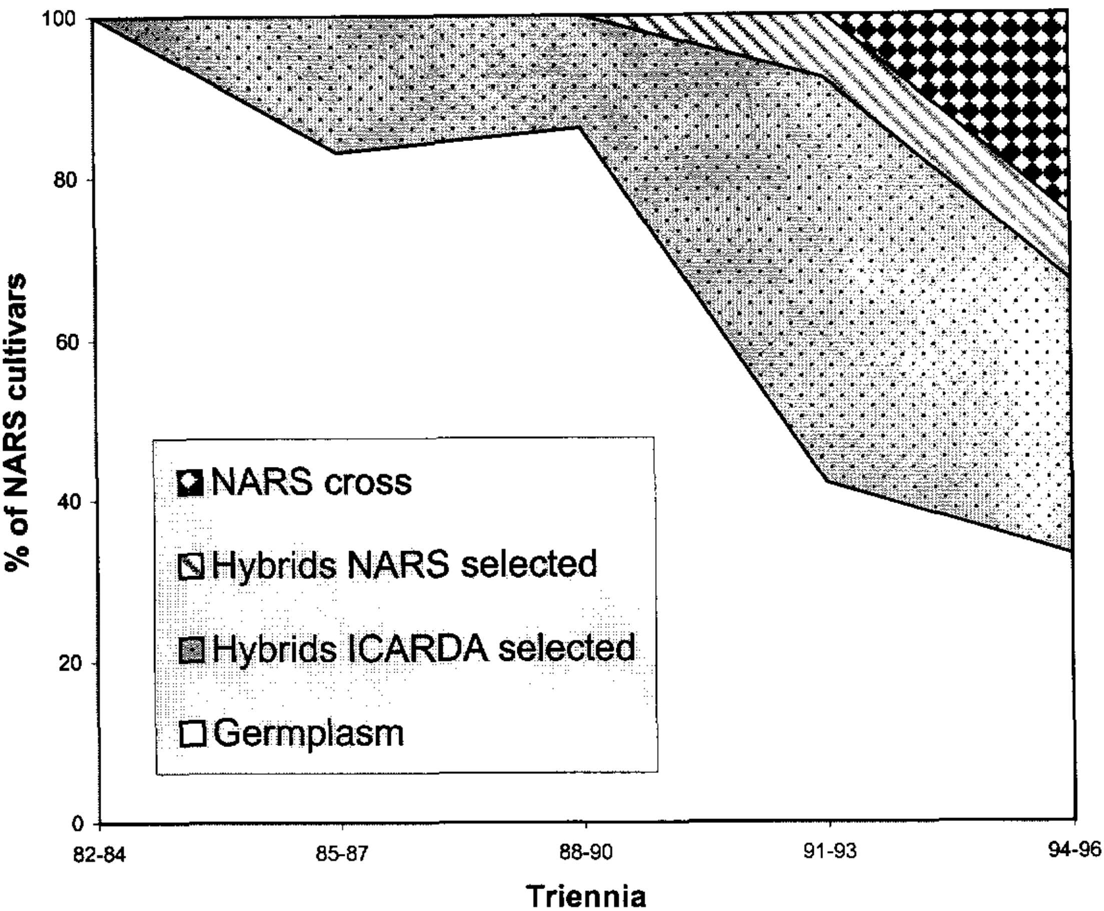


Fig. 2.1. Lentil varieties released by NARS (1982-1996).
Germplasm: Stage 1- Selections among and within accessions in ICARDA germplasm collection. Hybrids ICARDA selected: Stage 2- Selections made at ICARDA, Syria in segregating populations from ICARDA crosses.
Hybrids NARS selected: Stage 3- Selections made by NARS from segregating populations from ICARDA crosses.
NARS crosses: Stage 4- Selections made by NARS from segregating populations from NARS crosses with parents from ICARDA.

The average seed yield varied from 1971 kg/ha at Terbol, through 1287 kg/ha at Tel Hadya to only 270 kg/ha at Breda (Table 2.2). The corresponding biomass yields were 8.2 t/ha in Terbol, 5.4 t/ha in Tel Hadya and 3.5 t/ha in Breda. The harvest index (HI) was strikingly lower in Breda, at HI=0.11, compared to 0.24 at the other two trial sites. All the trials in Breda was so severely affected by cow pea aphid (*Aphis craccivora* Koch) that the crop failed to complete pod-filling. The percentage of lines yielding significantly more seed than the best check was greatest in Tel Hadya (31.7%) and lowest in Breda (1.1%). However, the percentage of lines ranking above best check for seed yield (excluding significantly different lines) was highest (60.2%) in Breda and lowest in Terbol (22.3%). The mean coefficient of variation over trials for seed yield was highest in Breda (33.4%) and lowest in Terbol (10.5%). However, the mean coefficient of variation for biomass was less than their corresponding mean coefficient of variation for seed yield in all the locations.

All trials (with one exception in Tel Hadya) were arranged in a 5x5 lattice design. A comparison was made between the efficiency of analysis as a lattice design and as a randomized complete blocks 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 31% over 15 trials (Table 2.2). The equivalent advantage of NNA over randomized blocks was 61% in the same trials. Clearly, NNA was superior to lattice analysis, which was, in turn, superior to analysis as randomized complete blocks. NNA should be assessed further as it is a method of adding value to existing trial data with little extra cost.

(W.Erskine, A.Sarker)

Table 2.2. Results of the lentil yield trials (preliminary and advanced) for seed (S) and biomass (B) yields (kg/ha) at three contrasting rainfed locations, Terbol (Lebanon), Tel Hadya and Breda (Syria) during the 1996/97 season.

Parameters	Terbol		Tel Hadya		Breda	
	S	B	S	B	S	B
Number of trials	5	5	6	6	4	4
Number of test entries*	110	110	123	123	88	88
% of entries sig. (P<0.05) exceeding best check**	3.6	2.7	31.7	42.3	1.1	11.4
% of entries ranking above best check (excluding above)	22.3	31.8	41.5	29.3	60.2	43.2
Yield of top entry (kg/ha)	2372	9519	1618	6150	543	4139
Best check yield (kg/ha)	2172	8635	1105	5016	384	3470
Location mean (kg/ha)	1971	8238	1287	5376	270	3486
Mean C.V. (%) over trials	11	8	20	11	33	7
Mean % advantage of lattice over RCB analysis across locations	32	13	13	29	48	64
Mean % advantage of NNA*** over RCBD analysis across trials	65	55	16	39	103	136

* 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

2.1.1.3. Screening for Vascular Wilt Resistance

Vascular wilt caused by *Fusarium oxysporum* f. sp. *lentis* is the major fungal disease of lentil in the Mediterranean region. As chemical control for the disease is not feasible, host plant resistance is the most practical method of disease management.

Screening of breeding material for wilt resistance

A total of 445 lines of breeding material were screened in the wilt sick plot at Tel Hadya (field A21) in the 1996/97 season for their reaction to wilt. The lines tested were planted in rows (50 cm) at 160-seed/ row. The experiment was in RCB with three replicates. The reaction to wilt (% of wilted / dead plants) was recorded at 3 different dates, May 7, 12 and 19.

The lines tested may be grouped into two categories:

Cycle I - new untested lines (preliminary screening nurseries-322 lines) and Cycle II - lines tested previously (advanced and preliminary yield trials-123 lines). On the basis of mean over replicates, the percentage of entries with a highly resistant (0-5% wilted plants, mean over replicates) or resistant (>5-20% wilted plants, mean over replicates) response to lentil vascular wilt were x in Cycle I and y Cycle II, indicating the reliability of the screening method. However for breeding purposes, we have selected for advancement a specific subset of the resistant lines - those which have a maximum plot score of < 20 % wilted plants in the last score. This screening is a key and integral part of the breeding program.

(B. Bayaa, C. Akem, W. Erskine)

2.1.1.4. Screening for Combined Resistance to Multiple Stresses

Screening for combined resistance to wilt and viruses

A subset of 35 lines with known reaction to FBNYV, SBDV and BLRV were screened in the wilt sick plot at Tel Hadya for their reaction to wilt.

Twelve lines were identified as resistant (>5-20% wilted plants, mean over replicates) to both wilt and FBNYV. These were: ILL 71, -590, -1712, 3614, -4400, -6198, -6154, -6797, 6797, -6994, -7010, -7618 and 7966. ILL 1712, -3614 and -7966 were resistant to wilt and three viruses (SBDV, BLRV and FBNYV). ILL 590 and 7966 were resistant to wilt and two viruses (BLRV and FBNYV).

(K. Makkouk, B. Bayaa, C. Akem, W. Erskine)

Screening for combined resistance to wilt/root rot

Forty one lentil accessions with known resistance to lentil vascular wilt were screened this season for their resistance to wet root rot (*Rhizoctonia solani*) under artificial inoculation in plastic house. For each entry, there were 4 treatments: (I), seed treatment with tolcophos methyl at 1 g a.i per kg seed + artificial inoculation with *R. solani* at planting; (ii), no seed treatment and no inoculation; (iii), no seed treatment + artificial inoculation with *R. solani* at planting; (iv), no seed treatment + artificial inoculation with *R. solani* one week after planting. Plants were scored twice for disease severity on 1 to 9 scales, where 1= healthy (no damage observed and 9= complete death.

Results indicated that inoculation at planting gives higher disease severity than inoculation 2 weeks after sowing. Disease severity increased with time. However, plant regeneration at later stage masks this effect. There were significant differences among genotypes tested for their disease reaction, seed yield and biological yield. The most resistant lines will be re-screened next season and were: ILL 5883, -6789, -6976, -6991, -6994, -7005, -7012, -7192, -7193, -7199, -7502, -7521 and -7713. In contrast lines ILL 2565. -3312, -7537, 7553 were particularly susceptible to wet root rot.

(B. Bayaa, C. Akem, W. Erskine)

2.1.1.5. Preliminary Results from Screening for Resistance to Cowpea Aphid

The cowpea aphid (*Aphis craccivora* Koch) is a serious pest of lentil in many parts of the world. Preliminary screening for resistance to cowpea aphid was done at Breda following a severe natural infestation when lentil crop was at late flowering /early pod setting stage. In most cases, the upper vegetative parts of the canopy coalesced from honeydew. A total of 88 lines and 4 checks were evaluated using a visual infestation score (VIS) from 1-5 and a visual damage score (VDS) from 1-4. One entry (95S7201-12 was significantly ($P<0.05$) more tolerant to cowpea aphid with a VIS of 3.8 and a VDS of 3.0 compared to a VIS of 4.8 and VDS of 3.5 of the local check. This entry and three other promising lines

(94S66102, 94S67123-5 and 94S67104-4) will be retested under artificial infestation next year.

(M. El Bouhssini, A. Sarker, W. Erskine, A. Joubi)

2.1.1.6. Screening for Winter-Hardiness in the Highlands

Lentil is currently sown in spring in Iran and Turkey at elevations above approximately 850m elevation on *ca* 400,000 ha. Research in Turkey has indicated that yields may be increased by up to 50 % by early sowing in late autumn with winter hardy cultivars. However, the use of such cultivars is not yet widespread in Turkey, because at elevations above *ca* 850 m the level of winter hardiness in the current cultivars is inadequate in cold winters.

A major program to recombine yield with the necessary winter hardiness is underway at the Central Research Institute for Field Crops, Ankara, Turkey through field screening. Two complementary approaches are being followed. In the first approach, winter-type germplasm collected from South-East Anatolia is being selected. In the second approach, crosses with winter-hardy germplasm sources and early generation material are being produced by the ICARDA program in Aleppo, Syria and then segregating populations are selected under severe winter conditions in highland Turkey.

The highland winter lentil project, initiated in 1991 between CRIFC and ICARDA, selected seven candidate lines (AkM 49, AkM 62, AkM 196, AkM 302, AkM 363, AkM395) were selected for winter planting in Central Anatolia after intensive selection and testing for several years on farmers' fields throughout the Central Anatolian Plateau. These seven lines, which are all Turkish red-type but differ in seed coat color and pattern, were recommended for registration for winter planting in Central Anatolia. This type of collaboration, which includes (I) developing early generation material at ICARDA, (ii) selecting from segregating material in Turkey, and (iii) getting farmers' opinions on selections before making the final decision for recommendation is a good example of collaboration between *national agricultural research systems* and ICARDA for decentralized breeding in the region.

In Iran screening for winter-hardiness has been undertaken at Gazvin by the Seed and Plant Improvement Institute. Autumn-sown lentil trials were out-yielding (>50%) the spring crop at Kermanshah and Ghazvin. Research on weed control for the autumn-sown crop is badly needed. The registration of two winter-hardy lines ILL 857 and 975 is imminent. They will form the seed base for early-sown lentils in Iran. Plans were made to start autumn-sowing on-farm trials of winter-hardy lines in the Kermanshah and Loristan regions next year.

(National Programs in Iran, Turkey)

2.1.1.7. Boron Deficiency on Lentil in Nepal

Lentil was grown on approximately 170,000 ha in Nepal from 1993 to 1995, where it is the most important food legume, representing 43% of the area planted to pulses. In a joint program funded by the Australian Centre for International Agricultural research (ACIAR) to improve lentil production with the Nepalese Grain Legume Improvement Program and the Centre for Legumes in Mediterranean Agriculture (CLIMA), lentil germplasm was introduced into Nepal. However, the evaluation of exotic germplasm at Rampur in the Chitwan region of Nepal revealed a striking micro-nutrient deficiency problem. Landraces from Nepal had no deficiency symptoms, whereas 82% out of 494 exotic accessions showed severe chlorosis and stunting (Slide 1). Parallel experimentation revealed that boron (B) deficiency was the *cause of the problem. Exotic germplasm from various* countries showed differences in B-deficiency symptoms (Figure 2.2). Accessions from Syria, representative of the Mediterranean region where lentil originated, all exhibited B-deficiency symptoms. Accessions without B-deficiency symptoms were mainly from Bangladesh (37% accessions free of B deficiency). In a subsequent trial to estimate yield losses due to boron deficiency, landraces from Nepal, which exhibited no deficiency symptoms, were B efficient and gave a mean seed yield of 1173 kg/ha. In contrast, 10 exotic lines *exhibited severe symptoms and gave no seed yield.*

In summary, the study revealed that in soil low in B striking genetic differences in B efficiency associated with geographic origin are apparent which may lead to complete yield loss in B-inefficient lentil germplasm. In practical terms, the introduction of exotic lentil germplasm to Rampur, Nepal revealed the B problem, which severely limits the scope for yield improvement in Nepal through plant introduction by limiting the size of the adapted gene pool. The geographic extent of the problem is being tracked through using susceptible 'probe' genotypes in yield trials. In the meantime, lentil introduction into Nepal is best conducted at a site with no B problem. The question may also be posed: Is yield in the Nepali landraces (with their high B efficiency) limited by B availability? This is being answered by experimentation with the addition of low levels of B to farmers' landrace lentils.

2.1.1.8. Inheritance and Linkage Relationships of Flowering Time and Morphological Loci in Lentil.

Lentil landraces exhibit specific adaptation to their ecological environment and have evolved into distinct ecotypes in different geographical regions. Adaptation for an appropriate phenology appears to be the main evolutionary force behind this differentiation. Lentils from South Asia (exclusively of the *pilosae* ecotype) are quite distinct from lentils from other countries in the qualitative morphological and phenological characters. Lentils selected in West Asia, when sown in India and Pakistan, mostly came into flower as the indigenous lentils maturing. The asynchrony in flowering between the lentil gene pools of South Asia and West Asia has resulted the reproductive isolation of *pilosae* lentils and been recognized as a major problem in the improvement of the crop. However, restructuring of genotypes for different flowering and maturity periods is possible through planned cross breeding

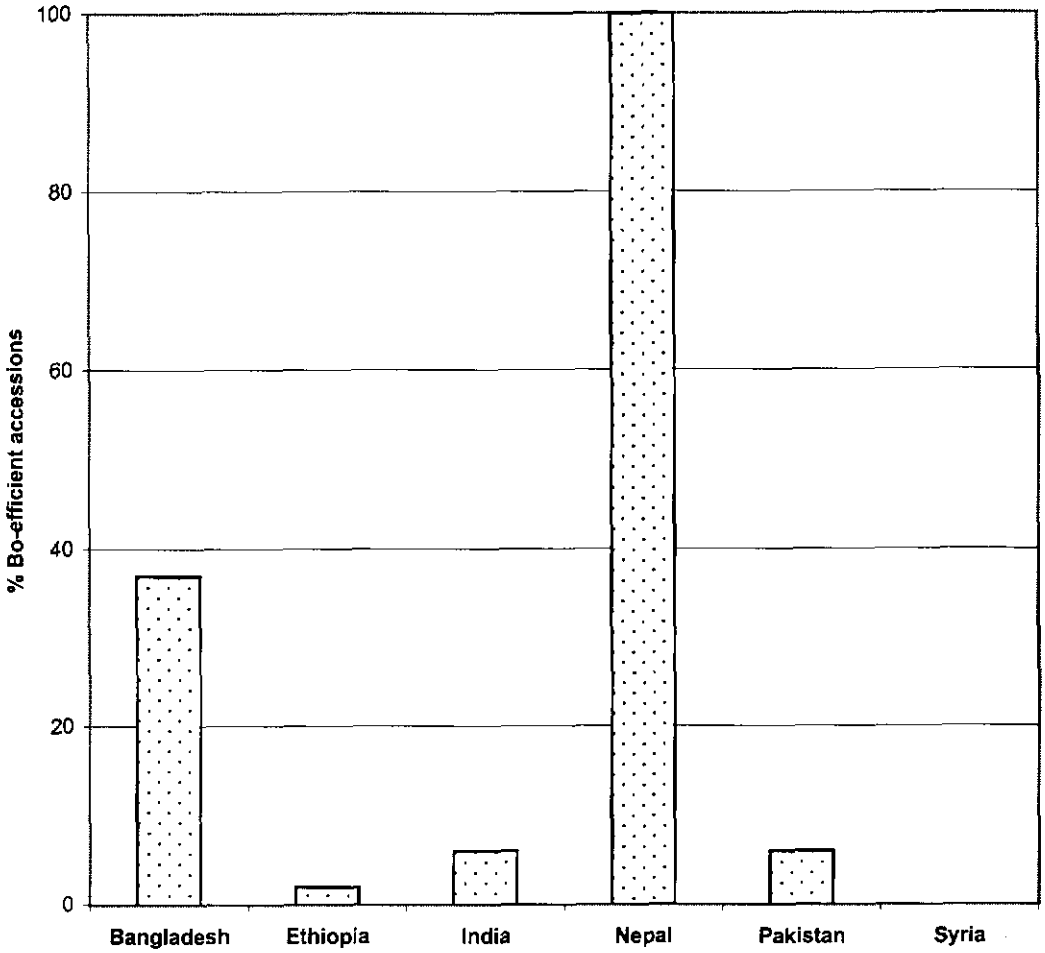


Fig. 2.2. Frequency (%) of boron-efficient lentil germplasm accessions.

program and for this purpose knowledge of genetic control of flowering is essential. This study aimed to determine the genetic control and linkage relationships of time to flower and the morphological traits, peduncle pubescence and tendril development in a diverse set of parents including *pilosae* lines from South Asia and representatives of other ecotypes.

Twenty one cross combinations among seven diverse parents were made in 1993/94 season. The parents, F_1s and F_2 s were grown at ICARDA, Tel Hadya, Syria and at New Delhi, India in 1995/96. To confirm the inheritance of flowering time and peduncle pubescence, four crosses segregating for flowering time in the F_2 generation and three crosses segregating for peduncle pubescence were sown at the F_3 generation in1997 at ICARDA, Tel Hadya.

The two environments differed greatly with respect to temperature but not in photoperiod. The mean temperature during vegetative growth in New Delhi and Tel Hadya was 15.7^0 C and 9.9^0 C respectively but there was little contrast in mean photoperiod between the environments (10.77 h in New Delhi and 11.59 h in Tel Hadya) due to different sowing times.

Inheritance of flowering time

In both India and Syria the flowering time in the F_1 generation in all the crosses was much higher than the mid-parental value and almost equal to that of the late parent, indicating late-flowering is dominant over early-flowering. The F_2 distributions were normal in most of the crosses but showed bimodality in crosses with ILL 4605 and ILL 6037. In Syria, in 4 crosses between extremes of flowering time (ILL 2501 x ILL 4605, ILL 2501 x ILL 6037, ILL 4605 x ILL 5773 and ILL 5773 x ILL 6037) the bimodality was so extreme as to be discontinuous. The F_2 plants were classified into two distinct classes, early flowering (<108 d) and late flowering (>114 d). The Mendelian analysis of F_2 populations in each of the 4 crosses from Tel Hadya, Syria provided a good fit to 3 (late flowering): 1 (early flowering) segregation ratio (P = 0.10 to 0.95) which was further confirmed by the F_3 progeny test (1 homozygous dominant : 2 segregating : 1 homozygous recessive) with high probability levels (P = 0.50 to 0.95) (Table 2.3) indicated a single recessive gene conferring earliness. We propose *Sn* gene symbol for flowering where homozygous late plants have the genotype *Sn/Sn* and homozygous early plants are *sn/sn*. The continuous distribution among F_2 segregants in other crosses suggested a polygenic system is also operating to control flowering time in lentil.

Considerable numbers of early transgressive segregants were observed in New Delhi, India. Crosses involving the parents ILL 4605 and ILL 6037 yielded more early transgressive segregants (10.96% ± 8.86) than the remaining crosses (0.86% ± 0.13). The occurrence of early transgressive segregants is due to the interaction of a major early flowering gene and minor genes contributing towards earliness.

Inheritance of peduncle pubescence

Peduncle pubescence is a new morphological trait we studied in lentil. The F_1 plants in all three crosses were pubescent indicating pubescence is dominant over glabrous. The F_2 segregation in the three crosses provided a good fit of 3:1 (pubescence: glabrous) segregation ratio (P=0.01 to 0.95)(Table 2.4). The hypothesis of single gene control was further confirmed in the three crosses in F_3 families by the 1:2:1 ratio (homozygous dominant: segregating: homozygous recessive) (P=0.25 to 0.90). We propose the gene symbol *Pep* for pubescent peduncle in lentil.

Linkage studies

The joint segregation of loci were investigated with varying number of crosses. Of them, four pairs of loci, *Sn* (flowering time) and *Scp* (seed coat spotting), *Pep* (peduncle pubescence) with *Scp*, *Sn* with *Pep*, and Tendrilled leaf (*Tnl*) with stem color (*Gs*) significantly deviated from independent assortment. The analysis showed that *Sn* is linked with *Scp* with a crossing over value of 22%, *Scp* and *Pep* with a crossing over value of 18%, and *Sn* is linked to *Pep* with 38% crossing over value. lies between *Sn* and *Pep* loci. Another loose linkage was detected between *Tnl* and *Gs* loci with 36% cross over value. The linkage analysis showed that *Sn*, *Scp* and *Pep* loci are located in the linkage group 5 with the *Scp* locus situated between the *Sn* and *Pep* loci (Figure 2.3). This is the first report of linkage between flowering gene and morphological loci in lentil. The *Tnl* locus was assigned to linkage group 1 where the *Gs* locus is located. Our present finding expands the existing linkage map of lentil genome.

(B. Sharma, M.C. Tyagi (Indian Agricultural Research Institute), A. Sarker, W. Erskine)

2.1.1.9. Relationship of Flower and Pod Numbers Per Inflorescence with Seed Yield in Lentil

In lentil there is variation in the number of flowers/pods produced per inflorescence within individual plants, between plants within a genotype, between genotypes, and due to environmental effects. This study was conducted to quantify such variations in flower and pod production, and then to answer the question 'Will selection for a high number of pods per inflorescence increase seed yield?'

In Season 1 all open flowers were tracked to maturity in a field experiment of two lentil genotypes sown at two dates. Genotype Talia 2 had a higher rate of flower abortion than pod abortion, in contrast to genotype ILL 2581 which showed the reverse. Flower abortion accounted for 15% of flowers opened in early sowing and increased to 22% in the late sowing. Pod abortion was 19% (of flowers opened) in early sowing and changed to 23% in late sowing. These are the first quantitative estimates of flower and pod abortion in lentil (Figure 2.4). From the data, a rapid sampling method was developed to estimate the average number of pods/inflorescence at maturity.

In Season 2 an experiment was conducted at two locations to estimate the average number of pods/inflorescence of 81 genotypes and relate this to final yield. Although the broadsense heritability of the number of pods per inflorescence was $h^2 = 0.68$ and its phenotypic correlation with seed yield was $r = 0.71$, the highest yielding genotypes were not those with the greatest number of pods per inflorescence. Selection for the number of pods per peduncle can not be recommended to increase seed yield in lentil.

(H.A.A. Tambal, R. Baalbaki, H. Zaiter (American University of Beirut, Lebanon), W. Erskine)

Table 2.3. Segregation for flowering time in lentil at Tel Hadya, Syria.

Cross (ILL)	Generation	Observed segregation #late	#segregating	#early	Expected ratio	X^2 value	P Value
2501x4605	F_1	All					
	F_2	64		22	3:1	0.015	0.95-0.90
	F_3	20	36	22	1:2:1	0.562	0.90-0.75
2501x6037	F_1	All					
	F_2	74		24	3:1	0.010	0.95-0.90
	F_3	22	47	21	1:2:1	0.199	0.95-0.90
5773x4605	F_1	All					
	F_2	110		28	3:1	1.632	0.25-0.10
	F_3	31	58	26	1:2:1	0.443	0.90-0.75
5773x6037	F_1	All					
	F_2	81		25	3:1	0.113	0.75-0.50
	F_3	19	45	18	1:2:1	0.804	0.75-0.50

Flowering time of parents : ILL 2501 - 135 $\pm$ 2.7, ILL 4605 - 100 $\pm$ 1.6, ILL 5773 - 116 $\pm$ 2.1 and ILL 6037 - 102 $\pm$ 1.2.

Table 2.4. Frequency and segregation for peduncle pubescence in F_2 and F_3 generations in lentil.

Cross (ILL)	Parents female	male	F_1	F_2 Frequency +	-	X^2 3:1	P Value	F_3 frequency +	seg.	-	X^2 1:2:1	P value
4605x7557	-	+	+	132	29	4.190	0.05-0.01	29	48	27	0.691	0.75-0.50
5773x7557	-	+	+	91	31	0.011	0.95-0.90	24	53	20	1.160	0.50-0.25
6037x7557	-	+	+	130	42	0.230	0.75-0.50	26	60	29	0.373	0.90-0.75
Total	-	+	+	353	102	4.431	0.25-0.10	79	161	76	2.224	0.75-0.50

+ present; - absen

Linkage relationship

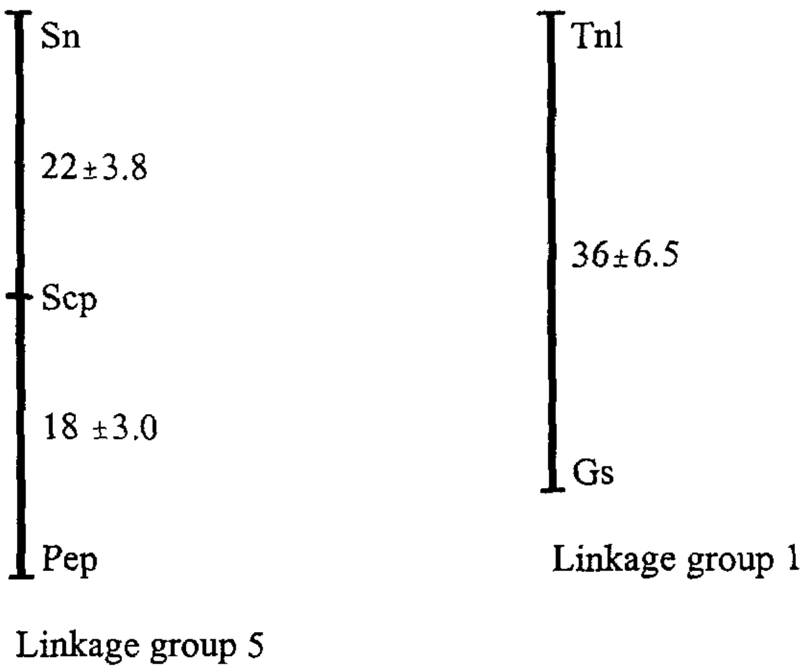


Fig. 2.3. Linkage map of 5 loci in Lentil

2.1.2. Use of Lentil Germplasm by NARSs

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 c. 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.

Table 2.5. lists lentil lines released as cultivars and Table 2.6. gives those lines selected for pre-release

multiplication and/or on-farm trials by NARSs.

In Syria the red-cotyledon line ILL 5883 awaits submission to the variety release committee following its testing in on-farm trials over the last six years, where it

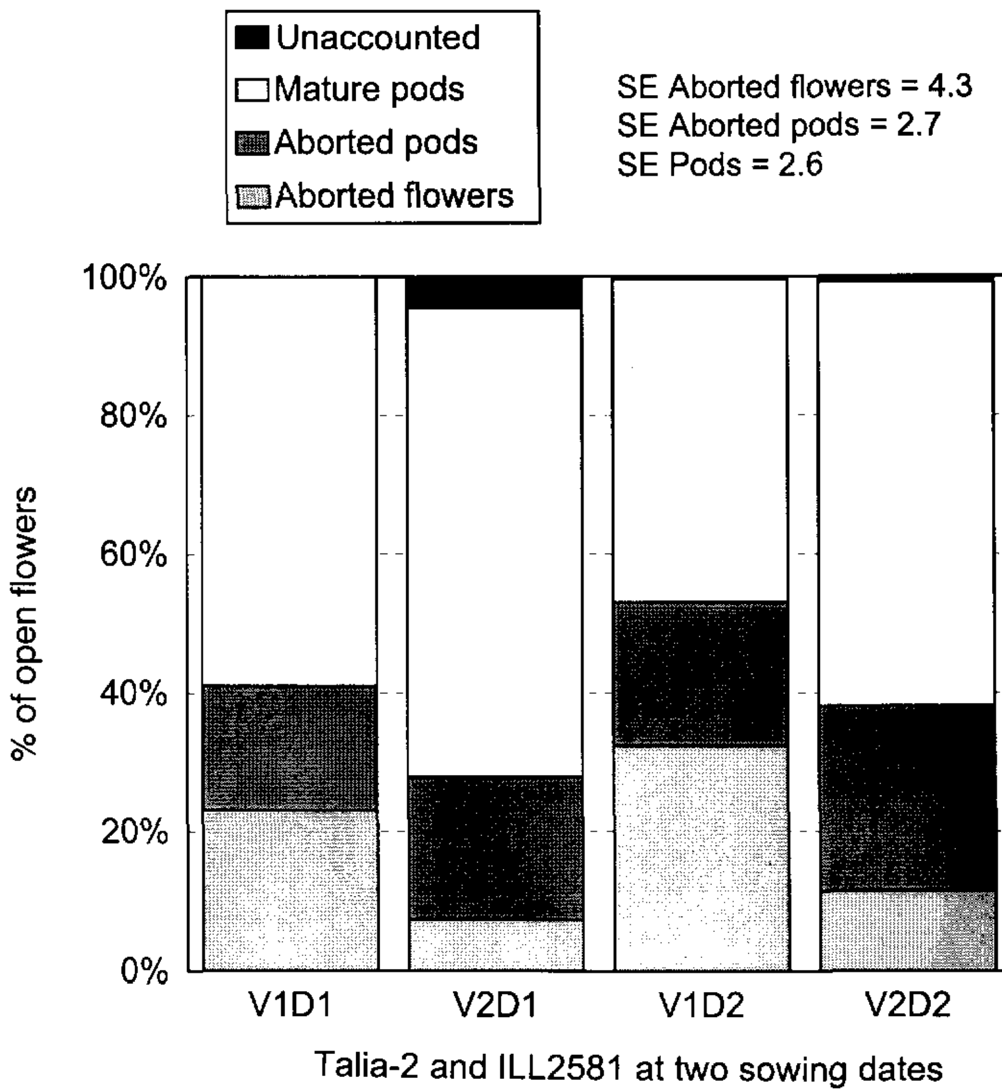


Fig. 2.4. Distribution in percentage among aborted flowers, aborted pods and mature pods of open flowers on genotypes Talia 2 (V1) and ILL 2581 (V2) at sowing dates 1 (D1) and @ (D2). Unaccounted flowers are also indicated.

Table 2.5. Lentil cultivars released by national programs.

Country	Cultivar name	Year of release	Specific features
Algeria	Syrie 229	1987	Yield, seed quality
	Balkan 755	1988	Yield, seed quality
	ILL 4400	1988	Yield, seed quality
Argentina	Arbolito (ILL 4605x-4349)	1991	Yield, tall & early
Australia	Aldinga (FLIP84-80L)	1989	Yield
	Digger (FLIP84-51L)	1993	Yield, red cotyledon
	Cobber (FLIP84-58L)	1993	Yield, red cotyledon
	Matilda (FLIP84-154L)	1993	Yield, yellow cotyledon
	Northfield (78S 26013)	1995	Yield, Asco. blight res.
Bangladesh	Falguni BARI Masur 2 (Sel.ILL4353xILL353)	1993	Rust res. & yield
	BARI Masur 4 (Sel. L5 x FLIP84-112L)	1995	Rust and Stemphylium resistance
Canada	Indianhead (ILL 481)	1989	Green manure
	CDC Redwing (Eston x ILL5588)	1994	Ascochyta res.
	CDC Matador (Indian-head x (Eston x PI 179310))	1994	Ascochyta res.
Chile	Centinela (74TA470)	1989	Rust res. & yield
China	FLIP87-53L	1988	Yield in Qinghai Prov.
Ecuador	INIAP-406 (FLIP84-94L)	1987	Rust res. & yield
Egypt	Precoz (ILL 4605)	1990	Intercropping in sugarcane
	Sinai 1 (sel ILL 4605)	1996	Early, yield in N. Sinai
	Giza 51 (FLIP84-51L)	1996	Tol. High soil moisture
Ethiopia	R 186	1980	Yield
	Chikol (NEL 2704)	1984	Rust res. & yield
	Chalew (ILL 358)	1984	Rust res. & yield
	FLIP84-7L	1994	Rust resistant & yield
	Gudo (FLIP84-78L)	1995	Rust resistant & yield
	Ada'a (FLIP86-41L)	1995	Rust resistant & yield
Iraq	Baraka (78S26002)	1994	Yield, standing ability
Jordan	Jordan 3 (78S 26002)	1990	Yield, standing ability
Lebanon	Talya 2 (78S 26013)	1988	Yield, standing ability
	Toula (FLIP86-2L)	1995	Yield, large seeds
Libya	El Safsaf 3 (78S26002)	1993	Yield, st. ability E. Libya
Morocco	Precoz (ILL 4605)	1990	Rust res. & yield
Nepal	Sikhar (ILL 4402)	1989	Yield
N Zealand	Rajah (FLIP87-53L)	1992	Yield, red cotyledon
Pakistan	Manserha 89 (ILL 4605	1990	Ascochyta & rust res.
	Masur-95 (18-12 x ILL 4400)	1995	Ascochyta & rust res.
	ShirAZ-96 (ILL 5865)	1996	Winter-hardy
Sudan	Aribo 1 (ILL 818)	1993	Yield in N. Sudan
	Rubatab 1 (ILL 813)	1993	Yield in Jebel Mara
Syria	Idleb 1 (78S 26002)	1987	Yield, reduced lodging
Tunisia	Ncir (ILL 4400)	1986	Large seeds & yield
	Nefza (ILL 4606)	1986	Large seeds & yield
Turkey	Firat 87 (75Kf 36062)	1987	Small seeds & yield
	Erzurum 89 (ILL 942)	1990	Spring sowing & yield
	Malazgirt89 (ILL 1384)	1990	Spring sowing & yield
	Sazak 91 (NEL 854)	1991	Winter sowing, red cotyledon
	Sayran 96 (ILL 1939)	1996	Yield & harvestability
U.S.A.	Crimson (ILL 784)	1991	Yield in dry areas

yielded significantly more grain than the local check in different geographic 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.

Large-seeded material occupies an estimated 20 % of the lentil area in Syria, which is dominated by red-cotyledon small-seeded lines. The spread in Syria of the earlier-registered, large-seeded line Idlib 1, which has good standing ability and yield, has been monitored through surveys. In 1992/93 only one percent of producers were using the new lentil cultivar. By 1996 this had risen to 12%, representing an area of 14,000 ha out of the total area of lentil production of *ca* 116,000 ha (mean of 1993-95 seasons).

In Lebanon results from an adoption study indicate that Talya 2 is starting to spread 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 which out-yielded Talya 2 in on-farm trials, was been registered for cultivation in the south of the country.

In Jordan the national program is in the process of releasing two lentil lines (FLIP88-6L & FLIP84-147L) which performed well in on-farm trials.

In South-East Turkey, where winter red lentil is widely grown, Sayran-96 (ILL 1939) was registered during 1996 on the basis of testing by the S. E. Anatolian Regional Research Station.

In Iraq the large-seeded, yellow cotyledon line 78S 26002 was registered in 1992 as Baraka. The red cotyledon line FLIP85-83L is in the process of being released to farmers in Iraq. To fuel the demand from Iraqi consumers for both red and yellow cotyledon lentil, the crop's area has been estimated to have grown to approximately 40,000 ha. To a large extent based on the new cultivar. A lentil adoption study is now being mounted in Iraq.

In Libya the line El Safsaf 3 (78S26002), released in 1993 for cultivation for the East of the country, continues to perform well in the East, but also has given high yields under central-pivot, irrigated conditions in Central Libya at Meknosa.

Table 2.6. Lentil lines in on-farm testing or pre-release multiplication by NARSs.

Mediterranean region	
Iraq	FLIP85-83L
Jordan	FLIP84-147L, FLIP88-6L
Lebanon	ILL 2126, FLIP84-59L, FLIP85-38L, FLIP87-56L
Morocco	FLIP86-15L, FLIP86-16L, FLIP87-19L, & FLIP87-22L
Syria	ILL 5883, ILL 7012
Tunisia	78S26002, FLIP90-13L
Highlands	
Iran	ILL 590, ILL707, ILL857, ILL975, ILL4400
Turkey	FLIP90-3L, FLIP84-147L, FLIP87-8L, FLIP88-10L, FLIP84-112L, FLIP84-51L, FLIP84-59L & FLIP86-35L
S. Latitudes	
Ethiopia	FLIP87-74L
Nepal	ILL 2580, ILL 4402
Sudan	FLIP88-43L
Yemen	ILL 4605, FLIP84-14L

In Tunisia variety 78S26002, 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.

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 there are several lentil 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. Rust screening under controlled conditions was started at Meknes and the lines ILL 5480 and FLIP 88-32L (ILL 6456) were confirmed as rust resistant.

The North African Regional yield trial on lentil was re-initiated for the 1996/97 season under the coordination of the Moroccan lentil breeder.

In Egypt the line Sinai 1 (sel. ILL 4605) is becoming popular in the north Sinai because its early maturity avoids drought stress under the low prevailing rainfall conditions region. The Governor of Sinai Province requested the Egyptian Minister of Agriculture for 1.2 tonnes of Sinai 1 to distribute to farmers in the north Sinai coastal region in the 1997/98 season. The seed was recently delivered and will be used to introduce the new early-flowering lentil cultivar to farmers in the North-East coast region of Egypt to sow under dry rainfed conditions. Giza 51 (FLIP84-51L) with small seeds was registered during 1996 because of its tolerance to high moisture conditions.

(National Agricultural Research Systems)

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 program 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 Masur 95, with ICARDA parentage, is proving popular with farmers in the Sialkot region on account of its rust resistance and high yield.

The major production problems in Bangladesh addressable through breeding are rust and Stemphylium blight. We have been making targeted crosses for Bangladesh of rust resistance sources with the local susceptible cultivar 'L5' 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, Falguni (BARI Masur 2) 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 BARI Masur 4 in 1995. It gave a yield advantage of 53 % over the local check and 28% over BARI Masur 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 high-lands after harvest of autumn rice. The other two lines are for the main lentil growing season.

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 our 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 vis. 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 land races in North India. Over all 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.

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 Centre for International Agricultural Research (ACIAR).

In Ethiopia Gudo = FLIP84-78L (ILL 5748) and Ada'a = FLIP86-41L (ILL 6027) were registered in 1995. Ada and Akaki are the areas where the released line NEL 358 is becoming very popular and a study on its impact is planned.

In Sudan, where lentil cultivation has grown from nothing to self-sufficiency, to underpin the change the cultivar Rubatab 1 (ILL 818) was released for cultivation in the Northern Province and Jebel Mara Region in 1993/94. The program identified FLIP88-43L (ILL 6467) *as promising in the* Northern Province.

(National Agricultural Research Systems)

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. Progress in winter sowing is summarized in Section 2.1.1.6. Briefly in Iran the line ILL 857 selected at Gazvin on the basis of winter-hardiness is in the pre-release stage and seven winter red lines are being entered for registration.

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.

(National Agricultural Research Systems)

2.1.2.4. Advances in other Areas

The lentil industry in New Zealand has declined to a point where only 1500-2000 M.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 phenological extremes - extra early and extra late flowering and maturity. ICARDA Mediterranean-adapted material has fitted in well into the vacuum. Lentils were sown on 1,500 ha in Australia in 1994. The area has risen to approximately 56,000 ha in 1997 with 50,000 ha in Victoria (Wimmera region), 5,000 ha in South Australia and 1,000 ha in Western Australia. 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. Next year the Center for Legumes in Mediterranean Agriculture (CLIMA), Perth will put two more lentil lines ILL 590 & ILL 7200 out to tender and the Victorian Institute of Dryland Agriculture (VIDA), Horsham intends to do the same for ILL 61 and ILL 7180. The average yields of the last two seasons in the Wimmera region have been about 3 t/ha, making it the most remunerative crop for farmers locally. In addition to the research at VIDA, the crop has been championed by the Lentil Company; which bought the rights to three of the cultivars and has offered an integrated service to farmers of seed and a guaranteed sale of the produce.

In response to epidemics of lentil Ascochyta blight in the Canadian Province of Saskatoon, the Crop Development Centre, 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'.

(National Agricultural Research Systems)

2.2. Lentil Pathology

The major diseases of lentil in the WANA region are vascular wilt caused by Fusarium oxysporum f. sp. lentis Vasud. & Srin. and rust caused by Uromyces fabae (Pers.) de Bary. Other diseases that are either sporadic or of restricted importance in the region are the root rots, induced by a complex of pathogens, among which wet root rot caused by Rhizoctonia solani Kuhn is most prevalent under wet conditions and Sclerotinia stem rot caused by Sclerotinia sclerotiorum (Lib.) deBary is common in some areas during seasons with above average rainfall. Ascochyta blight caused by Ascochyta lentis Bond and vassil. and downy mildew caused by Peronospora lentis Gaumann. periodically appear in fields but are presently of minor importance in most of the region.

Fusarium wilt is the major biotic constraint to lentil production in the region. It thus receives high priority in lentil pathology research. Rust does not occur in West Asia but can be a serious problem in some locations in North Africa and in the Indian subcontinent. Research on rust is carried out in a decentralised mode mostly in collaboration with the national programs that consider it as a major problem. The parasitic weeds, broomrapes, caused by Orobanche crenata Forsk and O. aegyptiaca L. are also important and can cause complete crop failure in some farms under favorable environmental conditions.

The general objectives of the lentil pathology research at ICARDA are to: (1) Monitor the occurrence and severity of lentil diseases in the region in collaboration with national scientists, (2) Screen and identify sources of resistance to the major diseases especially vascular wilt and rust, (3) Develop integrated disease management strategies for the control of the major diseases, (4) Assist national programs in screening and identifying sources of resistance to diseases of restricted importance.

During the 1996/97 cropping season, emphasis in lentil pathology research was concentrated in two areas: (i) Screening for host resistance to single and multiple stresses and (ii) integrated diease management studies which included the evaluation of biological control agents and their integration to control lentil vascular wilt, host resistance and chemical seed treatment to control wet root rot and integrated control of broomrape under field conditions.

2.2.1. Monitor of Diseases on Promising Lentil Lines

A survey was carried out during the month of May to access the reaction to lentil vascular wilt and sclerotinia stem rot, of some promising lentil lines (ILL 5883, ILL 6994, ILL 7009, ILL 2130, ILL 7012, and ILL 7201) planted at different locations in on-farm trials in Syria. The disease occurrence, as expected, corresponded to the different agro-ecological zones according to the annual rainfal of the zones.

More than annual average rainfall in most of the locations in zone 1 (rainfall >300 mm) supported good plant growth which favored the occurrence of sclerotinia stem rot caused by Sclerotinia sclerotiorum (Lib) DeBary on all the entries at most locations in that zonen (Table 2.7). Wilt was observed at low and insignificant incidence levels on the entries at most locations in zone 2 (rainfall <300 mm). The general reaction of the entries to sclerotinia stem rot suggests that we may have to consider screening for resistance to this disease in future selections for on-farm trials.

(C. Akem, M. Bellar, B. Bayaa)

Table 2.7. Incidence (%) of Sclerotinia stem rot on lentil entries in On-farm trials; Syria 1997.

Location	ILL 6994	ILL 7009	ILL 7012	ILL 7201	ILL 5883	ILL 2130
Jilleen	35	20	27	34	33	30
Hama St.	20	10	18	17	5	15
Ibleen	0	0	3	0	2	3
Taftanaz	6	5	4	2	6	5
Yahmoul St	5	3	10	3	2	4
Alkamiyeh	2	3	0	2	3	3
Tel Hadya	6	80	5	8	4	40
Kamishley	3	6	5	5	3	6
Mean	**9.6**	**15.9**	**9.0**	**8.9**	**7.3**	**13.3**

2.2.2. *New Sources of Resistance to Wilt*

A total of 64 lines were screened and/or re-screened for their reaction to lentil vascular wilt under high inoculum pressure in the wilt sick plot:

2.2.2.1. *In the core collection*: Twenty lines of the core collection, scored as resistant in the previous seasons were re-screened this season. Eleven lines confirmed their resistance (ILL 422, 813, 1220, 2313, 2684, 3597, 3613, 4774, 5490, 6409, 6830), Two lines were susceptible and rejected and seven lines had a rating between 25 to 30 in at least one replicate.

2.2.2.2. In the USATER collection: Seven out of 35 lines in this collection were resistant to wilt.

2.2.2.3. In the Pakistani collection: Only two lines out of 9 were found resistant

2.2.2.4. In the large-seeded : Sources of resistance to the disease have been more commonly identified in a small-seeded background than among large-seeded lentils. The 9 most large-seeded resistant germplasm lines identified in 1995/ 96 were re-screened this season to confirm their reaction to wilt. Resistance in six lines was confirmed. These were ILL 1005, 1815, 4308, 4673, 5488 and 6408. The other three were dropped because they had a score of 25-35% in only one replication. Some of these resistant lines will be included in the Lentil International Fusarium Wilt Nursery.

(B. Bayaa, W. Erskine, C. Akem)

2.2.3. Variability within the Syrian Population of *Fusarium oxysporum* f. sp. *lentis*.

During 1994/95 cropping season, likely wilt symptoms were recorded on ILL 5883 *in the on-farm trial at Najmouk*, northern Syria. This line proved to be resistant in different locations for several years. An experiment was designed to check the possible existence of a new race of the pathogen.

Three lentil lines with known resistance to fusarium wilt (ILL 7012 and ILL 5883 -resistant and ILL 4605 - susceptible) and two parents (P1, ILL 5588 -resistant and P2, *lens orientalis* - susceptible) were planted in pots (22-cm diameter) filled with sterilized mixture (1:1 soil: sand), and artificially inoculated with 39 isolates of the fungus collected from the major lentil production regions, and representing almost all Syrian isolates. Three surface sterilized seeds (sodium hypochlorite 0,525% for five minutes) of each entry tested were planted in the five equal sectors done on the surface of each pot. Artificial inoculation was performed, two weeks after planting, using 200 ml spore suspension (2.5×10^6 spore/ml) per pot of each isolate, control treatment was provided with 200 ml sterilized water. The experimental design was randomized complete block design with three replications.

The five lines were evaluated for their wilt reaction (disease severity) *according to 1 to 9 rating scale* described earlier. Two scores were recorded at 55 and 75 days after planting.

The overall means of disease severity recorded at 75 days after planting were: 8.6, 0,075, 0.116, 0.0 and 7.958 for ILL 4605, -5883, -7012, P1, and p2, respectively with

LSD value of 0.217.

Tested lines followed the same reaction with all isolates tested. Based on their reaction with the five entries tested, the isolates could be grouped in three groups of virulence. Group 1 comprised 28 isolates; group 2 comprised 9 isolates, which reacted similarly, but were more virulent than isolates in group 1 and group three, which comprised isolate No 38 from Najmouk. This isolate caused mild symptoms (severity 3) on ILL 5883 and ILL 7012 but not on P1 and severely attacked the susceptible lines (ILL4605 and P2) (severity 7 to 9).

Based on the above results, it was concluded that there is only a single race amongst Syrian isolates of *Fusarium oxysporum* f. sp. *lentis*. However, the isolates differ in their virulence. This confirms earlier results with another sets of isolates.

(B. Bayaa, W. Erskine, C. Akem)

2.2.4 Integrated Disease Management

2.2.4.1. Biocontrol of *Fusarium oxysporum* f.sp. *lentis*

Following the promising results of the *in-vitro* antagonistic activity of certain bacterial isolates, all belonging to *Bacillus* sp., their antagonistic activity was investigated, in 1995/96 and 1996/97, under field conditions in a wilt-sick plot. Two lentil lines were used: ILL 4605 (highly susceptible) and ILL 7136 (moderately susceptible). Lentil seeds were surfaces sterilized, coated with 0.2% dextrin solution and were treated as follows: (1) soaked for 10 min in the bacterial suspension of each of the most powerful antagonistic bacteria and their combinations. The nineteen treatments used in this trial (Table 2.8) comprised i, six bacterial strains used as monocultures; ii, six simple mixtures of isolates 1+9; 1+26; 1+27; 9+21; 17+26; and 26+27 and iii, three 3-component mixtures 9+17+21; 1+17+26; and 21+26+27 with controls (Dextrin only; Benlate only). In 1996/97, two additional treatment were used, they consisted of coating seeds with either *Trichoderma* sp or *Penicillium oxalicum* spores (ii) Soaked for 10 m in benomyl suspension (1 g a.i. kg^{-1} seed); and (iii) soaked for 10 min in cellulose gum solution. Seeds of all treatments were then dried under the laminar airflow and sown.

Table 2.8. Components of different treatments

Treatments	Antagonist isolates
1.	1
2.	9
3.	17
4.	21
5.	26
6.	27
7.	1 + 9
8.	1 + 26
9.	1 + 27
10.	9 + 17 + 21
11.	9 + 21
12.	17 + 26
13.	1 + 17 + 26
14.	21 + 26 + 27
15.	26 + 27
16.	*Penicillium oxalicum*
17.	*Trichoderma* sp.(4)
18.	C1 (cellulose gum)
19.	C2 (Benomyl)

After 106, 111,and 118 days of planting, wilt incidence was recorded as % wilted plants, for which there was a significant genotype by treatment interaction. The moderately susceptible genotype, ILL 7136, had significantly reduced wilt incidence (26.1-60% as compared with 83.3 for the control) in all the antagonists-treated plots compared to the untreated control. The highly susceptible line - ILL 4605 had (in score 1) significantly lower mean of wilt incidence in treatments 3, 4, 5, 8, 12 and 13 compared to control treatment with cellulose gum. However, these differences were not significant in score 2 and 3 where almost all plants died (>95%). This confirms the same trend observed in 1995/96 cropping season. There were significant increases in biomass in ILL 7136 in all treatments with antagonists. For ILL 4605, significant differences in biological yield were observed in treatments

2, 4, and 5 only. The increases in biomass this season was greater than the one observed last season. This may be due to the difference in environmental conditions at flowering stage (being wetter in 1996/97) that might have affected the activity of antagonists. Table 2.9 shows the statistical analysis of the effects of antagonists on wilt incidence (%) in three scores and biological yield/g in the field during 1996/97 cropping season.

(B. Bayaa, W. Erskine, S. El Hassan, C. Akem)

2.2.4.2. Integrated Control of Broomrape-Orobanche

Broomrape is a major problem of lentil, especially in the Mediterranean basin, 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, at two sites (Aleppo and Idlib) identified as hot spots for broomrape. The experimental plots consisted of 6 rows each of 1m length.

Seeds were sown at a rate of 100 seeds/row. The integrated control components include using two sowing dates (normal and late), two cultivars: the local (ILL 4400) and an early maturing cultivar adapted to late sowing (ILL 5882), in combination with either one pre-emergence application of imazethapyr at 20 g a.i. ha^{-1} (treatment 2) or two post emergence applications at 15 g a.i. ha^{-1} (treatment 3) and two post emergence applications of imazaquin at 7.5 ai ha^{-1}(treatment 4).

Results are summarized in Table 2.10) for Tel Hadya and in Table 2.11) for Idlib. In general, yield and Orobanche infestation rates were significantly higher in the first planting date than the second one. Number of orobanche in the control treatment was lower in plots planted with ILL 5882 indicating a cultivar effect. All chemical treatments, especially those with imazethapyr

Table 2.9. Statistical analysis of the effects of antagonists on wilt incidence (%) in three scores and biological yield/g in the field during 1996/97 cropping season.

Treat.	%of wilted plants 106days after sowing		%of wilted plants 111days after sowing		%of wilted plants 118days after sowing		Biological yield/g m^{-2}	
	ILL4605	**ILL7136**	**ILL4605**	**ILL7136**	**ILL4605**	**ILL7136**	**ILL4605**	**ILL7136**
1	61.7	12.8**	94.5	27.8**	98.9	60.0**	50.8*	105.6**
2	79.5	12.8**	97.8	22.8**	100.0	35.0**	33.1	111.3**
3	37.8**	13.3**	91.1	25.6**	97.2	51.1**	70.2**	67.9**
4	40.0**	15.6**	86.7	29.5**	96.7	43.9**	42.8	99.9**
5	42.2**	10.6**	90.6	22.8**	98.9	43.9**	31.4	102.8**
6	50.0	16.7**	83.3	32.8**	93.3	43.9**	68.5**	67.9**
7	61.1	13.3**	96.1	25.8**	92.8	43.9**	54.2*	110.8**
8	32.9**	16.1**	93.3	26.1**	97.8	42.2**	44.5*	58.8**
9	56.1	17.8**	92.2	21.7**	98.9	43.9**	57.1**	83.4**
10	51.7	9.5**	91.1	26.1**	95.6	26.1**	69.9**	70.2**
11	71.1	16.1**	96.1	34.4**	100.0	56.7**	50.2*	75.9**
12	48.9*	10.6**	90.0	19.4**	98.9	38.9**	66.2**	90.2**
13	45.0*	18.3**	91.7	29.4**	98.9	36.7**	46.8*	73.1**
14	66.7	16.7**	92.8	38.9**	95.0	53.9**	57.1**	73.1**
15	68.9	16.7**	92.8	22.2**	97.8	32.8**	49.1*	93.1**
16	57.2	13.3**	86.1	33.3**	97.8	56.7**	55.4**	95.4**
17	58.3	17.8**	91.1	30.6**	98.9	38.9**	36.7	97.1**
C1	61.1	39.5	90.0	58.9	100	83.3	14.3	13.1
C2	47.2*	13.9**	92.2	35.0**	96.1	57.22**	44.0*	68.5**
LSD(*P*=0.01)	16.59		19.97		20.81		7.137	
LSD(*P*=0.05)	12.11		14.58		15.19		5.210	

C1 = seeds treated with cellulose gum.
C2 = seeds treated with benomyl.
* = Significant reduction in wilt incidence at $P < 0.05$.
** = Significant reduction in wilt incidence at $P < 0.01$.

Table 2.10. Number of orobanche shoots/ m^2 and seed yield (SYD) g/m^2 in the different treatments at Tel Hadya.

Second planting date				First planting date				Treat.
ILL 5882		ILL 4400		ILL 5882		ILL 4400		
SYD g/m^2	No. shoot/m^2	SYD g/m^2	No. shoot/m^2	SYD g/m^2	No. shoot/m^2	SYD g/m^2	No. shoots/m^2	
3.3	1.3	8	0.5	25	25	18	32	Control
8.3	0	7	0	44	0	51	0	2
3.7	0.8	3	0.4	41	0	29	0.6	3
6.5	1.5	14	1	38	17	23	38	4

SE (No. shoot/m^2, SYD g/m^2) for planting date*treatment*genotype is 8, 10 between the planting dates and 7, 9 within the same sowing date for the two parameters, respectively

Table 2.11. Number of orobanche shoots/ m^2 and seed yield (SYD) g/m^2 in the different treatments at Idlib.

Second planting date				First planting date				Treat.
ILL 5882		ILL 4400		ILL 5882		ILL 4400		
SYD g/m^2	No. shoot/m^2	SYD g/m^2	No.shoot/m^2	SYD g/m^2	No. shoot/m^2	SYD g/m^2	No.shoot/m	
71	0.2	67	0.5	106	1.2	96	0.7	Control
81	0	78	0	140	0.21	144	0.14	2
63	0	57	0	102	0	104	0.07	3
72	0.1	54	0.1	103	0.34	112	0.34	4

SE (No. shoot/m^2, SYD g/m^2) for planting date*treatment*genotype is 0.16, 18 between the planting dates and 0.14,19 within the same sowing date for the two parameters, respectively.

caused significant reduction in number of orobanche shoot and increased seed yield compared to the control treatment. The experiment will be repeated to confirm the results obtained.

(B. Bayaa, N. El Hossain (DARC-Aleppo), W. Erskine)

2.2.4.3 Integrated Management of Vascular Wilt of Lentil

A study was initiated in the lentil wilt sick-plot to evaluate the effect of different control options in an integrated disease management package which composed of cultivars, sowing dates and fungicide seed treatment, on vascular wilt development and yield of lentil. Two disease parameters; Area Under the disease Progress Curve (AUDPC) and Terminal Wilt incidence ratings were used to evaluate effectiveness of the treatments. There were significant differences ($P=0.05$) among genotypes in AUDPC, percent terminal wilt, biological and seed yield. Significant interactions ($P = 0.05$) between sowing date and cultivar on percent wilt, biological and seed yields; and between sowing date and fungicide seed treatment on percent wilt were also observed. The experiment will be repeated to confirm the results.

(S. Kemal, C. Akem, B. Bayaa)

2.3. Lentil Mechanization

During the first decade of ICARDA, a major drive was made to develop economic machine harvest systems for lentil production (*FLIP Annual Reports 1986-1990; Legume Program* Annual Reports 1991-1993). Following the introduction and use by farmers in Syria and Turkey of such systems, a moratorium was placed on further technical research at ICARDA pending the completion of an adoption survey of producers in Syria and Turkey.

The joint survey was conducted with the Universities of Aleppo and Çukurova, Adana and the General Organization of

Agricultural Mechanization, Syria. A total of 171 lentil producers spread among the major lentil growing regions of Syria (El Hassake, Aleppo, Idleb and Deraa Provinces) and Turkey (Urfa, Antep, Yozgat and Çorum Provinces) were interviewed using a questionnaire format to elucidate the importance of lentil in the farming enterprise and issues related to harvest.

In both Syria and Turkey major contrasts were observed between the average area of lentil grown by farmers in different Provinces ranging in Syria from 0.6 ha in Dera'a to 32 ha in Hasseke and in Turkey from 0.9 ha in Çorum to 44 ha in Urfa (Table 2.12).

Approximately 90% of farmers grew lentil on flat, deep soil free of stone problems. All farmers in Dera'a and Çorum Provinces sowed by hand-broadcasting; by contrast, farmers in El Hassake, Idleb and Urfa Provinces all sowed by seed drill. The hand-broadcast system was used by 20 %, 60 % and 84 % of farmers in Antep, Aleppo and Yozgat Provinces, respectively.

Table 2.12. Number of farmers, average of total cropped area, average of lentil area and the percentage of lentil area to total cropped area - 1996 - in Syria and Turkey overall and by Province.

Country/ Province	No. farmers	Average of total cropped area (ha)	Lentil area (ha)	% lentil area to total
Syria - Overall	79	61	20	33
Hasseke	47	92	32	34
Aleppo	11	18	4	21
Idleb	11	16	4.5	28
Dera'a	10	16	0.6	4
Turkey - Overall	92	61	18	30
Urfa	29	128	44	34
Antep	26	35	10	28
Yozgat	25	31	6	18
Çorum	12	14	0.9	6

Large-seeded lentils were grown by 16 % of the sample farmers. Nine % of the sample farmers grew a new cultivar with ten farmers in Syria mostly in El Hassake Province growing 'Idleb 1' and five farmers in Turkey, mostly in Yozgat, growing 'Laird'.

Overall lentil harvest was mechanized by 44 % of the sample farmers. However, hand harvest was localized and still practiced by 100 % of the farmers in Aleppo, Deraa, Yozgat and Çorum. In Syria 74 % of farmers currently harvesting by hand would like to try mechanical harvesting in future, while in Turkey the equivalent figure was 87 %.

In Syria, mechanical harvesting was adopted by one farmer in Idleb using a small self-propelled mower and by 31 farmers in El Hassake (25 by combine, one small self-propelled mower, 4 large self-propelled mowers, one farmer used both last two machines together). The double-knife cutter bar was not used in Syria.

In Turkey, mechanical harvesting was only adopted in the lowland Provinces of Urfa and Antep by 43 farmers (17 by combine, 25 double-knife cutter bar, one farmer used both machines). The small and large self-propelled mowers were not used in Turkey.

The harvest machinery was rented by 91 % of adopter farmers in Syria and 74 % of the adopters in Turkey. It may be noted that the double-knife cutter bar was used only in Turkey, this is may be attributable to its lower cost than the other machines.

Mechanized harvesting had been tried but not adopted by 10 % of the sample farmers (12 farmers in Syria and 5 farmers in Turkey). These farmers reverted to hand-harvesting primarily because of large losses of grain and straw. Hand harvesting was preferred by 8 % of the sample farmers over other systems. While 5 %, 32 %, 50 % of the sample farmers preferred a cutting system, a cutting + gathering system, a cutting + gathering + threshing (combine) system, respectively. Clearly, the adoption of lentil harvesting mechanization is currently most advanced in South-East Anatolia, Turkey (Urfa and Antep Provinces).

A comparison was made at ICARDA Tel Hadya of the various harvest systems in the 1996/97season namely: 1- Hand-pulling + thresher, 2- Double-knife cutter bar + thresher, 3- Large self-propelled mower + thresher, 4-

Combine harvester. The trial was sown with cultivar ILL 5883 in a randomized complete block design with three replications. Losses of seed and straw were measured in all different steps of harvest (pulling or cutting, collection, transport and threshing) with 5 forms of losses (free seed and straw, pods, branches, stubble and lodged plants).

There were significantly greater seed losses from the self-propelled mower than from hand-harvesting. The losses are from two problems: the extreme width (4.4 m) of the header of the self propelled mower and the negative effect of the auger behind the cutter bar during swathing.
The combine lost 100% of the lentil straw, significantly more than from a hand harvest.

(Y. El Saleh, T. Özcan (Çukurova University, Adana, Turkey) S. Barbara (Aleppo University), W. Erskine)

Table 2.13. The average yield and losses (in kg/ha and as percentage of yield) of different harvest systems.

Treatment	Seed			Straw		
	Loss	Yield	% loss	Loss	Yield	% loss
Hand-pulling + thresher	126	1458	8.6	118	2392	4.9
Double-knife cutter bar + thresher	166	1083	15.3	149	1347	11.1
Large self-propelled mower + thresher	305	1105	27.6	265	1092	24.3
Combine harvester	170	1230	13.8	1555	1555	100

2.4. Lentil Entomology

2.4.1. Sitona

Sitona crinitus Herbst is the major insect pest of lentil in West Asia and North Africa. The larvae feeding in the nodules cause the main damage. In Morocco and in Syria, grain yield losses due to Sitona larvae were estimated at 25% and 20% respectively.

577 lentil accessions were screened in the field at Tel Hadya for resistance to *S. crinitus*. The experimental design

used was an RCBD with 2 reps. 40 seeds of each accession were planted in hill plots. The material was evaluated for leaflet and nodule damage. For the leaflet damage we used a visual damage scale (VDS) from 1-9, with 1= zero leaflet damaged; 3= 1-25% of the leaflet damaged; 5= 25-50% leaflet damaged; 7= 50-70% leaflet damaged and 9= > 70% leaflet damaged. This visual leaflet damage was taken on 26 February, whereas the evaluation of nodule damage was done by the middle of April. Five plants from each entry were randomly selected and examined under the microscope to assess the % nodule damaged by *Sitona* larvae.

The results showed that adult Sitona similarly preferred all the accessions, and the percent leaflet damaged was high for most of the entries. However, 12 entries showed a relatively low % nodule damage (28-35 %) compared to over 90% in most of the other entries. These entries will be re-screened next season for confirmation.

(M. El Bouhssini, M. El Damir, N. Al-Salti, A. Babi (University of Aleppo, Syria))

2.4.2. Cowpea Aphid

The Cowpea aphid, *Aphis craccivora* Koch is one of the most important aphid species that attack lentil in West Asia and North Africa. Yield could be severely reduced if infestations occur at early stages of the crop.

Preliminary screening for resistance to Cowpea aphid was done at Breda following a severe natural infestation when lentil crop was at late flowering/early pod setting stage. In most cases, the upper vegetative parts of the canopy coalesced from honeydew. A total of 88 entries and 4 checks were evaluated using a visual infestation score (VIS) from 1-5 and a visual damage score (VDS) from 1-4.

One entry (95S7201-12) was significantly ($P<0.05$) more tolerant to Cowpea aphid with a VIS of 3.8 and a VDS of 3.0 compared to a VIS of 4.8 and VDS of 3.5 of the local check. This entry and three other promising lines (94S66102, 94S67123-5 and 94S67104-4) will be retested in the field under artificial infestation next year.

(M. El Bouhssini, A. Sarker, W. Erskine, A. Joubi)

2.5. Lentil Biotechnology

2.5.1. Analysis of the Inheritance of Qualitative and Quantitative Traits Using an AFLP and RAPD Based Genetic Linkage Map of *Lens species*

In lentil (*Lens culinaris* Medik.) sources of resistance to key biotic and abiotic stresses have been identified and are being introduced into adapted lines. The availability of a detailed genetic linkage map is becoming of crucial importance for identifying the location of such traits to facilitate their directed manipulation in crop-improvement programmes. We identified a population that exhibited a relatively high level of polymorphism and little segregation distortion. This population was used to construct an extensive genetic linkage map in lentil using different types of DNA markers. Subsequently, this population was evaluated in the field at Tel Hadya to analyse the inheritance of qualitative and quantitative traits.

2.5.1.1. Inheritance of Morphological Traits

The pod indehiscence marker was assigned to *linkage group* (LG) 2. Flower colour (*W*) and seed color pattern (*Scp*) were linked at a distance of 0.5 cM and were assigned to LG 3. The two loci, *W* and *Scp* were flanked by OPs10 and P18m46b markers respectively, both at 10.6 cM (Figure 2.5).

2.5.1.2. Inheritance of Tolerance to Radiation Frost Injury

The plants were exposed to 13 and 24 frost events, maximum diurnal temperatures of 20.5°C and 22.6°C and absolute minimum temperatures of -6.6°C and -8.3°C, before the final scoring in 1995/96 and 1996/97, respectively. The parents had contrasting injury levels: P1 was undamaged in both seasons (mean score = 1.0), while P2 had scores of 5.1"0.65 and 7.7"0.55 in 1995/96 and 1996/97, respectively. The RILs showed a range of injury with mean score from 1.0 to 9.0 in both seasons. Chi-square test indicated monogenic inheritance of injury (Table 2.14, Figure 2.6).

In a search for a potential DNA marker co-segregating with the locus of tolerance multi-point linkage analysis of the entire RIL population with 254 markers was carried out. The analysis revealed that the frost tolerance locus (*Frt*) was linked to the RAPD marker OPS-16_{750} at 9.1 cM. The marker was linked in coupling (*cis*) to frost tolerance. The amplification product of this marker (750 bp) was confirmed to have a consistent and reproducible resolution. The RAPD marker and the frost-tolerant locus were not assigned to any of the major linkage groups previously identified in the genome.

Table 2.14. Single locus goodness of fit to 1:1 ratio for frost injury level. Case I has damaged and undamaged classes, and in case II include classification is based on seasonal LSD.

Case	Season	No. RILs in tolerant class	No. RILs in susceptible class	X^2	Probability
I	1995/96	Score 1 33	Score $1.1 48	2.42	0.12
	1996/97	47	34	1.92	0.18
II	1995/96	Score <3.7 45	Score $3.7 36	L.S.D. $_{P=0.05}$=1.3 1.00	0.38
	1996/97	Score <6.6 59	Score $6.6 22	L.S.D. $_{P=0.05}$=1.1 8.70	0.00

2.5.1.3. Inheritance of Resistance to Fusarium

For the analysis of resistance to vascular wilt caused by *Fusarium oxysporium* f.sp. *lentis* $F_{2:4}$ families (86 families) and the $F_{6:8,}$ and $F_{6:9}$ recombinant inbred lines (55 RILs) were evaluated for three seasons (1995, 1996 and 1997) in a well-established wilt sick-plot in a randomized complete block design with three replications.

The combined means of the RILs for two seasons were transformed into qualitative data. The lines with 0-20%

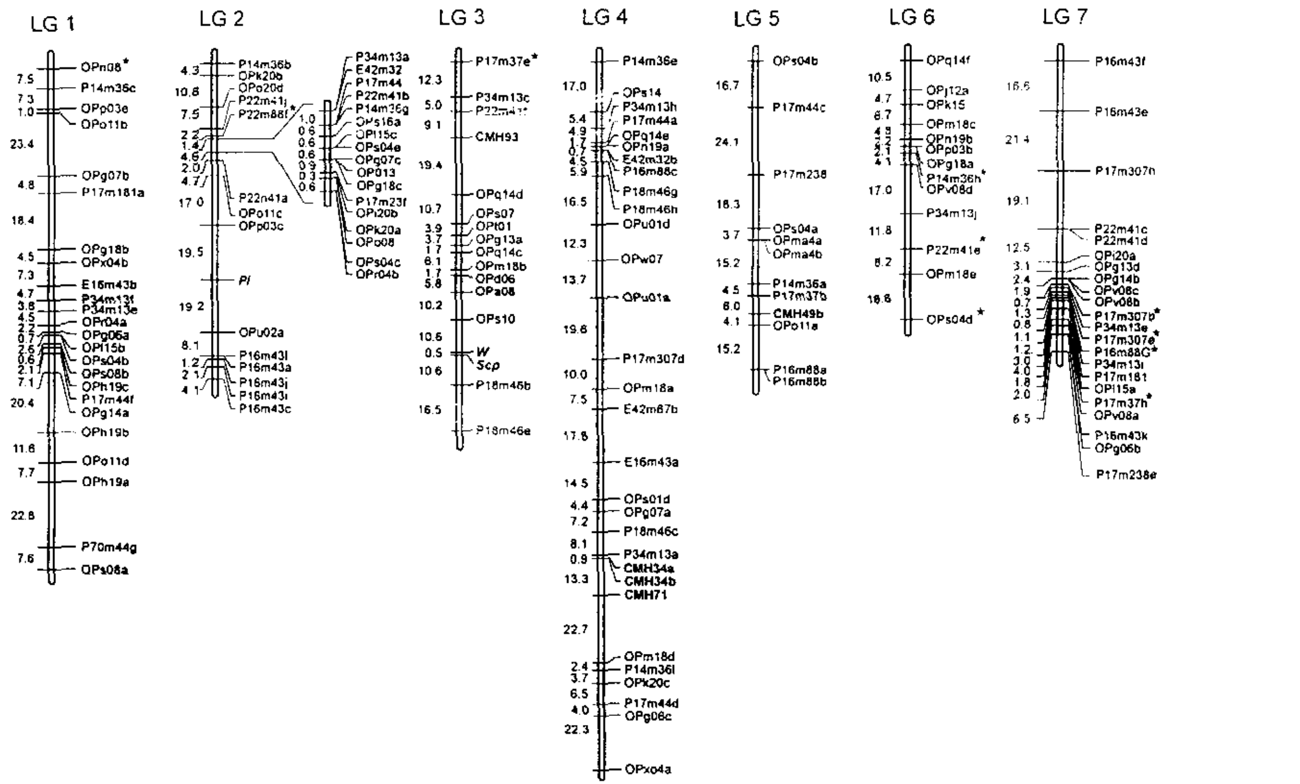


Fig. 2.5. Genetic linkage map of lentil showing distribution of different markers at LOD score of 4.0. The linkage groups are named LG1 through LG 7. Loci names (on the right side of the bars) preceded by P or E are AFLP markers and those preceded by OP are RAPD markers. The molecular weight of the AFLP and RAPD fragments is indicated by the last letter of the locus name, from a (highest) to z (lowest). The RFLP and morphological markers are in bold type. *Asterisks* denote the distorted loci. Genetic distances, on the left side of the bars, are in cM (Haldane function).

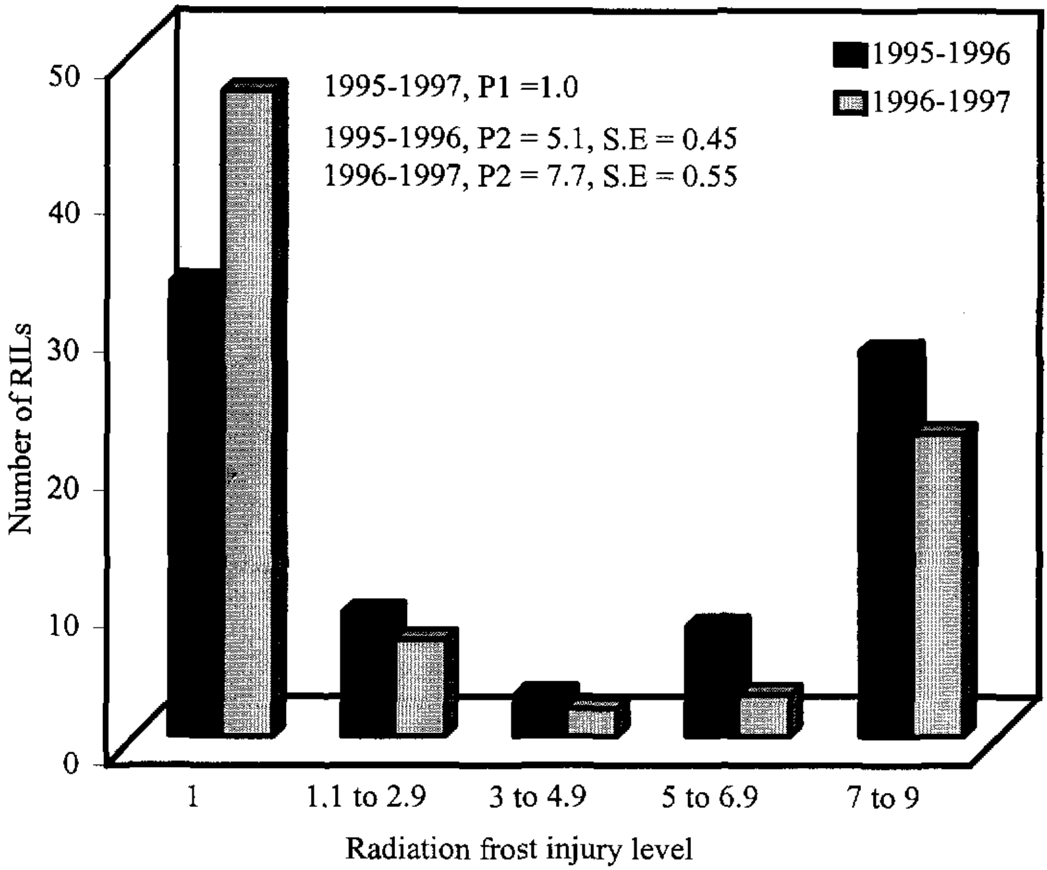


Fig. 2.6. Distribution of the level of wilted plants of the ***$F_{2:4}$ families and the RILs over three seasons.***

wilted plants are resistant and homozygous to the resistant parent, and those with >20 % wilted plants are susceptible and homozygous to P2. The check plots (ILL 4605) showed 100% mortality, reflecting sufficient inoculum to differentiate between resistant and susceptible genotypes in the sick-plot. Analysis of variance of the $F_{2:4}$ families data revealed a highly significant difference in the reaction level between the parents (P1= 3.3% " 13.2, P2 58.3% " 13.2). The segregation pattern of the 86 families significantly fitted a 3:1 ratio of resistant (<20% wilted plants) to susceptible

(>20% wilted plants) families indicating that the resistance is dominant over susceptibility and the effect of a single major dominant gene conferring resistance. Chi-square test for goodness of fit to 1:1 ratio was significant ($P > 0.05$) among the RILs. The segregation of the RILs confirmed the mode of inheritance found among the $F_{2:4}$ families (Table 2.15, Figure 2.7).

We exploited the AFLP and RAPD genotypic data used to construct the genetic map to determine the map location of *Fw*. The linkage analysis revealed that the *Fw* locus is located on one of the major linkage groups (LG6) and linked to the marker OP-K15$_{900}$ at 10.8 cM. The linkage between the RAPD markers and the *Fw* locus is relatively loose indicating insufficient number of markers to saturate that region. Therefore, bulked segregant analysis was used. DNA pools were constructed from an equal amount of DNA from each individual in each group to form the resistant and susceptible bulks. Two bulks were made of RILs: one comprised sixteen highly resistant (0-20%) RILs and the other was comprised of sixteen highly susceptible (>50%) lines. The RAPD protocol was followed as described earlier (Annual report 1996). Eighty deca-mer primers (from Operon technologies, Alameda, CA) were screened against the parents and the two DNA pools.

Of the 80 primers screened, 34 detected polymorphism between the parents and amplified 72 prominent and reproducible polymorphic fragments. Of the 72 fragments, three fragments generated by the primers (OP-B17, OP-C04 and OP-D15) discriminated between the resistant and susceptible bulks. Two of the three fragments (OP-B17$_{800}$ and OP-D15$_{500}$) were detected in the resistant individuals and their pooled DNA, indicating linkage in the coupling phase, and the third (OP-C04$_{650}$) in repulsion with the resistance trait. The primer OP-K15 was also used to amplify the two DNA pools to confirm its linkage to the *Fw* locus, which showed complete segregation with the susceptibility, that is, the band was detected in the susceptible RILs.

(I. Eujayl, W. Erskine, B. Bayaa, M. Baum, E. Pehu)

Table 2.15. Analysis of segregation pattern of the parents, $F_{2:4}$ progenies and RILs populations (in the three seasons) and the Chi-square test for the monogenic inheritance hypothesis.

Season	%wilting		Generation	Ratio tested	No of families or RILs		X^2	P
	P1	P2			<20% resist	>20% suscept		
1995	3.3	58.3	$F_{2:4}$	3.1	59	27	1.55	0.23
1996	1.7	48.3	$F_{6:8}$	1.1	21	34	2.61	0.11
1997	0	100	$F_{6:9}$	1.1	21	34	2.61	0.11

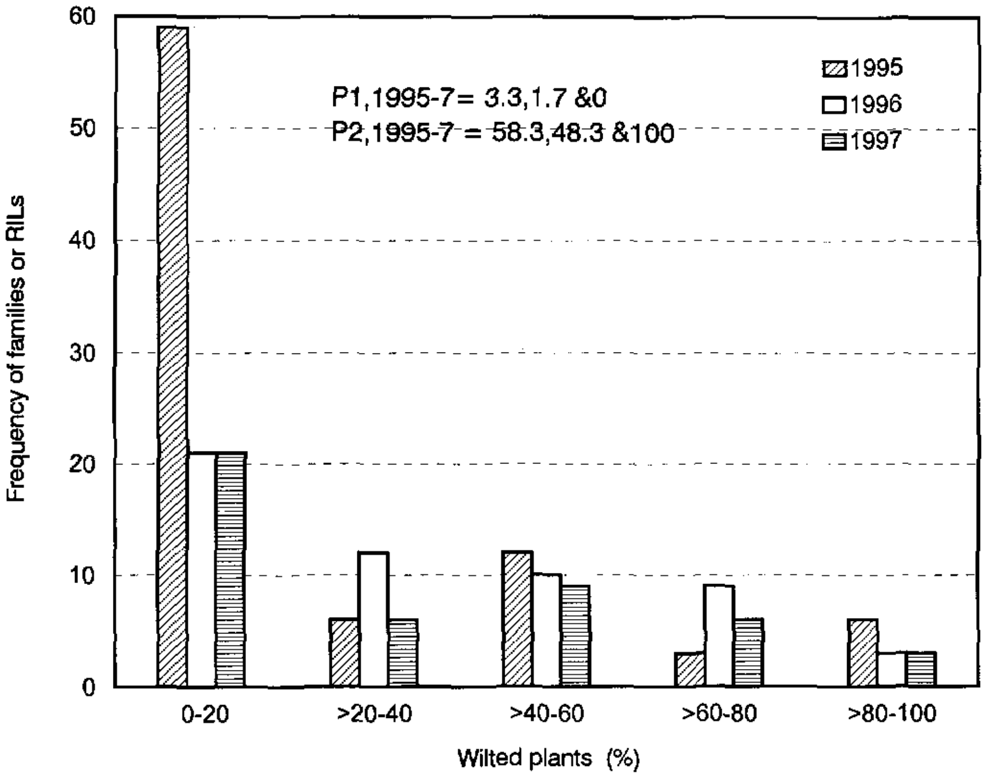


Fig. 2.7. Distribution of the radiation frost injury level among the RILs in two seasons.

2.5.2. Conservation of Chickpea Derived-STMS Markers in Lentil and Pea

Characterizing genome evolution among related plant taxa and analysis of genome structure are powerful applications of DNA marker technology. In order to know if microsatellite markers designed for a genus could be informative across genera, the ability of *STMS* primer pairs, derived from chickpea, to produce amplification products in other genera of the Leguminosae family was tested. 101 primer pairs were used to compare the DNAs from lentil and dry pea with that of chickpea. One accession per genus was used. 46.5% and 38.6% of chickpea primers were able to produce amplification products in dry pea and lentil respectively (Table 2.16).

Table 2.16. Conservation of STMS derived from chickpea in lentil and dry pea.

Loci	Chickpea	Lentil	Pea
Number of primers tested	101	101	101
Number of conserved loci in the 3 genera	101	39	47
Percentage of conserved loci in the 3 genera	100	38.6%	46.5%
Number of loci shared between pea and lentil	-	37	37
Percentage of loci conserved between lentil and pea		-	78%

The fragments amplified with the different primers pairs were, in the most of cases, polymorphic in size and number comparing with those amplified in chickpea (Figure 2.8).

The strong signal detected after hybridisation, of some amplification products from the different genera, with [γ-32P] end-labelled $(TAA)_{10}$ probe demonstrated the detection of the conserved loci. The absence of signal hybridisation indicated that these loci, even if they shared the same flanking sequences, were not conserved between the genera analysed.

In order to know if STMS derived from chickpea could be informative in the detection of polymorphism within another genus, different genotypes of cultivated and wild lentil have been analysed. Some STMS markers were able to detect polymorphism between the cultivars and the species of Lens used in this study.

The use of STMS markers derived from chickpea to amplify loci in others genera was possible in the case of Lens and Pisum. The sets of loci may be homologous in the sense of sharing the same single-copy flanking regions but they may differ in many other respects. This may give rise to problems in comparing the same areas of genomes in different genera.

(W. Choumane, M. Baum (ICARDA), P. Winter, G. Kahl (University of Frankfurt, Germany)).

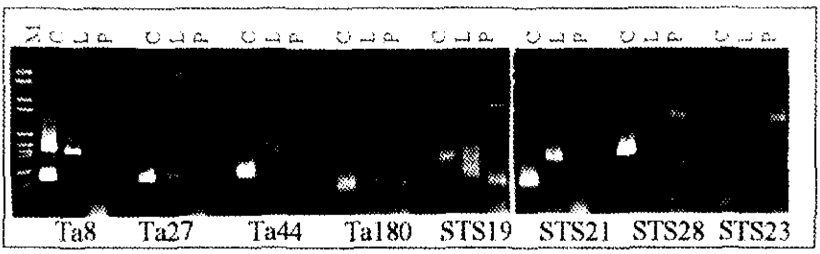


Fig. 2.8. Conservation of STMS derived from chickpea in lentil and pea. M: molecular weight marker. C: Chickpea, L: Lentil, P: Pea. Ta8, Ta27, Ta44, Ta180, STS19, STS21, STS28, STS23 are the STMS primers.

2.6. International Testing Program

The international testing program on lentil is a vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs in and outside the WANA region. The genetic materials comprise 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 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 1997/98 season is given in Table 2.17.

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.

Table 2.17. Distribution of Lentil International Nurseries to cooperators for the 1997/98 season.

International Trial/Nursery	*No. of* sets
Yield Trial, Large-Seed LIYT-L-98)	54
Yield Trial, Small-Seed LIYT-S-98)	28
Yield Trial, Southern Latitudes(LIYT-SL-98)	20
Screening Nursery, Large-Seed LISN-L-98)	41
Screening Nursery, Small-Seed LISN-S-98)	24
Screening Nursery, Southern Latitudes(LISN-SL-98)	23
Screening Nursery, Drought Tolerance (LISN-DT-98)	39
F_3 Nursery, Large Seed (LIF$_3$N-L-98)	10
F_3 Nursery, Small Seed (LIF$_3$N-S-98)	10
F_3 Nursery, Early (LIF$_3$N-SL-98)	10
F_3 Nursery, Cold Tolerance (LIF$_3$N-CT-98)	10
Cold Tolerance Nursery (LICTN-98)	25
Ascochyta Blight Nursery (LIABN-98)	35
Fusarium Wilt Nursery (LIFWN-98)	32
Rust Nursery (LIRN-98)	13
Total	374

The salient features of the 1995/96 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.

In lentil there were three different yield trials. The Lentil International Yield *Trial-Large* (LIYT-L) was reported from 20 locations in 11 countries. A number of test entries exceeded the local check by a significant margin *($P \leq 0.05$) at Talugan in Afghanistan; Tiaret and Sidi*

Bel Abbes in Algeria; Ardabil and Rabia in Iraq; Tolentino in Italy; Terbol in Lebanon; Jema'a Shain and Merchouch in Morocco; Breda and Gelline in Syria; and Beja in Tunisia. The five heaviest yielding entries across the locations were FLIP 93-30L, FLIP 95-14L, FLIP 95-17L, FLIP 88-10L, FLIP 91-12L with seed yields of 1721, 1711, 1710, 1706, and 1683 kg/ha, respectively. The stability analysis for seed yield revealed that both linear and non-linear portions of GXE interaction were significant (Table 2.18). The entries, FLIP 88-10L, FLIP 91-12L, FLIP 95-27L, 78S 26002, FLIP 95-20L, FLIP 87-9L and FLIP 90-3L were relatively stable across environments; another three entries namely, FLIP 92-15L, ILL 4400 and FLIP 95-22L exhibited specific adaptation to high yielding environments.

For the Lentil International Yield Trial-Small (LIYT-S) data were analyzed for seed yield for 17 locations from 9 countries. At some of the locations including, Saida and Tiaret in Algeria; Larissa in Greece; Gachsaran in Iran; Tolentino in Italy; Jema'a Shain and Merchouch in Morocco; Breda, Gelline and Heimo in Syria; and Diyarbakir in Turkey; some of the test entries exceeded the respective local check by a significant margin. The five best entries across locations were FLIP 92-28L, FLIP 89-31L, FLIP 90-41L, FLIP 92-19L and FLIP 92-20L with seed yield of 1961, 1948, 1943, 1934 and 1933 kg/ha, respectively. The stability analysis for seed yield revealed that only non-linear portion of GXE interaction was significant. The entries, FLIP 89-31L, FLIP 90-41L, FLIP 92-19L, FLIP 92-20L, FLIP 95-31L, FLIP 95-36L, FLIP 89-20L, FLIP 93-1L, FLIP 92-27L, FLIP 90-36L, FLIP 95-34L, and FLIP 92-36L, were relatively adaptable across environments.

For Lentil International Yield Trial-Southerly Latitudes (LIYT-SL) data were analyzed for seed yield for 11 locations from 8 countries. At Akaki in Ethiopia; Sri Nagar in India; Rawdat Harma in Saudi Arabia; Breda and Tel Hadya in Syria; and El Kef in Tunisia 4, 3, 14, 6, and 1 of the test entries exceeded the respective local check in seed yield by a significant margin ($P \leq 0.05$). On basis of mean across locations the five heaviest yielding lines included FLIP 88-41L, FLIP 92-52L, FLIP 88-43L, FLIP89-60L, and FLIP 89-67L with seed yields of 1288, 1219, 1115, 1085,

Table 2.18. Analysis of variance for stability for seed yield for the entries in LIYT-L-96, LIYT-S-96, and LIYT-SL-96 during 1995/96 in different countries.

Source of variation	LIYT-L		LIYT-S		LIYT-SL	
	d.f.	MS	d.f.	MS	d.f.	MS
Entry	21	845*	22	384**	22	89
Entry X Location (Linear)	21	261*	22	73**	22	160
Pooled deviation	330	85*	345	82**	184	182**
Pooled error	714	53	748	45	440	48

MS = Mean Square $(x10)^3$

and 1077kg/ha, respectively. The entry means over locations for time to flowering varied from 94 to 119 days. The entry FLIP 88-43L was the earliest to flower followed by FLIP 92-47L and JL-1. Stability analysis for seed yield revealed that only four of the 23 entries namely FLIP 89-60L, FLIP 88-34L, 87515, and FLIP 86-39L with above average seed yield and non-significant deviations from regression exhibited general adaptation over different environments.

For Lentil International Screening Nursery - Large (LISN-L), Lentil International Screening Nursery - Small (LISN-S), Lentil International Screening Nursery - Drought Tolerance (LISN-DT) and Lentil International Screening Nursery - Southern Latitudes (LISN-SL), the data for seed yield were analyzed for 16, 11, 12 and 10 locations, respectively. The analyses of data revealed that at 6 locations in LISN-L (Almora in India, Tiaret in Algeria, Jema'a Shain in Morocco, Gelline in Syria, and Beja and El Kef in Tunisia); one location in LISN-S (Jema'a Shain in Morocco); 7 locations in LISN-SL (Sids in Egypt, Akaki in Ethiopia, Sri Nagar in India, Khumaltar in Nepal, Dirab in Saudi Arabia, Tel Hadya in Syria, and Beja in Tunisia); and 7 locations in LISN-DT (Gansu in China, Rabia in Iraq, Sidi El-Aydi in Morocco, Khumaltar in Nepal, Breda and Tel Hadya in Syria, Beja in Tunisia) some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). On the basis of average over locations, the five best entries are selected and given in Table 2.19

The results of Lentil International F_6-Nursery Large

(LIF_6N-L), F_6-Nursery Small (LIF_6N-S), F_6-Nursery Southerly Latitudes (LIF_6N-SL), and F_6-Nursery Cold Tolerance (LIF_6N-CT) were received from 9, 6, 5 and 4 locations, respectively. The cooperators made some individual plant selections for their use from these nurseries.

Table 2.19 The five heaviest yielding lines across locations in different lentil screening nurseries, 1995/96.

Rank	LISN-L	LISN-S	LISN-SL	LISN-DT
1	FLIP 96-6L	FLIP 96-31L	FLIP 95-67L	FLIP 96-57L
2	FLIP 96-11L	FLIP 95-37L	FLIP 96-46L	FLIP 92-48L
3	FLIP 96-13L	FLIP 96-35L	FLIP 96-50L	FLIP 95-61L
4	FLIP 96-2L	FLIP 95-58L	FLIP 96-48L	FLIP 92-46L
5	FLIP 96-1L	FLIP 96-27L	FLIP 96-49L	FLIP 96-59L

The results of Lentil International Cold Tolerance Nursery were received from 4 locations. All the entries including the susceptible check were rated at 1 or 2 at Elvas in Portugal (on a 1-9 scale were 1 = free and 9 = plant killed). At Toshevo in Bulgaria all the test entries including the susceptible check were rated between 6 and 8, and were susceptible. Two test entries at Debre Zeit in Ethiopia (ILL 468, ILL 590) and three entries at Hymana in Turkey (ILL 468, ILL 759, and ILL 1878) were tolerant to cold (rating=5).

The results of Lentil International Ascochyta Blight Nursery were received from 4 locations. At three locations (Toshevo in Bulgaria, Valladolid in Spain, and Islamabad in Pakistan all the entries including the local susceptible check showed a reaction of $\leq$ 3 (on 1-9 scale, where 1=no infection and 9=killed). At Merchouch in Morocco, all the test entries with the exception of 2 showed a reaction of 4 and 5 and the local susceptible check took a rating of 9. The entries with 4 rating included ILL 2439, ILL 5244, ILL 5480, ILL 5588, ILL 5597, ILL 5684, ILL 5715, ILL 5725, ILL 5755, ILL 5871, ILL 6258, ILL 7508, ILL 7517, and ILL 7537.

The results of Lentil International Rust Nursery were reported from 3 locations (Pant Nagar, India; Jema'a Shain in Morocco; and Valladolid in Spain). All the test entries including the susceptible check showed a reaction of 1 at Jema'a Shain in Morocco and Valladolid in Spain. However at

PantNagar in India all the test entries showed reaction of 3 (except ILL 857, ILL 5753, and Local Check which took 9 rating).

The results of Lentil International Fusarium Wilt Nursery were reported from 3 locations (Hudeiba in Sudan, Toshevo in Bulgaria, and Khumaltar in Nepal). The local susceptible check was rated at 9 and 5 at Hudeiba in Sudan, and Toshevo in Bulgaria. Three entries were rated at 1 (ILL 632, ILL 5714, ILL 6976) and another three at 5 (ILL 590, ILL 2501, ILL 6024) at Hudeiba. Twenty entries were with reaction of 3 at Toshevo in Bulgaria. At Khumaltar in Nepal, 8 entries took a rating of 3 and 11 entries took a rating of 5.

(R.S. Malhotra, W. Erskine, NARSs)

3. FABA BEAN IMPROVEMENT

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 instability 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 a new improved populations, resistant or multi-resistant to biotic and abiotic stresses, in close cooperation with National Agricultural Research Systems.

The objectives of faba bean improvement 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 system.

This was the second season of the reviewed faba bean program.

The work plan of 1996/97 included;

- 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 best 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 will then distribute new sources of resistance and segregating populations to national programs. No yield trials are conducted on faba bean at ICARDA.

With these aims the main results in the 1996/97 season were:

1. Results of screening nurseries and trials, carried out in Tel-Hadya and Lattakia, indicated that nine germplasm accessions: ILB 4709, ILB 368-A, ILB 4726, BPL 710, ILB 3025, BPL 1179, ILB 3879, ILB 4708and ILB 3743-B were highly resistant to chocolate spot (*Botryts fabae*) disease.
2. Sixty three out of 204 breeding lines were promising for *Orobanche crenata* resistance.
3. A number of 48 F_7 populations combined early maturity with improved level for chocolate spot resistance were multiplied for evaluation next year.
4. Results of virus disease screening nursery indicated that 24 and 11 breeding lines showed useful resistance for Faba bean Necrotic yellow (FBNYV) and Bean Leaf Roll (BLRV) virus diseases respectively.
5. Seven out of 46 entries showed high level of frost tolerance under the environmental conditions 1996-97 growing season. The estimated yield ranged from 2.04 to 2.41 with a mean value of 2.2 t/ha in Tel Hadya.
6. A total of 108 crosses were made involving the recombination of the following characters: Chocolate spot (*Botryts fabae*), Ascochyta blight (*Ascochyta fabae*), Rust (*Uromycis fabae*) diseases and *Orobanche* (*Orobanche crenata*) and early maturity, frost tolerance, independent vascular system, auto-fertility and multiple stress resistance. These crosses will provide the genetic base for population improvements in faba bean pre-breeding system.
7. Eight F_3 populations which combined resistance to *Orobanche* and early maturity were multiplied for evaluation next season.
8. Seeds of faba bean germplasm accessions (175 entries) were multiplied under the screen houses for genetic purity maintenance.

9. A number of 120 Faba bean entries (FLIP lines, ILB accessions and others) were multiplied and fresh seeds are available on request.

(S. Khalil)

3.1. Pathology

Faba bean is susceptible to attack by a number of diseases. The major ones occurring in the WANA region are: Chocolate spot (*Botrytis fabae*), Ascochyta blight (*Ascochyta fabae*) and Rust (*Uromyces viciae-fabae*). These three diseases are widespread and are most likely to be detected in any faba bean in the region depending on the time of sampling. Other diseases of restricted importance are downy mildew (*Peronospora viciae*), Alternaria leaf spot (*Alternaria alternata*) and wilt/root rots (*Fusarium* spp. and *Rhizoctonia solani*). The parasitic weed, broomrape (*Orobanche crenata*) and the stem nematode (*Ditylenchus dipsaci*) are also major pests in most faba bean fields in the region.

The main objectives of the faba bean pathology research at ICARDA are (1) monitor disease occurrence in farmers fields in collaboration with national scientists, (2) develop screening techniques to screen germplasm for stable sources of resistance to the major diseases using prevailing isolates of the pathogens collected during disease monitoring, (3) develop integrated disease management strategies for the management of the major diseases in the region.

3.1.1. *Survey of Faba Bean Diseases in Syria*

To re-initiate research on faba bean pathology after a temporal suspension of research on the improvement of the crop in the region, a comprehensive survey was carried out in farmers' fields in all the faba bean-producing regions of

Syria during the 1996/97 cropping season, to determine the distribution and severity of the major diseases on the crop in Syria. This was particularly necessary to quantify the importance of each disease and at the same time collect pathogen isolates for the screening program. Fields were surveyed in the following 8 provinces where faba bean production in Syria is concentrated: Lattakia, Tartous, Dara'a, Hama, Homs, Idleb, Aleppo and Quinetra. Farmers fields in these provinces were randomly chosen based on size and accessibility. A total of 108 fields were visited during the 2 week survey period, representing 46 from the coastal region, 43 from zone 1 and 19 from zone 2. Table 3.1 summarizes the prevalence and mean disease incidence of the different faba bean diseases recorded during the survey by agro-ecological zones. Chocolate spot and rust were the predominant diseases in most of the fields in the coastal region. Other important diseases with high frequency of occurrence and severity were rust, Ascochyta blight and Cercospora leaf spot. Stem nematodes and Sclerotinia stem rots were also prevalent especially in the coastal region around Lattakia and Tartous provinces. Bacterial blight and wilt/root rots were also common in the fields. These observations will help in guiding research focus for host resistance screening and for developing other appropriate control strategies for faba bean diseases in Syria. A similar exercise shall be carried out in some selected faba bean producing countries in the region.

(C. Akem, M. Bellar)

Table 3.1. Prevalence (%) and incidence (%) of faba bean diseases in different agro-ecological zones of Syria; 1996/97.

Disease	Coastal Regions*		Zone 1*		Zone 2*	
	Prevalence	Mean Incidence	Prevalence	Mean Incidence	Prevalence	Mean Incidence
Chocolate spot	91	51	44	19	0	0
Rust	93	58	60	23	0	0
Ascochyta	57	20	63	25	32	17
Grey mold	52	25	70	18	32	6
Sclerotinia	54	16	49	15	0	0
Downy mildew	52	20	58	10	47	11
Cercospora	57	21	44	9	0	0
Stem nematode	65	19	26	6	0	0
Root rots	59	16	53	12	32	10
Alternaria	43	18	26	10	32	7
Stemphylium	52	13	30	7	11	5
Phoma	33	14	26	3	11	2
Bacterial blight	28	10	33	3	16	7

*>600 mm annual rainfall; Coastal regions
350-600 mm annual rainfall; Zone 1
250-350 mm annual rainfall; Zone 2

3.1.2. Screening of Faba Bean Germplasm for Disease Resistance

In collaboration with the Genetic Resources Unit, several breeding lines and land races were screened under field and controlled conditions for resistance to *Botrytis fabae*, the causal agent of chocolate spot, and *Ascochyta fabae*, the causal agent of Ascochyta blight, using artificial inoculations. The lines were also screened for resistance to *Uromyces fabae*, the causal agent of rust under natural *infection conditions*. The experiments were conducted at Lattakia where conditions favour the occurrence and epidemics of the diseases. Good infections were obtained from the inoculations but the virulence of the isolates used for the inoculations was not high. Several sources of resistance to the different diseases were identified. Screening for resistance to rust could not be done because no natural epidemic of the disease occurred on the site. Some farmers' fields with heavy infection by rust identified during the survey were marked for infected straw collection for use in screening the next season.

(C. Akem, S. Khalil)

3.1.3. Comparison of Screening Techniques for Chocolate Spot Resistance

Three screening techniques; leaf drop, leaf soak and plant spray were evaluated using detached and intact faba bean plants to determine the reactions of faba bean lines to chocolate spot under controlled conditions. Twenty six lines selected because of their varying backgrounds and observed field reactions to chocolate spot were planted in pots in a plastic house. Each line was planted in 3 replicated pots with 5 plants per pot. After 8 weeks, fully expanded leaves were detached from each plant and taken to the lab for the detached leaf tests.

A cocktail of *Botrytis fabae* was made from a combination of 4 isolates of the pathogen grown in faba bean meal agar for 10 days, and used to inoculate the leaves either by leaf drop or by soaking in the solution and placing on moist filter paper in plastic plates. The plates were incubated under continuous light on lab benches under laboratory conditions. Ratings were made on a scale of 1-4 of the reactions of each leaf to the pathogen after 48 hrs for the leaf drop and soak inoculations.

The remaining plants from which the leaves were detached were spray-inoculated with the inoculum solution using a hand sprayer. Plants in each pot were sprayed until drip wet and covered with plastic sheet for 48 hrs. Recordings were made on a scale of 1-9 on reactions based on symptoms produced after 2 weeks from inoculation. Table 3.2 groups the lines into resistant, susceptible and mixed reactions based on the 3 combined methods. About 77% of the lines exhibited the same reaction using either of the 3 screening methods. Eleven of the 26 entries were classified as resistant based on their reactions to the pathogen using all 3 screening techniques. The leaf soak and drop methods have the advantage of simplicity, quickness, is less labour intensive and results are comparable with other methods.

(C.Akem S.Kemal, S. Khalil)

3.2. Entomology

3.2.1. Biological Control

The performance of the newly introduced predator (*Harmonia axyridis* Pallas) was studied in comparison to the already established one, *Coccinella 7-punctata,* under lab conditions on two aphid species, Russian wheat aphid (*Diuraphis noxia* Mordvilko) and Black bean aphid (*Aphis fabae* Scopoli).

The results showed that *H. axyridis* had significantly higher fecundity than C. 7-punctata. When reared on Black bean aphid and Russian wheat aphid, Harmonia laid respectively a total of 1536 and 843 eggs/female. C. 7-punctata, on the other hand, only laid respectively 1164 and 218 eggs/female. The other biological parameters (oviposition period, adult longevity, % egg hatch) were similar for the two predators (Table 3.3). These data indicate that *H. axyridis* could be a potential predator of aphids in WANA.

This predator has been sent to Egypt for testing on faba bean aphid (Cowpea aphid) and wheat aphids (greenbug and bird cherry-oat aphid). If it proves to be effective and efficient, *Harmonia* will be considered for release in Nile Valley countries where aphids are the most damaging pests of cereals and food legumes.

(M. El Bouhssini, K. Mardini, A. Babi, N. Al Salti (University of Aleppo))

Table 3.2. Grouping of faba bean lines based on reactions to *Botrytis fabae* using 3 screening techniques.

Resistant reactions	Susceptible reactions	Mixed reactions
ILB 4708	ILB 3743-A	ILB 3870-A
ILB 4711	ILB 603-B	ILB 3363
ILB 3879	ILB 3743-B	ILB 2845
ILB 4712	ILB 3881-A	ILB 1814
BPL 1179	ILB 603-A	S. Giant
BPL 710	ILB 3810-B	ILB 4121-A
ILB 4709	ILB 2026-A	
ILB 368-A	ILB 4713	
ILB 3866	R-40	
ILB 2931-A		
ILB 3865		
11	**9**	**6**

- Detached leaf reactions were based on a scale of 1-4; with 1-2 = resistant and >2 = susceptible
- Pot reactions were based on a scale of 1-9; with 1-4 = resistant and >4 = susceptible

Table 3.3. Reproduction of two Coccinellid predators on two aphid species.

Biological parameters	*H. axyridis*		*C.7-punctata*	
	A. fabae	*D. noxia*	*A. fabae*	*D. noxia*
No. eggs laid/Female	1536±186 Aa	843±199 Ba	1164±420 Ab	218±58 Bb[1]
No.eggs laid/Female/day	28±4 Aa	15±3 Ba	23±11 Aa	4±1 Bb
Oviposition period (days)	46±4 Aa	40±4 Ba	38±4 Ab	44±4 Ba
% egg hatch	43±2 Aa	44±3 Aa	41±3 Aa	46±2 Ba
Female longevity(days)	56±2 Aa	55±3 Aa	53±6 Aa	61±3 Ba
Male longevity (days)	55±1 Aa	58±3 Aa	50±5 Ab	61±3 Ba

[1] Lower case letters are comparisons of the biological parameters of the two predators when reared on the same host and upper case letters are comparisons within the same predator reared on different hosts.

4. 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 are the major insect pest. 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 1997, 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. The project on "Development of chickpea germplasm with combined resistance to ascochyta blight and fusarium wilt using wild and cultivated species" was collaborated with four Italian Institutions. 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.

4.1. 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.

(R.S. Malhotra)

4.1.1. Use of Improved Germplasm by NARSs

4.1.1.1. International Nurseries/Trials and other Breeding Lines

During 1997, 17656 samples of diversified chickpea materials were distributed to NARSs in 54 countries. These materials included different international nurseries, specific genetic materials for research purposes, and improved elite lines requested by NARSs.

(R.S. Malhotra)

4.1.1.2. On-farm Trials in Syria

On-farm trials were conducted in many countries including Algeria, Iran, Iraq, Jordan, Lebanon, Morocco, Syria, Tunisia, and Turkey. The results of Chickpea On-farm Trial conducted during the last three years in Syria are discussed in this section.

Three chickpea lines namely, FLIP 88-85C, FLIP 89-29C, and FLIP 90-96C, along with the improved check, Ghab 3 were included in the On-Farm trials. The Directorate of Agricultural and Scientific Research, Ministry of Agriculture and Agrarian Reforms conducted these trials at 15, 15, and 13 environments, during 1994/95, 1995/96, and 1996/97, respectively. The mean seed yields over locations for different years are given in Table 4.1.

During 1996/97 the on-farm trial was planted for the first time at the farmer's field in Tartous to see the potential of winter chickpea in the coastal area. The seed yields were very high and all the entries yielded more than 4.4 tons/ha.

Table 4.1. Mean seed yield (kg/ha) of entries in the on-farm trials reported from 15, 12 and 13 locations, respectively, in 1994/95,1995/96 and 1996/97.

Entry	1994/95	1995/96	1996/97	Mean
FLIP 88-85C	2654	1701	2137	2164
FLIP 89-29C	2327	1285	1813	1808
FLIP 90-96C	2230	1662	1920	1937
Ghab 3	2397	1682	1970	2016
Location mean	2402	1583	1960	
LSD at P $\leq$0.05	NS	194	186	
C.V. (%)	4.32	3.85	2.98	

The entry, FLIP 88-85C with an overall seed yield of 2164 kg/ha ranked number 1 and was followed by Ghab 3 (Improved check), FLIP 90-96C, and FLIP 89-29C.

The quality traits including protein content, cooking time and Hummos Bitehineh in FLIP 88-85C are comparable with earlier released cultivars. As ascochyta blight and cold tolerance are the most important traits for winter-sown chickpea, the new line FLIP 88-85C with a larger seed size and relatively more tolerance to these stresses (Table 4.2) is a good candidate for release for general cultivation in Syria.

In addition, chickpea demonstration trials (using Ghab 3 and local) were conducted at 8 locations (2 in Darra'a, 1 in Damascus, 2 in Hama, 2 in Idleb and 1 in Aleppo). At two of these sites, one in Aleppo and other in Damascus 2 field days were organized by the Directorate of Extension which were well received by the farmers.

(NARSs Scientists, R.S. Malhotra)

4.1.1.3. Pre-release Multiplication of Cultivars by National Programs

A large number of lines have been chosen by different NARSs during 1996/97 from the chickpea materials supplied from

Table 4.2. Agronomic traits of chickpea entries in the on-farm trials conducted jointly with the Directorate of Agriculture and Scientific Research, Syria and ICARDA during 1996/97.

Entry	100-SW (g)	PLHT (cm)	DFLR	DMAT	AB score	Cold score[a]
FLIP 88-85C	32	51	141	183	3	3
FLIP 89-29C	32	55	141	181	4	3
FLIP 90-96C	34	53	143	185	4	3
Ghab 3	27	50	143	181	4	5
Location mean	31	52	142	182		

[a] Scale: 1-9, where 1 = free, 9 = killed; recorded at Tel Hadya.

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. Most of the new lines possess tolerance to ascochyta blight and cold. and also have large seed size. If grown in winter, they attain a minimum height of 40 cm and can be thus harvested by machine.

(NARS Scientists, R.S. Malhotra)

4.1.1.4. Release of Cultivars by NARSs

To date, NARSs in 22 countries (in four major chickpea production regions) have released 73 lines as cultivars from the improved germplasm furnished by ICARDA (Table 4.3). Forty-nine of these have been released for winter sowing in the Mediterranean region, 15 for spring sowing including four in China, and six for winter sowing in more southerly latitudes. These releases cover four major chickpea production regions.

(NARS Scientists, R.S. Malhotra)

4.1.2. Screening for Stress Tolerance

4.1.2.1. Cultivated Species

4.1.2.1.1. Wilt Resistance

Fusarium wilt induced by *Fusarium oxysporum* Schlecht. Emend. Snyd. & Hans. f. sp. *ciceri* (Padwick) Snyd. & Hans. is the second most important disease of chickpea worldwide. In WANA, it is prevalent in parts of North Africa and in the Nile Valley. *F. oxysporum* f. sp. *ciceri* 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. During the year under the report the preliminary evaluation of 495 FLIP lines against Fusarium wilt in Fusarium wilt sick plot revealed that 28 lines were resistant with rating between 2 and 4 on 1 to 9 scale (with <20% killing). The results of 77 germplasm accessions revealed that 12 were resistant.

Another 209 lines were evaluated for confirmation of their reaction to Fusarium wilt, out of these 38 lines were completely free from damage (rating 1) and 89 lines were resistant/tolerant with rating between 2 and 4.

The Chickpea International Fusarium Wilt Nursery (CIFWN) with 40 test entries, the fusarium wilt differential with 10 entries, and 635 entries from various preliminary and international yield trials were evaluated in wilt-sick plot. The evaluation of entries in CIFWN, wilt differential and yield trials (Table 4.4) showed that 30, 6, and 181 lines, respectively, were tolerant (with rating $\leq$ 4).

(R.S. Malhotra, C. Akem, S. Kemal)

Table 4.3. Kabuli chickpea cultivars released by national programs.

Country	Cultivars Released	Year of Release	Specific Features
Algeria	ILC 482	1988	High yield, blight resistance
	ILC 3279	1988	Tall, blight resistance
	FLIP 84-79C	1991	Cold, blight resistance
	FLIP 84-92C	1991	Blight 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
Cyprus	Yialousa (ILC 3279)	1984	Tall, blight resistance
	Kyrenia (ILC 464)	1987	Large seeds
Egypt	Giza 195	1993	High yield under irrigation
France	TS1009 (ILC 482)	1988	Blight resistance
	TS1502 (FLIP 81-293C)	1988	Blight resistance
	Roye Rene (F 84-188C)	1992	Cold, blight 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, blight resistance
	ILC 3279	1995	High yield, blight resistance
	FLIP 84-48C	1995	High yield, blight resistance
Iraq	Rafidain (ILC 482)	1991	Blight resistance, high yield
	Dijla (ILC 3279)	1991	Tall, blight resistance
Italy	Califfo (ILC 72)	1987	Tall, blight resistance
	Sultano (ILC 3279)	1987	Tall, blight resistance
	Pascia (FLIP 86-5C	1995	Blight resistance, high yield
	Otello(ICC6306/NEC206)	1995	Blight resistance, desi, feed
Jordan	Jubeiha 2 (ILC 482)	1990	High yield, blight resistance
	Jubeiha 3 (ILC 3279)	1990	High yield, blight resistance
Lebanon	Janta 2 (ILC 482)	1989	High yield, wide adaptation
	Baleela (FLIP 85-5C)	1993	Green seed consumption
Libya	ILC 484	1993	High yield, blight resistance
Morocco	ILC 195	1987	Tall, blight resistance
	ILC 482	1987	High yield, blight resistance
	Rizki (FLIP 83-48C)	1992	Large seed, blight resistance
	Douyet (FLIP 84-92C)	1992	Large seed, blight resistance
	Farihane (FLIP 84-79C)	1995	Large seed, blight resistance

	Moubarak (FLIP 84-145C)	1995	Large seed, blight resistance
	Zahor (FLIP 84-182C)	1995	Large seed, blight resistance
Oman	ILC 237	1988	High yield, irrig. conditions
	FLIP 87-45C	1995	High yield, blight resistance
	FLIP 89-130C	1995	High yield, blight resistance
Pakistan	Noor 91 (FLIP 81-293C)	1992	High yield, blight resistance
Portugal	Elmo (ILC 5566)	1989	Blight resistance
	Elvar (FLIP 85-17C)	1989	Blight resistance
Spain	Fardan (ILC 72)	1985	Tall, blight resistance
	Zegri (ILC 200)	1985	Mid-tall, blight resistance
	Almena (ILC 2548)	1985	Tall, blight resistance
	Alcazaba (ILC 2555)	1985	Tall, blight resistance
	Atalaya (ILC 200)	1985	Mid-tall, blight resistance
	Athenas (ILC 2xCA2156)	1995	Large seed, blight resistance
	Bagda (ILC 72xCA 2156)	1995	Large seed, blight resistance
	Kairo (ILC 72xCA 2156)	1995	Large seed, blight resistance
Sudan	Shendi	1987	High yield, irrig. conditions
	Jebel Marra-1 (ILC 915)	1994	High yield, irrig. conditions
	Wad Hamid-1(FLIP89-82C)	1996	High yield, large seeded
Syria	Ghab 1 (ILC 482)	1986	High yield, blight resistance
	Ghab 2 (ILC 3279)	1986	Tall, blight resistance
	Ghab 3 (FLIP 82-150C)	1991	High yield, cold & blight res.
Tunisia	Chetoui (ILC 3279)	1986	Tall, blight resistance
	Kassab (FLIP 83-46C)	1986	Large seeds, blight resistance
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds, wilt resistance
	FLIP 84-79C	1991	Blight, cold resistance
	FLIP 84-92C	1991	Large seed, blight resistance
Turkey	ILC 195	1986	Tall, blight resistance
	Guney Sarisi 482	1986	High yield, blight resistance
	Damla (FLIP 85-7C)	1994	Blight resistance
	Aziziye (FLIP 84-15C)	1994	Blight resistance
	Akcin (87AK71115)	1991	Tall, blight resistance
	Aydin 92 (FLIP 82-259C)	1992	Large seed, blight resistance
	Menemen 92(FLIP 85-14C)	1992	Large seed, blight resistance
	Izmir 92 (FLIP 85-60C)	1992	Large seed, blight resistance
	Gokce (FLIP 87-8C)	1997	Large seed, moderate blight res.
USA	Dwelley (Surutato x FLIP 85-58C)	1994	Blight resistance
	Sanford (Surutato x FLIP 85-58C)	1994	Blight resistance

Table 4.4. Reaction of chickpea lines to Fusarium wilt in Fusarium wilt sick plot at Tel Hadya, 1996/97.

			Type of material[a]				
Rating Scale	% of plants killed	Lines for reconfirmation	New germplasm FLIP Lines	ILC Lines	CIFWN	Differential lines	Int.& PYT's
1	0	38	0	1	8	0	104
2	1-5	30	7	1	6	1	37
3	6-10	22	9	1	11	4	23
4	11-20	37	12	9	5	1	17
5	21-40	25	10	12	5	3	30
6	41-60	25	63	11	3	0	64
7	61-80	12	92	12	1	0	72
8	81-99	12	62	17	0	0	94
9	100	8	240	13	1	1	194
Total		209	495	77	40	10	635

4.1.2.2. Segregating Material

The breeding material comprising 22 F_2 crosses (5 for drought tolerance, 12 for early flowering and maturity, and 5 for large seed size), 10 F_4 Bulks and 1142 F_5 progenies, were grown in wilt-sick plot for screening for Fusarium wilt resistance. The seeds of resistant plants were bulked separately for each of the 5F_2 crosses. A large number of individual plants were selected from F_4 progenies and 112 progenies in F_5 were bulked (Table 4.5) for their yield evaluation.

4.1.2.2.1. Ascochyta Blight

Ascochyta blight caused by *Ascochyta rabiei* is the most serious foliar disease of chickpea in WANA region, particularly where low temperatures (15-25^{0}C) prevail during the crop season. Its occurrence is irregular and is weather dependent. However, a good season for the chickpea

Table 4.5. Reaction of breeding materials to Fusarium wilt under Fusarium wilt-sick plot at Tel Hadya, 1996/97.

Generation	Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
F_5 Progenies	574	233	69	51	55	99	43	12	6	1142
F_4 Progenies	0	0	3	3	2	1	1	0	0	10
F_2 Bulk Early	-	-	-	-	-	-	-	-	-	12
F_2 Bulk Drought	-	-	-	-	-	-	-	-	-	5
F_2 Bulk Large	-	-	-	-	-	-	-	-	-	5
Total	575	237	75	57	58	104	44	13	6	1169

crop is often favorable to Ascochyta blight. Winter sowing of chickpea provides an opportunity to increase chickpea yield by almost 100%; unfortunately, it also increases the risk of Ascochyta blight devastation. Therefore, control of Ascochyta blight is essential to increase chickpea production and yield stability. Host plant resistance is the most practical and economic way to manage the Ascochyta blight and it is the backbone of the chickpea breeding program at ICARDA. A large number of crosses and breeding material are developed every year and 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 of the mixed isolates when infection is low from the debris.

4.1.2.2.1.1. Evaluation of Segregating Populations for Resistance to Artificial Inoculation of Ascochyta Blight

The reaction of F_2, F_4 and F_5 generations to the existing race populations and a mixture of six races of Ascochyta blight sprayed in the field at Tel Hadya is given in Table 4.6.

Table 4.6. Reaction of breeding materials in F2, F4 and F5 generations to Ascochyta blight at Tel Hadya, 1996/97.

Generation	Scale (1-9)									Total
	1	2	3	4	5	6	7	8	9	
F_5 Tall	0	0	9	8	66	183	111	25	13	415
F_5 Large	0	0	38	55	122	197	183	102	102	1083
F_5 Early	0	0	49	77	136	207	120	67	67	835
F_5 general	0	0	113	245	424	977	718	419	419	3891
F_4 Bulk-Tall	-	-	-	-	-	-	-	-	-	3
F_4 Bulk-Large	-	-	-	-	-	-	-	-	-	33
F_4 Bulk	-	-	-	-	-	-	-	-	-	38
F_2 Bulk	-	-	-	-	-	-	-	-	-	242
Total	0	0	209	385	748	1564	1132	613	601	6507

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.

No progeny was rated 1 or 2. However, 209, 385, and 748 F5 progenies were rated 3, 4 and 5, respectively and were tolerant. On the basis of agronomic traits and Ascochyta blight reaction, 534 progenies were bulked in F5 for their increase and yield evaluation next season. From F_2 and F_4 bulks the individual resistant plants were selected for further evaluation in the next season.

(R.S. Malhotra, C. Akem)

4.1.2.2.1.2. Evaluation of Elite Lines from Different Trials for their Reaction to Ascochyta Blight Pathogen

Five hundred and eighty lines included in different yield trials and nurseries were evaluated in the Ascochyta blight nursery in the field during 1996/97 season (Table 4.7). None of the lines had 1 or 2 rating. However, 52, 91, and 122 lines had a rating of 3, 4, and 5, respectively.

(R.S. Malhotra, C. Akem)

Table 4.7. Reaction of elite breeding lines to Ascochyta blight in different trials at Tel Hadya, 1996/97.

Trial Name	Disease Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
CIYT-W-MR	0	0	0	7	5	6	1	0	3	22
CIYT-SPR	0	0	0	1	5	10	1	2	3	22
CIYT-SL1	0	0	0	3	5	7	3	2	2	22
CISN-W	0	0	6	6	17	12	10	4	6	61
CISN-SPR	0	0	0	6	14	17	13	8	3	61
CISN-SL1	0	0	5	6	15	20	7	3	5	61
PYT	0	0	41	62	61	73	43	12	39	331
Total	0	0	52	91	122	145	78	31	61	580

4.1.2.2.1.3. Reaction of the Entries in Chickpea International Ascochyta Blight Nursery (CIABN) to Ascochyta Blight at Tel Hadya

The CIABN comprised 50 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, one line (ICC 13729) had a rating of 4, 9 lines (FLIP 91-196C, FLIP 92-155C, FLIP 92-175C, FLIP 93-128C, FLIP 94-80C, S 95270, ICC 3912, ICC 3919 and ICC 4475) had a rating of 5 and were tolerant to Ascochyta blight. In addition, 16, 14, 8 and 2 lines had a rating of 6, 7, 8 and 9, respectively, and were susceptible to Ascochyta blight.

4.1.2.2.1.4. Reaction of Breeding Materials in the Gene Pyramiding Project

In the gene-pyramiding project for combining sources of resistance to Ascochyta blight, the resistant parents of diverse origin were crossed. Five F2 bulks, 400 F3 progenies, 20 F4 progenies and 101 F5 progenies were grown under field conditions for evaluation for Ascochyta blight reaction. The results (Table 4.8) revealed that 78 progenies in F5, 12 progenies in F4, and 143 progenies in F3 were resistant (with 2 or 3 rating), and another 76 progenies in F3, 4 in F4 and 9 in F5, were tolerant to Ascochyta blight (rating=4).

(R.S.Malhotra, C. Akem)

Table 4.8 Reaction of segregating populations/lines to Ascochyta blight in pyramiding of ***genes (resistant x*** **resistant crosses) at Tel Hadya, 1996/97.**

Generation	Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
F_5 Progenies	0	28	50	9	8	5	0	1	0	101
F_4 *Progenies*	0	2	10	4	2	1	1	0	0	20
F_3 Progenies	0	31	112	76	113	59	4	2	3	400
F_2 Bulk (5 crosses)										

Ascochyta blight rating: 1=free, 9=all plants killed.

4.1.2.2.2. Cold Tolerance

Cold tolerance is one of the most important pre-requisite 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 1996/97 season 4, 23, 72, 5, 91 and 9 progenies from *interspecific crosses* in F4, F5, F6, F7, F8, and F9 generations, respectively were grown in autumn and evaluated for cold tolerance under field conditions. All the progenies in F9, 12 in F8, 15 in F7, 3 in F6, 35 in F5, and 34 in F4 were tolerant to cold with rating $\leq$4.

Forty-seven test entries of different origin were tested in Chickpea International Cold Tolerance Nursery at Tel Hadya in Syria and Terbol in Lebanon. None of the entries was rated 1 or 2 on 1 to 9 scale (Table 4.9). However, 1, 21, and 6 entries were rated tolerant or resistant (rating ≤4). In another trial with 976 germplasm lines it was observed that only 19 lines were tolerant (rating=4).

Table 4.9. Evaluation of CICTN-97 and chickpea germplasm lines for cold tolerance at Tel Hadya, 1996/97.

	Cold rating*									Total
	1	2	3	4	5	6	7	8	9	
CICTN-97	0	0	1	21	6	9	6	3	0	46
Germplasm	0	0	0	19	2	1	14	134	806	976

* Cold rating: 1 = free, 9 = killed

(R.S. Malhotra)

4.1.2.2.3. Drought Tolerance

Drought causes severe yield loss in chickpea. A screening technique involving (1) delayed sowing by three weeks during spring at a relatively dry site, and (2) preliminary evaluation of materials on 1 (=resistant) to 9 (=susceptible) scale to discard susceptible lines was developed at ICARDA. Based on this technique a total of 1000 new germplasm lines were evaluated this season, and only 21 of these lines with rating 4 were drought tolerant (Table 4.10). Another 40 lines in Chickpea International Drought-Tolerant Nursery (CIDTN) were evaluated for drought tolerance and 38 lines with rating 3 and 4, were drought tolerant (Table 4.10).

One hundred and thirty four lines selected on the visual score during 1996 were grown both under irrigated and rainfed conditions and evaluated for their yield performance during 1997. Some of the entries including, ILC 3100, ILC 4809, ILC 4556, were among the high yielding under rainfed conditions and also responded to irrigation

(Table 4.11). Such lines will be used for further exploration for breeding for drought tolerance.

(R.S. Malhotra, C. Johansen)

Table 4.10. Evaluation of CIDTN-97 and chickpea germplasm lines for drought tolerance at Tel Hadya, 1997.

	Visual score*									
	1	2	3	4	5	6	7	8	9	Total
CIDTN-97	0	0	13	25	2	0	0	0	0	40
Germplasm	0	0	0	21	96	298	439	141	5	1000

*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.

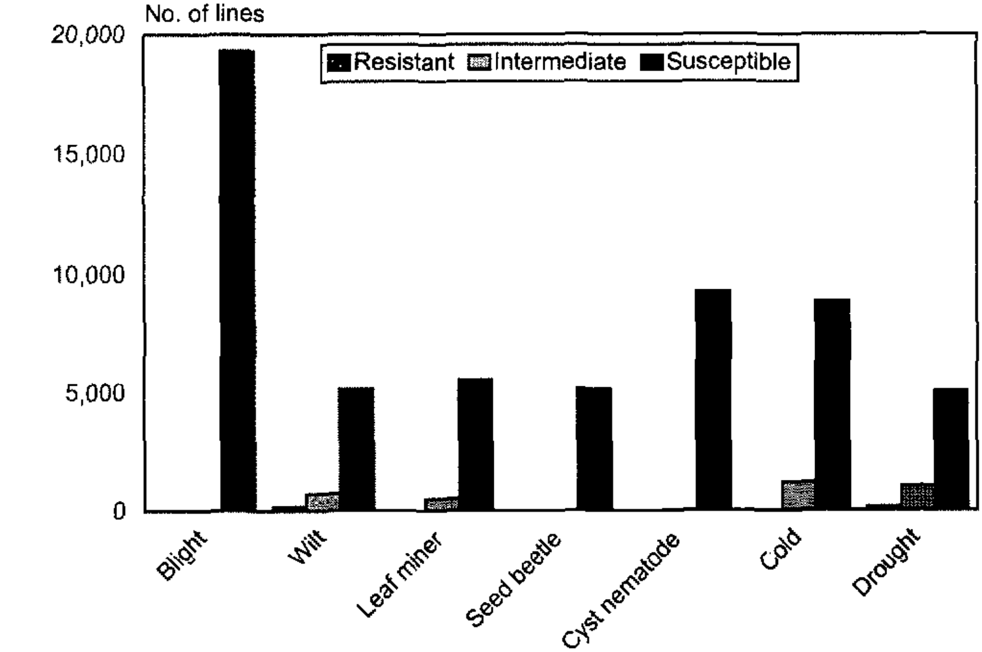
4.1.2.2.4. Combined Evaluation to Seven Stresses

The number of lines evaluated between 1978 and 1997 for different stresses are shown in Figure 4.1. The results include evaluations in the 1996/97 season for wilt and drought. Resistant sources have been identified for all stresses except to seed beetle and cyst nematode. Further evaluation of lines will continue only for wilt and drought because the germplasm has not been fully exploited for these stresses.

Table 4.11. Seed yield (SYLD), days to flowering (DFLR), visual score (VS) and rank (R) of some of the top yielding lines from confirmation of drought tolerant nursery conducted during 1997 at Tel Hadya.

S.N	Entry Name	SYLD (kg/ha)					
		Rainfed	Irrigated	Mean	DFLR	VS*	R
1	ILC 4276	1060	1174	1117	54	4	3
2	ILC 3100	940	1402	1171	50	3	1
3	ILC 3764	940	1114	1027	52	5	10
4	ILC 4477	937	1180	1059	51	4	6
5	ILC 3157	927	1182	1055	51	4	7
6	ILC 4809	920	1370	1145	53	4	2
7	ILC 4556	909	1299	1104	49	4	4
8	ILC 3176	863	1027	945	49	5	20
9	ILC 3182	836	1135	986	51	4	13
10	ILC 3193	829	1035	932	49	4	22
11	ILC 4738	827	1077	952	53	4	18
12	ILC 4270	815	1110	963	53	5	17
13	ILC 201	790	1008	899	53	4	26
14	ILC 4291	769	1149	973	47	4	14
15	ILC 2651	753	1021	887	51	4	30
16	ILC 3153	720	1117	919	50	5	23
17	ILC 3166	719	1024	872	53	4	31
18	ILC 3101	718	1068	893	49	5	28
19	ILC 3201	693	1371	1032	51	6	9
20	ILC 3167	631	1184	908	52	5	25
21	ILC 4474	612	1321	967	52	4	15
22	ILC 4453	564	1156	860	53	5	33
23	FLIP87-59C	736	584	660	47	5	97
24	ILC 3279	412	128	270	66	8	134
S.E.		142.5	158.8				
LSD 5%		398.9	444.6				
C.V (%)		29.7	24.7				

* Visual Score 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.



	Blight	Wilt	Leaf miner	Seed beetle	Cyst nematode	Cold	Drought
Resistant	32	187	8	0	0	32	156
Intermediate	9	704	485	0	20	1,193	1,012
Susceptible	19,329	5,150	5,532	5,153	9,237	8,846	5,037

Figure 4.1. Reaction of chickpea germplasm accessions to biotic and abiotic stresses, Tel Hadya, 1978-1997.

4.1.2.3. Wild Species

4.1.2.3.1. Fusarium Wilt

In search for higher level of resistance we evaluated 63 accessions from 6 wild *Cicer* species (Table 4.12) and observed that 1 accession from *C. bijugum*, 7 from *C. judaicum*, and 10 from *C. pinnatifidum*, were free from the damage by Fusarium wilt. In addition one accession from *C. cuneatum*, 16 from *C. judaicum* and 3 from *C. pinnatifidum*, were resistant to Fusarium wilt.

(R.S. Malhotra, C. Akem, S. Kemal)

Table 4.12. Reaction of wild *Cicer* species to Fusarium wilt grown in sick plot field at Tel Hadya, during 1997 season.

Cicer species	Rating scale*									Total
	1	2	3	4	5	6	7	8	9	
C. bijugum	1	2	0	0	1	6	3	0	1	14
C. cuneatum	0	1	0	0	0	0	0	0	0	1
C. echinospermum	0	0	0	0	0	0	0	0	1	1
C. judaicum	7	16	0	1	1	0	3	0	0	28
C. pinnatifidum	10	3	0	1	0	0	0	0	3	18
C. reticulatum	0	0	0	0	0	1	0	0	0	0
C. yamashitae	0	0	0	0	0	0	0	0	1	1
Total	18	22	0	2	2	7	6	0	6	63

* 1 = free from damage, 9 = all plants killed.

4.1.2.3.2. Drought Tolerance

The material of this experiment comprised 39 accessions of *C. bijugum*, 11 accessions of *C. echinospermum*, and 49 accessions of *C. reticulatum*, and two cultigen checks, ILC 3279 (susceptible check) and FLIP 87-59C (a tolerant check). The experiment was conducted under field condition at Tel Hadya. Sowing was done on 26 March 1997 about 20 days later than the traditional spring sowing in order to expose the experimental material to high soil and air water stress. To create a water-differential between the two experimental units, 70 mm of water was given by sprinkler to one unit at the flowering time. This supplemental irrigation corresponded to 16% of the total precipitation of the season, and to 51% of the precipitation during the experiment span. The mean differences in seed yield between the two water regimes were highly significant for all the three species and the mean of genotypes under irrigation were superior to those under rainfed. Seed yield ranges under water stress condition were 0.4-2.3 g per plant in *C. bijugum*, 0.4-1.4 g in *C. echinospermum*, and 0.4-3.0 g in *C. reticulatum*. The results revealed that *C. reticulatum* was the most adapted species under dry conditions, whereas *C. echinospermum* was very poor in performance under drought (Table 4.13). As *C. reticulatum* is readily crossable with the cultigen the high yielding accessions of *C. reticulatum* could be used in hybridization with the cultigen to improve the response of the cultigen to water stress.

(R.S. Malhotra, B. Ocampo)

Table 4.13. Seed yield of some of the high yielding accessions of wild *Cicer* species under rainfed and irrigated conditions at Tel Hadya, 1997.

Species	Entry name	SYLD (g^{-plant})			DFLR
		Rainfed	Irrigated	Mean	
C. bijugum	ILWC 7	2.3[a]	4.2	3.2	71
	ILWC 69	2.0	2.9	2.5	71
	ILWC 71	1.7	3.2	2.4	72
	ILWC 77	1.5	3.2	2.4	73
	ILWC 285	2.0	2.7	2.4	72
SE		0.51	0.51	0.36	
LSD		1.43	1.43	1.01	
C. echinospermum	ILWC 288	1.4	1.0	1.2	64
	ILWC 179	1.2	0.8	1.0	74
	ILWC 235	0.8	2.5	1.7	72
	ILWC 230	0.6	1.6	1.1	76
	ILWC 39	0.8	0.9	0.9	58
SE		0.33	0.33	0.23	
LSD		1.00	1.00	0.71	
C. reticulatum	ILWC 122	3.0	4.4	3.7	68
	ILWC 258	2.9	2.9	2.9	65
	ILWC 116	2.9	2.5	2.7	62
	ILWC 129	2.4	2.9	2.6	61
	ILWC 104	2.3	2.7	2.5	67
SE		0.58	0.58	0.41	
LSD		1.62	1.62	1.15	
C. arietinum	ILC 3279	1.4	3.4	2.4	69
	FLIP 87-59C	3.3	3.1	3.2	54

[a] = Average of three plants per plot; plots were single-row 2.5 m long.

4.1.2.3.3. Cold Tolerance

Thirty-nine accessions of three wild *Cicer* species were evaluated for confirmation of their reaction to cold. *C. bijugum* exhibited highest level of cold tolerance followed by *C. reticulatum and C. echinospermum* (Table 4.14.). The evaluation of wild species up to-date revealed that 24 accessions of *C. bijugum*, and 5 accessions of *C. reticulatum* were highly tolerant to cold (rating 1 or 2).

Table 4.14. Reaction of wild *Cicer* species to cold under field conditions "reconfirmation" at Tel Hadya, 1996/97.

Species	Cold rating				Total
	1	2	3	4	
C.bijugum	0	8	2	0	10
C.echinospermum	0	0	1	3	4
C.reticulatum	0	0	9	16	25
Total	0	8	12	19	39

Cold rating: 1-9; 1 = free, 9 = all plants killed.

(R.S. Malhotra)

4.1.3. Germplasm Enhancement

4.1.3.1. Improvement in Shoot Biomass Yield

Low shoot biomass in the Mediterranean basin is an important reason among others for poor yield. Our previous results show that seed yield in chickpea is highly correlated with biomass yield (above ground plant parts). As a result of hybridization between parents involving high yield and biomass the progenies were bulked and evaluated for biomass. Twenty-eight test entries along with two checks were tested for biomass yield and other agronomic characters during 1996/97 at Tel Hadya. The results are summarized in Table 4.15. The highest biomass yield was 4255 kg/ha for S 96261 as compared to the trial mean of 3346 kg/ha.

Table 4.15. Seed yield (SYLD), biomass (BYLD), plant height (PTHT), 100-SW, and harvest index (HI) of high yielding lines in PYT-Biomass at Tel Hadya, 1996/97.

Name	Parentage	SYLD	BYLD	PT HT	100 SW	HI
S96258	FLIP91-162CXFLIP81-77C	1443	3571	59	30.2	40.4
S96268	FLIP91-162CXFLIP81-77C	1435	4041	58	30.3	35.5
S96255	FLIP91-147CXILC72	1435	4245	59	28.9	33.8
S96272	FLIP91-162CXFLIP81-77C	1287	3851	59	37.5	33.4
S96249	FLIP91-147CXILC72	1194	2898	52	25.1	41.2
S96247	FLIP91-147CXILC72	1151	3510	52	29.5	32.8
S96270	FLIP91-162CXFLIP81-77C	1147	2891	55	29.4	39.7
S96261	FLIP91-162CXFLIP81-77C	1133	4255	55	28.1	26.8
S96260	FLIP91-162CXFLIP81-77C	1117	3143	56	24.8	35.5
S96264	FLIP91-162CXFLIP81-77C	1095	3711	55	43.7	29.5
S96271	FLIP91-162CXFLIP81-77C	1082	3510	59	37.5	30.8
S96257	FLIP91-147CXILC72	1072	3694	59	28.9	29.4
S96251	FLIP91-147CXILC72	1047	3878	60	29.2	27.0
S96259	FLIP91-162CXFLIP81-77C	1047	2919	54	27.2	35.9
S96262	FLIP91-162CXFLIP81-77C	1014	3102	55	25.8	32.7
S96256	FLIP91-147CXILC72	1000	2932	53	27.0	34.1
S96250	FLIP91-147CXILC72	997	3076	54	29.4	32.4
S96269	FLIP91-162CXFLIP81-77C	994	3225	58	29.8	30.8
S96246	FLIP91-147CXILC72	989	3148	59	33.1	31.4
S96253	FLIP91-147CXILC72	957	2694	54	27.4	35.5
S96266	FLIP91-162CXFLIP81-77C	955	3089	56	32.2	30.9
S96265	FLIP91-162CXFLIP81-77C	926	3303	55	39.8	28.0
S96267	FLIP91-162CXFLIP81-77C	912	3286	55	32.7	27.8
S96252	FLIP91-147CXILC72	893	3197	54	30.1	27.9
S96273	FLIP91-162CXFLIP81-77C	872	3531	60	36.4	24.7
S96254	FLIP91-147CXILC72	843	2470	53	27.4	34.1
S96263	FLIP91-162CXFLIP81-77C	829	2919	57	34.7	28.4
S96248	FLIP91-147CXILC72	826	3612	54	25.8	22.9
ILC3279		1270	3817	59	26.6	33.3
ILC482		1294	2857	36	28.5	45.3
Mean		1075	3346			

4.1.3.2. Improvement in Seed Yield in the Cultigen

Two hundred and seventy four newly bred lines were evaluated in six preliminary yield trials (PYTs) in winter and 208 lines were evaluated in five trials in spring at Tel Hadya and Terbol. Several lines were numerically superior to the check-Ghab 1 (the check in winter) and ILC 1929 (the check in spring) in seed yield. But the seed yields of only 64 lines at Tel Hadya and 99 lines at Terbol were significantly superior to check in winter. Among the spring-sown trials, 34 lines at Tel Hadya and 19 lines at Terbol, were significantly superior to the check (Table 4.16).

In general, the seed yields were good both for winter and spring planting in 1996/97 season. The winter-sown chickpea produced 141% more seed yield than the spring-sown chickpea at Tel Hadya, and 31% more at Terbol, with an overall increase of 65%. On the basis of overall mean seed yield for these locations for the last fourteen years, winter sowing gave 69% increase over spring sowing (Figure 4.2).

(R.S. Malhotra)

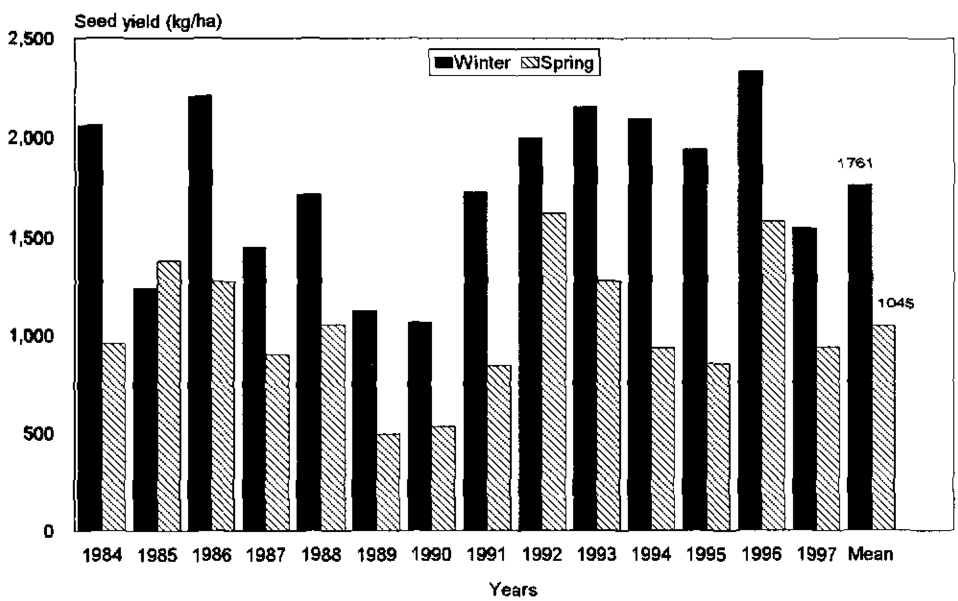


Figure 4.2. Mean seed yield (kg ha^{-1}) of chickpea grown in winter and spring at three locations (Tel Hadya, Jindiress and Terbol) in eleven years (1984-94) and two locations (Tel Hadya and Terbol) in the last three years (1995-97).

Table 4.16. Performance of newly developed lines under winter and spring-sown conditions at Tel Hadya and Terbol, 1996/97.

Location and season	No. of trials	No. of entries			Seed yield (kg/ha)		Range for	
		Tested	Exceeding check	Sig. exceeding check	Mean of location	Mean of highest yielding entry	C.V. (%)	LSD ($P \leq 0.05$) (kg/ha)
Tel Hadya								
-Winter	7	288	64	12	1374	1913	12-31	268-698
-Spring	5	208	34	20	570	1162	22-39	117-668
Terbol								
-Winter	6	274	99	18	1719	2647	12-48	338-876
-Spring	5	208	19	0	1309	1667	11-17	265-422

4.1.3.3. Improvement in Seed Yield in Interspecific Derived Lines

The potential of winter-sown chickpea can be fully realized only if winter-sown cultivars possess cold tolerance. The evaluation of about 10,000 germplasm and breeding lines developed through hybridization between genotypes in the cultivated chickpea (*Cicer arietinum* L.) for cold tolerance has demonstrated that the level of cold tolerance in chickpea is hardly sufficient to cope up the requirements of medium to low elevation areas. The evaluation of available germplasm of eight annual wild *Cicer* species for cold tolerance at ICARDA revealed that the level of cold tolerance was higher in the wild *Cicer* species as compared to that of the cultigen. Although some accessions from *Cicer bijugum*, *Cicer reticulatum*, and *Cicer echinospermum* exhibited higher level of tolerance to cold but only the later two were cross compatible. Thus the crosses between the tolerant accessions of cross compatible wild species (*Cicer reticulatum*) and (*Cicer echinospermum*) with the cultigen (*Cicer arietinum*) were made to incorporate higher level of tolerance from wild to the cultivated. Seventy-eight derived lines and three checks were evaluated for seed yield and cold tolerance during autumn (early October sowing) and winter (December-sowing) at Tel Hadya and Terbol during 1996/97. The seed yields of winter-sown entries ranged between 477 to 2226 kg/ha at Tel Hadya, and 866 to 3143 kg/ha at Terbol, and autumn-sown entries ranged from 0 to 5711 kg/ha at Tel Hadya (Table 4.17). Most of the high yielding entries in autumn (early October sowing) also possessed 2 or 3 rating for cold tolerance. The location means for Winter-sown crops at Tel Hadya and Terbol, and Autumn-sown crop at Tel Hadya were, 1324, 1985, and 3206 Kg/ha, respectively. This showed that higher seed yields could be obtained if cold tolerance level was higher as is the case with autumn-sowing. Ten top yielding entries in the autumn sowing included, Sel 96TH 11409, -11442, -11485, -11490, -11439, -11516, -11517, -11518, Sel 95TH 1716, and Sel 93TH 1745, and gave seed yields between 4439 and 5711 kg/ha (Table 4.17). These derived lines also possess good agronomic and quality traits like the cultigen. These findings demonstrate the complementarity of the yield genes with the cultigen and wild species. It is expected that these lines may perform well under relatively higher altitudes under early spring or in late autumn. Also wide hybridization as a tool may widen the future scope for improvement of chickpea cultigen.

(R.S. Malhotra)

4.1.4. Cyst Nematode Resistance

The earlier studies on evaluation of 9257 accessions of the cultigen for resistance to cyst nematode revealed absence of resistance in the cultivated species. The evaluations of wild *Cicer* accessions, however, revealed that 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. Forty-three derived lines from these crosses were increased in Terbol in the off-season. These newly developed lines have tolerance to cyst nematode but they have small and dark-colored seeds. Efforts are being made to improve their seed quality.

During 1996/97, 2284 plants in various segregating generations were screened for cyst nematode resistance under controlled conditions in the plastic house at Tel Hadya in mid November (Table 4.18). Five hundred and four plants in F_2, 130 plants in F_3, 203 plants in F_4, and 159 plants in F_5 that showed resistance behavior (0 to 2 rating) were selected.

(R.S. Malhotra, M. Di Vito, N. Greco, M.C. Saxena)

Table 4.17. Seed yield and 100-seed weight of top 15 lines derived from interspecific crosses involving *C. arietinum* (ILC 482) and *C. reticulatum* (ILWC 36 and ILWC 182) at Tel Hadya sown during autumn (TH-A), winter (TH-W) and at Terbol during winter (Ter-W), 1996/97.

Sel. No.	Parentage	SYLD (kg/ha)					
		TH-W	TH-A	TER-W	Mean	100 SW	CTR
96TH11485	ILC482XILWC36	1094	5711	1539	2781	28.3	2
96TH11490	ILC482XILWC36	1387	5539	1501	2809	27.9	3
96TH11439	ILC482XILWC182	1528	5022	1682	2744	26.2	3
96TH11518	ILC482XILWC182	1823	4883	2392	3033	27.6	3
95TH1716	ILC482XILWC182	1542	4784	2677	3001	27.2	2
96TH11516	ILC482XILWC182	1591	4714	2027	2777	27.0	2
96TH11409	ILC482XILWC36	1529	4556	1613	2566	26.5	3
93TH1745	ILC482XILWC36	1238	4512	1560	2437	26.8	2
96TH11442	ILC482XILWC182	1564	4467	2463	2831	26.1	3
96TH11517	ILC482XILWC182	1608	4439	2310	2786	27.3	3
96TH11515	ILC482XILWC182	1590	4434	2685	2903	26.9	2
96TH11483	ILC482XILWC36	1652	4300	2543	2832	28.2	2
96TH11404	ILC482XILWC36	1365	4150	1249	2255	33.1	2
96TH11406	ILC482XILWC36	1730	3995	1669	2465	27.4	2
96TH11403	ILC482XILWC36	1146	3950	1553	2216	29.4	2
FLIP82-150C		1299	0	1848	1049	24.3	8
ILC 8262		1154	3500	1409	1409	26.1	4
ILC 8617		833	2895	1565	1764	26.9	4
Mean		1324	3206	1985			
CV (%)		21.2	18.6	18.6			
LSD		1130	427	739			

CTR = Cold tolerance reaction on 1-9 scale

Table 4.18. Reaction of plants from interspecific crosses in F_2, F_3, F_4 and F_5 generations to cyst nematode in the greenhouse at Tel Hadya, 1996/97.

Generation	Cross no.	Parents	Scale[1]						
			0	1	2	3	4	5	Total
F_2	X 96TH127	Sel.95Tr. 35-3-1 X FLIP 84-92C	34	129	37	252	194	31	677
	X 96TH128	Sel.95Tr. 37-1-1 X FLIP 82-150C	36	94	56	225	53	4	468
	X 96TH129	Sel.95Tr. 37-1-4 X FLIP 88-85C	4	21	3	25	7	4	64
	X 96TH130	Sel.95Tr. 47-1-1 X FLIP 93-186C	6	39	45	158	64	15	327
	Total		80	283	141	660	318	54	1536
F_3	X 95TH112	FLIP 84-92C X ILWC 292	5	18	10	22	12	0	67
	X 95TH113	FLIP 82-150C X ILWC 292	17	38	7	50	10	1	123
	X 95TH114	FLIP 88-85C X ILWC 292	4	22	9	36	10	1	82
	Total		26	78	26	108	32	2	272
F_4	X 94TH186	(ILC 482XILWC 292)XILC 482	70	95	28	94	1	0	288
	X 94TH187	(ILC 482XILWC 292)XILC 482	3	7	0	1	1	0	12
	Total		73	102	28	95	2	0	300
F_5	X 94TH188	(ILC 482XILWC 292)XILC 482	31	52	28	9	0	0	120
	X 94TH189	(FLIP87-69CXILWC292)XFLIP87-69C	15	24	9	8	0	0	56
	Total		46	76	37	17	0	0	176

1/ Scale 0 = no cyst formation on roots, 2 = ≤ 5 cysts on roots, 5 = ≥ 50 cysts on roots.

4.1.5. Interspecific Hybridization

So far we have succeeded in crossing between the cultigen and two other species namely, *C. reticulatum* and *C. echinospermum*. To exploit other wild species for introgression of desirable resistance genes, we renewed our efforts during 1996/97, and attempted 1712 pollinations between four lines of *C. arietinum* (S94673, S94683, ICC 3912 and ICC 3991) and two accessions of each of *C. bijugum* (ILWC 42, ILWC 260) and *C. pinnatifidum* (ILWC 249, ILWC 250). Crosses between *C. judaicum* and *C. arietinum* were unsuccessful. It was interesting to note that 222 putative F1 seeds were obtained from *C. bijugum* x *C. arietinum* and 127 putative F1s from *C. arietinum* x *C. pinnatifidum*. These crossed seeds will be evaluated for confirmation of their hybridity next season.

(B. Ocampo, R.S. Malhotra)

4.1.6. Interspecific Hybridization and Improvement in Cold Tolerance:

A large number of breeding materials in different generations (Table 4.19) were sown in autumn for evaluation for cold tolerance. The individual plants and progeny rows were selected for their evaluations for cold tolerance and other agronomic traits in 1997/98 season.

4.1.7. International Testing Program

The international testing program on Kabuli chickpea is a vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs in and outside the WANA region. The genetic materials comprise

Table 4.19. Evaluation of breeding material derived from interspecific crosses for cold tolerance at Tel Hadya 1996/97.

Generation	Sown	Selected
F9 Progenies	4	4
F8 Progenies	23	12
F7 Progenies	72	15
F6 Progenies	5	3
F5 Progenies	91	35
F4 Progenies	9	4
F3 Progenies	8	8
F7 BC1	56	1
F5 Bulk	5	5
F4 Bulk	2	2
F3 BC1	13	13
F2-F3 Dial.crosses	15	14

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 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 for the 1997/98 season is given in Table 4.20.

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 1995/96 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 reported from 21 locations in 9 countries. A number of test entries exceeded the respective local check by a significant margin ($P \leq 0.05$) at Sidi Bel Abbes in Algeria;

Table 4.20. Distribution of Chickpea Nurseries to Cooperators in 1997.

International Trial/Nursery	No. of sets
Yield Trial Spring (CIYT-Sp-98)	41
Yield Trial Winter, Medit. Region (CIYT-W-MR-98)	53
Yield Trial Southerly Latitudes-1 (CIYT-SL1-98)	18
Yield Trial Southerly Latitudes-2 (CIYT-SL2-98)	10
Yield Trial Latin America (CIYT-LA-98)	17
Screening Nursery Winter (CISN-W-98)	38
Screening Nursery Spring (CISN-Sp-98)	33
Screening Nursery, South. Latitudes-1(CISN-SL1-98)	8
Screening Nursery, South. Latitudes-2(CISN-SL2-98)	7
Screening Nursery, Latin America (CISN-LA-98)	7
F_4 Nursery, Mediterranean Region (CIF_4N-MR-98)	24
F_4 Nursery, Southerly Latitudes (CIF_4N-SL-98)	4
Ascochyta Blight Nursery: Kabuli (CIABN-A-98)	42
Ascochyta Blight Nursery: Kabuli and Desi (CIABN-B-98)	30
Fusarium Wilt Nursery (CIFWN-98)	41
Cold Tolerance Nursery (CICTN-98)	36
Drought Tolerance Nursery (CIDTN-98)	58
Total	467

Caracal in Romania; Gelline, Hama and Heimo in Syria; Bousalem in Tunisia; and Eskisehir in Turkey. The five heaviest yielding entries across 21 locations were FLIP 93-58C, FLIP 92-9C, FLIP 91-202C, FLIP 91-203C and FLIP 93-79C, respectively, with seed yield of 1411, 1386, 1384, 1383 and 1381 kg/ha. Only 17 locations could be used for the stability analysis for seed yield in CIYT-SP. The results revealed that both linear and non-linear portions of entry x environment (GxE) interaction were significant (Table 4.21). The entries, FLIP91-203C, FLIP 93-79C, FLIP93-58C, FLIP91-202C, FLIP93-31C and FLIP91-187C, had above average mean, regression coefficient (b) non-significantly different from 1, and deviations from regression approaching to zero. Thus these entries were generally adapted across environments. However, FLIP 91-186C had above average mean seed yield, regression coefficient exceeding unity, and deviation from regression approaching to zero, and was thus responsive to high yielding environments. The entries namely, FLIP91-209C, FLIP 92-9C, ILC 482, FLIP 91-26C and FLIP 82-150C with significant deviations from regression were unpredictable in response.

For Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) data were reported from 24 locations in 12 countries. However, the analyses were feasible for 21 locations. At Khroub and Sidi Bel Abbes in Algeria; Tolentino in Italy; Terbol in Lebanon; Caracal in Romania; *Heimo, Izra'a and Tel Hadya in Syria*, some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). The five heaviest yielding lines across locations included FLIP 92-169C, FLIP 92-162C, FLIP 93-93C, FLIP 91-222C and FLIP 93-186C and gave seed yields of 2385, 2343, 2322, 2293, and 2280 kg/ha, respectively. The ANOVA for stability analysis revealed that MS due to both GxE interaction (Linear) and deviation from regression (non-linear) were non-significant. The results thus indicated the absence of variability for response of varieties to varying environments.

Table 4.21. ANOVA for stability parameters for seed yield for the entries in CIYT-SP and CIYT-W-MR conducted during 1995/96

Source of Variation	CIYT-SP		CIYT-W-MR	
	Df	*MS* $(x10)^3$	*df*	*MS* $(x10)^3$
Entry	22	239.773^{**}	22	262.189^{**}
Entry x Location (Linear)	22	65.086^{*}	22	108.468^{ns}
Pooled deviation	345	41.474^{**}	345	92.667^{ns}
Pooled error	748	22.196	748	65.506

• = Significant at $P \leq 0.05$, ** Significant at $P \leq 0.01$

The results of Chickpea International Yield Trial Southerly Latitudes-1 (CIYT-SL1) were reported from 3 locations in 2 countries. At two locations, Gujarat in India and Tel Hadya in Syria, 2 and 13 test entries exceeded the local check in seed yield by a significant margin. The five heaviest yielding entries across locations included, FLIP 91-33C, FLIP 92-172C, FLIP 92-136C, FLIP 93-97C and FLIP 92-69C with seed yields of 1629, 1582, 1474, 1392 and 1379 kg/ha, respectively. On the basis of average over locations for time to flowering the entries FLIP93-57C and FLIP 92-24C were among the earliest to flower.

The results for Chickpea International Yield Trial Southerly Latitudes-2 (CIYT-SL2) were reported from 5 locations in 5 countries. The stability analysis for seed yield revealed that only deviation from regression (non-linear) were significant. The ten heaviest yielding entries across locations having general adaptation included FLIP 91-71C, FLIP 90-126C, FLIP 91-75C, FLIP 92-92C, FLIP 90-125C, FLIP 93-45C, FLIP 92-7C, FLIP 89-82C, FLIP 91-85C and FLIP 93-32C and gave yields of 1536, 1436, 1367, 1343, 1303, 1279, 1274, 1268, 1240 and 1208 kg/ha, respectively. The data on days to flowering revealed that the entry means over locations varied from 62 to 89 days. Among locations, the earliest location mean was at Hudeiba in Sudan (46 days) followed by Kanpur in India (52 days) and Akaki in Ethiopia (54 days). The entries namely were adaptable across environments.

Table 4.22 ANOVA for stability parameters for seed yield for the entries in CIYT-SL2 and CIYT-LA conducted during 1995/96

Source of	CIYT-SL2		CIYT-LA	
Variation	df	MS $(x10)^3$	df	MS $(x10)^3$
Entry	22	130.079**	22	155.206**
Entry x Location (Linear)	22	37.488	22	116.474
Pooled deviation	69	59.154**	23	97.353**
Pooled error	220	34.220	132	35.575

** = Significant at $P \leq 0.01$

The results for Chickpea International Yield Trial Latin America (CIYT-LA) were reported from 3 locations in 3 countries. The ANOVA for seed yield revealed that at only at Tel Hadya in Syria, five test entries exceeded the local check by a significant margin ($P \leq 0.05$). Some heaviest yielders across locations included ILC464, FLIP 90-16C, FLIP 87-90C, FLIP 90-18C, FLIP 90-15C, FLIP 93-71C and FLIP 88-6C with seed yields of 2803, 2740, 2679, 2581, 2576, 2545 and 2439 kg/ha, respectively were adaptable across environments.

The data on seed yield of Chickpea International Screening Nurseries -Winter (CISN-W), -Spring (CISN-SP), -Southerly Latitudes-1 (CISN-SL1), -Southerly Latitudes-2 (CISN-SL2) and -Latin America (CISN-LA) were reported from 23, 21, 5, 2, and 3 locations, respectively. Some of the test entries exceeded the local check by significant margins at 11, 6, 4, 2 and 2 locations, in CISN-W, CISN-SP, CISN-SL1, CISN-SL2 and CISN-LA, respectively. The five heaviest yielding entries across locations for these nurseries are given in Table 4.23.

Table 4.23. The five heaviest seed yielding lines across locations in different chickpea international screening nurseries, 1995/96.

Rank	CISN-W	CISN-SP	CISN-SL1	CISN-SL2	CISN-LA
1	F[a] 93-139C	F 94-1C	F 94-67C	F 94-77C	F 90-17C
2	F 94-50C	F 94-61C	F 93-151C	F 94-81C	F 93-84C
3	F 93-144C	F 94-95C	F 93-168C	F 93-46C	F 94-36C
4	F 94-3C	F 94-27C	F 94-90C	F 94-78C	F 93-2C
5	F 94-32C	F 93-110C	F 94-76C	F 93-214C	ILC 464

[a] F = FLIP

Chickpea International F_4 Nurseries for Mediterranean (CIF_4N-MR) and for Southerly Latitudes (CIF_4N-SL) were supplied to cooperators for 26 and 10 locations. Cooperators from only 9 locations (for CIF_4N-MR) and for 3 locations (for CIF_4N-SL) reported the usefulness of these nurseries under their environmental conditions. They also made individual plant selections for their use in breeding programs.

The Chickpea International Ascochyta Blight Nursery (CIABN) results for kabuli type (CIABN-A) were reported from 8 locations and for desi + kabuli type (CIABN-B) from 4 locations. None of the entries (kabuli or desi) except FLIP 94-508C which showed tolerance at all the four locations was tolerant to Ascochyta blight across all locations. Considering the frequency of occurrence of an entry among the tolerant group (with rating $\leq$ 5 on 1-9 scale) in Kabuli types, entries ILC 3279, FLIP93 -114C, and FLIP 93-160C showed tolerance at 11 out of 12 locations, and were the best. The other lines, ILC 200, FLIP 91-196C, FLIP 92-45C, FLIP 92-155C, FLIP 92-159C, FLIP 92-190C, FLIP 93-128C, FLIP 93-130C, FLIP 93-131C, FLIP 93-146C, FLIP 93-174C and FLIP 93-175C which occurred 10 times, also had high level of ascochyta blight tolerance. Similarly, among desi lines all the entries showed tolerant reaction at 3 out of 4 locations from desi types. Further, the differential reaction of lines at various places revealed the presence of variability in the pathogen. This nursery has been very useful in the identification of resistant sources to ascochyta blight and several NARSs have used these resistant sources in their breeding programs.

The Chickpea International Drought Tolerant Nursery (CIDTN) was initiated for the first time in 1995. The nursery was sent to 40 locations but results were reported from 5 locations only. Drought tolerance was scored on 1-9 scale and the lines with rating $\leq$ 5(where 1 = free from damage, and 9 = killed or no yield) were scored as tolerant. Seven lines, ILC 19, ILC 28, ILC 2293, ILC 3843, ILC 4339, FLIP 87-58C and FLIP 87-85C were tolerant to drought at all the locations; and were followed by ILC 23, ILC 71, ILC 142, ILC 1900, ILC 1988, ILC 2537, ILC 3089,

ILC 3210, ILC 3321, ILC 3550, ILC 3764, ILC 5371, ILC 6119, FLIP 87-7C, FLIP 87-51C, FLIP 87-59C, FLIP 88-42C, and ICCV-2 which were resistant at 4 out of 5 locations.

The results of Chickpea International Fusarium Wilt Nursery (CIFWN) were reported from 4 locations. Some of the lines namely, ILC 911, ILC 1278, FLIP 84-65C and FLIP 85-35C were scored as resistant ($\leq$ 20% plants killed) at all the locations.

The results of Chickpea International Cold Tolerance Nursery (CICTN) were reported from 4 locations (Chillan in Chile, Kermanshah and Maragheh in Iran and Valladolid in Spain). All the entries were rated 1 at Chillan and Kermanshah, and 3 at Valladolid (on 1 to 9 scale where 1 = free, 9 killed). Only 4 entries FLIP 93-250C, FLIP 93-261C, ILWC 81, and ILWC 139, were rated 5 at Maragheh and were tolerant.

(R.S. Malhotra, NARS Scientists)

4.1.8. ICARDA/Italian Institutions Collaborative Program on Development of Chickpeas Resistant to Biotic and Abiotic Stresses using Interspecific Hybridization and Genetic Transformation

4.1.8.1. Collection and Characterization of Italian Isolates of *Ascochyta rabiei*

The collection of *A. rabiei* in the Institute of Plant Pathology, Rome (ISPaVe) has been enlarged by new isolates coming from survey in chickpea growing areas.

A characterization for mating type has been carried out on isolates from Italy, Australia, Syria and USA.

Out of 12 Italian isolates, 55% have been classified as belonging to the mating type 1 and 45% to the mating type 2; this suggests the chances to obtain the perfect stage of the fungus under field conditions. Other 18 Italian isolates will be characterized in near future.

Identification of genetic diversity among fungal isolates, either at inter or at intraspecific level, and possible correlations between isozyme patterns and differences in pathogenicity are being studied by isozyme analysis. After standardization of the best conditions for the growth of isolates of *A. rabiei, A. pisi, Mycosphaerella pinodes, A. fabae* and *Phoma pinodella* and evaluation of the soluble native protein content in the culture medium, an extractive procedure of endomycelial and extracellular native proteins together with their quantitative analysis by Polyacrilamide Gel Electrophoresis (PAGE) have been developed. In order to establish criteria for a taxonomic, functional and geographic origin identification on the basis of linking isozyme markers, the isolates are being characterized for the presence of cytoplasmic and/or endomycelial isozymes (such as the deydrogenases IDH, MDH, ME, LDH, ADH, GDH, etc., and the transferase/lyase EST, ACP, GOT, PGI, PGM, etc). The fungal litic enzymes (PG, PL, PE, PPO, Xilanase) produced in the liquid culture are being assessed for a functional characterization in the pathogen-plant interaction. Intraspecific analyses of the *A.rabiei* isolates by isozyme patterns showed monomorphisms in PG, ADH, GDH, PGM and SOD; polymorphisms have been observed in EAST, ACP, MDH, PL and XYL. All the species under study were identified by some isozyme patterns and, in particular, by the analysis of EAST profiles.

To extend the knowledge of the genetic variability of *A.rabiei* and to identify molecular markers for virulence or other interesting characters, a DNA-extraction protocol has been developed to study the isolates by a RAPD analysis. By this procedure, 50-75 µg of DNA, corresponding to 0.10-0.15% of initial dry weight, are usually being obtained. With the aims to investigate relationship among isolates in natural populations of *A.rabiei* and to obtain specific genetic markers, reproducible DNA patterns have already been obtained, although with only few primers and with eight strains.

4.1.8.2. Screening for Resistance to Ascochyta Blight in *Cicer* spp.

In order to identify sources of durable resistance to *Ascochyta rabiei*, also effective against Italian aggressive isolates, 127 accessions of *Cicer* spp. were artificially inoculated by spraying conidial suspension of the fungus under controlled conditions.

Twenty-four accessions coming from *C.bijugum, C.judaicum, C.pinnatifidum and C.reticulatum* showed interesting levels of resistance to the isolate of the 3rd Italian pathogenic group of *A.rabiei* (symptoms classified between 0 and < 2 on a 0-5 scale. The most interesting average scores (<1,7) corresponding to a reaction of high resistance to Ascochyta blight, were noticed in 11 accessions coming from *C.bijugum*, *C.judaicum*, *C.pinnatifidum* and *C.reticulaturm*. The response of these accessions will be confirmed in due course in order to eliminate possible escapes.

4.1.8.3. Interspecific Hybridization

Two cycles of hybridization have been performed, in both spring and summer periods, using genotypes of *C.arietinum* (ICC 5127, ILC 484, Italian cvs Sultano, Visir, Ali) as female parents, and wild accessions of *C.judaicum*, *C.bijugum*, *C.pinnatifidum* and *C.echinospermum* as male parents. On total, 484 flowers were pollinated, and only 9 cross-combinations (ICC 5127 and ILC 484 x *C.bijugum*, Sultano, Ali and Visir x *C.bijugum*, ICC 5127 and ILC 484 x

C.judaicum, ILC 484 and Sultano x *C.pinnatifidum*) produced pods. These involved all crosses among *C.arietinum* and *C.bijugum*, and a total of 4 combinations between *C.arietinum* x *C.judaicum* and *C.arietinum* x *C.pinnatifidum*. Some pistils from successful cross-combinations with *C.bijugum*, *C.judaicum* and *C.pinnatifidum* have been collected for both histological and fluorimetric analyses, other 70 to try embryo rescue.

4.1.8.4. Studies on Incompatibility Barriers and Embryo Rescue

The level of interspecific incompatibility barriers is being studied by fluorimetric technique on *in situ* pollen germination as well as by histological analyses on flowers of *C.arietinum* collected 6, 24 and 48 hrs after pollination with *C.bijugum*, *C.judaicum* and *C.pinnatifidum*. Incompatibility barriers do not seem to exist at the stigmatic level but further studies are still in progress.

Histological analyses on flowers collected 2, 4, 6 days after pollination with *C.judaicum*, *C.bijugum* and *C.pinnatifidum*, allowed to observe the zygote formation 48 hrs after pollination. This indicates the occurrence of post-zygotic barriers in the cross-combinations with each of the three wild relatives. Only from the cross-combinations of *C.arietinum* x *C.judaicum* and *C.arietinum* x *C.bijugum*, hybrid embryo development has been evident already 4 days after pollination. Further analyses on the flower buds collected are still in progress.

Studies are also in progress to overcome the incompatibility barriers among *Cicer* species by embryo rescue. Two, four and six day old ovaries are being cultured on five different media. From a total of 230 ovaries cultured, 120 ovules have been extracted and then *in vitro* cultured. In general, a better development of both *pods and* ovules appeared on three of the substrates used. Eight embryos have been extracted from the cutured ovules but no evidence of a further development has been shown.

4.1.8.5. Evaluation of Progenies from Interspecific Hybridization and Development of Agronomical Practices

Four F3 families derived from interspecific crosses between *C.arietinum* x *C.reticulatum* and *C.arietinum* x *C.echinospermum* and reciprocals were grown under field conditions in Viterbo. From these families, the individual plants were selected on the basis of seed size, seed color, growth habit, resistance to Ascochyta blight and bulked for further evaluation.

With the aim to agronomically assess the progenies from interspecific hybridizations which already are under selection, it appeared convenient to develop some agronomical practices, mainly referred to plant density and Rhizobium inoculation. Only genotypes corresponding to the winter ideotype were considered because of the large increases in grain yield anticipated from winter-sowing.

Experiments conducted with different plant densities (30, 50, 70, 90 plants/m^2) showed that it is possible to increase plant population up to 90 plants/ m^2 using a dwarf and erect plant type, whereas a density of 50 and 70 plants/m^2 resulted optimal respectively for other genotypes, both characterized by semi-erect and medium-tall or tall plants.

The *Rhizobium* inoculations, however, did not show any significant difference among genotypes and strains for grain yield. This might be due to the fact that *Rhizobium* naturally available in the soil has a high efficiency similar to that of the strains utilized in the experiment. The effect of rhizobial inoculation was evident on 100 seed weight rather than on seed yield.

In general, the application of agronomical practices such as plant density and rhizobial inoculation, appropriate for the new genotypes developed, could enhance the seed yield of the lines as well as the seed size

4.1.8.6. Genetic Transformation

In order to verify if the over expression of cell wall degrading enzymes such as chitinase and β-glucanase leads to an improvement of the resistance to fungal diseases in transgenic plants, the work aimed at (I) evaluating regeneration and transformation attitude of different kabuli chickpea genotypes; (ii) improving the transformation efficiency and introduce useful genes in Italian chickpea genotypes. An innovative approach to plant disease control in the genetic transformation experiments consists in the use of chitinases from the antagonistic fungus *Tricoderma harzianum*, as these enzymes are more effective than those isolated from other sources.

The first experiments on the induction of multiple buds from mature embryos of cv. Sultano and of three breeding lines (1001, 1014, 1017) produced a number of shoots (after 30 days of culture) variable with the genotype used (2.6-3.8 shoots/embryo in the breeding lines 1001 and 1014, and 2.1-2.0 in cv. Sultano and the breeding line 1017).

The *Agrobacterium*-mediated gene transfer protocol, developed by the group of Dr. Higgins at the CSIRO-Plant Industry Division, in Camberra, has been applied on mature embryos of a kabuli chickpea genotype. The *Agrobacterium* strain used was AGL1 (Gerard *et al.* 1991) bearing the binary vector pBin19 with the marker bar gene and the *endochitinase gene* ThEn42. *After transformation with* pBin-endo/bar on a total of 3.895 ex plants producing a viable callus, sometimes regenerating abnormal plantlets were observed. Callus was positive to PCR analysis, performed with *nptII* specific primers, but it was negative to PCR analysis performed with *virD* specific primers.

(F. Saccardo, A. Porta-Puglia, C. Stamigna, R. Mancinelli, A. Infantino, E. Campiglia, P. Crinò, P. Vitale, T. De Martino, N. Pucci, R.S. Malhotra, B. Ocampo)

4.1.9. ICARDA/University Of Cordoba Collaborative Program on Race Identification of *Fusarium oxysporum* f. sp. *ciceris* in Chickpea in the Mediterranean Region

One hundred and forty six isolates of *F. oxysporum* obtained from different chickpea growing countries were provided by collaborating investigators. These included, seven from Lebanon, five from Syria, five from Turkey, 16 from Italy; 47 from Morocco, and 24 from Tunisia. DNA from monosporic cultures of these isolates was analyzed by means of PCR using a set of two primers which are specific for the yellowing (Y) and wilting (W) pathotypes of *F. oxysporum* f. sp. *ciceri*; or by means of RAPD using arbitrary single primers which amplify DNA markers for race 0, race 1 B/C, race 6, and nonpathogenic isolates of *F. oxysporum*. It should be taken into account that race 0 and race 1 B/C induce the yellowing syndrome, while races 1A, 2, 3, 4, 5 and 6 induce the wilting syndrome.

In addition, isolates of *F. oxysporum* from Lebanon, Syria and Turkey, as well as some of the isolates from Tunisia, were further characterized to race by means of biological pathotyping.

Six out of seven isolates of *F. oxysporum* from Lebanon were characterized as *F. oxysporum* f. sp. *ciceri* race 0 (yellowing pathotype) by means of molecular and biological pathotyping. The remaining isolate was nonpathogenic to chickpea.

Of five isolates from Syria, four were of the yellowing pathotype (of which three were further characterized as race 0 and one was race 1 B/C). All five isolates from Turkey were of the yellowing pathotype and belonged to either race 1 B/C (4) or race 0(1).

All isolates from Italy were characterized as nonpathogenic by means of RAPD analysis. Twenty one out of 47 isolates from Morocco were characterized as wilting pathotype by means of specific - PCR analysis, and 20 isolates were identified as representative of the yellowing pathotype. Of these 20, 14 were characterized as race 0 by RAPD analysis. Six of the isolates from Morocco were characterized as nonpathogenic.

All 24 isolates from Tunisia were of the yellowing pathotype, and they were characterized as race 0 (23) or race 1 B/C by RAPD analysis.

(Jiménez Díaz, R.S. Malhotra, C. Akem)

4.2. Chickpea Pathology

Diseases form a major biotic constraint to the production of chickpea in the WANA region. Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. is the most serious foliar disease of chickpea in the region, particularly on the winter crop when low temperatures of 15-25°C prevail during the cropping season. Its annual epidemics is not regular and is usually weather-dependent. A good season for the chickpea crop is often favourable for Ascochyta blight development. With the increased adoption of winter chickpea, the risks of frequent Ascochyta blight epidemics continue to increase. It is therefore absolutely necessary to control or manage Ascochyta blight if advantage is to be taken of winter-sown chickpea to increase and stabilize yields in the region. A major emphasis in chickpea pathology is therefore given to identify durable and stable sources of resistance to Ascochyta blight for use in the hybridization program. Emphasis is also given to the evaluation of other methods of containing the disease through an integrated disease management program that integrates host resistance with minimal chemical use as seed treatments and the manipulation of agronomic practices.

Fusarium wilt caused by *Fusarium oxysporum* Schlecht. Emend Snyd. & Hans. f. sp. *ciceris* (Padwick) Snyd. & Hans. is the most important soil-borne disease of chickpea in the region. It is prevalent on the spring-sown crop when dry and hot conditions favour its development. Other soil-borne diseases such as black root rot (*Fusarium solani*), and wet root rot (*Rhizoctonia solani*) that are favoured by high moisture conditions are important in some areas in Ethiopia and irrigated fields in Egypt and Sudan. Dry root rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*) and stem rot (*Sclerotinia sclerotiorum*) are other soil-borne diseases that also occur on chickpea in the region but overall, they are less important than Fusarium wilt.

The objectives of the chickpea pathology research are:(1) screen chickpea germplasm to identify sources of resistance to the major diseases using laboratory, greenhouse and field screening techniques; (2) share the resistant accessions identified, with national programs through international disease nurseries; (3) collect information on disease prevalence and severity in the WANA region in collaboration with the national scientists; (4) study the epidemiology and pathogenic variability of the major diseases; (5) develop integrated disease management strategies for the control of the major diseases; and (6) develop research collaboration with national programs and advanced institutions in the management of these.

4.2.1. Field Survey for Chickpea Diseases

4.2.1.1. Syria

As in previous years, the objective of the disease survey in Syria was to evaluate the disease situation and to assess the disease reaction of some promising lines (F90-96, F88-85, and F89-29) in the 2 agro-ecological zones, in on-farm and on-station trials and in demonstration plots in farmers fields. The performance of these lines and their reaction to Ascochyta blight as compared to Ghab 3, the currently grown cultivar, was of particular interest.

Disease incidence and severity on chickpea was surveyed in Deraa, Homs, Hama, Aleppo, Idleb and Hassakeh Provinces in Syria. In total, 33 locations, including off-station and on-farm trials were visited and the disease incidence and severity assessed.

Among the three promising entries, FLIP 88-85C generally performed better than Ghab 3 across all the 15 locations in which the on-farm trials were planted. It recorded an overall significant mean disease severity rating of 2.3 as compared to 2.7 for Ghab 3. Being the 4th year of this entry in the on-farm trial, and with consistently good yield and low reaction to Ascochyta blight, it has been nominated for pre-release evaluation by the Syrian NARS to complement Ghab 3 which is presently the only recommended winter chickpea variety in Syria.

(C. Akem, M. Bellar, NARS Scientists from Syria)

4.2.1.2. Morocco

A survey for the occurrence of chickpea diseases was carried out during the month of May, 1997, covering the 5 major food legume producing regions of Morocco. A total of

121 chickpea fields were visited during the 2-week survey period.

The extended dry period characteristic of the cropping season in Morocco during the year favored the occurrence of fusarium wilt of chickpea. The disease was observed in 101 of the 124 fields surveyed. It was recorded in all the regions visited during the survey. The frequency of occurrence varied from region to region, with a low of 70% in Zaers to a high of 86% in the Tadla region.

Ascochyta blight was observed only on 7% of the fields surveyed during the 1996/97 cropping season. Root roots were observed in 13% of the fields. Laboratory analysis of samples collected showed that the main root rot pathogens were: *Rhizoctonia bataticola*, *Fusarium solani*, *F. oxysporum* f.sp. *ciceris* and *Pythium* species.

(C. Akem, NARS Scientists from Morocco)

4.2.1.3. Iran

The survey was carried out during the month of June in the 1996/97 cropping season. It covered chickpea fields in the major chickpea growing areas of western Iran in Kermanshah, Kordestan and Lorestan Provinces. In Kermanshah province, 89 fields were surveyed, while in Kordestan and Lorestan Provinces it was 54 and 69 fields, respectively.

Fusarium wilt and Ascochyta blight were the most prevalent diseases in all 3 Provinces. Ascochyta blight was more severe on winter and early-planted kabuli chickpea while fusarium wilt was severe on the desi chickpea in the lowland areas. Other disease of localized importance were root rots and stunt virus.

(C. Akem, NARS Scientists from Iran)

4.2.2. Improving the Field Screening Techniques

In the 1995/96 season, the Ascochyta blight screening nursery had a lower level of blight infection than a neighboring non-inoculated field. Based on this observation, it was considered necessary to improve the screening procedure for resistance to Ascochyta blight.

An experiment was therefore carried out with a 3 time of debris spread treatment. The dates of debris spread started from December soon after germination and concluded in February. For this experiment, 2 cultivars; Ghab 1 (susceptible) and Ghab 3 (moderately resistant) were planted in mid-November. The frequency of the susceptible check was also varied, at every 2, 4, and 8 rows.

By mid-March when infection was becoming apparent in most of the entries in the field, all the material inoculated with debris in December were completely killed. There was very good infection from the January debris inoculation and little infection from the February inoculations. The results are summarized on Table 3. Thus it is clear that debris spread soon after germination in December produced the most infection followed by applications in January. The current practice of spreading debris in February produced little disease infection and thus needs to be supplemented by frequent spore sprays. Results from this trial when confirmed will be incorporated to improve the field screening techniques so as to reduce or eliminate the need for spore sprays with conidial suspensions since infected debris when spread early release more infective ascospores.

Conditions were particularly favourable for the development and spread of Ascochyta blight in 1996/97. This included continuous morning drizzles and cool temperatures during the winter months of March and April, which coincided with the flowering and pod filling stages of most of the entries. This had been proceeded by frost temperatures and snow cover during which the plants were weakened. There was no artificial inoculation of the nursery as in previous seasons because of the weakened conditions of the plants and the reactions of the susceptible checks which suggested there was enough inoculum in the nursery.

General observations in the Ascochyta blight nursery revealed that disease symptoms on seedlings were widespread by early March. Thus there was no need to supplement the infection with spore suspensions. As in previous years, the mist irrigation system was turned on by mid April to quicken disease development.

(C. Akem, S. Kemal)

4.2.3 Integrated Disease Management

4.2.3.1. Ascochyta Blight

A set of experiments were initiated during the 1996/97 cropping season to evaluate the effect of different control components in simple integrated packages for the management of Ascochyta blight on winter chickpea cultivars. In common to all the packages were cultivars with different levels of reaction to the disease, seed treatments with fungicides and the variation of one agronomic practice.

To determine the optimum time for minimal foliar spray with fungicides to manage Ascochyta blight, four different times (seedling, vegetative, flowering and podding) of foliar spray application of the fungicide Bravo (Chlorothilonil) were evaluated on 4 chickpea cultivars to determine the optimum time of application for best disease control. As can be seen from Table 4.24 the best disease control on all the 4 cultivars was obtained with sprays made at the seedling stage. Average disease severity rating at this treament was 2 as compared to 4.2 for the untreated controls. Seed yields were however, significantly higher for treatments made at the flowering stage for most of the cultivars in the trial.

In another trial, four different planting dates (Dec, Jan, Feb and March) were used to plant treated and untreated seed of 4 chickpea cultivars and to evaluate for control of Ascochyta blight.

From Table 4.25 the lowest disease ratings on both treated and untreated seed were recorded with the March spring planting, while the highest was with the first two plantings with untreated seeds and with the second date planting with the treated seed. The lowest yields were also obtained from the March plantings even though they had the lowest disease because of additional factors of low rain.

In another experiment to determine the effect of plant population integrated with seed treatment on control of Ascochyta blight, four different row spacings (30 cm, 45 cm, 60 cm, and 75 cm) were used. There were significant differences in disease severity between the different row spacings and significant yield increase with the 75 cm row spacing, contributed largely by increased plant branching (Table 4.26). As a seed treatment, Thiabendazol (Tecto) has been found to be effective at reducing early infection from Ascochyta blight sown under winter condition. One of the main reasons farmers in the region are not readily using it to treat their seeds is its unavailability in the local markets. To overcome this constraint and to give them an alternative but readily available fungicide, four other fungicides from the local market were compared for their efficacy as seed treatments with Tecto on three cultivars that are presently available to the farmers in Syria. Table 4.27 summarizes the performance of the fungicides in this trial. The performance of Vitavax was comparable to Tecto on 2 of the cultivars. Thus it could be a good substitute to Tecto and is available at an affordable cost. These findings will be confirmed in a repeated trial.

(C. Akem, S. Kemal)

Table 4.24. Effect of time of fungicide application on Ascochyta blight severity and yield of chickpea cultivars; Tel Hadya - 1996/97

Growth Stage at application	*Cultivars* F90-96C DS	F90-96C Yield	F91-188C DS	F91-188C Yield	F91-220C DS	F91-220C Yield	Ghab 3 DS	Ghab 3 Yield	Mean DS	Mean Yield
Seedling	2.0*	688	2.0*	763	2.0*	781	2.0*	732	2.0	741
Vegetative	3.3	740	4.3	830*	3.3	702	4.0	762	3.7	758
Flowering	3.3	809*	3.0	720	4.3	760	3.6	841*	3.5	782
Podding	3.0	704	3.3	630	3.6	692	4.0	692	3.5	680
None (Control)	4.0	693	4.0	680	4.3	714	4.6	670	4.2	689

*Significant at 0.05; Disease Severity (DS) on 1-9 rating scale; Yield in kg per plot

Table 4.25. Effect of planting date and seed treatment on severity of Ascochyta blight on chickpea cultivar; Tel Hadya - 1996/97.

Non-Treated Seed	DS (1-9) of *Cultivars*				
Planting Date	F90-96C	F91-188C	F91-220	Ghab 3	Mean
December 22	4.3	5.3*	4.6*	4.3	4.6
January 20	4.3	4.6*	5.0*	4.3	4.5
February 23	4.0	4.3	4.3	3.3	3.9
March 18	3.3	3.6	3.3	3.6	3.4
Mean	3.9	4.4	4.3	3.8	
Treated Seed					
December 22	2.6	3.0	3.6	3.3	3.1
January 20	3.6	3.6	3.6	4.3*	3.8
February 23	3.3	4.0	3.0	3.6	3.5
March 18	3.0	3.3	3.3	3.0	3.1
Mean	3.1	3.5	3.4	3.5	

* Significantly different from March planting at 0.05; Disease Severity (1-9).

Table 4.26. Effect of row spacing on Ascochyta blight and yield of chickpea cultivars Tel Hadya - 1996/97.

	Cultivars							
Row Spacing	**F90-96C**		**F91-188C**		**F91-220C**		**Ghab 3**	
	DS	**Yield**	**DS**	**Yield**	**DS**	**Yield**	**DS**	**Yield**
30 cm	4.5	637	4.3	602	4.0	616	4.3	544
45	4.3	768	4.7	675	4.0	749	4.3	600
60	3.7	880	4.3	1019*	3.8	911	4.0	848
75	3.0*	1208*	3.7	1103*	3.5	1161*	3.4	1102*
Mean	3.9	873	4.2	850	3.8	859	4.0	773

DS = Disease Severity (1-9); Yield = g/plot

- Significantly different from 30 cm spacings at P<0.05

Table 4.27. Comparison of fungicides as seed treatments on severity of Ascochyta blight on chickpea cultivars; Tel Hadya - 1996/97.

	DS (1-9) of Cultivars			
Fungicides	**Ghab 1**	**Ghab 2**	**Ghab 3**	**Mean**
Tecto	6.0	4.0*	4.3*	4.8
Benlate	6.0	4.3	4.7	4.8
Methyltiram	5.0	4.3	4.7	4.6
Vitavax	5.0	3.7*	4.3*	4.3
Control (None)	6.0	4.7	5.3	5.3
Mean	5.5	4.2	4.7	

*Significant to the control at 0.05; DS (1-9)

4.3. Chickpea Biotechnology

4.3.1. Increased Genetic Variability in Chickpea via Wide *Crossing and Genetic Engineering*

In addition to the plant material used in 1996, three new cultivars have been used. They are *C. arietinum* desi types namely: ICC 12004, ICC 13729 and ICC 14903. ICC 12004 has moderate resistance against *Ascochyta* blight and is used as a reference line in *Ascochyta* screening at ICARDA. ICC

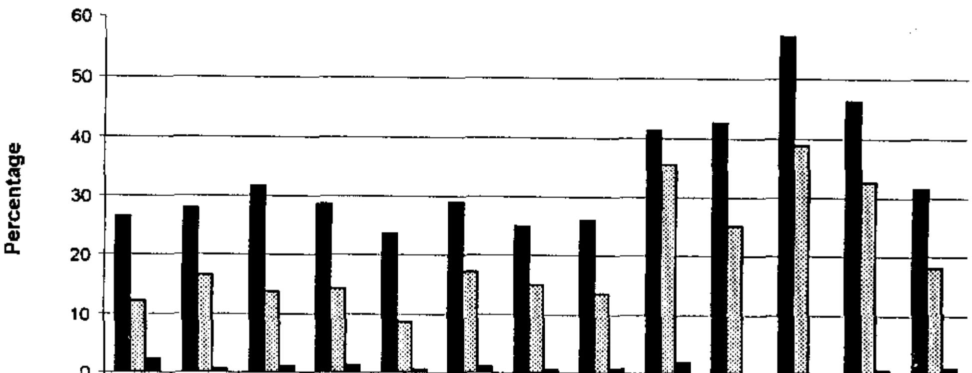
13729 and ICC 14903 have been identified by the breeder as cultivars with good resistance and tolerance for a number of biotic and abiotic stresses. In 1997 the focus has been on optimizing the hormone/time interval combination used at the interspecific crosses.

During 1997, 1378 crosses were made between the cultigen and three wild species, C. bijugum, C. judaicum and C.pinnatifidum and 438 of the crosses (32%) set pods and gave 252 (18%) ovules. From 13 ovules embryos could be rescued. After crossing three hormone solutions; I (8mg/l GA3, 1mg/l KIN, 1 mg/l NAA), II (200 mg/l GA3) and III (87.5 mg/l GA3, 25 mg/l NAA, 5 mg/l KIN) combined with three different application periods A (one drop of solution every day the first 10 days), B (a drop of solution every other day until harvest of the pods) or C (Twice a day the first three days). These nine combinations were tested ann all cross combinations (see Fig 4.3).

There was no significant difference between cultivars or hormone solutions. However, application periods exhibited significant differences. These differences were similar for different accessions. All combinations except IIC gave ovules from which embryos could be rescued. Application period C results in a high percentage of pod setting and ovules but this does not result in a higher than average number of embryos. Embryos obtained from crosses where solution I was applied germinate more successful than with other solutions (see Table 4.28). Ovules and embryos have been cultured on various media (D3E, (modified U2.5 medium), ½ strength Murashige & Skoog, Z and Z+ (modified Murashige & Skoog medium)). Some ovules and embryos developed shoots and roots on all media but roots became necrotic after 6 weeks eventually followed by the death of the putative hybrid. Z+ medium seems to overcome this problem. Six putative hybrids are now developing in vitro, and from two explants have been taken.

Table 4.28. Successful cross combinations.

Hormone	Cross combination	Plantlet Y/N	Media
IA	ILC 519 x ILWC 171	Y	B5L2
IA	ILC 519 x ILWC 171	Y	1/2 MS, 1/2 MSZ
IA	ILC 519 x ILWC 236II	Y	B5L2, 1/2 MSZ
IA	ICC 12004 x ILWC 236II	Y	MSc, 1/2 MSY
IB	ILC 482 x ILWC 79	Y	B5L2
IB	ICC 13729 x ILWC 236I	Y	B5L2,1/2 MS,1/2 MSZ
IB	ICC 13729 x ILWC 236II	Y	1/2 MS, 1/2 MSZ
IC	ILC 482 x ILWC 171	Y	1/2MS, 1/2 MSZ
IC	ICC 13729 x ILWC236II	Y	MSa, 1/2 MSZ
IIA	ICC 12004 x ILWC 171	N (callus)	Mg
IIA	ICC 14903 x ILWC 236I	Y	B5L2, 1/2 MSZ
IIB	ILC 200 x ILWC 79	N (callus)	B5L2
IIB	ICC 12004 x ILWC 171	Y	1/2 MS
IIIA	AMDOUN-1 x ILWC 95	Y	B5L2, 1/2 MSY



	IA	IIA	IIIA	A	IB	IIB	IIIB	B	IC	IIC	IIIC	C	TOTAL
% pods	26.5	27.9	31.7	28.7	23.7	29	25	26	41.3	42.6	57	46.3	31.6
% ovules	12.2	16.6	13.9	14.3	8.7	17.2	15.1	13.7	35.6	25.2	38.9	32.7	18.2
% embryos	2.2	0.54	1.1	1.3	0.58	1.1	0.58	0.75	1.9	0	0	0.65	0.94

Hormone mixture/time of application

Fig. 4.3. Effects of hormone solutions and their time of application on interspecific among *Cicer* species crosses.

To be able to clone putative hybrids a system for explant culture of *in vitro* grown plantlets (on media with a high percentage of sucrose) has been developed (see Table 4.29). Medium MSa (modified Murashige & Skoog medium) is most suitable for regenerating shoot from explants. These shoots are than transferred to ½ MSZ (½ strength modified Murashige & Skoog medium) to regenerate roots.

(B. van Dorrestein, M.Baum)

Table 4.29. Regeneration capacity of different sources of explants from annual wild Cicer species on different regeneration media.

Medium	Source of Explant	No of Explant With callus	Explant with roots	Explants with shoots	Explants
B5L2*	Root	20	15	3	0
	Internode	14	14	0	0
	Leaf	23	21	0	2
	Shoot	5	0	0	3
	Total	62	50	3	5
Msa	Root	42	38	2	0
	Internode	48	38	0	7
	Leaf	54	54	0	0
	Shoot	18	2	0	15
	Total	162	132	2	22
Msb	Root	25	15	8	0
	Internode	35	24	3	0
	Total	14	5	0	9
Msc	Root	21	12	9	0
	Internode	16	16	0	0
	Leaf	13	12	0	0
	Shoot	9	0	0	9
	Total	59	0	9	9
Total of all media		385	291	48	48

*B5L2: Modified B5 medium from Gamborg

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	Shoot	18	2	0	15
	Total	162	132	2	22
Msb	Root	25	15	8	0
	Internode	35	24	3	0
	Total	14	5	0	9
Msc	Root	21	12	9	0
	Internode	16	16	0	0
	Leaf	13	12	0	0
	Shoot	9	0	0	9
	Total	59	0	9	9
Total of all media		385	291	48	48

*B5L2: Modified B5 medium from Gamborg

that this may be the case come from sequencing the plasmids. In some of them the original cloning side was lost and unrelated sequences were present adjacent to the primer binding site used for sequencing. However, 52 of these clones are already sequenced and primers designed for 32 of them. The aim of the project is to develop around 300 STMS markers that cover the entire chickpea genome.

4.3.2.1. Generation of an Integrated Genome Map for Chickpea

To generate the first codominant marker map of the chickpea genome two populations of recombinant inbred lines (RILs) were used. RILs are derived by propagating individual F_2 lines to F_6 or F_7 by selfing. They offer several advantages over F_2 populations. One of the two RILs was derived from a wide cross between *C. reticulatum* and chickpea accession ICC 4958, whereas the other was derived from a narrow cross between a kabuli chickpea accession, C104, and desi accession WR315. Both populations segregate for resistance to *Fusarium oxysporum* races 1 to 6. In the wide cross 82 STMS markers were mapped that - at a LOD score of 3 - span 490 cM of the estimated 1000 to 1200 cM of the chickpea genome in 10 linkage groups (Fig. 4.4). Eight markers are still unlinked. In the narrow cross, 45 markers were mapped that - at a LOD score of 5 - span around 200 cM in 9 linkage groups.

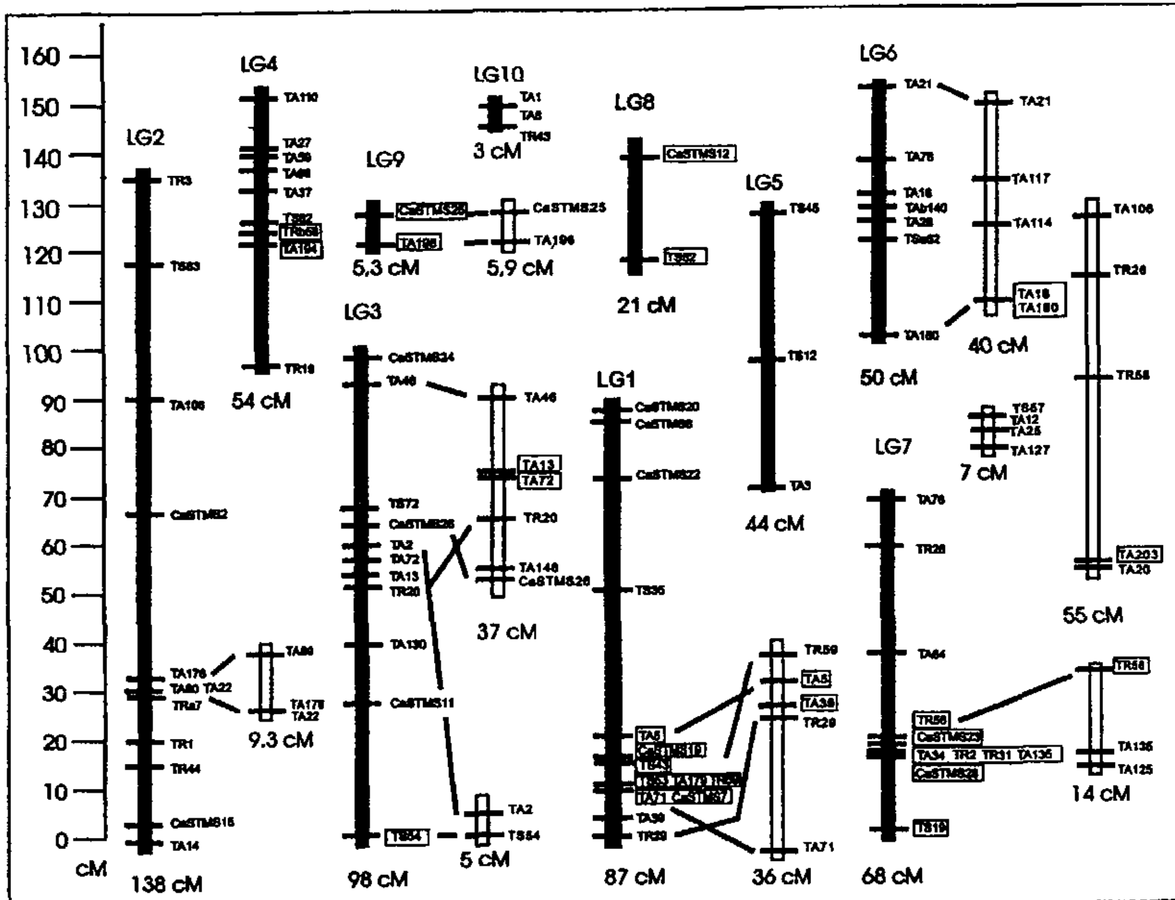
Genome mapping was continued in both the wide cross (*Cicer arietinum* x *C. reticulatum*) and the narrow cross (C104x WR315). About 100 STMS markers were used for mapping. The mapped markers were further being used for segregation analysis in segregating population derived from ILC 1272 x ILC 3279 which is segregating for resistance to pathotype *II of Ascochyta rabiei.* About 28 markers have been tested so far, all of them revealed polymorphism between ILC 1272 and the ILC 3279. Along with these markers, further segregation analysis with some more number of markers coupled with screening of the population for the disease resistance will allow to identify marker very close to the genes of resistance.

(P. Winter, S. Sahi, R. Arreguin, B. Huettel, S. Udupa, F. Muehlbauer, G. Kahl)

4.3.3. Genetic Variability of *Ascochyta rabiei* in Syria, Pakistan and Tunisia

A naturally infected chickpea field in Tel Hadya, ICARDA's research station was selected to study the genetic variability and migration of *Ascochyta rabiei*. Isolates were collected from 9 well-separated infection sectors in a hierarchical way. Apart from two infection sectors, all other infection sectors were dominated by a single genotype-H. In these dominated sectors, the frequency of the genotype-H varied from 55% to 100%. In three sectors, all the isolates collected were genotype-H (100%). In other two sectors, the frequency of genotype-H was 30% and 40%. In general, the genotype-H predominated in the field with a frequency of 67% (49 out of 73 isolates analyzed).

Genetic variability within Syria: During April 1997, the disease samples were collected from different chickpea growing regions in Syria namely, Tel Hadya (73), Heimo (8), Jellin (7), Sqelbieh (9), Al-Ghab (6) and Yahmoul (5). The pathogen was isolated from the disease samples and single-spored. DNA was extracted from the single-spore-derived mycelia and RAPD analysis was performed. The analysis revealed that all the chickpea growing regions except Tel Hadya were genotype-H to an extent of 100%.



A genetic linkage map of chickpea with microsatellite markers

Fig. 4.4. A genetic linkage map of chickpea with microsatellite markers.

Comparative genetic analysis of *A. rabiei* isolates from Syria, Tunisia and Pakistan: Seventy-eight isolates from different chickpea growing regions of Tunisia and six isolates from Pakistan were analyzed with the genotype-H specific DNA marker. Thirteen (16.7%) isolates from Tunisia and one isolate (16.7%) from Pakistan showed the genotype-H specific pattern. The pathotyping of these isolates is in progress.

(S.M.Udupa, F. Weigand, G. Kahl)

4.3.4. Utilization of Sequenced Tagged Microsatellite Sites (STMS) Derived from Chickpea in the Genus *Cicer*

Several types of molecular markers have been used in plant breeding for a wide range of applications. Generally, single-locus codominant markers are preferred, because they make it possible to tag and map the same loci in many different populations and even species. Probably the best markers in this respect are microsatellites. In view of effort and expense involved in designing microsatellites it is attractive to consider their use in other species.

One of the aims of our work is the marker-assisted utilization of the primary and secondary gene pool of chickpea for the improvement of this crop. Therefore, we explored: 1). Whether and to which extent STMS primers designed for the chickpea could also be applied to genome analysis in wild *Cicer* species. 2). If conservation of microsatellite-flanking sequences reflect the known evolutionary relations between these species. 3). The reason for the differences in number and size of amplification products derived from the same or different species. Nine annual and one perennial species were used in this study, (Table 4.30). Total DNA was extracted by the CTAB protocol. Ninety primer pairs (developed in Frankfurt University) were used in this study. DNA from *C. bijugum,* *C. reticulatum and C. cuneatum* amplified with the primers *Ta18, Ta14s and Ta37 respectively, were sequenced and* compared with the chickpea sequence.

The DNA of one accession for each species has been amplified with 90 chickpea-derived STMS primer pairs. Amplification resulted either in the presence or absence of products (Table 4.31). Several STMS created bands from all species. For other STMS loci, only one or two STMS/species combinations were successful which could be used as specific markers. The percentage of conserved loci, ranged from 92 % for *C. reticulatum* to 50 % for *C. cuneatum*,

Table 4.30. *Cicer* species and their accessions used in marker assisted studies.

Species	Accessions	Species	Accessions
C.arietinum	ILC1504, ILC1930, ILC1939, ILC2550, ILC2639	*C.judaicum*	ILWC7, ILWC31, ILWC43, ILWC44, ILWC273
C. bijugum	ILWC7, ILWC32, ILWC79, ILWC195, ILWC240	*C.pinnatifidum*	ILWC9, ILWC29, ILWC49, ILWC171, ILWC226
C.cuneatum	ILWC40, ILWC185, ILWC187, ILWC232, ILCW37	*C.reticulatum*	ILWC105, ILWC109, ILWC123, ILWC242, ILWC247
C.chorassanicum	ILWC23, ILWC90, ILWC146, ILWC147	*C. yamashitae*	ILWC3, ILWC53, ILWC55, ILWC214, ILWC215
C.echinospermum	ILWC180, ILWC181, ILWC235, ILWC238, ILWC239	*C.anatolicum*	

seemed to reflect known phylogenetic relationships between the species.

In a second set of experiments, 31 STMS primer pairs were used to amplify the DNA from all other available accessions. The results revealed a large amount of polymorphism concerning not only the size of the amplification products but also their number. Whereas in *C. arietinum* in most cases one or, exceptionally, two bands were visible, the same primer pair gave rise to up to maximum 5 bands in the wild species (e.g. Ta18, Fig. 4.5). The number of bands varied not only between species but also between accessions of a species.

In order to understand the observed differences in number and size between amplification products we selected the following cases for sequencing analysis:

1) Differences in the number of bands between different species (locus Ta37). One fragment of 283 pb was amplified in *C. arietinum* while 3 fragments (cu1, cu2, cu3) were produced in *C. cuneatum*. All these fragments were sequenced. Cu1, cu2 and cu3 possessed some small homologies to the fragment from chickpea, however without the $(TAA)_{20}$ tract present there.
2) Large size differences between products from different species (locus Ta18, fig.4.5). We analysed the 1094 bp fragment from *C. judaicum* amplified by Ta18 and compared it with that of 150pb amplified in *C. arietinum*. It did not contain the $(TAA)_{22}$ microsatellite found in chickpea.
3) Large variation in size of products from accessions of the same species (locus Ta14s, Fig.4.5). It was analysed by sequencing the 274 bp fragment of *C. reticulatum* accession ILWC247 and the 724 bp fragment of *C. reticulatum* ILWC105. Their sequences were compared with the 249 bp fragment derived from *C. arietinum*. The reason for the difference between the amplification products of *C. arietinum* and

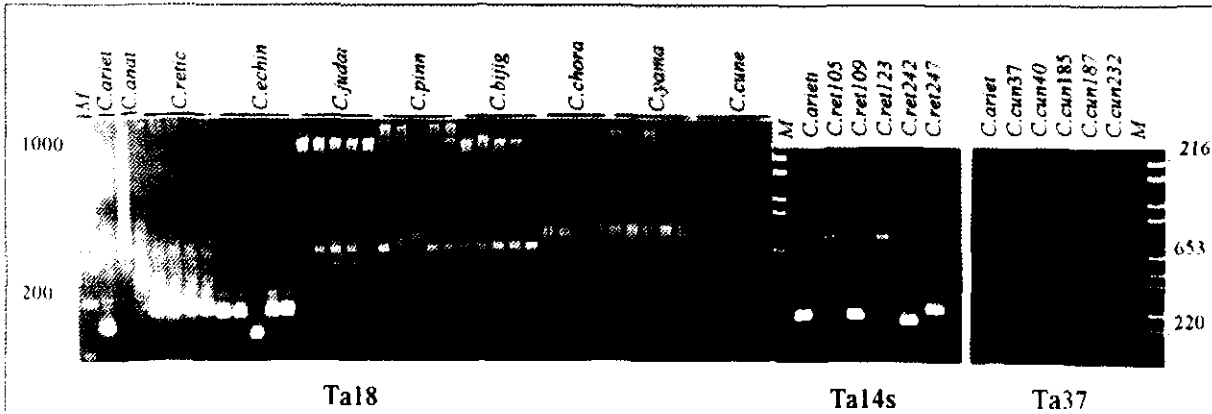


Fig. 4.5. Polymorphism detected between and within different species of the genus *Cicer*. **Ta18: amplification realized with Ta18. Order of samples: M: molecular weight marker, 100pb DNA ladder. *C.ariet: C.arietinum* ILC3279, *C.anat: C.anatolicum, C.retic: C.reticulatum* ILWC105, ILWC109, ILWC123, ILWC242, ILWC247, *C.echin: C. echinospermum* ILWC180, ILWC181, ILWC235, ILWC238, ILWC239, *C.judai: C.judaicum* ILWC7, ILWC31, ILWC43, ILWC44, ILWC273, *C.pinn: C. pinnatifidum* ILWC9, ILWC29, ILWC49, ILWC171, ILWC226, *C.bijug: C. bijugum* ILWC7, ILWC32, ILWC79, ILWC195, ILWC240, *C.chora: C. chorassanicum* ILWC23, ILWC90, ILWC146, ILWC147, *C.yama: C. yamashitae* ILWC3, ILWC53, ILWC55, ILWC214, ILWC215, *C.cune: C. cuneatum* ILWC37, ILWC40, ILWC185, ILWC187, ILWC232. Ta14s : amplification realized with Ta14s. Order of samlpes: *C.arietinum* ILC3279, *C.ret: C.reticulatum* ILWC105, ILWC109, ILWC123, ILWC242, ILWC247. With Ta37: *C.arieti: C.arietinum* ILC3279, *C.cun: C. cuneatum* ILWC37, ILWC40, ILWC185, ILWC187, ILWC232. Molecular weights are given in pb.**

Table 4.31. Conservation of chickpea loci between the different wild *Cicer* species. *C.ari: C.arietinum*, C.ana: *C.anatolicum*, *C.ret: C.reticulatum*, *C.ech: C.echinospermum*, *C.jud: C.judaicum*, *C.pin: C. pinnatifidum*, *C.bij: C. bijugum*, *C.cho: C.chorassanicum*, *C.yam: C. yamashitae*, *C.cun: C. cuneatum*.

1= indicates the presence of amplification products, 0= indicates the zero allele.

**Cicer loci* : represent the 33 primer pairs that give amplification products in all investigated species (Ta1, Ta3, Ta5 ,Ta8, Ta18, Ta20, Ta22, Ta27, Ta37, Ta71, Ta76, Tr2s, Tr9, Tr43s, Tr59, Ts17, Ts53, Ts47, CaSTS1, CaSTS3, CaSTS4, CaSTS7, CaSTS8, CaSTS9, CaSTS11, CaSTS12, CaSTS17, CaSTS18, CaSTS21, CaSTS22, CaSTS25, CaSTS26, CaSTS27).

Loci	C.ar	C.an	*C.ret*	*C.ech*	*C.jud*	*C.pin*	*C.bij*	*C.cho*	*C.yam*	*C.cun*	Loci	C.ar	*C.ana*	*C.ret*	*C.ech*	*C.jud*	*C.pin*	*C.bij*	*C.cho*	*C.yam*	*C.cun*
Ta2	1	0	1	1	1	1	1	0	0	1	Tr44	1	1	1	1	1	1	1	0	1	0
Ta11	1	1	1	1	1	1	1	1	1	0	Tr56	1	1	1	1	0	0	0	0	0	0
Ta14s	1	0	1	1	1	0	1	1	1	1	Tr58s	1	1	1	1	0	0	0	0	0	1
Ta21	1	0	1	0	0	0	0	1	1	0	TS12	1	1	1	0	0	0	0	1	0	0
Ta34	1	1	1	1	1	1	1	1	1	0	1TS19	1	0	1	1	0	0	0	0	0	0
Ta34s	1	1	1	1	1	1	1	1	1	0	TS23	1	1	1	1	0	0	0	0	0	0
Ta45	1	0	1	1	0	0	0	0	0	0	TS45	1	0	1	1	0	0	0	1	0	0
Ta52	1	0	1	0	0	0	0	0	0	1	TS52	1	0	1	0	0	0	0	0	0	0
Ta54	1	0	1	1	0	0	1	0	0	0	TS53	1	0	1	0	0	0	0	0	0	0
Ta59	1	1	1	1	1	1	1	1	0	0	TS 54	1	0	1	1	0	0	0	0	0	1
Ta64	1	1	1	1	0	0	0	0	0	0	TS 57	1	1	1	1	0	1	1	1	1	0
Ta72	1	1	0	0	0	0	0	0	1	0	TS 72	1	1	1	1	0	1	0	0	0	1
Ta78	1	1	0	0	0	0	0	0	0	0	TS83	1	0	1	1	1	1	1	1	1	1
Ta80s	1	0	1	1	0	0	1	1	1	1	TS104	1	0	1	1	0	0	0	0	0	0
Ta89	1	0	1	1	0	0	0	0	0	0	TS105	1	1	1	1	1	1	1	1	0	0
Ta96s	1	0	1	1	0	1	0	0	1	0	TS129	1	0	1	1	1	1	1	0	0	1
Ta104	1	1	1	1	1	1	1	1	0	0	CaSTS2	1	1	0	0	0	0	0	1	0	0
Ta106	1	0	1	1	0	0	0	1	1	0	CaSTS5	1	1	1	1	1	1	1	1	1	0
Ta110	1	1	1	1	1	1	1	1	1	0	CaSTS7	1	0	1	1	1	1	1	1	1	1
Ta117	1	1	1	0	0	0	0	1	1	0	CaSTS10	1	1	1	1	0	0	0	0	0	0
Ta125	1	1	1	1	1	1	1	1	1	0	CaSTS16	1	1	1	1	1	1	1	1	1	0
Ta146s	1	0	1	1	1	1	0	0	0	0	CaSTS19	1	1	1	1	1	1	1	0	0	0
Ta180	1	1	1	1	0	1	0	0	1	1	CaSTS20	1	1	0	1	0	0	0	0	0	0

Loci	*C.ar*	*C.an*	*C.ret*	*C.ech*	*C.jud*	*C.pin*	*C.bij*	*C.cho*	*C.yam*	*C.cun*	Loci	*C.ar*	*C.ana*	*C.ret*	*C.ech*	*C.jud*	*C.pin*	*C.bij*	*C.cho*	*C.yam*	*C.cun*
Ta203	1	0	0	0	0	0	1	0	0	0	CaSTS23	1	1	1	1	1	1	0	1	1	0
Tr1	1	1	1	1	1	1	1	1	1	0	CaSTS24	1	1	1	0	1	1	1	0	0	0
Tr7	1	0	1	0	0	1	1	1	0	0	CaSTS28	1	0	1	1	1	0	1	1	1	1
Rr19	1	0	1	0	0	1	1	0	0	0	***Cicer loci****	1	1	1	1	1	1	1	1	1	1
Tr20s	1	0	0	1	0	0	0	0	0	0	No.of tested loci	90	90	90	90	90	90	90	90	90	90
Tr23	1	1	1	0	1	0	0	0	0	0	*No.of* conserved loci	*90*	*65*	*83*	75	57	60	60	59	55	45
Tr29	1	1	0	0	0	0	0	0	0	0	% of conserved loci	*100*	72.2	*92.2*	*83.3*	*63.3*	*66.6*	*66.6*	65.5	61.1	50
Tr43	1	1	1	1	1	1	1	1	0	0											

C. reticulatum ILWC 247 was the insertions of a $(CAA)_4$ and a 12 bp sequences with other deletions and substitutions along the fragment. The 724 bp amplification product of *C. reticulatum* ILWC105 differed in size from that of *C. arietinum* by 475 bp. This big variation was mainly caused by the amplification of the 35 (TAA) repeats present in *C. arietinum* to 161 units in *C. reticulatum* ILWC105. There, only the fragments derived from *C. reticulatum* were homologous to the Ta14s *C. arietinum* locus, contained a microsatellite, and, thus most probably represent the same locus. The fragments derived from *C. cuneatum* locus Ta37 and *C. judaicum* locus Ta18 did not contain the expected microsatellite, and moreover, were unrelated to the respective sequences from *C. arietinum*.

The consequence is that STMS markers derived from chickpea will reliably detect synthenic loci only in the first crossability group. Between members of the second crossability group they may detect polymorphism, but care must be taken to regard them as alleles of chickpea loci.

W.Choumane, F.Weigand (ICARDA), P. Winter, G. Kahl (University of Frankfurt, Germany)

4.3.5. Development of Efficient Regeneration Methods Including Protoplast Isolation and Regeneration Suitable for Agrobacterium-Mediated and Direct Transformation of Chickpea

Engineering host-plant resistance genes in chickpea via genetic transformation is an alternative way to increase the level of resistance against Ascochyta blight. We have now identified the most suitable explant and culture conditions for the three ICARDA chickpea varieties. Shoot tips from 3-4 day old green or etiolated seedlings are routinely used for the isolation and culture of protoplasts. About 13-15 million viable protoplasts are obtained per g fresh weight, exhibiting good cell division frequency. A plating efficiency of around 0.8% was determined (i.e. 1 g fresh material will result in up to 100,000 individual callus-lines). More than 4,000 callus lines are now subject to regeneration experiments according to de novo protocols published already for pea and faba-bean.

Transformation experiments with about 1 million protoplasts/experiment, using PEG are under way, in order to determine the respective transformation and selection conditions.

4.3.5.1. Agrobacterium-Mediated Transfer of Recombinant DNA into Chickpea

Transient expression assays using recombinant *gusA*- and a modified *gfp*-gene clearly show the susceptibility of chickpea. However, as in other grain legumes, the tendency to exhibit low susceptibility of regenerative tissue is a major constraint. The adoption of comparably efficient protocols in pea is rather difficult. First, because the use of immature material is not practical due to the amount of seeds needed and the fact that only one seed per pod can be harvested. Nevertheless, mature material can be used as well as recent publications imply. In these protocols, embryo axes from mature seeds have been used for *Agrobacterium*-inoculation or particle bombardment and the transmission of the transgene into the next generation has been demonstrated. A modified protocol, using seed material provided by ICARDA, has shown that the formation of multiple shoots is induced by growth regulators BAP and TDZ. We are currently modifying the respective protocol by keeping the embryo-axis attached to the cotyledon during inoculation to maintain and improve the regenerative capacity during cocultivation. However, the regeneration -especially in the extremely recalcitrant kabuli-types- has been significantly improved. In addition, comparable experiments in other grain legumes -namely pea- show, that this system is less time-consuming and that Agrobacteria tend to introduce only one or a few copies of the recombinant gene, easing the use of transgenic prototypes in subsequent breeding programmes and minimizing the risk of cosuppression of transgene-expression.

4.3.5.2. Vector Constructs for *Agrobacterium*- and Direct DNA-Transfer

Two plasmid vectors have been provided by the BAYER AG, harbouring the vst-gene from *Vitis vinifera*. The respective genes -one with the original promotor, a second with the vst-gene tuned by a transcriptional enhancer, have been subcloned into relaxed cloning vectors for their use in direct DNA-transfer experiments. Transformation experiments in protoplasts will be carried out in order to determine the kind and level of phytoalexines produced.

Since the enhancer containing vst-gene may produce stilbene-derivatives at a phytotoxic level, careful estimation and viability analysis is necessary before respective binary constructs are used for transformation and regeneration experiments.

In addition, a suitable binary vector has been identified to harbour the vst-gene and the pat-gene as selectable marker in a suitable architecture. Based on the use of hypervirulent *Agrobacterium* strains EHA101 and EHA105, a basic vector system -pGIN- is available as well.

4.3.5.3. Transformed Chickpea Plants

Up to this moment, DNA-based data on transgenic plants have not been obtained. However, several shoot cultures develop *in vitro* under selective conditions. Further analysis will be done upon transfer into the green-house. Since seed material is needed in chickpea, a final evaluation only makes sense if genes have been transmitted into the next generation.

(Heiko Kieseker, Andre de Kathen, H.J. Jacobsen, B. van Dorrestein, M. Baum)

5. FORAGE LEGUME IMPROVEMENT

Introduction

Livestock are an integral part of farming systems where crop production is limited by large seasonal variations in rain-fall. 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 (Ethiopia, Bangladesh, China, *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 3-N-Oxalyl-L-2, 3-diaminopropionic acid (*B*-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 agroecological 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 rain-fall 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.

5.1. 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 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* ssp. *amphicarpa*) and underground chickling (*Lathyrus ciliotatus*) are adapted to areas with marginal lands, hilly rocky non-arable lands and low rainfall.

5.2. 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 5.1. In the first approach in wild

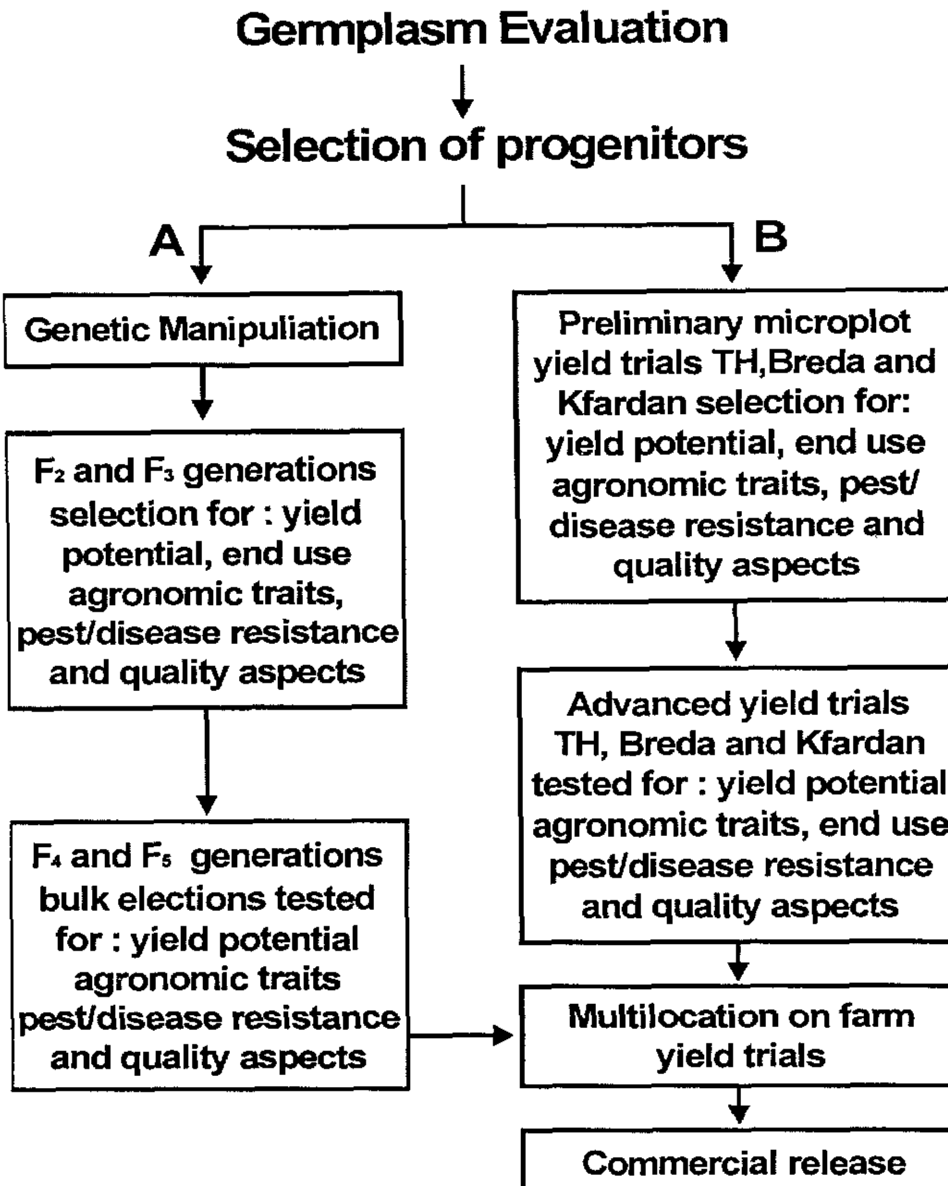


Figure 1. Structure of forage legumes breeding program: (A) Hybridization, and (B) Selection.

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.

5.2.1. Evaluation of Germplasm

An evaluation was conducted on 376 accessions of *Vicia* spp; and 109 accessions of *Lathyrus* spp., collected from different origins, in nursery observation rows. A total of 100 accessions of *Vicia* spp. and 36 of *Lathyrus* spp. were selected on the basis of seedling vigour, cold tolerance, winter and spring growth, leafiness, erect growth habit and earliness in flowering and maturity.

Special attention will be given to these genotypes in further evaluation of their herbage and seed yields, reaction against major foliar and root diseases and suitability for different end-uses. Detailed results of this part are reported in 1997 Annual Report of GRU.

(L.D. Robertson, A.M. Abd El-Moneim)

5.2.2. Vetches Adaptation Trials

Three experiments were conducted at Tel Hadya. Two hundred and twenty-five accessions from different origin each of common vetch (*Vicia sativa*), narbon vetch (*V. narbonensis*) and bitter vetch (*V. ervilia*) were planted in a cubic lattice design with three replicates (6 rows each) for each experiment. The experiments were fertilized with 40 kg/P_2O_5/ha.

In these trials, the accessions were visually scored at 1-9 scale (1 = poor; and 9 = very good) for cold tolerance winter growth, spring growth, leaf retention and pod-shattering. The two middle rows were harvested at full maturity to estimate the grain yield. Time to start flowering, and full maturity were recorded.

A broad variation was observed between the three species and within the same species for the character studied (Table 5.1). 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.

(A.M. Abd El-Moneim)

5.2.3. Preliminary Evaluation in Microplot Field 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 cultivars.

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 lines by national programs.

In the 1996-97 season microplots trials of two *Vicia* spp., *Vicia narbonensis* (narbon vetch), *V. panonica* (Hungarian vetch), and three *lathyrus* spp. *L. sativus* (Grasspea), *L. cicera* (Dwarf chickling) and *L. ochrus* (Ochrus chickling) were grown at Tel Hadya in 3.5 m^2 plots arranged in triple lattice design. Then number of entries in each trial was 49 except in ochrus chickling where it was 25. Seed rate was 120 *kg/ha for narbon vetch and ochrus chickling* and 100 kg/ha for the other trials, and fertilizer was applied at 40 kg P_2O_5/ha. These microplots were divided into to two sets, one was harvested at 100% 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. The results of the microplot yield trials are now given by species.

Table 5.1. Range, mean, standard error and coefficient of variation (CV%) for 6 character of three *Vicia* spp.

Character	*Vicia sativa*				*Vicia narbonensis*				*Vicia ervilia*			
	Range	Mean	SE	CV %	Range	Mean	SE	CV %	Range	Mean	SE	CV %
Cold tolerance*	3.0-8.0	4.6	0.58	18	3-9	6.0	0.7	16	3-9	5.6	0.73	18
Winter growth*	3.0-9.0	6.0	0.70	16	1-9	4.5	0.7	21	3-9	6.4	0.72	16
Spring growth*	3.0-9.0	8.0	0.80	12	1-9	5.0	0.9	28	5-9	7.6	0.97	17
Days to flowering	114-132	126	1.5	5	93-137	115	2.3	3.0	107-144	130	2.64	3.0
Days to maturity	158-177	165	1.9	3	153-176	165	2.2	2.0	166-174	165	1.30	1.5
Seed yield (kg/ha^{-1})	351-2390	1450	155	15	35-2850	700	280	29	227-1715	722	185	31

* On visual score, where 1 = poor; 9 = very good.

5.2.3.1. Narbon Vetch (*Vicia narbonensis*)

A total of 49 genotypes (selections) were tested at Tel Hadya. The total biological yield (grain and straw) at maturity varied from 4300 to 9600 kg/ha (mean of 7400 kg/ha), grain yield from 750 to 2900 kg/ha (mean of 1790 kg/ha), and harvest index from 14 to 30%. Because narbon bean is susceptible to *Orobanche crenata* and the field was heavily infested by broomrape. the late maturing genotypes produced low seed yield with low harvest index: the early genotypes are also susceptible but are able to form pods and set seeds by escaping the worst effects of *Orobanche* are felt. Seed yield was therefore strongly negatively correlated ($r = -0.69$, $P < 0.01$) with days to flowering. *The results indicate the need to search for early maturing* genotypes. The top 10 entries which combined high biological and grain yields are shown in Table 5.2. These entries were also resistant to the downy mildew (*Peronospora viciae*) and chocolate spot (*Botrytis fabae*), and showed a high level of cold tolerance through 45 frost nights with absolute minimum temperature of -8.3°C. These entries are identified as sources of frost tolerance in our breeding program and for further testing in high elevation areas.

5.2.3.2. Hungarian Vetch (*Vicia panonica*)

Forty-nine selections were assessed in microplot yield trials at Tel Hadya. Herbage yield varied from 5000 to 8000 kg/ha, whereas grain yield varied from 1000 to 2200 kg/ha. Hungarian vetch showed a high level of cold tolerance, had slow winter growth which was followed by rapid spring growth and a long-flowering period. Late maturing lines were severely affected with *Orobanche*. Table 5.3 shows the performance of the top 10 lines for both biological and grain yields.

Table 5.2. Winter growth (WG), biological (B) and grain (G) yields and time (days) to flowering and maturity of the top 10 selections of narbon vetch in Microplots Yield Trials at Tel Hadya.

IFLVN Sel. #	WG+	Yield kg/ha-1		HI (%)	Days to	
		B	G		Flower	Mature
2561	7.7	9600	1900	19	114	159
2383	5.2	9659	2474	26	113	158
2393	5.7	9648	2900	30	112	165
2462	7.0	9155	2100	24	113	163
2466	6.5	8770	1470	25	112	161
2468	5.0	8500	2100	25	110	159
2472	6.0	7900	2100	27	112	160
2477	5.5	7900	2150	27	115	160
2704	6.0	7900	1800	23	114	165
2744	5.5	7700	1900	25	115	163
Mean++	5.0	7400	1790	24	114	165
S.E. ±	0.50	580	250	2.2	1.2	1.4
CV (%)	19.0	14.0	24	16	1.7	1.5

+ On a scale 1 to 9, where 1 is slow, and 9 very rapid growth measured in mid-February, 1997.
++ Mean of all 49 entries.

5.2.3.3. Grasspea (*Lathyrus sativus*)

Forty-nine selections were tested at Tel Hadya. Results of the top 10 are shown in Table 5.4. Herbage yield varied from 2700 to 5400 kg/ha with a mean of 3900 kg/ha. Seed yield ranged from 500 to 1500 kg/ha with a mean of 1020 kg/ha whereas the biological yield ranged from 4000 to 6000 kg/ha, with a mean of 5400 kg/ha. Harvest index (HI) ranged from 9 to 30%. The low values of HI were due to attack by *Orobanche* damage. Seed yield was negatively correlated with days to flowering ($r = -0.65$, $P < 0.01$). Grasspea was characterized by slow winter growth, rapid growth in spring, long flowering and late maturity. The exceptionally high rainfall in 1996-97 (433.7 mm) also favored attack by powdery mildew (*Erysiphe pisi*) when pods were forming.

Table 5.3. Cold effect (CE), winter growth (WG), herbage (H), biological (B) and grain (G) yields (kg/ha), harvest index (%) and time (days) to flowering and maturity of the top 10 selections of Hungarian vetch in preliminary Microplot Yield Trials at Tel Hadya.

IVLVP	CE+	WG	Yield kg/ha			HI	Days to	
			H	B	G	(%)	Flower	Mature
2653	7.0	6.0	5990	6800	2200	32	140	169
2655	7.0	5.6	6500	7700	1900	25	139	170
2658	7.0	6.8	7600	7500	2200	29	137	186
2659	7.7	6.3	6200	7300	1800	25	138	171
2662	7.0	7.0	6300	6500	1600	25	139	171
2667	8.0	8.0	6400	7200	1400	19	138	170
2670	8.5	9.0	6000	7500	1500	20	140	172
2673	7.7	7.8	8000	6800	1700	25	142	170
2675	7.9	7.7	7500	7800	1500	19	137	169
2677	9.0	7.0	7200	7900	1700	21	137	171
Mean++	7.5	7.0	6700	6950	1700	24	142	171
S.E.±	0.68	0.80	570	500	175	2.9	1.5	1.7
C.V. %	15.0	20	17	13	25	24	1.4	1.9

+ On a scale 1 to 9 where 1 is severely affected by cold and 9 is unaffected.
++ Mean for all 49 entries.

To improve the grain yield on grasspea it will be necessary to select for early maturity to escape the worst effects of *Orobanche*. However, it dry areas where we consider grasspea to be of value *Orobanche* is not widespread, and it is considered as an insurance crop during the time of drought-induced famine, because of its drought tolerance.

Table 5.4. Cold effect (CE), herbage (H), biological (B) and grain (G) yield kg/ha, harvest index (%) and time (days) to flowering and maturity of the top 10 selections of grasspea in preliminary yield trials at Tel Hadya.

IFLLS	CE	Yield kg/ha			HI	Days to	
		H	B	G	(%)	Flower	Mature
				-+			
737	7.0	3400	5100	1040	20	123	170
738	5.0	3000	5300	1600	30	120	172
741	6.0	3500	5000	1100	22	122	175
743	5.0	5400	4900	1400	28	121	171
744	6.0	4000	5900	1400	24	119	173
747	7.0	3900	5500	1450	26	120	174
752	7.0	4100	5300	1150	22	118	175
753	6.0	3500	5700	1460	26	124	175
754	8.0	4500	6000	1500	24	125	172
755	7.0	3300	5800	1400	24	124	171
Mean^{+}	6.0	3900	5400	1020	19	126	175
S.E. ±	0.8	517	350	150	2.5	1.3	1.9
CV (%)	20	18	15	24	26	2.2	2.0

(+) Mean for all 49 entries.

5.2.3.4. Dwarf Chickling (*Lathyrus cicera*)

Forty-nine selections, derived from nursery evaluation in 1995-96 were tested in microplots at Tel Hadya. Herbage yield varied from 5500 to 8100 kg/ha, with a grand mean of 6900 kg/ha. Seed yield ranged from 950 to 1800 kg/ha, with a grand mean of 1400 kg/ha, and harvest index varied from 13 to 23%. Table 5.5 shows the performance of the top 10 selections. Dwarf chickling produced more seed and straw than grasspea because it flowered earlier and was less affected by frost and *Orobanche*.

5.2.3.5. Ochrus Chickling (*L. ochrus*)

Twenty-five selections of ochrus chickling, derived from nursery evaluation of 1995-96 were tested in microplots at Tel Hadya. The total biological yield varied from 5000 to

Table 5.5. Cold effect (CE), herbage (H), biological (B), grain (G) yields (kg/ha), harvest index (%) and time (days) to flowering and maturity of the top 10 selections of dwarf chickling in preliminary yield trials at Tel Hadya.

IFLLS	CE	Yield kg/ha			HI (%)	Days to	
		H	B	G		Flower	Mature
088	8.0	7500	7400	1750	23	115	160
629	7.7	6200	7200	1500	21	116	160
630	7.0	6800	7100	1400	20	115	162
631	9.3	8100	7100	1700	20	115	159
632	8.7	7300	7200	1600	22	113	160
633	8.2	6000	7200	1650	23	114	161
634	7.7	7200	7200	1500	21	116	160
635	8.0	7500	8500	1800	21	115	160
638	7.9	7700	7000	1500	21	114	161
642	7.5	7200	6900	1400	20	113	160
Mean+	7.5	6900	7100	1400	20	117	164
S.E. ±	0.7	610	490	195	2.5	0.9	1.7
CV (%)	16	15	14	22	20	1.4	1.8

(+) Mean for all 49 entries.

6970 kg/ha, with a grand mean of 5500 kg/ha. Seed yield varied from 1600 to 2500 kg/ha, with a grand mean of 1600 kg/ha, with harvest index ranging from 25 to 38%. Table 5.6 shows the performance of the top 5 entries with combined high herbage and total biological yields. Ochrus chickling produced high seed and biological yields due to its relative earliness and as had field resistance to *Orobanche*.

The study of variation in agronomic traits in the microplot yield trials helps us to establish a suitable breeding program to develop improved cultivars for different niches and utilizations. Selection for genotypes with desirable traits such as rapid winter growth, cold tolerance, early flowering and maturity, high herbage and total biological yields begins in microplots in a year after nursery rows evaluation. This leads to more critical evaluation in advanced yield trials before multilocation testing of selected promising lines.

Table 5.6. Cold effect (CE), herbage (H), biological (B), grain (G) yields (kg/ha), harvest index (%) and time (days) to flowering and maturity of the top 5 selections of ochrus chickling in preliminary yield trials at Tel Hadya.

IFLLO	CE	Yield kg/ha			HI (%)	Days to	
		H	B	G		Flower	Mature
761	5.3	6600	6700	2300	34	123	166
762	6.5	6750	6800	2200	32	123	164
766	5.0	6000	6200	2100	34	126	165
767	5.0	5700	6300	2400	38	124	160
185	7.0	6300	6900	2500	36	122	162
Mean+	4.0	4500	5500	1600	29	127	168
S.E. ±	0.6	350	420	160	3.2	2.1	1.0
CV (%)	24	18	16	18	15	3.0	1.2

(+) Mean for all 25 entries.

Bearing in mind that forage legumes can be used for grazing during winter and early spring or harvested for grain and straw for winter feeding, one can see how the five studied species can fit into farming systems. The high harvest index and early maturity of narbon vetch suggest that it can be used for straw and grain production, whereas, grasspea and dwarf chickling would be recommended for hay, straw and grain production. Dwarf chickling can also be used for direct grazing in spring. Because of its resistance to *Orobanche*, and susceptibility to cold effect, ochrus chickling can be used either for direct grazing or for grain and straw production in areas of moderate winter and where *Orobanche* is endemic. Hungarian vetch is more suitable for cold areas, because of its cold tolerance and maybe of its requirement for vernalization.

(Ali M. Abd El-Moneim)

5.2.4. Advanced Yield Trials (AYT)

Elite lines from our breeding program are tested over multiple environments (locations and years) for yield performance, utilization (grazing, hay, grain and straw) and consistency. Yield of these lines and their relative ranking or consistency in performance form the basis for recommendation to growers.

Experiments were carried out to test elite promising lines of *Vicia* spp., (Vetches) and *Lathyrus* spp., (chicklings) at Tel Hadya (TH), Breda (Br), Terbol (T) and Kfardan (Kfr). Materials used in these trials are either *progenies of single plants (selections or pure lines)*, selected from the wild types or selected 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 years. The trials were sown and managed as in the same way microplots but had larger plot size (28 m^2).

5.2.4.1. Advanced Yield Trials of Narbon Vetch (*Vicia narbonensis*)

Twenty-five promising lines of narbon vetch were evaluated under rainfed conditions at Tel Hadya, Breda in Syria and Kfardan in Lebanon to determine the relative value of these locations for development of high and stable yielding lines.

Winter growth, biological and grain yield and harvest index were measured at each location (Table 5.7). There were differences in the performance of the tested lines for all the traits. Yields were greater at Tel Hadya and Kfardan than Breda, both for biological and grain yield.

Table 5.7. Location means of winter growth (WG), biological (B) and grain (G) yields, harvest index (HI) and time (days) to flower and mature for 25 lines of narbon vetch in AYT.

Location		Yield kg/ha			Days to	
	WG+	B	Gr	HI %	Flower	Mature
Tel Hadya	7.5	5700	1200	21	101	164
	±0.52	±570	±190	±2.0	±0.9	±1.7
Breda	7.2	4200	900	21	103	152
	±0.54	±250	±87	±1.7	±0.64	±0.80
Kfardan	8.0	4700	1100	23	110	160
	±0.60	±280	±95	±1.8	±1.2	±0.9

(+) On 1 to 9 visual scale basis, where 1 = poor and 9 = excellent growth on 21 February, 1997.

The harvest index at Kfardan was greater than Tel Hadya and Breda. The low biological and grain yields at Breda were mainly due to relatively low rainfall (230 mm) which represent 87% of long term average. The high rainfall, especially late season rains favored the development of downy mildew (*Peronospora viciae*) which caused a severe damage to certain lines.

The high yielding lines at each location are shown in Table 5.8. IFLVN # 2561 showed high yield across all the three locations. Line # 2384 was promising at Tel Hadya and Breda, whereas, # 2377 was promising at Breda and Kfardan. These lines showed a high degree of resistance to downy mildew and earliness in flowering and maturity.

Table 5.8. The most promising and adapted lines of narbon vetch at Tel Hadya, Breda and Kfardan.

Location	Promising lines IFLVN #				
Tel Hadya	2561	2384	2470	2469	2601
Breda	2561	2379	2384	2469	2377
Kfardan	2561	2381	2376	2385	2377

5.2.4.2. Advanced Yield Trials of Wooly-pod Vetch (*Vicia villosa ssp. dasycarpa*)

Twenty-five lines were tested at Tel Hadya, Breda and Kfardan. There were differences between lines at the three locations and also between locations (Table 5.9). Herbage and grain yields were greater at Tel Hadya than Breda and Kfardan. The low yields at Breda were mainly due to low rain fall, although the crop was unaffected by frost that occurred for 49 nights with an absolute minimum temperature of -10 to 0°C. In contrast to other feed legume crops, wooly-pod vetch is characterized by a long flowering period, high herbage and straw yields and low seed yields. These characters makes it most suitable for grazing or hay making. Because we consider leafiness and leaf retention as important selection criteria for wooly-pod vetch, the high herbage yielding lines are characterized by high leaf-retention which is a high desirable character for high quality hay. Our results also confirmed that wooly-pod vetch is resistant to broomrape (*Orobanche crenata* Fosk). Table 5.10 shows the most promising lines at the three locations. IFLVD # 683 and 2438 showed promise at all three locations. More emphasis has to be given to reduce yong-pod abortion, pod shattering, high leaf-retention and earliness to flowering and maturity to improve the productivity of wooly-pod vetch.

5.2.4.3. Advanced Yield Trials of Bitter Vetch (*Vicia ervillia*)

Twenty-five lines were tested at Tel Hadya and Breda in Syria and Terbol and Kfardan in Lebanon. Herbage yield varied from 1500 kg/ha at Breda to 5200 kg/ha at Terbol, whereas, grain yield varied from 500 kg/ha at Breda to 2000 kg/ha at Terbol (Table 5.11). Herbage and biological yields were greater at Terbol and Kfardan than Tel Hadya and Breda. The low grain yield at Tel Hadya was mainly due to the severe attack by Orobanche, whereas at Breda due to the low rainfall.

Table 5.9. Location means of winter growth (WG), herbage (H), biological (B) and grain (G) yields harvest index (HI) and time (days) to flower and mature for 25 lines of wooly-pod vetch.

Location	WG+	Yield (kg/ha)			HI (%)	Days to	
		H	B	G		Flower	Mature
Tel Hadya	6.5 ±0.7	7000 ±590	8800 ±620	890 ±127	10 ±1.8	130 ±1.2	170 ±1.5
Breda	7.5 ±0.65	3600 ±410	5000 ±390	300 ±60	6 ±0.9	113 ±0.70	162 ±0.90
Kfardan	6.7 ±0.8	4500 ±550	5500 ±350	722 ±100	13 ±1.2	140 ±0.6	175 ±0.9

(+) On 1 to 9 visual scale basis, where 1 = poor and 9 = excellent growth on 21 February, 1997.

Table 5.10. The most promising and adapted lines of wooly-pod vetch at Tel Hadya, Breda and Kfardan.

Location	Promising lines IFLVD#
Tel Hadya	683, 2438, 2443, 2424
Breda	683, 2438, 2454, 2445
Kfardan	683, 2438, 2439, 2452

Bitter vetch showed cold tolerance and rapid winter growth compared with other vetches. No symptoms of downy mildew, powdery mildew or ascochyta blight appeared, but the late maturing lines were affected by *Orobanche*. Table 5.12 shows the most promising and adapted lines at each location. None of the lines showed high yield across all four locations.

Table 5.11. Location means of winter growth (WG), herbage (H), biological (B) and grain (G) yields harvest index (HI) and time (days) to flower and mature for 25 lines of bitter vetch.

Location	WG+	Yield (kg/ha)			HI (%)	Days to	
		H	*B*	*G*		*Flower*	*Mature*
Tel Hadya	5.0	3000	3500	800	22	115	160
	±0.6	±290	±300	±140	±2.5	±1.5	±1.4
Breda	4.5	1500	2000	500	25	110	155
	±0.66	±135	±160	±55	±3.0	±1.3	±1.5
Kfardan	5.7	4000	6500	1500	23	135	172
	±0.9	±380	±510	±230	±2.9	±1.0	±1.1
Terbol	6.5	5200	8000	2000	25	147	183
	±0.4	±500	±320	±180	±1.5	±0.6	±0.5

(+) On 1 to 9 visual scale basis, where 1 = poor and 9 = excellent growth on 21 February, 1997.

Table 5.12. The most promising and adapted lines of bitter vetch at Tel Hadya, Breda, Kfardan and Terbol.

Location	*Promising lines IFLVE#*
Tel Hadya	2517, 2520, 2510, 2649, 2519
Breda	2513, 2514, 2508, 2522, 2549
Kfardan	2513, 2646, 2511, 2646, 2508
Terbol	2646, 2649, 2648, 2514, 2519

5.2.4.4. Advanced Yield Trials of Common Vetch (*Vicia sativa*)

Thirty-six lines were tested at Tel Hadya, Terbol and Kfardan. The three locations were chosen to sample the environmental conditions of cereal zone in Syria and Lebanon. There were large variation between lines within the same location and between locations for winter growth, herbage, biological and grain yields Table 5.13. The total biological yield was greater at Tel Hadya and Terbol than at Kfardan. The grain yield 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 cold effect as indicated by the highly significant correlation between cold effect and total biological yield of r = -0.510, r = -0.700 and -0.820 at Tel Hadya, Terbol and Kfardan, respectively.

Table 5.13. Location means of winter growth (WG), herbage (H), biological (B) and grain (G) yields harvest index (HI) and time (days) to flower and mature for 36 lines of common vetch.

Location	WG+	Yield (kg/ha)			HI (%)	Days to	
		H	B	G		Flower	Mature
Tel Hadya	7.5	5500	7200	1120	15.0	124	160
	±0.6	±560	±385	±145	±1.5	±0.8	±1.0
Breda	6.5	6500	8200	1500	18	135	170
	±0.5	±500	±510	±130	±1.8	±0.7	±0.9
Kfardan	6.8	4500	5500	1250	22	134	165
	±0.7	±400	±320	±125	±1.5	±0.4	±0.9

(+) On 1 to 9 visual scale basis, where 1 = poor and 9 = excellent growth on 21 February, 1997.

Table 5.14 shows the most promising and adapted lines at each location. IFLVS # 2566 showed high adaptation and was the most promising across the three locations. Its exploitation in future breeding program in case of high herbage and grain yields would be most desirable.

Table 5.14. The most promising and adapted lines of common vetch at Tel Hadya, Kfardan and Terbol.

Location	Promising lines IFLVS#
Tel Hadya	2566, 2567, 2627, 2628, 2637
Terbol	2566, 2496, 2497, 2499, 2502
Kfardan	2566, 2496, 2488, 2493, 2499

5.2.4.5. Advanced Yield Trials of Palestine vetch (*Vicia palaestina*)

Twenty-five lines of palestine vetch *Vicia palaestina* were tested at Tel Hadya and Kfardan. Herbage, grain and biological yields were greater at Tel Hadya than Kfardan (Table 5.15). Herbage yield varied from 2500 to 5500 kg/ha at Tel Hadya, and from 1800 to 3500 kg/ha at Kfardan. At maturity the grain yield ranged from 1000 to 2100 kg/ha at Tel Hadya and from 700 to 1200 kg/ha at Kfardan. The relatively low yields at Kfardan were mainly due to the sensitivity of palestine vetch to cold which occurred for 81 frost nights with an absolute minimum temperature of -10°C.

Table 5.15. Location means of winter growth (WG), 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 Palestine vetch.

Location	WG	Yield (kg/ha)			HI (%)	Days to	
		H	B	G		Flower	Mature
Tel Hadya	5.0	4300	5900	1660	28	117	150
	±0.8	±290	±360	±170	±2.4	±1.0	±1.1
Kfardan	4.0	2500	3800	900	24	130	160
	±0.70	±165	±290	±110	±1.7	±0.3	±0.8

5.2.4.6. Advanced Yield Trials of Three *Lathyrus* spp.

Twenty-five promising lines each of grasspea (*Lathyrus sativus*), dwarf chickling (*L. cicera*) and ochrus chickling (*L. ochrus*) were tested at Tel Hadya, Breda and Kfardan. Table 5.16 shows herbage, biological and grain yields at the three locations. *Lathyrus ochrus* produced the highest herbage and biological yields at the three locations followed by *L. cicera* and *L. sativus*. This is mainly due to its high resistance to the broomrape (*Orobanche crenata*). The low grain yield of *L. sativus* was mainly due to the severe effect of broomrape during the pod formation and grain filling stage, especially at Tel Hadya. Great variability was observed both between species and within the same species. The early maturing lines of *L. cicera* had high grain yields and the high herbage yield was mainly due to the rapid winter growth of the selected lines. The high yielding lines were identified for more critical testing in the international nurseries program by NARS.

The results of the advanced yield trials of five *Vicia* species and three *Lathyrus* species show great differences between the three 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. These variation could be exploited by the appropriate breeding procedures to develop high yielding cultivars. These cultivars can contribute significantly to animal production in rainfall agriculture. Their use in rotation with cereals will increase the sustainability of farming systems by acting as a disease and *Orobanche* break, and by contributing to the nitrogen nutrition of cereals.

The utilization of different species varies between regions. Consequently characters for selection must vary accordingly 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 long-flowering period, prostrate or semi-erect growth habit rapid winter and spring growth, cold tolerance and high herbage production are the most important attributes to make wooly-pod vetch the most suitable for grazing especially in the cold areas. The high grain and straw yields and early maturity of narbon vetch make it ideal feed legume for producing winter stocks of straw and grain for feeding sheep during the peak of feed demand in winter. It does not lose its leaves during harvest like many other feed legumes and its seeds contain around 28% crude protein. Palestine vetch can be used for hay making in spring or late grazing because of its rapid spring growth, high leaf-retention and vigorous growth habit. Common-vetch is a versatile feed legume crop.

The rapid winter growth and cold tolerance lines, can be used for early grazing, the non-shattering-pods erect types can be used to produce grain and straw, and the leafy and rapid spring types can be used for hay making either in pure stand or in mixtures with barley or oats. For farmers who require hay or grazing dwarf chickling could be another option. Grasspea is susceptible to *Orobanche*, but in dry areas it can still be used for grain and straw, because of its tolerance to drought. Ochrus chickling is resistant to *Orobanche* and can be used for grazing or grain and straw production to reduce the build-up of seed bank of the parasite in areas where mainly food and forage legumes are grown and can be of value of developing integrated *Orobanche* control system.

In our breeding program, many selection criteria are considered important in the improvement of yield and quality of forage vetches and chicklings. It is also

Table 5.16. Means and ranges of herbage, biological and grain yields (kg/ha) of three *Lathyrus* spp. in advanced yield trials at Tel Hadya (TH), Breda (Br) and Kfardan (Kfr).

Species	Herbage Yield (kg/ha)			Biological Yield (kg/ha)			Grain Yield (kg/ha)		
	TH	Br	Kfr	TH	Br	Kfr	TH	Br	Kfr
L. sativus									
Mean +	5800	1900	3500	5700	2800	4000	820	310	830
SE	570	205	340	490		315	115	30	98
Range	(3900-7800)	(1600-2100)	(1400-4000)	(4500-6500)	(200-3500)	(2800-5000)	(350-1400)	(170-400)	(600-1100)
L. cicera									
Mean	5000	3700	3500	6500	3500	5200	1400	460	1700
SE	310	240	290	510	390	530	170	60	215
Range	(4000-6000)	(2600-4500)	(2000-4100)	(4500-7700)	(1500-4500)	(3400-6100)	(950-2000)	(290-750)	(900-2100)
L. ochrus									
Mean	6400	1900	4200	6700	1500	5200	1500	700	1000
SE	405	205	350	386	210	270	150	85	110
Range	(3900-7700)	(800-3000)	(2000-5700)	(4000-7500)	(600-2200)	(4000-6000)	(900-1900)	(200-900)	(800-1400)

(+) Mean for all 25 lines.

considered convenient to group the characters considered desirable in two categories: (a) characters related to presistence, these include flowering time and duration, resistance to trampling and ability to regrow after early grazing to produce seed for resowing and tolerance to diseases and insects. (b) characters related to productivity, which include good winter and spring growth, ability to grow well in cold winters and high harvest index and high palatability and freedom from toxic properties that are injurious to animal health. However, it should be noted that there is some overlap between these two categories.

Time of flowering and maturity are considered to be major importance in determining the suitability of forage vetches and chicklings to particular environment. In dry areas with less than 300 mm rainfall, the essential requirement is that flowering must start early enough for adequate pods to be formed and matured by the end of the growing season. There are marked differences between species and within the same species in their time of commencement of flowering and maturity and this facilitates the selection of suitable genotypes for wide range in length of the growing season. In our breeding program, we maintain genetic diversity for location specificity for yield, agronomic requirements for different end uses and quality factors in improved populations to be used by NARS, through our international nurseries program.

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5.3. Nutritional Quality

Improved forage quality is an important objective in our breeding program. Also, achieving high yield potential and adaptation to different miches and agroecological zones needs to be complemented by ensuring that the end products are accepted by livestock. Therefore, quality of hay, straw and grains are given great consideration.

5.3.1. Hay and Straw Quality of *Vicia* spp. and *Lathyrus* spp.

The quality parameters utilized in the forage breeding program are protein %, neutral detergent fiber (NDF%), acid detergent fibers (ADFY) and dry matter organic matter digestibility (DOMD%).

Large differences were observed both between and within species. Generally, hays of vetches are more nutritious having higher protein contents than straw (Table 5.17a). Hay of *V. dasycarpa* has the highest protein content followed by *V. sativa*, *V. ervilia*, and *V. palaestina*. *V. ervilia* has low fiber contents that resulted to high digestibility. *V. palaestina* has relatively low protein content, high fiber and low digestibility. This is mainly due to its tiny leaves, tall stems and low leaf: stem ratio.

Hays of *Lathyrus sativus* and *L. cicera* are high in protein content and digestibility Table 5.17b. This is mainly due to high leaf: stem ratio and high degree of leaf retention at harvest. The same trend was found in the case of straw.

5.3.2. Protein and Neurotoxin β-N-Oxalyl-L-x-B-Diaminopropionic Acid (β-ODAP) Contents in Three *Lathyrus* spp. Grains, at Two Locations, Tel Hadya and Breda.

Chicklings (*Lathyrus* spp.) have high yield potential in areas with less than 300 mm rainfall. Grasspea (*Lathyrus sativus*) is particularly adapted to dry areas. It represents the major component of human diets in times of

Table 17a. Mean and range of protein content % NDF %, ADF %, and DOMD % for hays and straw of five *Vicia* spp. promising lines in advanced yield trials at Tel Hadya.

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
Vicia sativa								
Mean	20.0	37.0	26.0	77.0	13.0	50.0	38.0	61.0
SE ±	1.0	2.5	1.7	3.0	1.5	2.5	1.5	4.5
Range	18-22	35-45	23-31	72-82	8-16	45-55	34-41	47-68
V. ervilia								
Mean	19.0	29.0	21.0	81.0	15.0	38.0	30.0	69.0
SE ±	1.5	2.4	1.7	3.9	1.3	3.5	1.6	5.7
Range	15-23	23-35	18-26	72-83	12-17	31-46	27-34	51-78
V. dasycarpa								
Mean	22.0	34.0	24.0	72.0	11.0	37.0	52	61.0
SE ±	1.2	3.8	1.9	3.0	2.0	4.5	5.0	6.6
Range	17-24	25-44	21-29	60-76	7-13	34-42	47-65	45-72
V. Palaestina								
Mean	17	40.0	25.0	70	10.0	53.0	35.0	44
SE ±	1.6	2.7	1.7	4.0	1.7	2.0	1.6	5.0
Range	13-19	35-47	20-57	58-79	5-14	47-56	31-39	32-57
V. narbonensis								
Mean	--	--	--		12.0	48.0	36.0	57.0
SE ±	--	--	--		1.9	4.0	2.2	5.0
Range	--	--	--		8-16	39-56	30-40	45-70

Table 17b. Mean and range of protein content % NDF %, ADF %, and DOMD for hays and straw of three *lathyrus* spp. Promising lines in advanced yield trials at Tel Hadya.

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
L. sativus								
Mean	22.0	44.0	29.0	76.0	13.0	54.0	32.0	63.0
SE ±	1.0	4.0	2.4	3.8	1.2	2.2	2.8	4.0
Range	20-25	34-55	23-35	66-82	8-15	45-55	28-40	55-75
L. cicera								
Mean	23.0	32.0	23.0	75.0	15.0	46.0	28.0	61.0
SE ±	1.4	3.2	2.0	2.9	1.0	5.0	2.5	4.0
Range	21-26	26-39	18-28	66-80	10-18	34-67	24-37	47-68
L. Ochrus								
Mean	--	--	--	--	12.0	44.0	27.0	66.0
SE ±	--	--	--	--	0.8	6.0	3.0	4.5
Range	--	--	--	--	9-14	27-70	20-45	48-75

drought-induced famine in Asia and East Africa. One of the drawbacks of grasspea, however, is that it excessive consumption causes 'Lathyrism', a nerveus disorder resulting in incurable paralysis of lower limbs. This disease in human beings and domestic animals is caused by the presence of a free amino acid known as β-N-Oxalyl-L-α β-Diaminopropionic Acid (β-ODAP) in the seeds.

Protein and neurotoxine β-ODAP for promising lines of *Lathyrus sativus*, *L. cicera* and *L. ochrus* grown at Tel Hadya and Breda were estimated by a Near-Infrared Reflectance (NIR) Spectroscopy Model NEOTEC 5000, with a wave length setting between 1100 and 2500 mm. Every tenth sample was verified by Micro-Kjeldahl method for crude protein and classical spectrophotometnic analysis for β-*ODAP*. It was possible to develop a good calibration which gave the correlations r = 0.90 and 0.93 for β-ODAP and crude protein, respectively. Table 5.18 summarizes the results of crude protein % and β-ODAP for 25 promising lines each of *L. sativus*, *L. cicera* and *L. ochrus* grown at *two locations*, *Tel Hadya* and Breda with rainfall of 433 and 230 mm, respectively. The results indicate than 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 in the same species. *Lathyrus ochrus* had the *highest protein and* B-ODAP, whereas, *L. cicera* had the lowest protein and B-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 5.18. Mean and range of protein content % and β-*ODAP*% for grains of promising lines of three *Lathyrus* spp. at Tel Hadya and Breda.

Species	Tel Hadya		Breda	
	Protein %	β-ODAP	Protein %	β-ODAP
L. sativus				
Mean	29.0	0.17	31.0	0.25
SE ±	1.9	0.03	1.2	0.05
Range	27-33	0.09-0.24	25-33	0.1-0.35
L. cicera				
Mean	27.0	0.13	28.0	0.20
SE ±	1.2	0.02	1.0	0.02
Range	24-31	0.15-0.35	25-30	0.14-0.28
L. ochrus	32	0.40	32	0.44
SE ±	2.0	0.08	1.9	0.09
Range	27-34	0.30-0.60	25-35	0.28-0.65

5.3.3. Tanins and Protein Contents of *Vicia narbonensis* Seed

In small ruminants tanins in narbon vetch seeds have a negative effect as an antipalatability factor and a positive effect as a protein out-flow from rumen.

Non of forty-nine lines of narbon vetch were tanin-free. Tanin content of the whole seed varied from 0.02% in Sel. # 2397 to 0.25%, Sel. # 2378, whereas, protein content varied from 23.5% in Sel. # 2478 to 32.0% in Sel. # 2385. Lines with very low tanin were susceptible to downy mildew (*Peronospora viciae*), aphis (*Aphis craccivora*) and pod-borer (*Helicoverpa* sp.). The presence of moderate levels of tanins 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 paramount importance to the performance of ruminant animals (sheep and goats). A modest increase in protein and digestibility from the development of new promising 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 always supplemented by improving the quality of the herbage, grain, and straw. Forage vetches and chicklings improved in quality are developed by breeding for (a) greater nutritional value, (b) increasing intake and digestibility (c) lower content 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 stages of our breeding program and could help in the improvement of nutritive value of the herbage and straw. Leafiness has also been found to be positively correlated with protein and digestibility.

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5.4. Genetic Improvement

5.4.1. Improving Seed Retention (Pod-Shattering) in Common-vetch (*Vicia sativa*).

An essential character of a grain legume crop and a desirable one in a forage legume crop is the ability to retain its seeds long enough to allow mechanical harvesting at full maturity. Pod-shattering in common vetches reduces its popularity as feed legume crop for fallow replacement. Vetch 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 three natural wild non-shattering mutants with undesirable agronomic traits.

The genetic of pod-shattering was studied using parental (P_1, P_2), falial 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 matured types. After five backcrosses generations eight superior lines, IFLVS 2708, 2709, 2714, 2717, 2721, 2724, 2556 and 2558 were selected having 95-98% non-shattering pods as compared to 20-30% in the original breeding lines. The grain yields of these lines is above 2.0 tons/ha.

Developing non-shattering cultivars in common vetch is continuing with the aim to incorporate the erect habit. IFLVS # 2558 was identified as erect and non-shattering and is also characterized by white flowers, which facilitates maintenance selection of the line. Seed multiplication for this line is being done at Tel Hadya and Terbol 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.

5.4.2. Improving Herbage Production of Underground Vetch (*Vicia sativa* ssp. *amphicarpa*) and Cold and Drought Tolerance of Common-vetch (*Vicia sativa* ssp. *sativa*)

Species and subspecies hybridization is an important aspect in feed legume breeding, to incorporate useful genes carried out by parental species and also to increase variation for selection. Our studies on underground vetch (*V. sativa* ssp. *amphicarpa*) 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 the 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 (*V. 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 crop from both of them.

The material was derived from crosses of improved lines of common vetch (IFLVS # 1416, 715, 713, 1448 and 1416) with two wild accessions of underground vetch (# 2416 from Eastern Anatolia, Turkey, and # 2614 originated from Gabal Abd El Aziz area, in Syria). High vegetative vigour 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 numbers of underground pods, cold tolerance and leaf: stem ratio and herbage yield.

Selection was done in F_3 from individual plants selected in F_2. Through selection in F_3, 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, families with cold tolerance and a 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 collaboration with NRMP. Improved lines of common vetch will be used for winter sowing common vetch in Turkey.

5.4.3. Improving Nutritional Quality of Grasspea (*Lathyrus sativas*)

A breeding and selection program has been established at ICARDA to develop genetic material which combines low neurotoxin β-ODAP, agronomically high yield and a maintained adaptability to adverse conditions.

The basic material for this program consisted of thirty landraces of *L. sativus* representing the available variability for β-ODAP (more than 0.40%) and diversity in agroclimatic conditions among places of their origin. These land races were crossed with five lines with low β-ODAP (below 0.1%) as testers and the 150 hybrid combination were obtained. Gene markers such as seed, flower, and stem colours were used to eliminate pods which might have developed from selfing. Selection from F_2 to F_6 was directed for early maturity, small and large seed size, and less than 0.1% β-ODAP content. In the 1996-97, 110 families were grown under rainfed conditions at Tel Hadya and Breda to assess their yield potential and B-ODAP content. The ten families with lower β-ODAP and high grain yield were selected at Tel Hadya and Breda, (Table 5.19).

Table 5.19. The β-ODAP content (%) and grain yield of 10 promising lines of grasspea at Tel Hadya and Breda.

Tel Hadya			Breda		
IFLLS#	Grain yield (kg/ha)	β-ODAP (%)	IFLLS#	Grain yield (kg/ha)	β-ODAP (%)
680	1500	0.072	681	933	0.073
654	1400	0.071	671	980	0.083
678	1350	0.077	654	500	0.084
698	1300	0.078	711	1000	0.088
681	1600	0.076	735	900	0.084
667	1300	0.080	698	1200	0.085
715	1200	0.080	686	1300	0.090
704	1500	0.081	678	1100	0.087
734	1600	0.073	710	1000	0.088
707	1400	0.090	660	950	0.090
Mean^{+}	1100	0.11		780	0.13
SE ±	115	0.059		97	0-029

(+) Mean for all 110 tested line.

From these studies it is apparent that the neurotoxin B-ODAP is much lower than most of the land races. Further, it is interesting to note that the yield potential of these lines is relatively high when rainfall at Breda was 233 mm. The results reported here appear to be highly encouraging for the development of low neurotoxin varieties to overcome the problem of 'lathyrism' of this drought tolerance and hardy crop.

(Ali M. Abd El-Moneim, H. Nakkoul)

5.4.4. Use of Somoclonal Variation in *Lathyrus sativus*

Recently protocols have been developed to obtain plants with low neurotoxine β-ODAP. Different explants are cultured on medium and dedifferentiated into calli. From *these calli plants were regenerated* through subculturing them on different media. Due to somoclonal variation, these plants gave a good opportunity to select for low β-ODAP content.

This technique was conducted at ICARDA with five lines with different seed colour and cotyledons colour. From a total of 1104 explants culture, 95% developed into callus and 6% developed into plantlets (Table 5.20). Roots could be regenerated from all tissue analysed. However, only internodes and shoot meristems gave rise to new shoots. Rooting of shoot meristem was only successful when these explants were subcultured on MSL+ medium followed by a subculture on modified Murashinge and Skoog medium (MSL++). The time from culturing explants till transferring plants into the plastic house was an average of 10 months.

Significant differences between the selections analysed could be observed for regeneration capability. Regenerated plants showed high variation for morphological traits such as flower colour, leaf shape, pod length and number of seeds/pod as compared to the original lines.

(B. Van Dorrestein, M. Baum, A.M. Abd El-Moneim)

5.5. Biological Nitrogen Fixation in Forage Legumes (BNF)

Biological Nitrogen Fixation has been estimated in vetches advanced yield trials of 1994/95 season at Tel Hadya, Breda and Kfardan stations with rainfall 313, 244 and 365 mm., respectively using ^{15}N dilution method technique. In each entry/treatment a microplot of 1 x 1 m area was marked after planting, ^{15}N fertilizer was added as a solution to the soil equivalent to 10 kg N/ha at 10% enriched ammonium

Table 5.20. Number and origin of explants to cultured and their regeneration.

IFLLS#	β-ODAP %	No. of explants	No. of callogenic explants	No. of plants with *roots*	No. of explants with *shoots*	No. of plants *regenerated*	Regenerated plants (%)
85	0.430	457	247	86	76	11	2.4
482	0.280	181	76	64	19	12	6.6
36	0.220	107	38	36	14	13	12.1
521	0.230	126	81	25	16	6	4.7
508	0.300	233	85	68	43	26	11.2
Total	-	1104	527	279	168	68	6.0

sulphate. Similar plots (3 replicates) were planted with non-nodulating chickpea (PM-233) and barley (Arabi Aswad) and within each plot a microplot of 1 x 1 m was marked and received 40 kg N/ha as 2.5% enriched ammonium sulphate. At a physiological maturity stage, 3-5 plant shoots of the middle of each microplot (legumes & reference crop) were collected for the estimate of % ^{15}N, plant samples were ground and sieved and sent for analysis to Europa Scientific and CSIRO laboratories to estimate the average of % ^{15}N used to calculate the amount on nitrogen fixed biologically by the legumes.

Table 5.21. Estimation of biological nitrogen fixation as N fixed (kg/ha) in different *Vicia* spp. Grown in Tel Hadya, Breda and Kfardan locations in 1994/95 season.

Nitrogen derived from fixation

Species	No. of entries	Location		
		Tel Hadya	Breda	Kfardan
V. narbonensis	36	62 ± 10	23 ± 4.9	88 ± 18.6
V. villosa Subsp. *Dasycarpa*	25	73 ± 8.9	18 ± 3.6	64 ± 10.0
V. ervilia	25	75 ± 11.3	--	75 ± 12.1
V. sativa	25	64 ± 7.8	--	66 ± 10.2
V. palaestina	16	50 ± 13.7	20 ± 4.6	24 ± 6.6

The results revealed great variability among the five species within the same location and also among the three locations (Table 5.21). At Tel Hadya, the total nitrogen derived from fixation was higher in *V. dasycarpa* and *V. ervilia* than the other species, whereas, at Kfardan *V. narbonensis* and *V. ervilia* gave the highest nitrogen derived from fixation. Generally, nitrogen derived from fixation was lower at Breda than Tel Hadya and Kfardan. This is mainly due to the low rainfall.

(F. Afandi, M.C.Saxena, A.M. Abd El-Moneim)

5.6. Forage Legume Pathology

Resistance to major stem and leaf diseases continued to be one of the selection criteria for developing productive forage legumes suitable for the WANA region. The main diseases occurring on forage legumes in the WANA region are: Downy mildew *(Peronospora viciae)*, Ascochyta blight (*Ascochyta pisi* f.sp. *lathyri)* and Botrytis grey mold *(Botrytis cinerea). The forage legume project* has identified several promising lines of *Vicia* and *Lathyrus* spp. for yield and adaptation in the region but their reactions to these major diseases need to be assessed.

The objectives of the pathology research in the project are to: 1) Evaluate selected genotypes for resistance to the major diseases and obtain information on sources of resistance to individual and multiple diseases from new genetic resources. 2) Monitor the relative importance of these diseases through periodic disease surveys in the region.

5.6.1. *Screening for Disease Resistance*

Germplasm accessions of *Vicia* and *Lathyrus species* were evaluated for resistance to Ascochyta blight, downy mildew and Botrytis stem blight under artificial inoculation conditions in the field. Prolonged rains and cool temperatures greatly favoured foliar disease development and thus there was high infection on the susceptible checks in the trials.

Table 5.22 shows the reaction of four *Vicia species* to the diseases that usually occur on these crops, evaluated under artificial infection conditions with infected debris and spore suspension sprays. None of the *V. villosa* lines showed high levels of resistance to Botrytis grey mold. All were moderately resistant. None of the *V. sativa* lines showed high resistance to Ascochyta blight. About half of the entries (17) were moderately resistant. Most of the *V. ervilia* entries showed good levels of resistance to Ascochyta *blight* and *Botrytis grey mold*. Within the *V. narbonensis* entries, most showed intermediate levels of resistance to Ascochyta blight and to Botrytis grey mold. They were largely susceptible to downy mildew.

Under natural field infection conditions 5 *Vicia species* and 3 *Lathyrus species* were evaluated for their reactions to downy mildew. Table 5.23 shows the summary of the reactions. Within the *Vicia narhonensis* nursery, 25 lines were highly resistant to the disease even though the majority of the entries were susceptible. Most of the *V. narbonensis* entries in the AYT and microplot were susceptible to downy mildew.

About 50% of the entries in the *V. sativus* nursery were highly resistant to downy mildew, while entries in the AYTs also showed good levels of resistance. All the *V. palaestina*, *V. panonica* and *V. villosa* entries were highly resistant with no infection detected in any of the lines.

Most of the lines in the *Lathyrus sativus* nursery showed intermediate levels of resistance while those in the AYT and microplot were mostly susceptible. All the *L. ochrus* entries were highly resistant while *L. cicera* entries *in* the AYT *and microplot were resistant*.

Based on the field observations from natural infection, good levels of resistance to downy mildew exist in the *Vicia* species evaluated but highly resistant sources are still unavailable in the *Lathyrus* species. From the artificial inoculations with *Ascochyta* and *Botrytis* blights, low levels of resistance to Ascochyta blight exist but highly resistant sources are also not available. *V. ervilia* has good sources of *resistance to Botrytis grey* mold. Thus resistance to downy mildew in the *Vicia* species and Ascochyta blight in the *Lathyrus* species will continue

Table 5.22. Disease reaction (1-5 scale) of promising *Vicia* and Lathyrus species lines under field artificial conditions, Tel Hadya, 1996/97.

Legume spp. and disease		No. of lines in each disease category					Total
		1	2	3	4	5	
Vicia narbonensis							
Ascochyta blight		0	8	34	21	0	63
Downy mildew	Nursery	0	2	23	17	104	25
Downy mildew	AYT	1	0	21	10	31	63
Botrytis		0	5	33	24	1	63
V. ervilia							
Ascochyta blight		0	15	10	0	0	25
Botrytis		4	13	8	0	0	25
V. sativa							
Ascochyta blight		0	0	17	8	0	25
V. villosa							
Botrytis		0	0	25	0	0	25

to receive high priority in the forage legume improvement project.

(C. Akem, A.M. Abd El-Moneim, M. Bellar)

5.7. Forage Legumes Entomology

A preliminary assessment of the infestation by aphids was carried out on the advanced yield trials of 9 forage species, 25 entries each and 4 reps. The level of infestation was estimated by counting the number of aphids on a white board (25 x 50 cm). The predominant aphid species was the pea aphid, *Acyrthosiphon pisum* Harris.

The results showed that *Vicia ervilia* and *V. narbonensis* had the highest number of entries with low

Table 5.23. Disease reactions to downy mildew in selected *Vicia* and *Lathyrus* species under natural field infection conditions, Tel Hadya, 1996/97.

Legume species	Trial	No. of lines in each disease category					Total
		1	2	3	4	5	
Vicia	Nursery	1	24	26	5	40	144
Narbonensis	AYT	1	2	19	2	3	49
V. sativa	AYT 1	1	11	9	4	0	25
	AYT 2	16	3	3	3	0	25
	Nursery	55	54	2	9	5	147
V. palaestina	AYT	25	0	0	0	0	25
V. villosa	AYT	25	0	0	0	0	25
V. panonica	Microplot	25	0	0	0	0	25
Lathyrus sativus	AYT	0	2	1	6	0	25
	Microplot	0	0	1	6	0	25
	Nursery	4	16	4	0	0	63
L. cicera	AYT	0	14	11	0	0	25
	Microplot	1	15	19	0	0	35
L. ochrus	AYT	16	0	0	0	0	16
	Microplot	21	0	0	0	0	21
Total		191	141	190	105	48	675

Level of aphid infestation, respectively 19 and 25 entries. Three entries of *Vicia ervilia* (2511, 2514, and 1515) were free of aphids. Nine entries of *Vicia Villosa* ssp. *dasycarpa* also had a low level of aphid infestation. Two entries of each of *Vicia sativa* and *Vicia palaestina* and only one entry of each of *Lathyrus sativus* and *Lathyrus cicera* showed low aphid infestation. Where as all the entries of *Lathyrus ochrus*, showed a high infestation level by aphids (Table 5.24). The promising lines from this preliminary evaluation should be re-screened in hot spots or under artificial infestation to confirm these results.

(M. El Bouhssini, A.M. Abd El-Moneim)

5.8. Use of Forage Legumes by NARS

The Mashreq countries Iraq, Lebanon, Jordan and Syria have an extensive work on farmers' fields to demonstrate the potential of forage legumes, as the best alternative in rotation with barley or durum wheat in the fallow-cereal rotation or continuous barley rotation.

Improving feed production could be achieved through the promotion of rotations that include alternative feed legumes. The use of alternative feed legumes such as *Vicia* spp. and *Lathyrus* spp. in rotation with barley, and their alternative utilization (hay making, grazing, grain and straw) is quite promising. Results from Iraq, Jordan and *Syria showed an average daily life-weight gains of* lambs grazing *Vicia sativa* # 715 ranging from 90 to 275 grams. Results from Iraq showed an average increase in milk production from ewes grazing common vetch of 175 gm/ewe/day. In Lebanon after testing common vetch, dwarf chickling and bitter vetch in farmer's fields for three years, three cultivars were released: *Vicia sativa* # 715 named Baraka, *Vicia ervilia* # 3030 named Amara, and *Lathyrus cicera* # 492, named Jaboula. The first is for Saaydeh area, the second for Ain Esaoudah and the latter for the dry area of Kasr.

In Libya, at Zahra station, *Vicia villosa* spp. *dasycarpa, Vicia sativa, Lathyrus cicera,* and *L. sativus* were evaluated. The results revealed that IFLVS# 2484, 2073, 2742 and 2627 were the best producing 13.0 t/ha herbage yield and 1.7 t/ha grain yield. *Lathyrus cicera* # 88, 500, 572, 487 were the best producing around 8.0 t/ha herbage and 2.0 t/ha grain. Bitter vetch (*Vicia ervilia*) was not suitable to the local conditions. Table 5.25 shows the culivars released by national programs in collaboration with ICARDA.

(NARS Collaborators)

Table 5.24. Promising lines of forage species for aphid resistance selected at Tel Hadya.

Species		Selected entries
Vicia ervilia	IFLVE#	2508, 2509, 2511 to 2520, 2644 to 2547, 2649, 2650, 2652
Vicia narbonensis	IFLVN#	2376, 2381, 2382, 2384 to 2387, 2389, 2391, 2398, 2465, 2470, 2478, 2598, 2601
Vicia villosa subsp. dasycarpa	IFLVD#	2432, 2436, 2437, 2439, 2440, 2441, 2446, 2450, 2456
Vicia sativa	IFLVS#	2483, 2497, 2502. 2506, 2617, 2639, 2643
Vicia palaestina	IVLVP#	2535, 2692
Lathyrus sativus	IFLVS#	567
Lathyrus cicera	IFLLC#	88

Table 5.25. Forage legumes varieties released by national programs (NARS) in collaboration with ICARDA.

Crop	Variety	Country	Year of release	Specific features
Vicia sativa	IFLVS-1812	Morocco	1990	Erect, tolerant to broomrape, high yield
V. villosa subsp. *dasycarpa*	IVLVD-2083	Morocco	1992	High yield, resistant to broomrape
V. narbonensis	IFLVN-2387	Morocco	1994	High yield, early maturing
V. narbonensis	IFLVN-2391	Morocco	1994	High yield, early maturing
V. sativa	IFLVS-709	Morocco	1994	High yield, non-shattering
V. sativa	IFLVS-715	Jordan	1994	High yield, broomrape resistant
Lathyrus ochrus	IFLLO-101	Jordan	1994	High yield, broomrape resistant
V. villosa subsp. *dasycarpa*	IFLVD-683 (Kuhak)	Pakistan	1997	Cold tolerant, high yield
V. sativa	IFLVS-715 (Baraka)	Lebanon	1997	Cold tolerant, high yield, non-shattering
V. ervillia	IFLVE-2520 (Amara)	Lebanon	1997	Cold tolerant, high yield
L. cicera	IFLLC-492	Lebanon	1997	Drought tolerant, high yield

5.9. International Testing Program

The international testing program on feed legumes is a vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and 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.

The testing program helps in identification of genotypes with specific and wide adaptation. The performance data permits assessment of genotype x environment interaction and help in targeting breeding efforts for specific agro-ecological conditions.

We supplied 235 sets of 7 different types of trials and nurseries to various cooperating scientists in 31 countries for conduct during the 1997/98 season (Table 5.26).

Table 5.26. Distribution of Forage Legume International Nurseries to cooperators for the 1997/98 season.

International Trial/Nursery	No.of Sets
Lathyrus Adaptation Trial (ILAT)	
- *Lathyrus sativus* (ILAT-LS-98)	37
- *Lathyrus cicera* (ILAT-LC-98)	26
- *Lathyrus ochrus* (ILAT-LO-98)	24
Vetch Adaptation Trial (IVAT)	
- *Vicia sativa* (IVAT-VS-98)	45
- *Vicia narbonensis* (IVAT-VN-98)	38
- *Vicia ervilia* (IVAT-VE-98)	30
- *Vicia villosa* ssp *dasycarpa* (IVAT-VD-98)	35
Total	**235**

Several cooperators requested large quantities of seed of elite lines identified by them from the earlier *international nurseries for multi-location yield testing* and on-farm verification. The available seeds were supplied to the cooperators during the season.

The salient features of the 1995/96 international nursery results, received from cooperators are presented here. The ANOVA for stability parameters for seed yield were done using Eberhart and Russell (1966) model and are presented in Table 5.27.

During 1995/96, Three International Lathyrus Adaptation Trials (ILAT) and four International Vetch Adaptation Trials (*IVAT) were supplied to cooperators* during 1995/96. In each of these trials there were 15 test entries and one local check. The results of these trials are discussed separately as below:

In ILAT-LS, the results were reported from 19 locations from 9 countries. The mean seed yield and biological yield for selections across locations varied between 1077 and 1458 kg/ha, and 3420 and 4283 kg/ha, respectively. The stability analysis for seed yield revealed that only non-linear components of GxE interaction was important. The selections namely, Sel #530, Sel #504 and Sel #505 with non-significant deviations from regression were relatively adaptable across environments.

ILAT-LC was reported from 9 locations from 3 countries. At seven locations, some of the test entries exceeded the local check by a significant margin. The mean seed yield of entries across locations ranged between 849 and 1145 kg/ha. Six selections namely, Sel #497, #486, #491, #487, #500, and #490 gave higher seed yield than the overall mean (968 kg/ha). Four selections, namely Sel #486, #487, #500 and #490 showed general adaptation across environments, and one selection (Sel #491) with above average mean seed yield and regression greater than one showed specific adaptation to the high yielding environments. The mean biological yield of selections across locations varied between 2620 and 3086 kg/ha.

The results for ILAT-LO were reported from 7 locations from 4 countries. The mean seed yield of selections across locations ranged between 1433 and 1878 kg/ha. The five heaviest yielding entries across locations included Sel #547, #537, #550, #538, and #541 with seed yield of 1878, 1780, 1773, 1770 and 1738 kg/ha, respectively. The mean biological yield of selections across locations ranged between 3370 and 4240 kg/ha. The ANOVA for stability for seed yield revealed that the non-linear portion of variation was non-significant. The stability analysis of seed yield of the entries revealed that six selections namely, Sel #537, Sel #550, #538, Sel #541, Sel #542, and Sel #549 with above average seed yield (1692 kg/ha) and regression coefficient equal to one, were adaptable across environments. However, one selection, Sel #574 with regression co-efficient greater than one and above average seed yield showed adaptation to the high yielding environments.

The results of IVAT-VS, IVAT-VN, IVAT-VE, and IVAT-VD were reported from 15, 9, 9 and 6 locations, respectively. In IVAT-VS, the mean seed yield for entries across locations varied between 631 and 1143 kg/ha. The ANOVA for stability parameters indicated the significance of Entry X Location (Linear) and Pooled deviation components of GxE interaction. Ten selections namely, Sel #2558, #2504, #2497, #2639, #2560, #2559, #2637, #2556, #2638, and #2483 exceeded the overall mean yield (908 kg/ha). But only three selections namely, Sel #2497, #2559, and 2638, with non-significant deviation from regression and regression coefficient approaching to 1, were adaptable and predictable across environments. The mean biological yield across locations ranged between 1809 and 2739 kg/ha.

In IVAT-VN, the mean seed yield of selections across environments varied between 1422 and 2113 kg/ha with average seed yield of 1741 kg/ha. The mean over locations for biological yield ranged between 4106 and 4724 kg/ha. The stability analysis for seed yield revealed that both linear and non-linear components of GxE interaction were non-significant. Nine selections, Sel #2390, #2383, #2393, #2388, #2392, #2380, #2465, #2391 and #2467, with above average seed yield were relatively more adaptable across environments.

Table 5.27. ANOVA for stability parameters for seed yield for the entries in different international adaptation trials conducted during 1995/96.

Source of Variation	IVAT-VS		IVAT-VN		IVAT-VD		IVAT-VD	
	df	MS	df	MS	df	MS	df	MS
Entry	14	285**	14	308	14	46	14	8
Entry x Location (Linear)	14	201*	14	143	14	279**	14	5
Pooled deviation	210	106**	105	163	105	38*	60	12**
Pooled error	448	37	252	175	252	29	168	6

Table 5.27 Cont'd...

Source of Variation	ILAT-LS		ILAT-LC		IVAT-LO	
	df	MS	df	MS	df	MS
Entry	14	142**	14	33	14	69**
Entry x Location (Linear)	14	39	14	45*	14	61**
Pooled deviation	135	39**	90	25	75	29
Pooled error	308	19	224	22	196	25

* Significant at $P \leq 0.05$, ** Significant at $P \leq 0.01$.
MS = Mean Square ($x10^{3}$)

In IVAT-VE, the mean seed yield of selections varied between 963 and 1197 kg/ha. The ANOVA for stability revealed that both linear and non-linear portion of GE interaction were significant. Eight selections exceeded the overall mean seed yield (1078 kg/ha). Among these, three namely, Sel #2511, #2509, and #2508 were adaptable and predictable across wide range of environments. The mean biological yield over locations for selections ranged between 2113 and 4132 kg/ha.

In IVAT-VD, the mean seed yield of selections across locations varied between 631 and 745 kg/ha. The ANOVA for stability of performance revealed that only non-linear portion of GxE interaction was significant. Three selections namely, Sel #2455, #2441, and #2446 exceeded the overall mean in seed yield (680 kg/ha) and were adaptable across environments. The entry means for biological yield over locations varied between 2323 and 2837 kg/ha.

(R.S. Malhotra, A.M. Abd El-Moneim, NARS)

6. DRY PEA IMPROVEMENT

Although peas have been cultivated in the ICARDA region for millennia, yields are low because of a lack of high yielding and stable genotypes, and poor crop management. To rectify this problem an integrated approach to pea improvement was initiated at ICARDA in 1986/87 following the receipt of grant from the Ministry for Economic Cooperation, Germany (BMZ). Since research has been extensive on improvement of dry pea at a number of institutions in the developed and some developing countries, it was envisaged that ICARDA would capitalize on existing research and identify dry pea varieties adapted to the farming systems of WANA. The work on pea improvement is therefore concentrated in the following area:

I. Assembling enhanced germplasm/cultivars from institutes working on dry pea in developed and developing countries and testing them at ICARDA sites to identify superior lines for evaluation by the national programs in WANA.

II. Developing suitable production technology and its transfer to the national programs for testing and adaptation.

6.1. Germplasm Collection and Evaluation

Seventy eight germplasm and improved cultivars assembled from Australia (56 lines), Romania (13 lines), U.K. (1 line),USA (2 lines), Russia (1 line), New Zealand (1 line), Sweden (2 lines), and India (2 lines) were evaluated in Pea Genetic Evaluation Trial (PGEVT) at Tel Hadya. The data were recorded on various phenological and morphological characters.

Days to flower ranged from 102 to 124 days; days to maturity ranged from 137 to 161 days; plant height ranged from 36 to 77 cm; and the harvest index ranged from 2.6 to 38%; seed yield ranged from 13 to 1792 kg/ha, and biological yield ranged from 1705 to 4752 kg/ha. The twenty-five high seed yielding entries along with the checks are given in Table 6.1.

6.1.1. Evaluation for Cold Tolerance

In cold tolerance nursery 84 accessions were evaluated for confirmation and 310 new dry pea accessions were evaluated for the first time during 1996/97 season. Visual cold tolerance ratings on 1-9 scale (where 1 = free from damage, 9 = killed) were assigned after the susceptible check was killed. The frequency distribution of the lines for cold tolerance reaction is given in Table 6.2. From the reconfirmation experiment 6 and 31 entries exhibited rating of 3 and 4, respectively (Table 6.3). From the new dry pea accessions 45, 57 and 4 lines exhibited cold tolerance reaction with ratings of 3, 4 and 5, respectively and will be grown for their confirmation next season.

6.2. Yield Trials

6.2.1. Preliminary Yield Trial (PYT)

One hundred and forty one test entries selected from the genetic evaluation and preliminary yield trials of the previous season along with three checks were evaluated for yield performance in a 12 x 12 lattice design during 1996/97 at Tel Hadya and Terbol. Adjusted seed yield for the entries varied from 159 to 4386 kg/ha at Tel Hadya and 0 to 2248 kg/ha at Terbol. Because of late frost a large number of entries were affected at Terbol and seed yields were reduced. The location means at Tel Hadya and Terbol were 1544 and 434 kg/ha, respectively. One test entry (Acc. 642) at Tel Hadya and 19 test entries at Terbol exceeded the improved check cultivar Acc No. 225 by a significant margin. The top 20 entries at each of the locations are given in Table 6.4.

Table 6.1. Adjusted seed yield (SYLD=kg /ha) and rank (R), biological yield (BYLD=kg /ha), days to flowering (DFLR), days to maturity (DMAT), Plant height (PTHT) and harvest index (HI) of some of the high yielding entries in Pea Genetic Evaluation Trial (PGEVT) at Tel Hadya during 1996/97.

Acc. No.	Name	Origin	DFLR	DMAT	PTHT	SYLD	R	BYLD	HI
962	89P134-1-2	Australia	102	138	77	1792	1	4757	37.8
922	88P048-6-18	Australia	104	139	66	1545	2	4181	37.1
931	88P084-5-15	Australia	103	140	66	1459	3	4175	34.4
925	88P077-3-5	Australia	103	138	64	1408	4	3818	36.9
918	88P009-4-41	Australia	103	139	61	1374	5	3850	36.1
951	89P126-4-13	Australia	102	138	59	1363	6	3927	33.4
962	89P134-1-2	Australia	102	138	61	1342	7	3668	36.1
173	MG102703	India	110	143	72	1340	8	3784	37.0
927	88P077-3-10	Australia	107	139	66	1336	9	4014	32.1
969	89P150-15-19	Australia	105	140	64	1318	10	3769	34.4
955	89P132-5-18	Australia	102	139	63	1285	11	3293	37.8
971	89P153-9-1	Australia	105	139	68	1285	12	3615	35.1
966	89P150-15-8	Australia	105	139	65	1282	13	4010	31.6
968	89P150-15-18	Australia	107	140	66	1270	14	3734	33.5
941	88P089-3-37	Australia	106	138	66	1267	15	3181	38.0
956	89P133-4-2	Australia	102	139	56	1220	16	3474	35.7
921	88P048-6-10	Australia	103	139	59	1213	17	3872	31.2
928	88P084-4-1	Australia	106	141	61	1212	18	4136	29.8
957	89P133-4-3	Australia	103	139	66	1196	19	3571	31.6
953	89P132-5-2	Australia	103	139	70	1186	20	3626	30.7
932	88P084-5-22	Australia	109	140	65	1134	21	4002	27.6
403	Acc#1670	New Zealand	109	140	38	1130	22	3114	36.2
939	88P089-3-8	Australia	102	139	55	1112	23	3363	31.8
963	89P138-10-15	Australia	105	138	65	1104	24	3577	29.8
923	88P077-2-8	Australia	107	140	65	1100	25	3757	29.0
223	Syrian Local Damascus	Check1	117	148	53	523	73	3102	12.8
224	The Lincoln	Check2	104	140	45	821	55	2856	29.0
225	Syrian Local Aleppo-2	Check3	117	148	60	1088	27	3545	25.3
Grand Mean			107	141	57	924	-	3159	27.9
S.E. of Mean			4.2	3.5	6.7	313	-	618	7.1
LSD at P=0.05			11.7	9.7	18.8	884	-	1745	20.0
C.V. %			5.5	3.5	16.6	47.9	-	27.7	35.9

Table 6.2. Frequency distribution of 394 pea lines evaluated for cold tolerance at Tel Hadya during 1996/97.

	Cold tolerance rating (1-9 scale)									
Experiment	1	2	3	4	5	6	7	8	9	Total
Confirmation	0	0	6	31	6	5	27	12	2	84
New Lines	0	0	45	57	4	5	5	9	185	310
Total	0	0	51	88	10	10	10	12	213	394

Table 6.3. Pea accessions with tolerance to cold at Tel Hadya, 1996/97.

Rating 3	Acc No.	-190, -200, -210, -342, -344, -347
Rating 4	Acc No.	- 17, - 77, - 80, - 85, -111, -158, -184, -186, -195, -197, -199, -201, -202, -203, -205, -206, -207, -211, -212, -214, -243, -244, -337, -338, -339, -340, -343, -346, -352, -353, -354

6.2.2. Pea International Adaptation Trial (PIAT)

Twenty-three test entries along with two checks were tested in PIAT-97 at Tel Hadya and Terbol during 1996/97. All the test entries at Tel Hadya and 5 test entries at Terbol yielded significantly better than the local check. The late frost during the growing season at Terbol caused damage to pea crop and heavy losses in seed yield. The mean seed yields at Tel Hadya and Terbol were 1812 and 206 kg/ha, respectively (Table 6.5). The five highest yielding entries at Tel Hadya included Acc Nos. -554 (89P109-13), 602 (88P022-3-15), -552 (88P109-11), -501 (P397-4), and -8 (Syrian Local Aleppo-1); and at Terbol included Acc. Nos. -21 (Local Selection 1690), -225 (Syrian Local Aleppo-2), -8 (Syrian Local Aleppo-1), -501 (P397-4), and -553 (89P109-12)

(R.S. Malhotra)

6.3. International Testing Program

The international testing program on dry pea is a vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs in and outside the WANA region. The genetic materials comprise elite lines with wide or specific adaptation, and special morphological or quality traits. Nurseries are only sent on request and the pea germplasm has been assembled from other centers and then tested for adaptation at ICARDA. A total of 79 sets of the Pea International Adaptation Trials (PIAT) were dispatched for the 1997/98 season.

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 results of Pea International Adaptation Trial-1996 (PIAT-96) were reported from 18 locations. At 10 locations, some of the test entries exceeded the local check in seed yield by a significant ($P \leq 0.05$) margin. The mean seed yield across environments varied from 771 kg/ha at Maragheh (Iran) to 4867 kg/ha at Valladolid (Spain). The ANOVA for stability for seed yield revealed that both linear and non-linear components of GE interaction were significant and important. Two entries namely, Ethiopian Local Cultivar (Acc. 504) and 88PX0034 (Acc. 545)with above average seed yield and non-significant deviations from regression, were adaptable across environments. Another two entries namely 89P111-1 (Acc. 557) and 89P109-12 (Acc. 553) with above average seed yield, non-significant deviations from regression, and regression coefficient exceeding unity exhibited their adaptability to high yielding environments. A large number of lines with high seed yield were predictable in response.

(R.S. Malhotra, NARS)

Table 6.4. Adjusted seed yield (SYLD=kg /ha) and rank (R), days to flower (DFLR) and days to maturity (DMAT) of some of the high yielding entries in Preliminary Yield Trial at Tel Hadya, and Terbol during 1996/97.

Tel Hadya					Terbol				
Acc. No.	SYLD	R	DFLR	DMAT	Acc.No.	SYLD	R	DFLR	DMAT
642	4386	1	117	157	740	2248	1	182	217
647	2255	2	118	156	867	1938	2	177	216
661	2185	3	119	158	815	1911	3	153	191
711	2143	4	118	157	881	1870	4	174	208
741	2110	5	118	156	745	1839	5	182	219
668	2094	6	117	156	814	1821	6	184	217
850	2052	7	123	165	742	1648	7	202	238
631	2043	8	117	158	822	1620	8	198	234
709	2012	9	119	156	733	1611	9	184	215
770	2010	10	119	156	792	1593	10	194	230
698	2007	11	120	156	797	1502	11	167	204
765	1967	12	118	157	823	1483	12	172	208
664	1965	13	117	156	813	1468	13	198	233
775	1956	14	118	155	861	1418	14	186	221
680	1954	15	126	159	744	1394	15	184	216
683	1944	16	124	160	848	1384	16	185	225
708	1937	17	120	156	864	1338	17	164	202
667	1916	18	118	156	741	1332	18	179	212
707	1905	19	119	157	819	1244	19	189	219
884	1903	20	124	158	844	1107	20	171	211
223 (Check1)	779	138	131	169	223	0	137	-	-
224 (Check2)	1026	125	118	158	224	254	65	162	201
225 (Check3)	1867	29	126	158	225	676	37	179	211
Grand Mean	1544		124	160		434		180	216
S.E. of Mean	317					158			
LSD (P=0.05)	877					437			
C.V. %	29					51			

Table 6.5. Mean seed yield (SYLD=kg /ha) and rank (R), days to flower (DFLR), and days to maturity (DMAT) of entries at Tel Hadya and Terbol in PIAT-97.

Acc. No.	Name	Tel Hadya				Terbol			
		SYLD	R	DFLR	DMAT	SYLD	R	DFLR	DMAT
8	S.L. Aleppo-1	2052	5	126	156	262	2	177	211
21	L.S. 1690	2041	6	126	156	260	3	176	211
225	S.L. Aleppo-2	1815	17	124	157	267	1	179	211
501	P 397-4	2075	4	119	156	128	5	174	208
549	WA 933	1459	22	121	159	0	22	-	-
552	89P109-11	2114	3	121	156	107	9	174	210
553	89P109-12	2008	7	119	157	163	4	173	209
554	89P109-13	2186	1	119	156	83	11	172	212
557	89P111-1	1905	13	121	156	82	12	175	210
569	89P166-12	1995	8	121	157	110	8	174	211
602	88P022-3-15	2162	2	119	155	0	20	-	-
611	88P038-10-18	1986	9	122	158	12	18	179	210
613	88P050-6-9	1833	16	125	155	53	14	173	209
616	88P090-5-21	1883	14	123	156	112	6	172	209
618	88P090-5-26	1806	18	121	155	68	13	172	208
621	88P106-2-5	1857	15	122	157	5	19	173	212
623	88Px00-11-3	1439	23	118	157	0	21	-	-
627	88P035-4-4	1629	21	126	159	33	17	181	212
634	88P022-6-22	1353	24	126	161	97	10	175	211
637	Spring Pea 2	1906	12	126	158	0	23	-	-
652	DMR-4	1709	20	119	157	47	15	176	214
653	DMR-7	1972	10	121	158	110	7	174	211
655	DMR-20	1789	19	124	157	47	16	178	211
658	DMR-26	1925	11	125	157	0	24	-	-
	Local Check	404	25	133	168	0	25	-	-
	Grand Mean	1812		123	157	82		175	211
	S.E. of Mean	97.8				37.5			
	LSD (P=0.05)	280				107			
	C.V. %	8.4				79.5			

- Local check at Tel Hadya is Acc No. 223 and at Terbol is Acc No. 453.

7. VIROLOGY

Work on legume viruses during the 1996/97 growing season included (i) survey for legume viruses in Ethiopia, Pakistan and South Syria, (ii) evaluation of lentil genotypes for resistance to faba bean necrotic yellows virus (FBNYV), bean leaf roll luteovirus (BLRV) and soybean dwarf luteovirus (SbDV), and (iii) evaluation of faba bean genotypes for resistance to FBNYV. Activities also included regular testing for seed-borne viruses in seeds dispatched for international nurseries and testing gene bank accessions to free them from seed-borne infections. The virology lab continued to provide ELISA kits for virus testing to a number of NARSs laboratories of WANA upon request.

7.1. Survey for Lentil and Chickpea Viruses in Pakistan

An intensive survey of lentil and chickpea fields and research stations in the Punjab province in Pakistan was conducted during March 1-10, 1997. A total of 3413 lentil samples (1118 samples with symptoms suggestive of virus infection and 2295 samples were collected randomly) and 3092 chickpea samples (1096 samples with symptoms suggestive of virus infection and 1996 samples were collected randomly) were collected from the 43 lentil fields (39 farmers fields, 4 Research Station fields) and 42 chickpea fields (37 farmers fields, 5 Research Station fields). All samples were tested for the presence of 14 different viruses by Tissue-blot immunoassay (TBIA) procedure at the Plant Genetic Resources Institute (PGRI) of National Agricultural Research Center (NARC) at Islamabad. The following antisera were used in the test: two monoclonal antibodies for FBNYV and 5G4 (a broad spectrum monoclonal which reacts with all legume

Luteoviruses), and twelve polyclonal antibodies for alfalfa mosaic alfamovirus (AMV), bean yellow mosaic potyvirus (BYMV), broad bean mottle comovirus (BBMV), broad bean stain comovirus (BBSV), broad bean true mosaic comovirus (BBTMV), broad bean wilt fabavirus (BBWV), broad bean yellow band tobravirus (BBYBV), chickpea chlorotic dwarf geminivirus (CCDV), cucumber mosaic cucumovirus (CMV), pea early browning tobravirus (PEBV), pea enation mosaic enamovirus (PEMV) and pea seed-borne mosaic potyvirus (PSbMV).

Figure 7.1 compares numbers of chickpea fields surveyed falling into 5 different virus incidence categories based on (i) % plant observed with virus-like symptoms and (ii) laboratory testing of randomly collected samples. Fig. 7.2 does the same thing for lentil fields. It is interesting to note that for chickpea fields virus disease incidence assessment based on visual symptoms closely resembled the results obtained from lab testing of randomly collected samples. In contrast, in lentil fields (Fig. 7.2), visual observations grossly underestimated virus incidence in the field. For example, only 2 lentil fields were put in the higher than 21% incidence category based on visual observations whereas lab testing of randomly collected samples revealed that eleven fields were actually in this category.

Detailed results obtained from Laboratory tests are presented in Table 7.1. Lentil crop was found infected with FBNYV, luteoviruses, CCDV, PSbMV and CMV, whereas chickpea was found infected with FBNYV, luteoviruses, CCDV, PSbMV, CMV and AMV. Around 50% of samples containing luteoviruses were retested to determine which luteovirus was present. When 48 field isolates (15 lentil and 33 chickpea samples) which reacted positively with the broad-spectrum luteovirus monoclonal antibody 5G4, were retested against another four

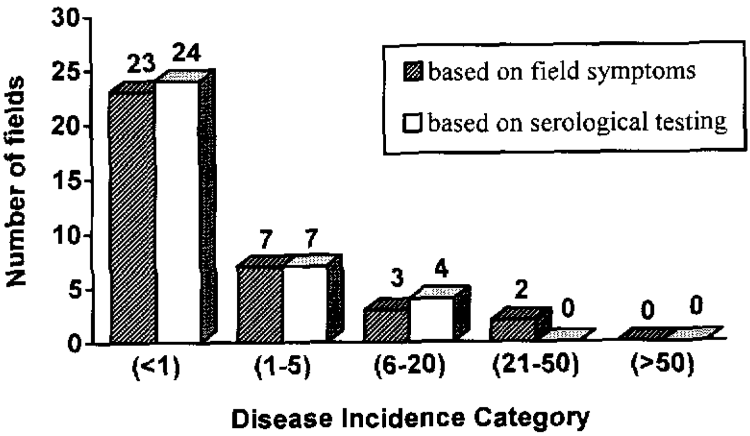

Fig. 7.1. Chickpea fields surveyed in Pakistan during March 1-10, 1997 - distribution of virus infection on the basis of virus disease symptoms observed in the fields and serological testing of randomly collected samples.

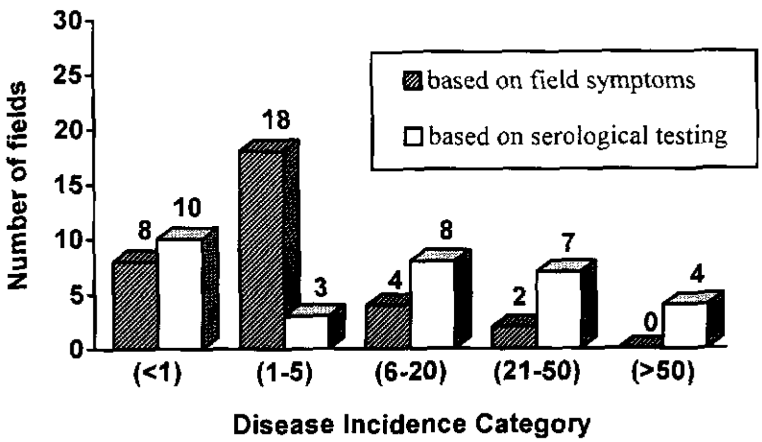

Fig. 7.2. Lentil fields surveyed in Pakistan during March 1-10, 1997- distribution of virus infection on the basis of virus disease symptoms observed in the fields and serological testing of randomly collected samples.

Table 7.1. Results of Laboratory tests conducted on 3413 lentil and 3092 chickpea samples collected from Pakistan during March 1-10, 1997. Identification was based on serological reactions (TBIA).

Crop Type of sample collected	No. of samples tested	No. of samples found positive for *					
		FBNYV	Luteo-virus	CCDV	PSbMV	CMV	AMV
Lentil							
Symptomatic	1118	14	27	23	344	170	0
Random	2295	1	15	6	393	22	0
Chickpea							
Symptomatic	1096	9	40	173	20	1	1
Random	1996	0	11	18	2	0	0

* All samples tested did not give a reaction against BBSV, BBMV, BYMV, BBWV, PEMV, PEBV, BBYBV, and BBTMV

more specific monoclonal antibodies [4B10 (BLRV), ATCC 650 (SbDV), ATCC 647 (BWYV) and 6F9 (BLRV or SbDV)] and polyclonal antibodies for Chickpea luteovirus (CpLV) isolated from chickpea in India and cucurbit aphid-borne yellows luteovirus (CABYV) isolated from cucurbit in France, eight different reaction patterns were obtained (Table 7.2). Such results suggested the existence of at least two luteoviruses BWYV and CpLV. Having some samples giving positive reaction with 6F9, CpLV or CABYV and no reaction with the specific monoclonals for BLRV, SbDV and BWYV *opens the possibility of having other luteoviruses* affecting lentil and chickpea in Pakistan which require further studies.

This is the first report for FBNYV and BWYV affecting both lentil and chickpea in Pakistan. It is also the first report from Pakistan of PSbMV and AMV infecting chickpea, and the first report of CCDV and CpLV affecting lentils.

(K.M. Makkouk and S.G. Kumari (ICARDA), M. Bashir (NARC, Pakistan), R. Jones (CLIMA, Australia))

Table 7.2. Differentiation among legume luteovirus isolates collected from Pakistan during March 1-10, 1997 by their reaction with five monoclonal and two polyclonal antibodies.

		Reaction with antibodies						
		Monoclonal antibodies					Polyclonal antibodies	
Crop	No. of samples	5G4 (broad)	4B10 (BLRV)	6F9[a]	ATCC 650 (SbDV)	ATCC 647 (BWYV)	CpLV[b] (from India)	CABYV (from France)
Lentil	2	+	-	-	-	-	-	-
	3	+	-	-	-	-	+	-
	2	+	-	-	-	+	-	-
	7	+	-	+	-	-	+	-
	1	+	-	+	-	-	+	+
Chickpea	6	+	-	-	-	-	-	-
	10	+	-	-	-	-	+	-
	6	+	-	-	-	+	-	-
	5	+	-	+	-	-	+	-
	1	+	-	+	-	-	+	+
	2	+	-	-	-	+	-	+
	2	+	-	-	-	-	+	+
	1	+	-	-	-	+	+	+

a A monoclonal produced against purified bean leaf roll luteovirus (BLRV) which reacts with different isolates of BLRV and soybean dwarf luteovirus *(SbDV) but does not react with* isolates of potato leaf roll luteovirus (PLRV), beet western yellows luteovirus (BWYV), groundnut rosette assistor virus (GRAV), cucurbit aphid-borne yellows virus (CABYV) and barley yellow dwarf luteovirus (BYDV) (MAV, PAV, RMV, RPV).

b Characterized at ICRISAT as a distinct legume luteovirus.

7.2. Survey for Legume Viruses in South Syria

This survey was conducted during the period of 8-9 May, 1997, to study the spectrum of viruses that are causing yellowing/stunting/necrosis and samples were collected accordingly. A total of 155 chickpea, 27 faba bean, 9 *Lathyrus*, 235 lentil and 8 *Vicia* samples were collected from 20 fields (6 chickpea, 3 faba bean, 1 *Lathyrus*, 9 lentil and 1 *Vicia*) in southern Syria from Damascus to Dara'a including Sweida. All samples were tested by the tissue-blot immunoassay (TBIA) using two monoclonal antibodies for faba bean necrotic yellows virus (FBNYV) and 5G4 (a broad spectrum monoclonal which react with all legume luteoviruses). Laboratory tests showed that among 434 samples tested 203 were found infected with a luteovirus (138 chickpea, 4 faba bean, 0 *Lathyrus*, 58 lentil and 6 *Vicia*) and 140 samples were infected with FBNYV (1 chickpea, 22 faba bean, 8 *Lathyrus*, 107 lentil and 2 *Vicia*).

When the 203 field isolates which reacted with the broad-spectrum luteovirus monoclonal antibody were tested by another set of one polyclonal and seven specific monoclonals antibodies by the TBIA test, 14 different types of reaction patterns were obtained (Table 7.3). Such results suggested the existence of 14 different luteovirus strains/viruses which needs further characterization.

(K.M. Makkouk, S.G. Kumari)

7.3. Survey for Faba Bean and Pea in Ethiopia

In Ethiopia a survey was conducted during Sept. 22-30, 1997 to identify viruses affecting faba bean and pea in the Ethiopia highlands. The survey covered the regions around Holetta, Ambo, Debre Zeit, Kulumsa, Asasa, Debre Birhan, Sheno and Selale. Collected samples were processed at Holetta using ELISA kits for the detection of 14 viruses provided by the Virology laboratory of ICARDA. Around 50 randomly selected fields were evaluated and samples were collected from them. From each field around 100 random samples and 15-20 samples with symptoms were collected. General field observations on such aspects as symptoms, virus diseases incidence, vector abundance and crop condition were recorded. Overall, virus incidence was low (1-5%) with few fields with virus incidence of 10-20%.

Table 7.3. Differentiation among legume luteovirus isolates collected from South Syria during May 8-9, 1997 by their reaction with one polyclonal and seven monoclonal antibodies.

Number of samples				Reaction with antibodies *							
				Monoclonal antibodies							Polyclonal antibody
Chick-pea	Faba bean	Lentil	*Vicia*	5G4	4B10	6G4	6F9	3B11	ATCC 650	ATCC 647	CpLV
47	0	2	0	+	-	-	-	-	-	-	+
37	2	4	0	+	-	-	-	-	-	+	+
22	0	43	6	+	+	+	+	+	-	-	-
10	0	0	0	+	-	-	+	-	-	+	+
6	0	4	0	+	-	-	+	+	-	-	-
4	1	5	0	+	-	-	-	-	-	-	-
2	0	0	0	+	-	-	+	-	-	-	+
1	0	0	0	+	+	+	-	-	-	+	-
1	0	0	0	+	-	-	-	+	-	+	+
1	0	0	0	+	-	-	-	+	-	-	-
1	0	0	0	+	-	-	+	-	-	-	-
1	0	0	0	+	-	-	+	+	-	-	+
1	0	0	0	+	+	+	-	+	-	+	+
1	1	0	0	+	+	+	+	+	-	+	+

* 5G4, 4B10, 6G4, 6F9, 3B11 monoclonals produced against purified bean leaf roll luteovirus (BLRV); 5G4 broad spectrum monoclonal which react with all legume luteoviruses, 4B10 and 6G4 react with isolates of bean leaf roll luteoviruses (BLRV); 6F9 and 3B11 react with different isolates of BLRV and soybean dwarf luteovirus (SbDV) but does not react with isolates of potato leaf roll luteovirus (PLRV), beet western yellows luteovirus (BWYV), groundnut rosette assistor virus (GRAV), cucurbit aphid-borne yellows virus (CABYV) and barley yellow dwarf luteovirus (BYDV) (MAV, PAV, RMV, RPV).
ATCC 650 is a monoclonal which reacts only with isolates of SbDV and ATCC 647 reacts only with isolates of BWYV.
Chickpea luteovirus (CpLV) antiserum characterized at ICRISAT as a distinct legume luteovirus.

Detailed laboratory results are not yet available, but the most commonly encountered viruses were faba bean necrotic yellows virus and a luteovirus, most likely, bean leaf roll virus.

(K.M. Makkouk (ICARDA), A. Abrahan (IAR, Ethiopia))

7.4. Screening for Faba Bean Necrotic Yellows Virus (FBNYV), Bean Leaf Roll Luteovirus (BLRV) and Soybean Dwarf Luteovirus (SbDV) Resistance in Lentil

Eighty lentil genotypes (35 genotypes among them were selected from the previous season as best performing lentil genotypes proved to be good yielders and highly tolerant to virus infection) were evaluated for their resistance to local isolates of FBNYV (SV66-95), BLRV (SV64-95) and SbDV (SL1-94) using artificial inoculation by aphids. Genotypes tested were planted in the field in two replicates, each represented by two one-meter rows, 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 7.4, 7.5 and 7.6. 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 suggested that one genotype was resistant to FBNYV, BLRV and SbDV (ILL 75), four genotypes were resistant to FBNYV and BLRV (ILL 74, 204, 213, 214), thirteen genotypes were resistant to FBNYV only (ILL 291, 292, 5818, 6031, 6198, 6239, 6435, 6816, 6972, 7553, 7671, 7686, 7700) and three genotypes were resistant to BLRV only (ILL 85, 7678, 7683). Moreover, there are few genotypes which were found resistant to viruses for more than one year (Table 7.7).

(K.M. Makkouk, S.G. Kumari)

Table 7.4. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with bean leaf roll luteovirus (BLRV) (SV64-95) evaluated during the 1996/97 growing season.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 85, 204, 213, 214, 324, 6811, 7213, 7618, 7671, 7678, 7683	0-10
ILL 203, 222, 5755, 5845, 6031, 6198, 6199, 6245, 6458, 6810, 6816, 7217, 7508, 7553, 7674, 7677, 7686, 7700	11-25
ILL 71, 86, 212, 291, 590, 2580, 5748, 5818, 6024, 6037, 6193, 6239, 6434, 6465, 6778, 6972, 6976, 6994, 7010, 7127, 7138, 7193, 7502, 7531, 7666, 7667, 7668, 7669, 7670, 7673, 7685	26-50
ILL 292, 323, 1712, 2581, 3614, 4400, 5480, 5597, 5816, 5871, 6435, 6789, 6797, 7168, 7184, 7521, 7676, 7966	51-100
	Symptom severity (0-3)
ILL 74, 75, 85, 204, 213, 214, 7678, 7683	0
ILL 71, 203, 324, 5845, 6031, 6199, 6245, 6811, 7213, 7618, 7671, 7674, 7677, 7686	1
ILL 86, 212, 222, 5748, 5755, 5816, 5818, 5871, 6024, 6037, 6193, 6198, 6239, 6434, 6435, 6458, 6465, 7508, 6797, 6972, 6976, 7138, 7193, 7531, 7553, 7667, 7668, 7669, 7670, 7673, 7676, 7685	2
ILL 291, 292, 323, 590, 1712, 2580, 2581, 3614, 4400, 5480, 5597, 6778, 6789, 6810, 6816, 6994, 7010, 7127, 7168, 7184, 7217, 7502, 7521, 7666, 7700, 7966	3

* Symptoms of infected plants was measured based on BLRV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms)

7.5. Testing for Seed-borne Viruses

7.5.1. Cleaning Germplasm in the Gene Bank from Seed-Borne Infections

269 lentil accessions planted in the field for multiplication were purified from seed-borne infections by

Table 7.5. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with soybean dwarf luteovirus (SbDV) (SL1-94) evaluated during the 1996/97 growing season.

Lentil Genotypes	Yield loss (%)
ILL 75	0-10
ILL 74, 213	11-25
ILL 71, 204, 214, 6458, 6810, 7217	26-50
ILL 85, 86, 203, 212, 222, 291, 292, 323, 324, 590, 1712, 2580, 2581, 3614, 4400, 5480, 5597, 5748, 5755, 5816, 5818, 5845, 5871, 6024, 6031, 6037, 6193, 6198, 6199, 6239, 6245, 6434, 6435, 6465, 6778, 6789, 6797, 6811, 6816, 6972, 6976, 6994, 7010, 7127, 7138, 7168, 7184, 7193, 7213, 7502, 7508, 7521, 7531, 7553, 7618, 7666, 7667, 7668, 7669, 7670, 7671, 7673, 7674, 7676, 7677, 7678, 7683, 7685, 7686, 7700, 7966	51-100
	Symptom severity (*0-3*)
ILL 75, 213	0
ILL 71, 74, 212, 214, 222, 6198, 6458, 6811, 6816, 7217, 7618	1
ILL 85, 86, 204, 291, 292, 590, 1712, 2581, 3614, 6037, 6193, 6434, 6465, 6789, 6797, 6810, 6972, 6976, 6994, 7010, 7138, 7168, 7184, 7213, 7502, 7521, 7670, 7671, 7673, 7674, 7683, 7685	2
ILL 203, 323, 324, 2580, 4400, 5480, 5597, 5748, 5755, 5816, 5818, 5845, 5871, 6024, 6031, 6199, 6239, 6245, 6435, 6778, 7127, 7193, 7508, 7531, 7553, 7666, 7667, 7668, 7669, 7676, 7677, 7678, 7686, 7966, 7700	3

* Symptoms of infected plants was measured based on SbDV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms)

eliminating infected plants during April (late flowering), and only healthy seeds were harvested to store in the Gene Bank.

A total of 1188 accessions of barley dry seeds were tested for the presence of barley stripe mosaic virus and

Table 7.6. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with faba bean necrotic yellows virus (FBNYV) (SV66-95) evaluated during the 1996/97 growing season.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 85, 204, 213, 214, 291, 292, 324, 2581, 5818, 6031, 6198, 6239, 6435, 6458, 6811, 6816, 6972, 7168, 7184, 7553, 7666, 7671, 7673, 7678, 7686, 7700	0-10
ILL 71, 203, 222, 2580, 5597, 5845, 5871, 6037, 6193, 6199, 6465, 7193, 7213, 7502, 7674, 7683, 7966	11-25
ILL 86, 212, 323, 1712, 3614, 4400, 5480, 5755, 5816, 6024, 6245, 6434, 6778, 6789, 6810, 6976, 6994, 7010, 7127, 7138, 7217, 7508, 7521, 7531, 7618, 7667, 7668, 7669, 7670, 7676, 7677, 7685	26-50
ILL 590, 5748, 6797	51-100
	Symptom severity (0-3)
ILL 74, 75, 204, 213, 214, 291, 292, 5818, 6031, 6198, 6239, 6435, 6816, 6972, 7553, 7671, 7686, 7700	0
ILL 71, 85, 86, 203, 212, 222, 323, 324, 2581, 5597, 5845, 5871, 6037, 6193, 6199, 6458, 6465, 6811, 7168, 7184, 7193, 7502, 7666, 7673, 7674, 7678, 7683	1
ILL 2580, 3614, 4400, 5480, 5755, 5816, 6245, 6434, 6778, 6789, 6976, 6994, 7010, 7138, 7213, 7508, 7521, 7531, 7618, 7667, 7668, 7669, 7670, 7676, 7677, 7685, 7966	2
ILL 590, 1712, 5748, 6024, 6797, 6810, 7127, 7217	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).

50 accessions were found to be infected with a seed-borne virus. The virus-free accessions will be stored in the Gene Bank, and accessions with virus-infected seeds will be cleaned later.

Table 7.7. Summary of the reaction of selected lentil genotypes to artificial inoculation with three different viruses tested over a period of three years (1995-1997).

Lentil genotypes	Origin	BLRV 1995/96	BLRV 1996/97	SbDV 1994/95	SbDV 1995/96	SbDV 1996/97	FBNYV 1994/95	FBNYV 1995/96	FBNYV 1996/97
ILL 71	TUR	-	M	S	-	M	R	-	M
ILL 74	CHL	-	R	S	-	M	R	-	R
ILL 75	CHL	-	R	R	-	R	R	-	R
ILL 85	TJK	-	R	S	-	S	R	-	R
ILL 86	ARM	-	M	S	-	S	R	-	M
ILL 203	ETH	-	M	S	-	S	R	-	M
ILL 204	ETH	-	R	M	-	S	R	-	R
ILL 212	AFG	-	M	S	-	S	M	-	M
ILL 213	AFG	-	R	M	-	M	R	-	R
ILL 214	AFG	-	R	M	-	M	M	-	R
ILL 222	PAK	-	M	M	-	S	R	-	M
ILL 291	DZA	-	M	S	-	S	R	-	R
ILL 292	DZA	-	M	S	-	S	M	-	R
ILL 323	YUG	-	S	S	-	S	R	-	M
ILL 324	YUG	-	R	S	-	S	M	-	R
ILL 590	TUR	R	M	-	S	S	-	-	S
ILL 1712	ETH	R	S	-	M	S	-	-	M
ILL 2581	IND	-	S	S	-	S	R	-	R
ILL 3614	IND	M	S	-	M	S	-	-	M
ILL 4400	SYR	-	S	S	-	S	M	-	M
ILL 5480	CSK	R	S	-	S	S	-	-	M
ILL 5816	SYR	-	S	S	-	S	R	-	M
ILL 6193	SYR	-	M	M	-	S	R	-	M
ILL 6198	SYR	-	M	S	-	S	R	-	R
ILL 6245	SYR	-	M	S	-	S	R	-	M
ILL 6435	SYR	-	S	S	-	S	R	-	R
ILL 6458	SYR	-	M	M	-	M	R	-	R
ILL 6797	SYR	R	S	-	S	S	-	-	S
ILL 6810	SYR	M	M	-	S	M	-	-	M
ILL 6994	SYR	-	S	S	-	S	R	-	M
ILL 7010	SYR	R	M	-	M	S	-	-	M
ILL 7217	SYR	-	M	S	-	M	R	-	M
ILL 7618	SYR	R	R	-	S	S	-	-	M
ILL 7700	SYR	R	M	-	S	S	-	-	R
ILL 7966	SYR	R	S	-	S	S	-	-	M

R = Resistant M = Moderately resistant
S = Susceptible - = Not tested

7.5.2. Testing for International Nurseries

During April, the health status of 283 accessions of lentils were evaluated in the field by testing fresh leaf samples (400 plants per accessions) for the presence of seed-borne virus infection, and 118 accessions were found to be virus-free. In addition, seed samples of 430 accessions were tested during July-September 1997 (400 seeds per accession) and 316 accessions were found virus-free.

A total of 68 accessions of faba bean (100 seeds per accession) were tested during September for the presence of BBSV, BYMV or PSbMV and seeds of three accessions only were found to be infected with seed-borne viruses.

A total of 197 accessions of chickpea were tested during September for PSbMV and 189 accessions were found to be virus-free.

A total of 24 pea accessions were tested during September for BBSV, BYMV or PSbMV and 21 accessions were found to be virus-free.

A total of 70 wheat accessions were tested during September for barley stripe mosaic virus, and all seeds were found virus-free.

A summary of the laboratory testing for seed-borne viruses is presented in Table 7.8.

(K.M. Makkouk, N. Attar)

7.6. Screening for Faba Bean Necrotic Yellows Virus (FBNYV) Resistance in Faba Bean

During the 1996/97 growing season, 200 faba bean genotypes were evaluated for their reaction to a local isolate of FBNYV (SV66-95) using artificial inoculation of the virus by aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Fifteen plants from each genotype tested

Table 7.8. Testing for seed-borne viruses of cereal and legume crops in the virology laboratory during 1997 growing season.

Source/ Crop	No. of accessions tested	No. of accessions found healthy	No. of seeds tested per Accession	Period of Testing	Seed-borne viruses checked
International Nurseries					
Lentil	713	434	400*	April, July-Sept.	BBSV, BYMV, PSbMV
Faba bean	68	65	200*	Sept.	BBSV, BYMV, PSbMV
Chickpea	197	189	200*	Sept.	PSbMV
Peas	24	21	200*	Sept.	BBSV, BYMV, PSbMV
Wheat	70	70	200**	Sept.	BSMV
Gene Bank					
Lentil	269	113	1000*	April	BBSV, BYMV, PSbMV
Barley	1188	1138	200**	Oct.-March	BSMV

* Seeds were tested in groups of 25
** Seeds were tested in groups of 50

were planted in the field in one row (2-m long). Results obtained suggested that eleven genotypes were not infected (985/338/95, 1001/591/95, 1002/636/95, 989/303/95, 995/409/95, 999/500/95, 1001/512/95, 1001/522/95, 1001/529/95, 1009/587/95, 1009/602/95). Seventeen genotypes had an infection level of 0.1-10%. Theses lines were: 1001/592/95, 1009/663/95, 987/260/95, 987/270/95, 987/271/95, 989/310/95, 998/454/95, 999/491/95, 1001/514/95, 1001/515/95, 1008/582/95, 1009/587/95, 1009/590/95, 1014/659/95, 1014/660/95, 1016/721/95, 1016/733/95. During the next growing season, the best performing lines will be re-evaluated.

(K.M. Makkouk, S.G. Kumari)

7.7. The Use of Imidacloprid (Gaucho®) as a Seed-dressing Insecticide Treatment for the Control of Three Persistently Transmitted Viruses by Aphids Affecting Faba Bean

The usefulness of seed-dressing with a nitroguanidine group insecticide Imidacloprid (Gaucho®) to reduce spread of the aphid vectored bean leaf roll luteovirus (BLRV), soybean dwarf luteovirus (SbDV) and faba bean necrotic yellows virus (FBNYV) was investigated in field experiments conducted at Tel Hadya, Aleppo, Syria.

Faba bean "Syrian Local Large" (ILB 1814) seeds were treated with Gaucho® at the rate of 0.5, 1, 2 and 4 g/kg of seeds and compared with untreated seeds (control). The experiments were carried out in a randomized complete block design with three replicates for each virus. Each replicate plot consisted of 4 rows (2 m long), 30 cm apart, with 10 cm between plants within row. Two months after sowing all plants were artificially inoculated with the virus by using the aphid vector *Acyrthosiphon pisum*.

Results were recorded visually six weeks after inoculation based on characteristic symptoms and serologically by using the tissue blot immunoassay (TBIA). Assessment of infection level by TBIA was more precise than that done visually and consequently is recommended for future screening.

Results obtained showed that the spread of SbDV, BLRV and FBNYV was decreased from 98, 92 and 28% (untreated plots) to 82, 13 and 1% in plots treated with 4g/kg, respectively. Moreover, the yield loss was decreased from 56, 80 and 37% (untreated plots) to 34, 7 and 0% in plots treated with 4g/kg, for the above three viruses, respectively (Table 7.9).

(K.M. Makkouk, S.G. Kumari)

Table 7.9. Effect of seed dressing insecticide treatment Gaucho® on Soybean dwarf luteovirus (SbDV), bean leaf roll luteovirus (BLRV) and faba bean necrotic yellows virus (FBNYV) incidence in faba bean and on faba bean yield after artificial inoculation with aphids *Acyrthosiphon pisum* two months after sowing under field conditions.

Virus	Treatment Gaucho® (g) /kg faba bean seeds	% of infection based on testing by TBIA	(%) Yield loss
SbDV	0.5	87	45
	1	85	46
	2	85	39
	4	82	34
	untreated	98	56
BLRV	0.5	34	27
	1	32	13
	2	23	14
	4	13	7
	untreated	92	80
FBNYV	0.5	5	4
	1	4	0
	2	2	0
	4	1	0
	untreated	28	37

Standard Error for yield/treatments = 14

7.8. Production of ELISA Kits

During 1997, antisera to broad bean true mosaic comovirus (BBTMV) and pea enation mosaic enamovirus PEMV) were produced. Accordingly, ELISA kits for the following viruses are now available at the Virology Laboratory of the Germplasm Program.

Legume viruses

- Alfalfa mosaic alfamovirus
- Bean yellow mosaic potyvirus
- Bean leaf roll luteovirus
- Beet western yellows luteovirus
- Broad bean mottle bromovirus

- *Broad bean stain comovirus*
- Broad bean wilt fabavirus
- Broad bean true mosaic comovirus
- Broad bean yellow band tobravirus
- Cucumber mosaic cucumovirus
- Pea enation mosaic enamovirus
- Pea early-browning tobravirus
- Pea seed-borne mosaic potyvirus
- Soybean dwarf luteovirus

Cereal viruses

- Barley yellow dwarf luteovirus
- Barley stripe mosaic hordeivirus
- Wheat streak mosaic potyvirus
- Wheat soil-borne virus from Turkey
  (virus not fully characterized yet)

(K.M. Makkouk, S.G. Kumari)

8. TRAINING AND VISITS

Training activities in Germplasm Program aim to assist researchers in NARS to develop their competencies in recognizing the breeding problems of cereals and legumes and applying modern techniques to solve these problems. The trainees are taught to design and manage conventional experiments in the various aspects of breeding, hybridization, note taking, diseases scoring, selection, analyzing and interpretation of experimental data and preparation of short technical reports; the trainees mainly are familiarized with practical application in the field as well as some lectures. Round table discussions take place in specialized short-term group training courses. A method for evaluating progress is developed 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 1997.

8.1. Short Courses

8.1.1. Faba Bean Improvement with Emphasis on Host Plant Resistance

Faba bean is one of the world's most important pulse crops, used as human food and animal feed and as a break crop in cereal rotation systems. Realizing the need of NARSs for strengthening the research skills in this field, a specialized short-term training course was conducted at Tel Hadya and Lattakia during 31 March-10 April, 1997; 9 researcher from Algeria (1), China (3), Egypt (2), Libya (1) and Morocco (1), and Syria (1) attended the course. The objectives were to develop the participants' skills in breeding methodology and genetics of faba bean with emphasis on major fungal viral diseases, nematodes, Orobanche sp and their control. The trainees evaluated the course as useful and very interesting.

8.1.2. Legume Diseases and their Control

This course was requested by NARSs and conducted during 6-16 April, 1997 at ICARDA. A total of 10 trainees attended the course; they came from 7 countries in WANA: Algeria, Egypt, Libya, Syria, Sudan, Tunisia, and Turkey. The training program focused on the major diseases of food and forage legumes (chickpea, lentil, faba bean and forages) with emphasis on the identification of the causal agents, importance, epidemiology and means of integrated control. The practical part of the course covered various aspects of laboratory techniques, screening and rating scales and used on-going field, greenhouse and laboratory experiments for illustrations. The trainees were provided with lecture notes, selected reprints and field manuals for the different diseases of chickpea, lentil and faba bean. It was a successful course as it was rated very good to excellent in the post-course evaluation and most of the trainees expressed their individual satisfaction in the new knowledge they had acquired.

8.1.3. Integrated Management of Cereal and Food Legume Insect Pests

A short-term course offered by ICARDA in Aleppo, Syria (27 April to 8 May, 1997). The course aims to strengthen the region's network of legume and cereal entomology through staff training in entomology research techniques. At the end of the course, the participants were able to assess insect infestation and damage, sample and monitor insects populations, screen for host plant resistance, collect and preserve insects and to apply skills in biological control research. This content was presented through theoretical class-room lectures, field and laboratory practical activities. Twelve researchers representing 11 countries (Egypt, Lebanon, Libya, Iran, Jordan, Morocco, Sudan, Syria, Tunisia, Turkey and Yemen) in WANA region participated in this course. They mentioned that a big improvement in their entomology skills was obtained. The overall mean performance between pretest and final test went from 34% to 76% at the end of the course.

8.1.4. DNA Molecular Marker Techniques for Crop Improvement

The course was again strongly requested by NARSs and other Mediterranean countries. ICARDA and CIHEAM jointly sponsored this two-week (14-25 September, 1997) specialized short training course. 11 participants from 9 countries (Table 8.1) attended lectures on genetics and current research issues in biotechnology, and spend most of their times working in the laboratory (RFLP, PCR) and application of these techniques for germplasm identification, evaluation and improvement. The course was well received by the trainees, most of whom were experienced in breeding or biotechnology. Two professors from Germany participated in lecturing. All the trainees expressed their satisfaction with the new knowledge they acquired.

8.1.5. Legume Harvest Mechanization

A legume harvest mechanization short course was organized at Tel Hadya from 15 to 19 June, 1997 Jointly conducted by the Germplasm Program and the Station Operations with input from the Natural Resource Management Program. The course was attended by five participants from Syria. The purpose of the training was to demonstrate a system of legume production and mechanization that decreases the cost of producing legumes. The program included both lectures and practical related to harvest machinery. Lectures were on problems of mechanization, breeding, agronomy, seed preparation and economy. The participants evaluated the course as highly successful and useful.

8.1.6. Food Legume Improvement

An in-country short training course on "Food Legume Improvement" held at Kermanshah, Iran, from 14 to 26 June, 1997. 16 trainees from various institutes in Iran attended the course with participation of five scientists from ICARDA, one scientist from ICRISAT and two Iranian scientists, who delivered lectures on breeding, genetic resources, wide hybridization, molecular biology, insect pests, diseases, weed management, agronomy, physiology and mechanization. Emphasis was also laid on hybridization techniques in food legumes.

This course was jointly sponsored by ICARDA, Iran and ICRISAT.

8.1.7. Training Workshop on Lentil Improvement

An in-country short training course on "Lentil Improvement" was conducted in Nepal on 7-11 March, 1997 in collaboration with NARC, CLIMA, and Victorian Institute for Dryland Agriculture (VIDA). This course was financed by Australian Center for Agricultural Research (ACIAR). There were a total of 27 participants, including (3) lecturers from Australia, (1) from ICARDA, the other participants comprised all the players in lentil research in Nepal, many papers discussing the status of lentil and its research in the country and a

Table 8.1. Attendance at DNA Molecular Marker Techniques short course - 1997.

Name	Country	Degree	Profession	Institution
Ms. Dalila Khendek	Algeria	M.Sc	Agronomist	ITGC
Ms. Mouna Taghouti	Morocco	M.Sc	Breeder	INRA
Ms. Louiza Bouabdauah	Algeria	M.Sc	Professor	Oran univ.
Mr. Çuma Akinçi	Turkey	M.Sc	Breeder	Dicle univ.
Mr. Nafiz Geliktas	Turkey	M.Sc	Biotechnologist	Cukurova univ.
Mr. Zouheer Ayyoubi	Syria	M.Sc	Breeder	A.E.C.
Mr. Raad Mohamed Salman	Iraq	Ph.D	Breeder	ARC
Mr. Ibrahim Ahmed Imbaby	Egypt	Ph.D	Plant pathology	ARC
Ms. Graca Pereira	Portugal	M.Sc	Agronomist	ENMP
Mr. Dixit Girish Prasad	India	Ph.D	Plant breeder	IFPR
Mr. Abdallah Youse Akhond	Bangladesh	M.Sc	Plant breeder	ARC

two-day field visit to lentil trials were presented and participants had the opportunity to discuss the problems of lentil production in Nepal.

8.1.8. Pedigree Management

A regional course on pedigree and data base management for cereal breeders was conducted on 24-28 February, 1997 in Tunis/Tunisia in collaboration with NARS's. The course was attended by eleven participants representing four countries (Egypt, Libya, Algeria and Tunisia). It was a practical course for using the computer for data management (randomization, data entry, selection based on multilocation/interpretation data analysis, multiyear) using QPRO or AGROBASE. Most of the time was devoted to practical training in computer laboratory. All trainees said that the course met its objectives.

8.2. Individual Training

8.2.1. Individual Non-degree Training

Training in specific areas was provided to 43 researchers from 16 countries who spent periods ranging between of 2 weeks to 3 months in cereal breeding, legume breeding, diseases, insects, virology, grain quality or DNA techniques. Individual training is most suitable for scientists who have undertaken research for a reasonable period of time, so their training programs were tailored to meet the specific needs of NARSs.

8.2.2. Graduate Research Training

The Germplasm Program continued to support 31 students from within and outside the region. During 1997, eleven ICARDA-supported students completed their thesis research or graduated, While seven new students started thesis research work at ICARDA. In addition two Ph.D students from France and Finland spent 4 months at ICARDA as part of their thesis research work.

8.3. Visits

Visits between the Germplasm Program and NARS is on effective tool for transferring scientific information and research experiences, In 1997, eight visiting scientists from Egypt, Sudan, Morocco other 5 researchers from Central Asia countries, (Azarbaijan, Kazakhstan, Kyrghistan, Turkmenistan and Uzbekistan) visited the Germplasm Program, and have an overviews on breeding activities on the improvement of mandate crops and get acquainted with breeding methodologic at ICARDA. More that 50 scientists were invited for a short periods to discuss joint projects, selected germplasm, lectures in training courses, discuss graduate student research, or gathered information on Germplasm Program activities and results. In addition, around 220 farmers and students from Syrian universities came to the Program for one day visit.

(A.J. Sabouni, GP Scientists)

8.4. Training and Networking

8.4.1. Group Training

A one week intensive course on **"Diagnosis of Plant Viruses With Special Emphasis on Faba bean necrotic yellows virus"** was offered at the Agriculture Genetic Engineering Research Institute (AGERI), ARC, Giza, Egypt during the period April 8-16, 1997. The course emphasized hand-on practicals using most advanced techniques in virus detection. Eleven scientists from Algeria, Egypt, Ethiopia, Jordan, Lebanon, Morocco, Sudan, Syria and Turkey attended the course. The course was organized by ICARDA, Agricultural Genetic Engineering Research Institute (AGERI) (Egypt), BBA (Germany) and Conseil National de Recherche Scientifique (CNRS) (Institute of Plant Sciences, Gif sur Yvette, France) and sponsored by the European Commission INCO-DC Programme.

8.4.2. Individual Non-Degree Training

8.4.2.A. *Training of ICARDA Personnel*

In cooperation with the Scottish Crop Research Institute (SCRI), Dundee, Scotland which has good experience and facilities to produce recombinant antibody-like proteins produced in bacterial cultures, Ms S. Kumari, Virology Lab, ICARDA spent three-months intensive virology training to get acquainted with recent techniques used in this field, during the period of July 29-October 25, 1997. Her work at SCRI focused on two activities, (i) clone a single chain Fv antibody fragment gene (scFv) into appropriate vector; (ii) expression of recombinant antibody in *E. coli* and assay for recombinant antibodies activity by ELISA methods.

The training course was funded by the British Council and was done under the supervision of Dr. M. Mayo with the *participation of Drs. L. Torrance and A. Ziegler.*

8.4.2.B. Training of NARS Scientists at ICARDA

During 1997 the Virology Laboratory received three trainees from Algeria, Greece and Lebanon for a period of two weeks to three months, working on different aspects of virus research.

(K.M. Makkouk, S.G. Kumari)

9. PUBLICATIONS

9.1. *Journal Articles*

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10. LEGUME VARIETIES RELEASED BY NATIONAL PROGRAMS

Crop	Country	Year of release	Variety
Kabuli Chickpea	Algeria	1988	ILC 482
Kabuli Chickpea	Algeria	1988	ILC 3279
Kabuli Chickpea	Algeria	1991	FLIP 84-79C
Kabuli Chickpea	Algeria	1991	FLIP 84-92C
Kabuli Chickpea	China	1988	ILC 202
Kabuli Chickpea	China	1988	ILC 411
Kabuli Chickpea	China	1993	FLIP 81-71C
Kabuli Chickpea	China	1993	FLIP 81-40WC
Kabuli Chickpea	Cyprus	1984	Yialousa
Kabuli Chickpea	Cyprus	1987	Kyrenia
Kabuli Chickpea	Egypt	1993	ILC 195
Kabuli Chickpea	Egypt	1994	Giza 195
Kabuli Chickpea	Egypt	1994	Giza 531
Kabuli Chickpea	Egypt	1994	Giza 88
Kabuli Chickpea	France	1988	TS1009
Kabuli Chickpea	France	1988	TS1502
Kabuli Chickpea	France	1992	Roye Rene
Kabuli Chickpea	India	1996	Pant G88-6
Kabuli Chickpea	Iran	1995	ILC 482
Kabuli Chickpea	Iran	1995	ILC 3279
Kabuli Chickpea	Iran	1995	FLIP 84-48C
Kabuli Chickpea	Iraq	1991	Rafidain
Kabuli Chickpea	Iraq	1991	Dijla
Kabuli Chickpea	Italy	1987	Califfo
Kabuli Chickpea	Italy	1987	Sultano
Kabuli Chickpea	Italy	1995	Pascia
Kabuli Chickpea	Italy	1995	Otello
Kabuli Chickpea	Jordan	1990	Jubeiha 2
Kabuli Chickpea	Jordan	1990	Jubeiha 3
Kabuli Chickpea	Lebanon	1989	Janta 2

Crop	Country	Year of release	Variety
Kabuli Chickpea	Lebanon	1993	Baleela
Kabuli Chickpea	Libya	1993	ILC 484
Kabuli Chickpea	Morocco	1987	ILC 195
Kabuli Chickpea	Morocco	1987	ILC 482
Kabuli Chickpea	Morocco	1992	Rizki
Kabuli Chickpea	Morocco	1992	Douyet
Kabuli Chickpea	Morocco	1995	Farihane
Kabuli Chickpea	Morocco	1995	Moubarak
Kabuli Chickpea	Morocco	1995	Zahor
Kabuli Chickpea	Oman	1988	ILC 237
Kabuli Chickpea	Oman	1995	FLIP 87-45C
Kabuli Chickpea	Oman	1995	FLIP 89-130C
Kabuli Chickpea	Pakistan	1992	Noor 91
Kabuli Chickpea	Portugal	1989	Elmo
Kabuli Chickpea	Portugal	1989	Elvar
Kabuli Chickpea	Spain	1985	Fardan
Kabuli Chickpea	Spain	1985	Zegri
Kabuli Chickpea	Spain	1985	Almena
Kabuli Chickpea	Spain	1985	Alcazaba
Kabuli Chickpea	Spain	1985	Atalaya
Kabuli Chickpea	Spain	1995	Athenas
Kabuli Chickpea	Spain	1995	Bagda
Kabuli Chickpea	Spain	1995	Kairo
Kabuli Chickpea	Sudan	1987	Shendi
Kabuli Chickpea	Sudan	1994	Jebel Marra-1
Kabuli Chickpea	Syria	1986	Ghab 1
Kabuli Chickpea	Syria	1986	Ghab 2
Kabuli Chickpea	Syria	1991	Ghab 3
Kabuli Chickpea	Tunisia	1986	Chetoui
Kabuli Chickpea	Tunisia	1986	Kassab
Kabuli Chickpea	Tunisia	1986	Amdoun 1
Kabuli Chickpea	Tunisia	1991	FLIP 84-79C

Crop	Country	Year of release	Variety
Kabuli Chickpea	Tunisia	1991	FLIP 84-92C
Kabuli Chickpea	Turkey	1986	ILC 195
Kabuli Chickpea	Turkey	1986	Guney Sarisi 482
Kabuli Chickpea	Turkey	1991	Akcin
Kabuli Chickpea	Turkey	1992	Aydin 92
Kabuli Chickpea	Turkey	1992	Menemen 92
Kabuli Chickpea	Turkey	1992	Izmir 92
Kabuli Chickpea	Turkey	1994	Damla
Kabuli Chickpea	Turkey	1994	Aziziye
Kabuli Chickpea	Turkey	1997	Gokce
Kabuli Chickpea	USA	1994	Dwelley
Kabuli Chickpea	USA	1994	Sanford
Lentil	Algeria	1987	Syrie 229
Lentil	Algeria	1988	Balkan 755
Lentil	Algeria	1988	ILL 4400
Lentil	Argentina	1991	Arbolito
Lentil	Australia	1989	Aldinga
Lentil	Australia	1993	Digger
Lentil	Australia	1993	Cobber
Lentil	Australia	1993	Matilda
Lentil	Australia	1995	Northfield
Lentil	Bangladesh	1993	Falguni - Barimasur-2
Lentil	Bangladesh	1995	Barimasur-4
Lentil	Canada	1989	Indian head
Lentil	Canada	1994	CDC Redwing
Lentil	Canada	1994	CDC Matador
Lentil	Chile	1989	Centinela
Lentil	China	1988	FLIP 87-53L
Lentil	Ecuador	1987	INIAP-406
Lentil	Egypt	1990	Precoz
Lentil	Egypt	1996	Sinai 1
Lentil	Egypt	1996	Giza 51

Crop	Country	Year of release	Variety
Lentil	Ethiopia	1980	R 186
Lentil	Ethiopia	1984	Chalew
Lentil	Ethiopia	1984	Chikol
Lentil	Ethiopia	1993	FLIP 84-7L
Lentil	Ethiopia	1995	Gudo
Lentil	Ethiopia	1995	Ada'a
Lentil	Iraq	1994	Baraka
Lentil	Jordan	1990	Jordan 3
Lentil	Lebanon	1988	Talya 2
Lentil	Lebanon	1995	Toula
Lentil	Libya	1993	El Safsaf 3
Lentil	Morocco	1990	Precoz
Lentil	Nepal	1989	Sikhar
Lentil	New Zealand	1992	Rajah
Lentil	Pakistan	1990	Manserha 89
Lentil	Pakistan	1995	Masur 95
Lentil	Pakistan	1996	Shiraz-96
Lentil	Sudan	1993	Rubatab 1 (ILL 813)
Lentil	Sudan	1993	Aribo 1
Lentil	Syria	1987	Idleb 1
Lentil	Tunisia	1986	Neir
Lentil	Tunisia	1986	Nefza
Lentil	Turkey	1987	Firat 87
Lentil	Turkey	1990	Erzurum 89
Lentil	Turkey	1990	Malazgirt 89
Lentil	Turkey	1991	Sazak 91
Lentil	Turkey	1996	Sayran 96
Lentil	U.S.A.	1991	Crimson
Faba Bean	Egypt	1994	Giza Blanca
Faba Bean	Egypt	1995	Giza 461
Faba Bean	Egypt	1995	Giza 714
Faba Bean	Egypt	1995	Giza 716

Crop	Country	Year of release	Variety
Faba Bean	Egypt	1995	Giza 717
Faba Bean	Egypt	1995	Giza 429
Faba Bean	Egypt	1995	Giza 643
Faba Bean	Egypt	1995	Giza 674
Faba Bean	Egypt	1997	Giza 2
Faba Bean	Egypt	1997	Giza 3
Faba Bean	Iran	1986	Barkat
Faba Bean	Portugal	1989	Favel
Faba Bean	Sudan	1990	Sellaim-ML
Faba Bean	Sudan	1991	Shambat 75
Faba Bean	Sudan	1991	Shambat 104
Faba Bean	Sudan	1993	Shambat 616
Faba Bean	Sudan	1993	Basabeer
Faba Bean	Sudan	1993	Hudeiba 93
Faba Bean	Syria	1991	Hama 1
Peas	Cyprus	1994	Kontemenos
Peas	Ethiopia	1994	061K-2P-2192
Peas	Oman	1995	Collegian Dry Pea
Peas	Oman	1995	MG 102703 Dry Pea
Peas	Oman	1995	A 0149 Dry Pea
Peas	Oman	1995	Syrian Local Dry Pea
Peas	Sudan	1989	Krema-1
Peas	Sudan	1994	Ballet
Forage Legumes	Jordan	1994	(*Vicia sativa*) IFLVS - 715
Forage Legumes	Jordan	1994	(*L. ochrus*) IFLLO-185
Forage Legumes	Jordan	1994	(*V. villosa ssp. dasycarpa*) IFLVD 683
Forage Legumes	Lebanon	1997	(*V. sativa*) Baraka
Forage Legumes	Lebanon	1997	(*V. ervillia*) Amara
Forage Legumes	Lebanon	1997	(*L. cicera*) Jaboulah

Crop	Country	Year of release	Variety
Forage Legumes	Morocco	1990	(*V. sativa*) ILFVS-1812
Forage Legumes	Morocco	1992	(*V. villosa ssp. dasycarpa*) IVLVD-2053
Forage Legumes	Morocco	1994	(*V. narbonensis*) IFLVN-2387
Forage Legumes	Morocco	1994	(*V. narbonensis*) IFLVN-2391
Forage Legumes	Morocco	1994	(*V. sativa*) IFLVS-709
Forage Legumes	Pakistan	1997	(*V. villosa ssp. dasycarpa*) Kuhak-96

11. STAFF LIST

1. Dr William Erskine	Lentil Breeder
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3. Dr Ali M. Abd El-Moneim	Forage/Legume Breeder
4. Dr Michael Baum	Biotechnologist
5. Dr Chrysantus Akem	Food Legume Pathologist
6. Dr Rajender S. Malhotra	International Trials Scientist
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8. Dr Seid A. Kemal	Post-Doctoral Fellow
9. Dr Ashutosh Sarker	Post-Doctoral Fellow
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11. Dr Bruno Ocampo	Research Associate
12. Mr Gaby Khalaf	Research Associate
13. Mr Nabil Trabulsi*	Research Associate
14. Mrs Bianca van Dorrestein	Research Associate
15. Mr Samir Hajjar	Research Associate
16. Mr George Zakko	Research Assistant
17. Ms Safa'a Kumari	Research Assistant
18. Mrs Siham Kabbabeh	Research Assistant
19. Mr Mustafa Bellar	Research Assistant
20. Ms Suheila Arslan	Research Assistant
21. Mr Imad Mahmoud	Research Assistant
22. Mr Hani Nakkoul	Research Assistant
23. Mr Hasan El Hasan	Research Assistant
24. Mr Abdalla Joubi	Research Assistant
25. Mrs Widad Ghulam	Senior Research Technician
26. Mr Moaiad Lababidi	Senior Research Technician
27. Mr Khaled El Dibl	Senior Research Technician
28. Mr Riad Ammaneh	Senior Research Technician
29. Mr Nidal Kadah	Senior Research Technician
30. Mr Omar Labban	Senior Research Technician
31. Mr Pierre Kiwan	Senior Research Technician (Terbol)
32. Mr Raafat Azzo	Research Technician
33. Mr Mohamed K.Issa	Research Technician
34. Mr Bounian Abdel Karim	Research Technician
35. Mr Diab Ali Raya	Research Technician
36. Mr Mohamed El Jasem	Research Technician
37. Ms Setta Ungi	Research Technician
38. Ms Nouran Attar	Research Technician

39. Ms Aida Naimeh	Assistant Technician (Terbol)
40. Mr Joseph Karaki	Assistant Technician (Terbol)
41. Mr Ghazi Khatib	Assistant Technician (Terbol)
42. Mr Noaman Ajanji	Driver/Store Keeper
43. Mr Fawaz El Abdalla**	Laborer
44. Mrs Tamar Varvarian	Secretary

Consultants

45. Dr B. Bayaa	Lentil Pathologist
46. Dr S. Khalil	Faba Bean Breeder

***Left the Program during 1997**
****Joined the Program during 1997**