GERMPLASM PROGRAM LEGUMES

Annual Report for 1996

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1. INTRODUCTION

Crop improvement research on cereals and legumes at the International Center for Agricultural Research in the Dry Areas (ICARDA) is conducted within the Germplasm 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 chickpea mandate Integrated Pest Management research at ICARDA is also within the Germplasm Program.

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

The overall objective of the Germplasm 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 1997/98 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; no variation occurred as regards Terbol. On average, temperatures were above the long term average (about 1°C for maximum and 5°C for the minimum).

In Bouider, the total precipitation was 23% above the long term average (279 mm versus 227 mm). The highest monthly precipitation deviations from the long term average occurred in October, January and April (positive deviations), and in February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 2°C below the long term average, while the minimum temperature was 8°C above the average. The monthly mean maximum temperature during the cropping season ranged from 9 to 35°C, and the minimum from 1 to 17°C.

In Breda, the total precipitation was 11% below the long term average (227 mm versus 254 mm). The highest monthly precipitation deviations from the average were negative and occurred in November and February. The average maximum temperature during the 1997/98 cropping season was 2°C above the long term average, while the minimum temperature was 5°C above the average. The monthly mean maximum temperature during the cropping season ranged from 9 to 36°C, and the minimum from 2 to 17°C.

In Tel Hadya, the total precipitation was 21% above the long term average (411 mm versus 340 mm). The highest monthly precipitation deviations from the average occurred in January and April (positive deviations), and in February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 3°C above the long term average, while no variation occurred regarding the minimum temperature. The monthly mean maximum temperature during the cropping season ranged from 11 to 36°C, and the minimum from 1 to 18°C.

In Terbol, the total precipitation was 533 mm, and was inline with the long term average. The highest monthly precipitation deviations from the average occurred in December, January and March (positive deviations), and in November and February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 1°C above the long term average, while the minimum temperature was 9°C above the average. The monthly mean maximum temperature during the cropping season ranged from 11 to 32°C, and the minimum from -1 to 9°C.

During the year the following changes in senior staff occurred:

a. Dr Willie Erskine was selected through international recruitment as the Leader of Germplasm Program. He was the lentil breeder also until the end of 1998.

B. Dr Amor Yahyaoui joined as the Senior Cereal Pathologist in the Program.

b. Dr Stefania Grando was recruited internationally as the Barley Breeder. She was earlier filling a lower international position.

c. Mr Issam Naji (Agronomist/Crop Physiologist) resigned.

d. Dr Mustapha Labhilili (Post-Doctoral Fellow / Biotechnology) resigned.

e. Dr Hala Toubia-Rahme (Post-Doctoral Fellow / Pathology) resigned.

f. Dr Wafa Choumane (Post-Doctoral Fellow / Biotechnology) resigned.

g. Mr Soren T. Jorgensen (Junior Professional Officer - Barley) resigned.

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 1998:

1. **Use of DNA-markers in selection for disease resistance genes in barley**, supported by BMZ and in collaboration with Technische Universität München, Lehrstuhl für Pflanzenbau und Pflanzenzüchtung, Munich, Germany (scientist in charge: M. Baum)

2. **DNA-Marker assisted breeding and genetic engineering of ICARDA mandated crops** supported by BMZ and in collaboration with University of Hannover, Prof. Dr.H.J. Jacobsen and University of Frankfurt, Prof. Dr. G. Kahl (scientist in charge: M. Baum)
3. **Improving yield and yield stability of barley in stress environments** supported by the Government of Italy (scientist in charge: S. Grando)
4. **Farmer participation and use of local knowledge in breeding barley for specific adaptation** supported by BMZ and in collaboration with University of Hohenheim (scientist in charge: S. Ceccarelli)
5. **Increasing the relevance of breeding to small farmers: Farmer participation and local knowledge in breeding barley for specific adaptation to dry areas of North Africa** supported by IDRC and in collaboration with IRESA (Tunisia) and INRA (Morocco) (scientist in charge: S. Ceccarelli)
6. **Resistance to nematodes in lentil and chickpea** in collaboration with the Institute of Nematology of Bari (scientist in charge: R.S. Malhotra)
7. **Development of chickpea resistant to biotic and abiotic stresses using interspecific hybridization and genetic transformation** supported by the Government of Italy and in collaboration with ENEA, University of Napoli and the University of Tuscia in Viterbo (scientist in charge: R.S. Malhotra)
8. **Fusarium wilt in chickpea** *supported by the Government of* Spain and in collaboration with INIA, Spain (scientist in charge: R.S. Malhotra)
9. **International durum wheat improvement** supported by GRDC, Australia in collaboration with the New South Wales Department of Agriculture (scientist in charge: M. Nachit)
10. **Coordinated improvement program for Australian lentils** supported by GRDC, Australia (scientist in charge: W.

Erskine)

11. **Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia** supported by ACIAR, Australia (scientist in charge: W. Erskine)
12. **Central and West Asia rusts network-enhanced regional food security through the development of wheat varieties with durable resistance to yellow rust** (scientist in charge: H.T. Rahme)
13. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN)** supported by IFAD, Italy (scientist in charge: M. Machit)
14. **Faba bean in China** supported by the ACIAR, Australia and in collaboration with the Genetic Resources Unit (scientist in charge: L. Robertson)
15. **Integrated management of pest and diseases** supported by BMZ, Germany (scientist in charge: K. Makkouk)
16. **Durum wheat improvement** supported by ACIAR, Australia (scientist in charge: M. Nachit)
17. **Kabuli chickpea** supported by ACIAR, Australia (scientist in charge: R.S. Malhotra)
18. **Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants** supported by ACIAR, Australia (scientist in charge: S. Ceccarelli)
19. **Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality** supported by Agricultural Technology, Utilization and Transfer Project-ATUT) (scientist in charge: M. Nachit).
20. **Development of high yielding, long spike bread wheat cultivars possessing high tiller, number, rust resistance and heat tolerance facilitated by microsatellite DNA-markers** supported by Agricultural Technology, Utilization and Transfer Project-ATUT (scientist in charge: O. Abdalla)

21. **Genetic transformation of barley for improved stress resistance** supported by CGIAR (scientist in charge: M. Baum).
22. **Adaptation of barley to drought and temperature stress using molecular markers** supported by USDA, Texas Tech University, U.S.A. (scientist in charge: S. Ceccarelli)
23. **Inheritance and linkage of winter hardiness in lentil** supported by USDA, Washington State University, U.S.A. (scientist in charge: W. Erskine)
24. **Use of entomopathogenic fungi for the control of Sunn pest** supported by USDA, University of Vermont, U.S.A. (scientist in charge: M. El-Bouhssini)
25. **Legume resistance to Luteoviruses** supported by GRDC, Australia (scientist in charge: K. Makkouk) (started in October 1998)
26. **Development of biotechnological research in the Arab States** supported by Arab Fund for Economic Social Development (AFESD) (scientist in charge: M. Baum)
27. **Improvement of lentil and grasspea in Bangladesh** supported by ACIAR (scientist in charge: A. Sarker)
28. **Pulse transformation technology transfer** supported by ACIAR, Australia (scientist in charge: M. Baum)
29. **Decentralized barley breeding with farmers' participation in North Africa** supported by OPEC (scientist in charge: S. Grando)

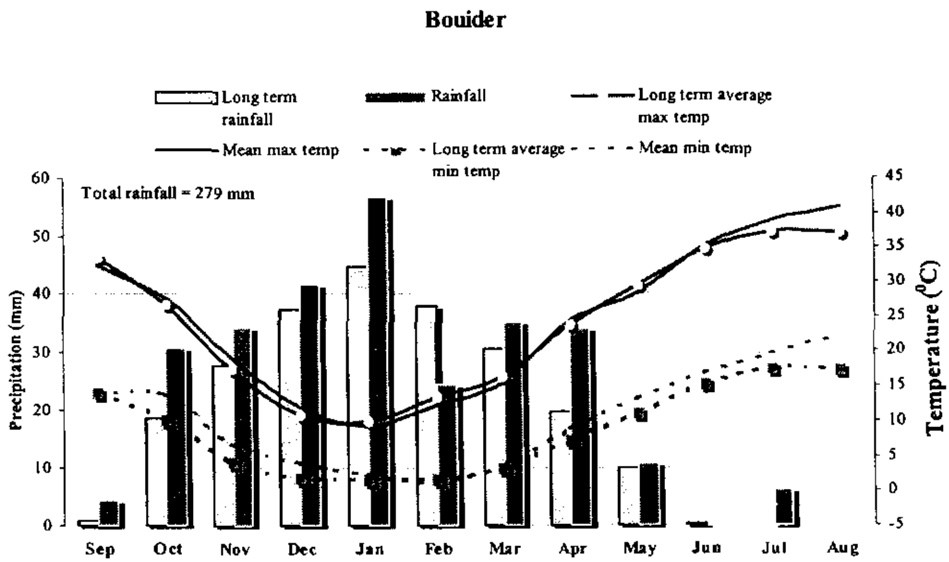
In addition the program is actively involved in the activities of the six Regional Programs and in the following special projects:

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 1997-98 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.



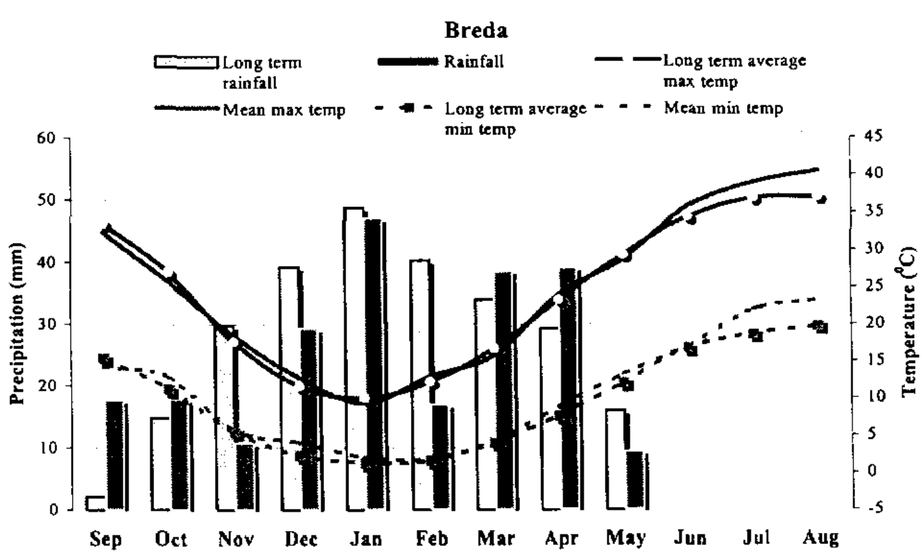
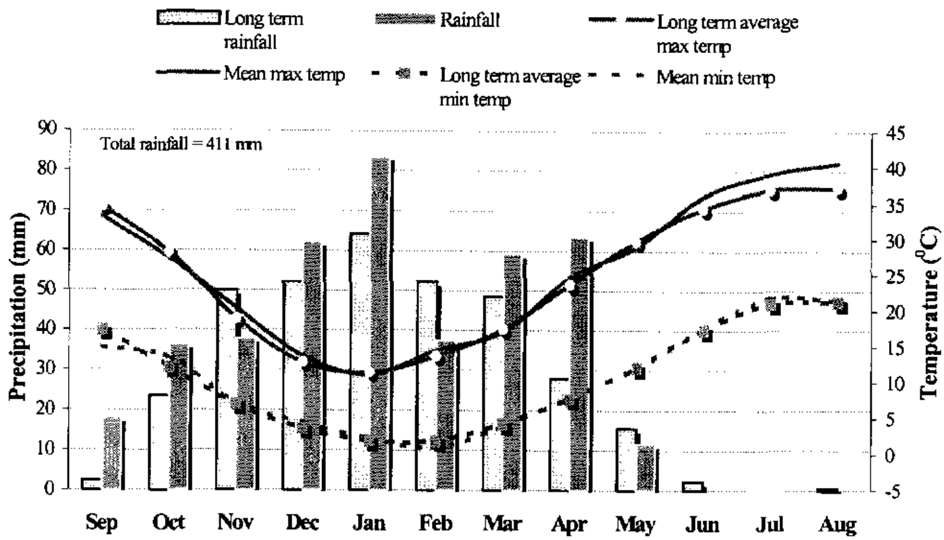


Fig. 1.1. Weather conditions at Bouider and Breda during 1997-98.

Tel Hadya



Terbol

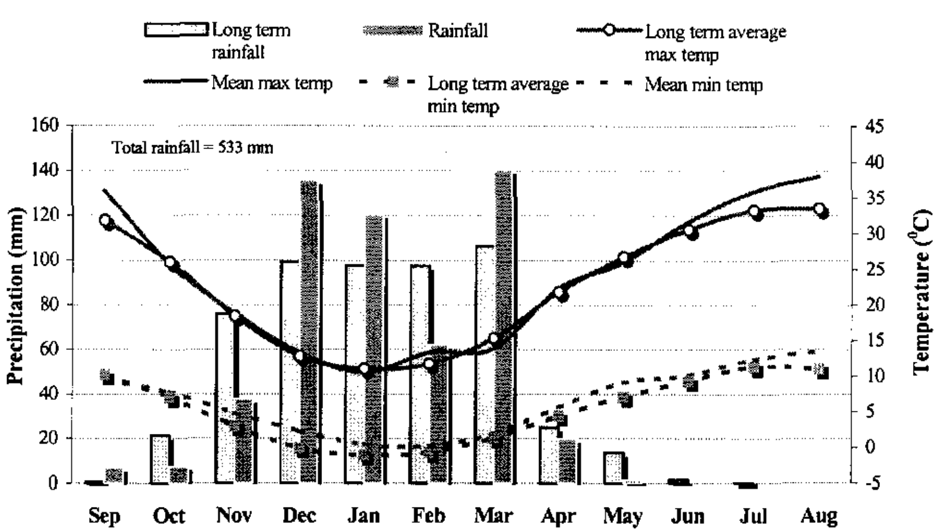


Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1997-98.

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, E. Africa and Yemen

2. Mediterranean low to medium elevation and 3. High elevation area of West Asia and North Africa. These correspond to the maturity groups of early, medium and late maturity. Within each of these major regions there are specific target areas. The target areas/regions and key traits for selection/recombination are tabulated in Table 2.1.

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

The breeding strategies used for this annual, diploid, self-pollinated food legume have evolved with time. In Stage 1, the variation in the ICARDA lentil germplasm collection was directly exploited with selection made among and within landraces. These selections were distributed to national programs through the International Nursery Network to test for local adaptation. As a result, many of the early lentil cultivars released by national programs are selections from landraces in the ICARDA collection (Figure 2.1.), illustrating the value of direct exploitation of landraces.

The particular combinations of characters required for specific regions were often not found *"on the shelf"* in the collection. Consequently, ICARDA started hybridization and selections from segregating populations to produce Stage-2 material. The stable lines were then distributed to the national programs for testing in their respective agro-climatic conditions. Stage 2 resulted in the release of a number of cultivars in different regions (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. More than 200 crosses are made annually at ICARDA targeted to address different stresses at specific agro-ecological region. Selections made by national programs are fed back into the International Nursery Network for wider distribution.

In Stage 4, the national programs use ICARDA-derived material in hybridization and selections are made locally.

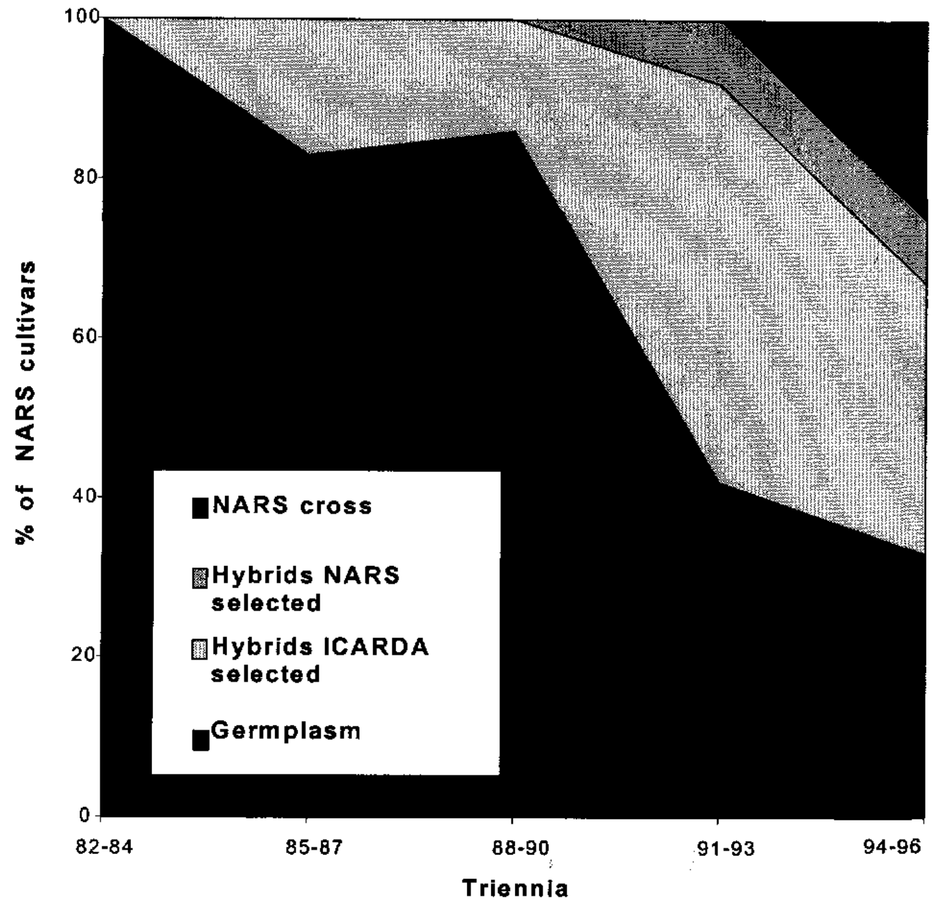


Figure 2.1. Lentil varieties released by NARS (1982-1996). Germplasm: Stage 1- Selections among and within accessions in ICARDA germplasm collection. Hybrids ICARDA selected: Stage 2- Selections made at ICARDA, Syria in segregating populations from ICARDA crosses.
Hybrids NARS selected: Stage 3- Selections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

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 1997/98 season was drier than average at Breda and Terbol with rainfall totals of 227 mm received in the growing season at Breda and 526 mm at Terbol. Tel Hadya location was wetter than long-term average with a total rainfall of 411 mm. The winter cold was shorter in Syria with 23 frost days at Breda and 30 days at Tel Hadya in the 1997/98 season, where the long-term averages are 43 d at Breda and 37 d at Tel Hadya. By contrast, the winter was cooler and longer at Terbol in Lebanon, where 43 frost events were recorded in the 1997/98 cropping season.

The average seed yield varied from 2740 kg/ha at Terbol, through 846 kg/ha at Tel Hadya to 632 kg/ha at Breda (Table 2.2). The corresponding biomass yields were 9.5 t /ha in Terbol, 2.6 t/ha in Tel Hadya and 2.3 t/ha in Breda. The harvest index (HI) was 0.28, 0.32 and 0.27 in Terbol, Tel Hadya and Breda respectively.The percentage of lines yielding significantly more seed than the best check was highest in Tel Hadya (6.7%) followed by Breda (6.5%), and lowest in Terbol (3.8%). The same trend was observed with the percentage of the lines performed better than the best check for seed yield (excluding significantly different lines). Tel Hadya gave 24.3% followed by Breda (17.4%) and Terbol (14.5%). The mean coefficient of variation over trials for seed yield was highest in Tel Hadya (25%) and lowest in Terbol (9%). However, the mean coefficient of variation for biomass was less than their corresponding mean coefficient of variation for seed yield in all the locations.

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 1997/98 season.

	Terbol		Tel Hadya		Breda	
Parameters	S	B	S	B	S	B
Number of trials	7	7	11	11	9	9
Number of test entries*	131	131	210	197	184	184
% of entries sig. (P<0.05) exceeding best check**	3.8	3.0	6.7	7.6	6.5	16.0
% of entries ranking above best check (excluding above)	14.5	18.3	24.3	25.4	17.4	22.0
Yield of top entry (kg/ha)	3085	10994	1176	3478	817	2729
Best check yield (kg/ha)	2848	10213	924	2808	698	2349
Location mean (kg/ha)	2740	9565	846	2582	632	2258
Mean C.V. (%) over trials	9	8	25	21	15	8
Mean % advantage of lattice over RCB analysis across locations	15	29	26	22	17	24
Mean % advantage of NNA*** over RCBD analysis across trials	17	38	42	63	31	44

* 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

Among the trials, 7 were arranged in 5x5 lattice, 2 were in 4x4 lattice and 2 were conducted in randomized complete block (RCB) design. A comparison was made between the efficiency of analysis as a lattice design and as a RCB 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 RCB was 19% over 11 trials across 3 locations (Table 2.2.). The equivalent advantage of NNA over RCB was 30% 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 without any extra cost.

(W. Erskine, A. Sarker)

2.1.1.3. Lentil Pathology

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

Fusarium wilt being the major biotic constraint to lentil production in the region, receives high priority in lentil pathology research. Research on rust is carried out in a decentralised mode mostly in collaboration with the national programs of Ethiopia India and Morocco. The parasitic weeds, broomrapes, (*Orobanche spp.*) are also important and can cause complete crop failure in some farms under favorable environmental conditions.

The objectives of the lentil pathology research within the food legume project at ICARDA are:(1) Screen and identify sources of single and combined resistance to the major diseases especially in the wilt/root rot complex, (2) Assist national programs in screening and identifying sources of resistance to diseases of restricted importance such as rust and ascochyta blight.

2.1.1.3.1. Screening for vascular wilt resistance

Vascular wilt caused by *Fusarium oxysporum* f. sp. *lentis* is the major disease of lentil globally. Efforts are underway at ICARDA to develop wilt-resistant genotypes to include in the international nurseries. In this endeavor, a total of 612 breeding lines and 468 germplasm accessions from the core germplasm collection were evaluated in the wilt-sick plot at Tel Hadya in the 1997/98 season for their reaction to vascular wilt. The lines were planted in 50 cm rows with 40 seeds per row. The experiment was conducted in a randomized complete block design with 3 replicates. The percent terminal wilt (% of wilted/dead plants) was recorded. The tent lines may be grouped into two categories: Cycle I - new untested lines (preliminary screening nurseries and germplasm accessions) and Cycle II - lines tested previously (lines in advanced and preliminary yield trials). 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) reaction ranged from 37-69% resistance in preliminary screening nursery and 25% among core collection accessions (Cycle I) (Table 2.3.). The test entries in Cycle II showed higher percentage of resistant sources (62-85%), 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 had a maximum plot score of < 20 % wilted plants in the last score. The new sources of resistance from the core collection are of particular importance, because they represent diverse agroecological zones worldwide. This screening is a key and integral part of the breeding program and only the resistant lines are included into the international nurseries. Resistant materials are tested by NARS under their own conditions and selection are made for release or inclusion in their breeding programs. In Syria, for example, ILL 5883 have been identified as resistant to vascular wilt and is a candidate line to release for general cultivation. Four other wilt resistant lines are in the pipeline for future release.

Table 2.3. Summary results of screening for fusarium wilt resistance in 1997/98 season

Cycle I				Cycle II			
Nursery	# of entries	# of res. Entries	% res. Entries	Nursery	# of entries	# of res. entries	% res. entries
PSN-L	51	25	49	LIFWN	40	31	75
PSN-S	164	61	37	AYT-L	13	4	31
PSN -SL	119	82	69	AYT-S	17	11	65
PUL	5	1	20	PYT-L	13	11	85
WRR	14	3	21	PYT-S	110	68	62
GRU	468	108	23	PYT-SL	57	43	78
				OFT	10	4	40

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

2.1.1.4. Inheritance of radiation frost tolerance and fusarium wilt resistance in lentil

Resistance to key biotic and abiotic stresses have been identified in the lentil germplasm of ICARDA and are being introduced into adapted lines. The availability of a detailed genetic linkage map and DNA marker systems facilitate identification and genome localization of key traits for their direct manipulation. We developed a recombinant inbred line (RIL) population that exhibited a high level of polymorphism and little segregation distortion. This population was used to construct an extensive genetic linkage map in lentil using RFLP, RAPD and AFLP. This population was evaluated in the field for radiation frost injury and fusarium wilt resistance.

Inheritance of frost tolerance

The seedlings of the RILs were exposed to 13 and 24 frost events in the field, maximum diurnal temperatures of 20.5 ^{0}C and 22.6 ^{0}C and absolute minimum temperatures of -6.6 ^{0}C and -8.3 ^{0}C, before 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 ± 0.6.5, and 7.7 ± 0.55 in 1995/96 and 1996/97 seasons, respectively. The recombinant inbred lines (RILs) showed a range of injury with mean score from 1.0 to 9.0 in both the seasons.

The Chi-square test from two seasons' data revealed that a single major gene (*Frt*) controlling frost tolerance in this population (Figure 2.2.) The DNA marker linkage analysis revealed that the frost tolerance locus (*Frt*) was linked to the RAPD marker OPS-16$_{750}$ at 9.1 cM. The marker confirmed linked in coupling (*cis*) phase to frost tolerance by bulked segregant analysis.

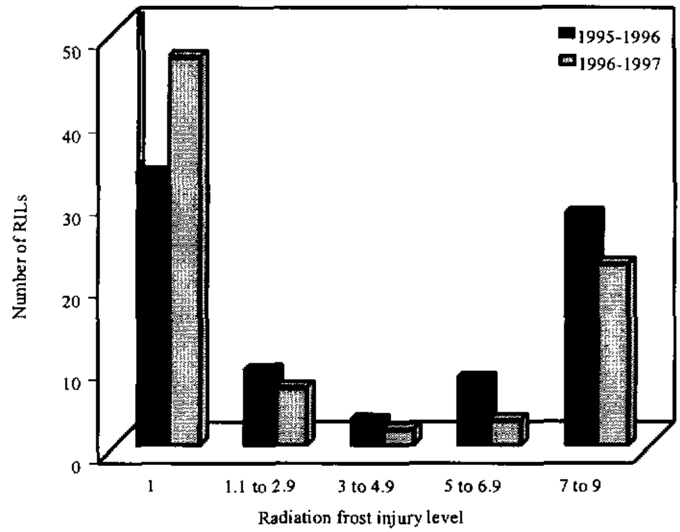


Fig. 2.2. Distribution of response of RILs to radiation frost

Inheritance of resistance to fusarium wilt

The $F_{2:4}$ and RILs with 0-20% 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. 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 $F_{2:4}$ families significantly fitted a 3:1 ratio of resistant to susceptible families indicating that the resistance is governed by a single dominant gene (*Fw*). 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 (Figure 2.3).

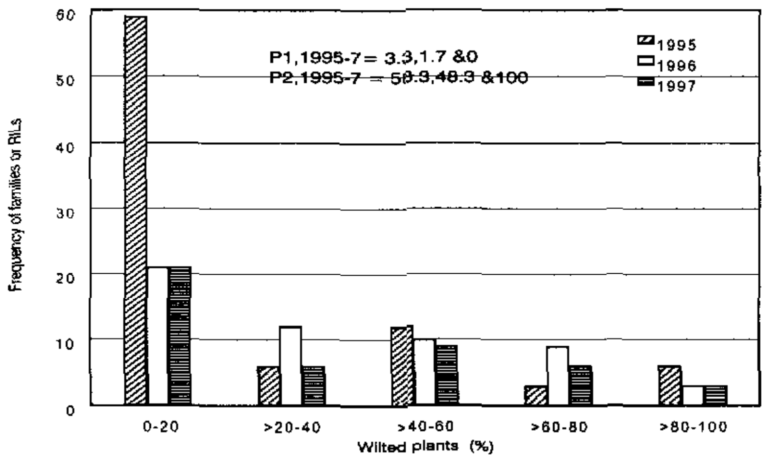


Fig.2.3. Segregation of fusarium wilt resistance in RILs

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 bulked segregant analysis was used. Out of 72 polymorphisms, 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$_{500}$) indicating linkage in the coupling phase, and the third (OP-C04$_{650}$) in repulsion with the resistance trait. This type of linkage (in repulsion) will be valuable for marker-assisted selection. However, the PCR amplification by a RAPD marker is often specific to an individual cross. To utilize this type of markers on other populations/germplasm it is necessary to develop more specific primers such as allele-specific associated primers (ASAP) as has been done for *Fw* in chickpea.

(I. Eujayl, M . Baum, B. Bayaa, W. Erskine, A. Sarker)

2.1.1.5. Screening for combined resistance to multiple diseases

The wilt/root rot complex of lentil is common in many areas, where the crop is grown under excess moisture and exposed to high temperature and moisture stress as at the end of the season. The main pathogens of this complex are: *Fusarium oxysporum* f. sp. *lentis*, *Rhizoctonia solani*, *R. bataticola* and *Sclerotinia sclerotiorum*. It has been difficult to identify resistance to this complex because of the nature and complexity of pathogens involved. In an effort to systematically screen for resistance to the main pathogens in the complex, screening for combined resistance was initiated.

A set of accessions with known resistance to fusarium wilt was screened under plastic house conditions for resistance to *R. solani* and *S. sclerotiorum*. Plants screened for reaction to *R. solani* were inoculated by incorporating the inoculum, which consisted of 2 g fresh weight of mycelia mat/ pot (5 kg soil), in the upper 2 cm of the potted soil. After inoculation, 10 surface-sterilized lentil seeds/ pots were sown at 2-cm depth. Percent pre- and post-emergence damping-off was recorded after 45 days of sowing. Lentil lines showed resistance to *R. solani* were evaluated for reactions to *S. sclerotiorum*. To do this, twenty day-old seedlings grown in sterilized soil (10 plants/pot) were singly inoculated at the base of the plant with 0.5 cm mycelial plugs of the pathogen, taken from one-week old culture of *S. sclerotiorum*. The pots were then irrigated and covered with transparent plastic bags for 72 hrs. Disease ratings were taken 2 and 15 days after removing the coverings as percentage killed plants. In another set, 2-month old plants were inoculated and evaluated following similar procedure. The experimental design, in both the cases, was RCB with three replications.

Data were subjected to analysis of variance. Only two lines (ILL 6994 and ILL 7502) had good resistance to wilt and *R. solani* and tolerance to *S. sclerotiorum* (Table 2.4). The experiment will be repeated in 1999 season for confirmation.

Table 2.4. Reaction of selected lentil lines to wilt/root rot under plastic house conditions

Genotypes	% killed by *F.oxysporum*	% killed by *R. solani*	% killed by *S. sclerotiorum* (seedling)	(adult)
ILL 5883	1.7	16.7	56.7	58.3
ILL 6798	6.7	16.7	86.7	90.0
ILL 6976	0	33.3	50.0	54.0
ILL 6991	0	13.3	50.0	86.7
ILL 6994	0	26.7	46.7	45.0
ILL 7005	0	13.3	63.3	56.0
ILL 7012	3.3	20.0	46.7	79.3
ILL 7192	0	43.3	60.0	60.0
ILL 7193	3.3	50.0	50.0	36.0
ILL 7199	3.3	40.0	76.7	63.3
ILL 7502	0	23.0	43.3	47.3
ILL 7521	1.7	6.7	66.7	93.3
ILL 7713	1.7	20.0	80.0	64.7
LSD (0.05%)	18.3	19.2	24.9	22.0

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

2.1.1.6. Screening for ascochyta blight resistance

Ascochyta blight of lentils, caused by *Ascochyta fabae f. sp. lentis* (*Afl*) is one of the most important foliar diseases of lentil globally. Research on ascochyta blight resistance in lentil is decentralized and is being done in disease hot spots. Screening for ascochyta blight was done under the ACIAR project PN 9436, where ICARDA is a cooperating partner. This work was carried at the Victorian Institute for Dryland Agriculture (VIDA), Victoria, Australia and at the National Agricultural Research Center (NARC), Islamabad, Pakistan. A systematic evaluation of 1705 germplasm accessions collected from various sources was undertaken at VIDA under glasshouse condition on a 1 to 9 scale. ILL 156, ILL 319, ILL 358 and ILL 7537 are among 125 accessions were found to be resistant and later confirmed in field evaluations at VIDA and Rosebery. Another set of 334 lines from ICARDA was evaluated under field conditions for resistance to foliar infection. The majority (74%) of them showed a resistant reaction (Table 2.5). A total of 99 wild lentils were also screened and 75 showed good level of resistance against *Alf*. Screening of 658 accessions was undertaken in glasshouse condition at NARC, Pakistan. Of them, 53 showed resistant reaction against PK-10 isolate.

Table 2.5. Field reaction of lentil lines to ascochyta blight at VIDA

Alf reaction	Score (1-9)	# of entries	% of total
Resistant	Up to 3	247	74
Moderately resistant	3.1-5	58	17
Susceptible	5.1-7	27	8
Highly susceptible	>7	2	1

(M. Nasir, T. Bretag, S. Hussain, W. Erskine)

2.1.1.7. Screening for Faba Bean Necrotic Yellows Nanovirus (FBNYV) and Bean Leaf Roll Luteovirus (BLRV) resistance in lentil

Eighty lentil genotypes (including 15 genotypes selected from the previous season proved to be good yielders and highly tolerant to virus infection) were evaluated for their resistance to local isolates of FBNYV (SV66-95) and BLRV (SV64-95) using artificial inoculation by aphids. Genotypes tested were planted in the field in two replicates, each represented by two one-meter rows, with 35 plants per meter in a RCB design for both the inoculated and non-inoculated treatments. Yield loss (%) and symptom severity (SS) on a 0-3 scale were determined for all the genotypes tested and are summarized in Tables 2.6 and 2.7. Based on these results the genotypes were divided into four categories: (1) Highly resistant: genotypes which did not produce symptoms (SS=0) and grain yield loss was less than 10%; (2) Resistant: genotypes where SS=1 and grain yield loss was less than 25%; (3) Moderately resistant: genotypes where SS=2 and grain yield loss was less than 50%; (4) Susceptible genotypes: which had a yield loss above 50% and SS was 3. Results obtained during this growing season suggested that seven genotypes had combined resistance to FBNYV and BLRV (ILL 6816, -7201, -7697, -7971, -7972, -7973, -8073), nine genotypes were resistant to FBNYV (ILL 5818, -7184, -7962, -7974, -8063, -8066, -8070, -8081, -8088) and three genotypes were resistant to BLRV (ILL 7553, -7666, -7698). Moreover, three genotypes (ILL 74, -75, -85) showed resistance to FBNYV for three years and to BLRV for two years, four genotypes (ILL 204, -213, -2581, -6435) were found to be resistant to FBNYV for three years (Table 2.8.)

Table 2.6. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with FBNYV (SV66-95) evaluated during 1997/98

Lentil Genotypes	Yield loss (%)
ILL 75	0
ILL 74, 204, 213, 214, 292, 324, 2581, 5818, 6435, 6816, 7184, 7201, 7697, 7962, 7971, 7972, 7973, 7974, 8063, 8066, 8070, 8081, 8088	1-10
ILL 85, 291, 5883, 6031, 6198, 6458, 6811, 6972, 7666, 7673, 7678, 7683, 7700, 7960, 7964, 7967, 8067, 8068, 8069, 8073, 8076, 8077, 8078	11-25
ILL 6015, 6239, 7168, 7213, 7553, 7671, 7686, 7698, 7713, 7948, 7952, 7957, 7961, 7963, 7966, 8064, 8071, 8072, 8075, 8079, 8080, 8082, 8083, 8089, 8090	26-50
ILL 7618, 7949, 7950, 7953, 7954, 7955, 7959, 8084	51-100

	Symptoms severity (0-3)
ILL 74, 75, 85, 204, 2581, 5818, 6031, 7184, 7201, 7553, 7697, 7962, 7971, 7972, 7973, 8063, 8068, 8070, 8073	0
ILL 213, 214, 292, 324, 5883, 6198, 6435, 6458, 6816, 6972, 7666, 7673, 7678, 7683, 7686, 7698, 7700, 7948, 7960, 7964, 7967, 7974, 8066, 8067, 8069, 8072, 8078, 8081, 8088	1
ILL 291, 6015, 6239, 6811, 7168, 7213, 7618, 7671, 7713, 7949, 7952, 7955, 7957, 7959, 7961, 7963, 7966, 8064, 8071, 8075, 8076, 8077, 8079, 8082, 8083, 8084	2
ILL 7950, 7953, 7954, 8080, 8089, 8090	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).

Table 2.7. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with BLRV (SV 64-95) evaluated during 1997/98

Lentil Genotypes	Yield loss (%)
ILL 74, 75	1-10
ILL 85, 6816, 7553, 7666, 7201, 7697, 7698, 7972	11-25
ILL 204, 213, 214, 6458, 7618, 7952, 7957, 7959, 7971, 7973, 8073	26-50
ILL 291, 292, 324, 2581, 5818, 5883, 6015, 6031, 6198, 6435, 6239, 6811, 6972, 7700, 7168, 7184, 7213, 7671, 7673, 7678, 7683, 7686, 7713, 7948, 7949, 7950, 7953, 7954, 7955, 7960, 7961, 7962, 7963, 7964, 7966, 7967, 7974, 8063, 8064, 8066, 8067, 8068, 8069, 8070, 8071, 8072, 8075, 8076, 8077, 8078, 8079, 8080, 8081, 8082, 8083, 8084, 8088, 8089, 8090.	51-100
	Symptoms severity (0-3)
ILL 74, 75, 85, 6816, 7553, 7697, 7698	0
ILL 213, 214, 6031, 6458, 6811, 7213, 7618, 7666, 7673, 7201, 7959, 7966, 7971, 7972, 7973, 8069	1
ILL 204, 292, 324, 5818, 5883, 6015, 6198, 6239, 6435, 6972, 7168, 7184, 7671, 7686, 7700, 7713, 7948, 7952, 7953, 7954, 7955, 7957, 7960, 7961, 7962, 7963, 7964, 7967, 7974, 8063, 8066, 8067, 8068, 8071, 8072, 8073, 8075, 8077, 8078, 8080, 8081, 8082, 8083, 8084, 8088	2
ILL 291, 2581, 7678, 7683, 7949, 7950, 8064, 8070, 8076, 8079, 8089, 8090	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).

Table 2.8. Summary of the reaction of selected lentil genotypes to artificial inoculation with FBNYV and BLRV tested over a period of three growing seasons

		BLRV			FBNYV		
Lentil genotypes	Origin	1995 /96	1996/ 97	1997/ 98	1994/ 95	1996/ 97	1997/ 98
ILL 74	CHL	-	R	R	R	R	R
ILL 75	CHL	-	R	R	R	R	H
ILL 85	TJK	-	R	R	R	R	M
ILL 204	ETH	-	R	M	R	R	R
ILL 213	AFG	-	R	M	R	R	R
ILL 214	AFG	-	R	M	M	R	R
ILL 291	DZA	-	M	S	R	R	M
ILL 292	DZA	-	M	S	M	R	R
ILL 324	YUG	-	R	S	M	R	R
ILL 2581	IND	-	S	S	R	R	R
ILL 6198	SYR	-	M	S	R	R	M
ILL 6435	SYR	-	S	S	R	R	R
ILL 6458	SYR	-	M	M	R	R	M
ILL 7618	SYR	R	R	M	-	M	S
ILL 7700	SYR	R	M	S	-	R	M

H= Highly resistant; R = Resistant; M = Moderately resistant;
S= Susceptible; - = Not tested

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

Virus Testing for International Nurseries.

During April, 1998, 292 lines were evaluated in the field by testing fresh leaf samples (400 plants per entry) for the presence of seed-borne virus infection, and 217 lines were found to be virus-free (BBSV, PsbMV and BYMV). In addition, seed samples of 374 entries were tested during July-September (400 seeds per entry) and 275 accessions were found virus-free. Seed-borne virus test is an important part of international seed dispatch, where only virus-free material are sent to the cooperators.

(K. M. Makkouk, N. Attar)

2.1.1.8. Inheritance and mapping of gene(s) for winter-hardiness

Lentil is traditionally a spring-sown crop grown on approximately 400,000 hectares of the highlands of West Asia (Iran and Turkey) where yields are typically poor. Late-autumn sowing of winter-hardy lines can lead to major yield increases estimated at 50% or more by making better use of available water resources. As a result, screening for winter-hardiness has become a major feature of lentil improvement programs for this region. Sufficient winter-hardiness is available in the lentil germplasm to enable survival of the crop in these regions. However, the winter-hardiness genes need to be identified and transferred to otherwise acceptable genetic backgrounds. Thus far progress has been slow due to the difficulty in the identification and transfer of the winter-hardiness genes using relatively unpredictable field screening. The problem of field screening for the winter-hardiness genes could be alleviated with the use of molecular markers in a marker assisted selection program. Our objectives in this study were to determine the inheritance pattern of winter-hardiness genes, tagging of winter-hardiness genes with molecular markers, and to investigate the feasibility of using marker-assisted selection for winter-hardiness in lentil (see also section 2.1.1.4 on inheritance of frost tolerance).

Ten populations of recombinant inbred lines (RILs) were developed from 10 crosses among five parents that varied for winter-hardiness. The five parents were crossed in all possible combinations in a half-dialle design, excluding reciprocals. Winter-hardiness level of the parents and the number of RILs within each of the 10 populations is shown in Table 2.9. and Figure 2.4. The F_6 -derived RILs were field tested at Haymana, Turkey and at Pullman, Washington, USA in 1997/98. Frequency distributions of RILs indicated that winter-hardiness was controlled by more than one gene.

Table 2.9. Parental lines with levels of winter-hardiness and number of recombinant inbred lines in each population

Genotype	Precoz Susceptible	ILL-669 Intermediate hardy	ILL-1878 Intermediate hardy	WA8649090 Hardy	WA8649041 Most Hardy
Precoz Susceptible	-	-	-	-	-
ILL-669 Intermediate hardy	104	-	-	-	-
ILL-1878 Intermediate hardy	105	105	-	-	-
WA8649090 Hardy	106	104	108	-	-
WA8649041 Most Hardy	101	115	120	121	-

The five parental lines were evaluated for polymorphism using 700 RAPD primers, 32 isozyme assays and 100 inter simple sequence repeat (ISSR) primers. In addition, Precoz and WA8649090 were screened for polymorphism using 48 AFLP primer combinations (4 EcoR1 - 4 MSE1 and 4 MSE1 - 8 Pst). There was good polymorphism between Precoz and WA8649090 (52%) and therefore the RIL population from that cross which consisted of 106 lines was chosen as the mapping population due to high seed yield in this population and high winter-hardiness of WA8649090. Currently, polymorphisms for 55 RAPD, 10 ISSR, and AFLP markers have been scored, and a preliminary genetic map has been developed. Using RAPD and ISSR markers, one putative QTL in the interval between UBC440-1 and UBC715-1 (7.6 cM) was found which explained 23.9% of phenotypic variance (LOD=3.28) for winter-hardiness. Single point marker analysis revealed two other RAPD markers associated with winter-hardiness, UBC610-1 and UBC502-2, and phenotypic

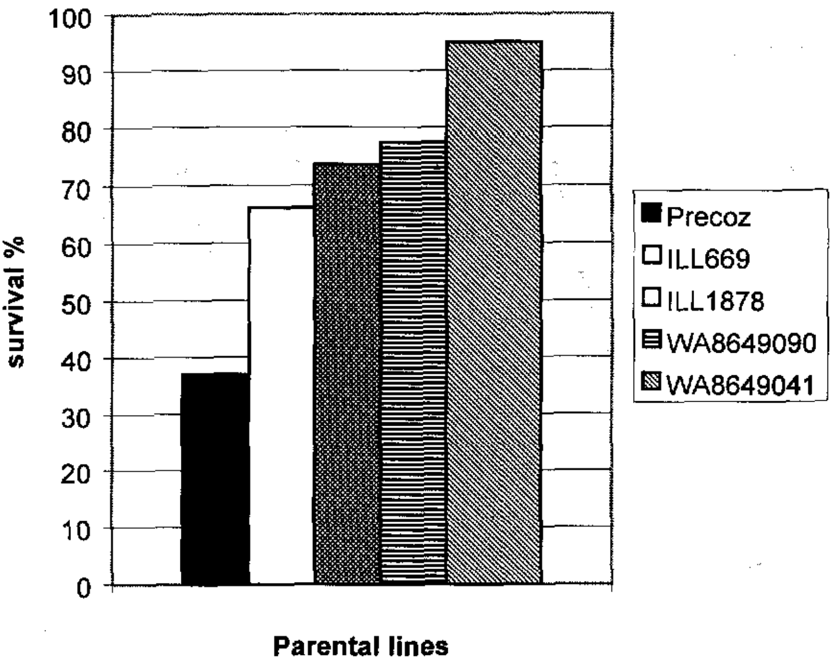


Figure 2.4. Winter survivability score (in percentage) among parental lines

variance explained by these markers was 11.0 and 12.0%, respectively.

The 10 RIL populations will be evaluated in 1998/99 for winter-hardiness at Pullman, USA and at Hymana and Sivas in Turkey. Work will continue on identifying polymorphism for molecular markers to increase the marker density of the developing map based on the RILs from the WA 8649090 X Precoz cross. After development of a high-density genetic linkage map of lentil, the genomic regions conferring winter-hardiness in lentil should become clearer.

(A.Kaharaman, I.Kusmenoglu, F. J. Muehlbauer, N.Aydin, W. Erskine)

2.1.1.9. Combined resistance to ascochyta blight and winter-hardiness

Nine promising lines and 11 checks were evaluated under Winter Red Lentil Regional Yield Trial at 4 locations (Hymana, Konya, Karaman and Yozgat) in Turkey. Observations on seed yield, winter-hardiness and ascochyta blight resistance were analyzed and presented in Table 2.10. In Karaman, winter-hardiness was not scored because of complete plant death due to soil freezing. Mean seed yield was also less in Karaman (1599 kg/ha) compared to other locations (2039-2555 kg/ha). Winter-hardiness and ascochyta blight resistance were scored on a 1-9 scale. The test entries showed 2 to 9 score for winter-hardiness and 2 to 5 for ascochyta blight resistance across locations. Considering higher seed yield, good levels of winter-hardiness (score 2) and ascochyta blight resistance (score 2), 4 lines were selected for further evaluation in these locations during 1998/99.

Table 2.10. Seed yield and winter-hardiness at various locations during 1997/98 in Turkey

Location	Mean yield (kg/ha)	Mean yield of sel. Lines (kg/ha)	Cold score (1-9)
Hymana	2555	2831	2-5
Konya	2081	2031	2-4
Karaman	1599	1666	-
Yozgat	2039	2099	5-9

(Ascochyta blight score was between 2 and 5 across locations).

(N. Aydin, A. Aydogan, A. Gurbuz (Turkey))

2.1.1.10. Screening for boron toxicity

Boron (B) toxicity occurs mainly in arid and semi-arid areas. It was reported in South Australia, India, Iraq, Pakistan, Peru, USA, and the Mediterranean region. B toxicity is increasingly being recognized as a problem in WANA. A total of 231 lentil accessions from 7 countries were screened in plastic house under natural sunlight. Visual scores on B-toxicity symptom severity (1-5, 5=high) five weeks after sowing were taken as a measure of B-toxicity tolerance. There were significant ($P<0.001$) differences between accessions in B-toxicity symptom scores, which ranged from 1.2 for accession ILL 1765 from Afghanistan to 4.3 for ILL 2031 from Ethiopia. On average, Afghanistan material had the least symptoms, followed by India, Iraq, Syria, Europe, Ethiopia and Nepal (Table 2.11.) The Nepalese accessions had the lowest variability, as measured by the standard deviation, in symptom scores besides being the most susceptible.

Table 2.11. Mean B-toxicity symptom scores for lentil accessions from different countries/regions.

Country/region	# of accessions	Symptom scores (1-5)	S. D.
Afghanistan	30	2.3 a	0.67
India	30	2.5 a	0.61
Iraq	23	2.9 b	0.53
Syria	30	3.0 b	0.55
Europe	59	3.0 b	0.63
Ethiopia	30	3.2 bc	0.52
Nepal	29	3.3 c	0.38

Scores followed by the same letter are not significantly different at $P<0.05$

(S. K. Yau, W. Erskine)

2.1.1.11. Efficiency of spatial methods in lentil yield trials

Use of complete or incomplete blocks has been a major feature of variety trials in order to control and account for the soil heterogeneity. Although the use of incomplete block designs may show considerable improvements over complete blocks when measured in terms of the efficiency of elementary contrasts, or in reducing experimental error mean squares, or coefficient of variation, it may still leave considerable amount of variability within a block with traditional analyses. A part of experimental variability can be captured by the use of a covariate measuring the inherent plot fertility level around the plot when estimated by an average residual from neighboring plots. Several covariance structures can be used to model the spatial behavior if the plot errors are in one-dimension and two-dimensions field layouts. The purpose of this study was to elucidate the behavior of experimental errors from yield trials, effectiveness of the incomplete blocks and examine the performance of analysis methods based on various spatial error structures. Our aim is also extended with a view to evaluate improvement in efficiency in comparing a pair of genotypes means and expected gain due to selection in lentil seed yield.

A total of 53 trials comprising preliminary and advanced yield evaluations over a period of three years (1996 to 1998) from Tel Hadya, Breda and Terbol were analyzed using the following ten spatial models.

Model no.	Description (Abbreviation)
-1.	Randomized complete block, independent plot errors (RCB)
Latt.	Lattice blocks, independent errors (Lattice)

1. First order auto-regressive structure (AR (1)) in errors along column direction (AR Cols)
2. AR (1) in errors along column and row directions (AR Cols and Rows)
3. AR (1) in errors and cubic spline along column direction (AR and CS in Cols)
4. AR (1) in errors along column and row directions and cubic spline in columns (AR Cols and Rows, CS in Cols)
5. First-order moving average (MA (1)) structure for errors in column direction (MA Cols
6. MA (1) in errors along column and row directions (MA Cols & Rows)
7. MA (1) in errors and cubic spline in columns (MA and CS in Cols)
8. MA (1) in errors along column and row directions and cubic spline in columns (MA Cols and Rows, CS in Cols)
9. First-order autoregressive and moving average structure (ARMA) along column direction (ARMA Cols)
10. ARMA in errors and cubic spline in columns (ARMA and CS in Cols)

In above models, RCB (-1) served as a control for comparing efficiency of the other procedures.

With a number of trials, the spatial models showed statistically significant improvement over RCB based on the test of reduction in deviance. However, some of them were rarely/less successful in capturing the spatial pattern in the plot errors in these 53 trials. Of the remaining, Models 2, 3, 4, 10 and lattice provided an increase in efficiency (19.8-31.9%) to compare two genotypes over RCB (Table 2.12). The selected models based on efficiency considerations, lead to a considerable gain in selection and Model 10 (ARMA and CS in Cols) provided highest genetic gain (33.1%). There were changes in the ranks of genotypes due to adjusted means compared to that under RCB. These models with correlated error structures showed much less percentage (16-26%) of common genotypes in top 20% of the test entries compared with lattice (82%). This indicates that modeling of spatial variability can result into identifying a different group of genotypes which did not appear from RCB analysis. Thus, an appropriately selected spatial model can lead to more efficient comparison of genotypes compared with RCB or even lattice design. Since the use of spatial models requires no new major input beyond computation or any change in field layout, their use is recommended as an add-on advantage.

Table 2.12. Efficiency, expected genetic gain and percentage of common entries of top 20% of the total genotypes of spatial models over RCB

Model	Efficiency (%)	Genetic gain (%)	% common lines comp.with RCB
Lattice	19.8	20.5	82
AR in C &R	25.4	28.5	16
AR &CS in C	22.8	26.9	21
AR in C&R+CS in C	31.9	23.3	20
ARMA+CS in C	25.7	33.1	26

AR= First-order autoregressive; C= Column; R= Row; CS= Cubic spline and ARMA= Autoregressive moving average

(A. Sarker, M. Singh, W. Erskine)

2.1.1.12. Predictive models for lentil seed and straw yields

Lentil is mostly cultivated as a rain-fed crop globally. In the farming systems of West Asia it is sown in winter between rainfall isohyets of 300 and 400 mm. The amount and distribution of rainfall and winter cold are known to affect profoundly its growth and yields. This study aimed to quantify the effects of climatic variables on lentil seed and straw yields through the fitting of simple empirical models to trial data. A total of 39 environments comprising yield trials from Breda, Tel Hadya (Syria) and Terbol (Lebanon) from 1985-97 were used in this study. Correlation between climatic variables and seed and straw yields were calculated. Stepwise forward and backward regressions were performed to identify climatic variables (seasonal rainfall, and monthly rainfall and temperature from January to May) to derive best empirical models using the mean seed and straw yields as the dependent variables and climatic data as independent variables over 39 environments. Mean, standard deviation and range of yield variables (seed and straw) and five climatic variables, which were most often included in the best-fit models, are shown in Table 2.13. Both seed and straw yields varied greatly (193-3214 kg/ha seed and 381-6287 kg/ha straw) over environments. The rainfall and temperature patterns were highly variable. For example, the total seasonal rainfall of the 39 environments varied from 183 to 984 mm.

Table 2.13. Mean, standard deviation (S.D.), minimum (min.), maximum (max.) seed and straw yields and environmental variables occurring in models over 39 environments

Variable	Mean	S.D.	Min.	Max.
Yield variable				
Seed yield (kg/ha)	1304	707	193	3214
Straw yield (kg/ha)	2722	1436	381	6287
Environmental variables				
Seasonal rainfall (mm)	385.8	169.66	183.0	984.0
January rainfall (mm)	74.3	38.16	1.2	159.0
May temperature (°C)	19.6	2.24	14.2	22.6
May rainfall (mm)	14.3	13.49	0.0	57.8
Absolute min. temp. (°C)	-7.9	2.29	-14.5	-4.5

Model for seed yield

The 39 environments cover the two distinct geographical regions of lentil production; Syria (Breda and Tel Hadya) and Lebanon (Terbol). We tried first to develop a single model using a linear equation for total seasonal rainfall from all 39 environments. In this model, only data from Breda and Tel Hadya showed linearity with total seasonal rainfall (mm). To provide a generalized model for three locations, we looked for a quadratic equation using the variable total seasonal rainfall square. From the multiple regression analysis it was observed that the total seasonal rainfall together with total seasonal rainfall^2 accounted for 63.2% of the variance in mean seed yield (1304 kg/ha; S.D. 707) (Table 2.14). Thus a simple model is:

Seed yield (kg/ha) = -1442 + 10.46 Total Rain - 0.00168 Total Rain^2

Along with these, May rain explained 71.3% and May temperature accounted for 75.1% of the variance in mean seed yield. The addition of other monthly rainfall and temperature variables to this multiple regression did not improve the fit significantly. Thus the prediction model for seed yield in lentil is:

Seed yield (kg/ha) = -82 + 11.04 Total Rain - 0.00866 Total Rain^2 + 12.42 May Rain - 79.2 May Temperature (R^2 = 75.1%).

The response of mean seed yield to total seasonal rainfall was 11.04 ± 0.86 kg/ha/mm rain. The predicted gain in mean seed yield due to May Rain is 12.42 ± 0.78 kg/ha/mm. However, May temperature reduced seed yield drastically.

Table 2.14. Variables accounted for greater % variance for seed and straw yields

Seed yield		Straw yield	
Variables (+ added)	% R^2	Variables (+ added)	% R^2
Seasonal total rain (mm)	44.2	Seasonal total rain (mm)	26.4
+ Seasonal total rain (mm)^2	63.2	+ Seasonal total rain (mm)^2	61.4
+ May rain (mm)	71.3	+ Absolute min. temp. (°C)	69.6
+ May temperature (°C)	75.1	+ January rain (mm)	74.9

Model for straw yield

Lentil straw is an important animal feed particularly in WANA region. In dry years the straw is as valued as seed. The straw yield data from all 39 environments were used using multiple regression models in a quadratic equation to find out the effect of rainfall and temperature variables on straw yield. Total seasonal rain + Total seasonal rain^2 accounted for 61.4% variance in mean straw yield (2722 kg/ha; S.D. 1435)(Table 2.14). From these variables a most simple model can be constructed as follows:

Straw yield (kg/ha) = -3246 + 24.48 Total Rain - 0.01966 Total Rain^2

By adding absolute minimum temperature to the above variables, 69.6% variance was observed for straw yield. Extending the model to include January rain, the highest variance was realized, accounted for 74.9% in straw yield. But the use of other variables in the model no longer improved the fit. Therefore, the predictive model for straw yield is:

Straw yield (kg/ha) = -1579 + 26.8 Total Rain - 0.01926 Total Rain^2 + 206.4 Absolute Min. Temperature - 13.41 January Rain (R^2 = 74.9).

The response of straw yield to total seasonal rainfall was 26.8 ± 2.2 kg straw/ha/mm rain and to absolute minimum temperature was 206.4 ± 10.8 kg straw/ha/-C^0. January rain had a negative effect on straw yield with a rate of -13.41 ± 2.5 kg/ha/mm.

Thus, the study showed considerable value of simple empirical models in accounting for variation in lentil seed and straw yields using historical data. The simple models not only describe the variation in seed and straw yields, but may also be used for predictive purposes.

(A. Sarker, W. Erskine, M. Singh)

2.1.1.13. Genotypic variation in seedling shoot and root systems

Study of crop root systems, particularly in legumes has lagged behind that of above ground plant characteristics. Further, there is scanty information available on the genetic variation of young roots and shoots in lentils. The crop is generally grown in stressful soil environments. Crop performance under such stressful conditions is closely related to root system development. For example, drought tolerance is closely related to the distribution of root system, or rooting pattern in the soil, which is, in general, the consequence of root growth of plants in the early growth stage. Knowledge of genotypic variation within cultivated lentils is essential for agronomy as well as genetic improvement of the crop.

Forty genotypes including landraces from diverse geographical origin and breeding lines from ICARDA were used for this study. Seedlings of each genotype were grown in pots containing 7 kg soil (1 part soil: 1 part sand) and the pots were placed in field under natural conditions in completely randomized arrangement with 3 replicates. Irrigation was applied as and when necessary. The 35-day old seedlings were removed and washed from the pots for recording data. Observations were recorded from 2 plants per pot on stem length, stem weight, tap root length, lateral root number, total root length and total root weight. It can be seen from Table 2.15. That the genotypes differed significantly with respect to all the characters under study. Mean tap root length ranged from 15.8 to 46.0 cm and total root length ranged from 0.75 to 6.55 m. Considerable variations were observed for lateral root number (13-57) and total root weight (0.12-1.55 g). The genotypes also varied greatly in stem length (5.2 to 12.6 cm) and stem weight (0.1 to 0.71 g). Total root length was highly correlated with lateral root number ($r = 0.74$), root weight (r = 0.79), stem weight (r = 0.69) and tap root length (r = 0.54). Significantly positive correlation was also observed between root weight and stem weight (r = 0.78). The experiment will be repeated and the seedling characters will be correlated with the field performance.

Table 2.15. Summary statistics of shoot and root characters in lentil

Characters	Mean	S.D.	Min.	Max.	Sig. level
Stem length (cm)	7.8 ± 0.11	1.19	5.2	12.6	**
Stem wt. (g)	0.32 ± 0.01	0.15	0.1	0.71	**
Tap root length (cm)	32.1 ± 0.65	7.10	15.8	46.0	*
Lateral root number	27.3 ± 0.81	8.91	13.0	57.0	**
Total root length (m)	2.22 ± 0.14	0.51	0.75	6.55	*
Total root wt. (g)	0.55 ± 0.03	0.09	0.12	1.55	**

Significant at P< 0.05%; ** P<0.01%

(A. Sarker, W. Erskine)

2.1.1.14. Screening for resistance to *Sitona*

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

Twelve entries selected in 1997 as having low nodule damage were retested in Tel Hadya in 1998 for confirmation. Four Syrian local cultivars were included as susceptible checks. The experiment was conducted in RCB with 2 replications. Forty seeds of each accession were planted in hill plot. 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 damage; 3= 1-25% of the leaflet damage; 5= 25-50% leaflet damage; 7= 50-70% leaflet damage and 9= > 70% leaflet damage.

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* preferred similarly all the accessions, and the percentage leaflet damage was high for all the entries (VDS = 7-9). The entries also showed a high level of nodule damage, which ranged between 80 and 96%. As no resistance has been found yet in the cultivated species, a collection of 100 accessions of *Lens culinaris* ssp. *orientalis* will be evaluated for resistance to *Sitona* in 1999 season.

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

Screening technique for resistance to *Sitona* under artificial infestation

This study was carried out in the plastic house and in the field at Tel Hadya, ICARDA. Five densities of *Sitona* adult were used, 2, 4, 6, 8 and 10 pairs per pot (10 plants). The plants were covered with a plastic cage (15 cm in diameter by 30 cm high) with a cloth screen top and screened ventilation holes on sides. The plants were infested when nodules developed, approximately one month after planting. The experimental design used was a RCB with 4 replications. In the field, a similar experiment was conducted, except that seeds were planted in hill plots. The method of evaluation for both visual damage score and nodule damage was similar to that already described in section 2.1.1.15.

The results showed that infesting 10 lentil seedlings with 2 pairs (4 adults) of *Sitona* caused high (60%) nodule damage, which was not significantly different from that of the other densities (4, 6, 8, 10 pairs) (Table 2.16). However, 6 pairs were needed to cause high leaflet damage (visual damage score of 7 in a 1-9 scale). The results also showed high correlation between visual damage score and nodule damage, r= 0.69 and 0.75 respectively in the field and in the plastic house. Because of this positive correlation, the evaluation of lentil for resistance to *Sitona* under artificial infestation could be based on visual damage score alone. Thus, large number of lentil accessions could be screened for resistance to this pest in a short period of time.

Table 2.16. Leaflet damage (VDS) and percent nodule damage (%ND) of lentil as affected by different densities of *Sitona* adults.

No. of insect pairs	Visual damage score		% Nodule damage	
	Plastic house	Field	Plastic house	Field
2	3d	3c	60a	62a
4	5c	6b	54a	62a
6	7b	9a	60a	70a
8	9a	9a	67a	63a
10	9a	9a	71a	68a
L.S.D	1.5	1.4	18.7	23.3
C.V	14.6	12.4	19.4	23.3

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

2.1.1.15. Screening for aphid resistance

Cowpea aphid

The cowpea aphid, *Aphis craccivora* Koch is the most important field pest causing substantial yield loss globally. Yield could be severely reduced if infestation occurs at early stages of the crop. Eight lentil genotypes reported to be resistant to cowpea aphid from Egypt and four lines, which were found to be moderately resistant at Breda in 1996/97, were evaluated for their resistance under artificial infestation at Tel Hadya. The experiment was conducted in RCBD with 4 replications, and each entry was planted in 4 rows of 2 m length. Plants were infested at 6-8 cm height using 10 aphids per plant. About one month later, evaluation was made using a visual damage score (VDS) in a 1-5 scale (1= no damage; 2= slight damage, some curling of the leaves, no honeydew production; 3= moderate damage, obvious curling of the leaves, honeydew production; 4= Severe damage, severe curling of the leaves, heavy honeydew production, stunted plants; 5= severe stunting). The results (Table 2.17) showed that only one line (ILL 6256) had a VDS of 2.7. Four other accessions (ILL 6024, ILL 6458, 94S 66102-13 and 94S 72101-12) had a VDS of 3, and could also be considered as moderately resistant. These five lines will be confirmed in 1999 under artificial infestation in field condition.

Table 2.17. Reaction of lentil lines for resistance to cowpea aphid under artificial infestation

Genotype	Visual damage score (1-5)
ILL 2022	5.0
ILL 3490	4.0
ILL 3693	3.3
ILL 6024	3.0
ILL 6211	3.3
ILL 6256	2.7
ILL 6458	3.0
ILL 6819	3.3
94S 66102-13	3.0
94S 67104-4	3.3
94S 67123-5	4.0
94S 72101-12	3.0
LSD at 0.05%	0.67
C.V.	11.8

Pea aphid

The Pea aphid, *Acyrthosiphon pisum* Harris, is a major field pest of lentil, pea and grass pea in several parts of WANA. In Ethiopia, yield losses have been estimated up to 50%. Six ICARDA accessions previously identified as resistant to Pea aphid in Ethiopia, were screened for confirmation of resistance under artificial infestation at Tel Hadya. The experiment was conducted in RCB design with 4 replications and each entry was planted in 4 rows of 2 m length. Plants were infested when they were about 6-8 cm high using 10 aphids per plant. About one month later, the evaluation was made using a visual damage score (VDS) from 1-5, similar to that used for the Cowpea aphid. The results (Table 2.18.) showed that only two accessions (ILL 2704 and ILL 6449) had a VDS of 3, and could be considered as moderately resistant. These two accessions will be retested for confirmation under artificial infestation in 1999.

Table 2.18. Reaction of lentil accessions for resistance to Pea aphid under artificial infestation.

Genotype	Visual damage score (1-5)
ILL 2612	3.3
ILL 2704	4.0
ILL 5538	3.0
ILL 6010	4.0
ILL 6205	3.3
ILL 6449	3.0
LSD at 0.05%	0.5
CV (%)	8.3

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

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 ca. 850 m around the Mediterranean Sea. To date, more use has been made by NARSs of lines than segregating populations and few lentil crosses are made outside ICARDA in North Africa and West Asia.

A list of lentil lines released as cultivars by NARS has been given at the end of this report (See page 248) and Table 2.19. gives those lines selected for pre-release multiplication and/or on-farm trials by NARSs.

In Syria the red-cotyledon line ILL 5883 has been submitted to the variety release committee following its testing in on-farm trials over the last six years, where it yielded significantly more grain than the local check in different regions and rainfall zones. Additionally, it has improved standing ability for harvest mechanization over the local check and resistance to vascular wilt disease, the most important disease of lentil in Syria.

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, has been registered for cultivation in the south of the country.

Table 2.19. Lentil lines in on-farm testing or pre-release multiplication by NARSs.

Mediterranean region	
Iraq	FLIP85-83L
Jordan	FLIP84-147L, FLIP88-6L
Lebanon	ILL 2126, FLIP84-59L, FLIP85-38L, FLIP87-56L
Morocco	FLIP86-15L, FLIP86-16L, FLIP87-19L, & FLIP87-22L
Syria	ILL 5883, ILL 7012, ILL 6994, ILL 7201
Tunisia	78S26002, FLIP90-13L
S. Latitudes	
Ethiopia	FLIP87-74L
Nepal	ILL 2580, ILL 4402
Sudan	FLIP88-43L
Yemen	ILL 4605, FLIP84-14L
Highlands	
Iran	ILL 590, ILL707, ILL857, ILL975, ILL4400
Turkey	Spring: FLIP90-3L, FLIP84-147L, FLIP87-8L, FLIP88-10L, FLIP84-112L, FLIP84-51L, FLIP84-59L & FLIP86-35L Winter: AKM-49, -62, -196, -302, -362, -363 and -395

In Jordan the national program is in the process of releasing two lentil lines (FLIP88-6L and 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 higher tested yield and with resistance by the S. E. Anatolian Regional Research Station.

In Iraq the large-seeded, yellow cotyledon line ILL 5582 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.

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 terminal drought stress under the low rainfall conditions. 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 one is in Islamabad. Over the last five years ICARDA has worked closely with these programs in joint selection as the focus of a thrust to broaden the genetic base of lentils in South Asia. The cultivar Masoor 93, with ICARDA parentage, is proving popular with farmers in the Sialkot region on account of its rust resistance and high yield and reputed to cover 25% of the main production areas.

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, Barimasur-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 Barimasur-4 in 1995. It gave a yield advantage of 53 % over the local check and 28% over Barimasur-2. It also has resistance to Stemphylium blight and an erect plant stature suitable for inter-cropping in sugarcane, and mixed cropping with mustard, which is a widespread production practice for lentil in Bangladesh. Another four lines having high yield potential and combined resistance to rust and stemphylium blight are in pre-release stage. Two of them have been identified for late planting condition (about 1 month late) for medium high-lands after harvest of autumn rice. From current year, an ACIAR project on lentil improvement has started operating with the Pulses Research Centre, Bangladesh Agricultural Research Institute, where ICARDA is a cooperating partner.

India has a strong lentil-breeding program coordinated under the All India Coordinated Pulse Improvement Project of the Indian Council of Agricultural Research (ICAR). The All-India coordinated lentil trial program has recently started two new categories of trial/nursery, as a result of broadening the genetic base of lentil in S. Asia. These are: 1. Extra bold seeds (>35 g/1000 seeds) and 2. Extra early (maturity <110 d). The extra-early nursery is particularly important because it opens up a large new potential niche for lentil in India by using a late-sown lentil (using an early maturing cultivar) following the harvest of a long-season rice crop. At present, there are 4 million ha left fallow in winter after the harvest of long-season rice in India annually. The new early lines mature in 110 days compared to the maturity of 135-145 days of landraces in North India. Overall, in the coordinated lentil testing program, lines with ICARDA-derived parentage represent 38% of entries.

Rust resistance, selected in Morocco, is holding in Kanpur. We have established cooperation with Pantnagar Agricultural University on screening for rust resistance in breeding lines, the wild germplasm and the possibility of collaboration in the search for markers for rust resistance. Our vascular wilt resistance lines are being widely used as source parents within India.

Nepal grew around 170,000 ha of lentil spread from the Terai area adjacent to India to the lower Mid-Hills last season. ICARDA has been requested for specific targeted crosses by Nepali program. ILL 2580 and ILL 4402 are among entries being considered for release. Another line ILL 7537 has been identified as early, high yielding, and resistance to wilt-root rots complex and ascochyta blight and adapted to the mid-hills region.

Bilateral interaction - ICARDA directly with the NARSs of S. Asia - has been strong in the fields of the exchange of germplasm and in the development of tailored breeding material. The value to NARSs of such bilateral interaction has fueled the felt need for more support to regional activities on lentil improvement. At an ICARDA/ICAR sponsored seminar on 'Lentil in S. Asia' held in Delhi in 1991, participants from S. Asia were enthusiastic about the need and value of a regional network on lentil improvement and its potential for the development of the crop in their individual countries. We were catalytic in securing funding for a project entitled 'Improvement of drought and disease resistance in lentils from the Indian Sub-continent' from the Australian Centre for International Agricultural Research (ACIAR).

In Ethiopia Gudo = FLIP84-78L (ILL 5748) and Ada'a = FLIP86-41L (ILL 6027) were registered in 1995.

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. Briefly, in Iran the lines ILL 590, ILL 857 and ILL 975 selected at Gazvin on the basis of winter-hardiness are in the pre-release stage and seven winter red lines are being entered for registration. A total of approximately 500 ha of winter lentil were sown in the Gazvin Province last year.

In Baluchistan (Pakistan) the lentil cultivar ShirAZ-96 (FLIP-85-27L) was released to farmers in 1996. The line was selected at the Arid Zone Research Institute, Quetta, on the basis of its cold tolerance and a larger seed size than the local cultivar.

(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 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's 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. In 1998, CLIMA, Western Australia, has released Cumra (ILL 590) and Cassab (ILL 7200) for cultivation in low rainfall regions for higher yield and the Victorian Institute of Dryland Agriculture (VIDA), Horsham intends to release 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 the farmers.

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 Harvest Mechanization

Lentil is an important component of the rainfed farming systems in the dry areas of West Asia and North Africa. But the lentil area in some countries has been declining in the recent years due to high hand-harvest cost. 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). ICARDA is cooperating with the Çukurova University, Turkey, the Aleppo University, and the General Organization of Agricultural Mechanization, Syria on the following aspects of lentil harvest mechanization. 1. Survey on adoption of machine harvest in Syria and Turkey 2. Comparison among different harvest systems with respect to harvest loss 3. Studies on variety traits suitable to mechanical harvesting.

A total of 171 lentil growers spreaded over the major lentil growing regions of Syria (El Hassake, Aleppo, Idleb and Dera provinces) and Turkey (Urfa, Antep, Yozgat and Çorum provinces) were interviewed. The farmers were classified to three groups: Small producers with < 3 ha, Middle producers with 3-30 ha and Large producers with > 30 ha represented 37%, 51% and 12% respectively.

It can be seen from Table 2.20. that 94% of small farmers used hand-harvest. The middle category farmers adopted more or less equally the three different systems. However, the large farmers mostly used combine (48%), followed by mower-swather/ double-knife cutter bar (38%) with minimum hand harvest.

Several important facts came out from this study about the costs of lentil harvest. Among those, farmers who used hand harvest, the harvest costs amounted to 44.2% (28.4% pulling, 7.2% transport and 8.6% threshing) of the total production costs. The costs of pulling, transport and threshing were 64.2%, 16.2% and 19.6% of harvest costs, respectively. In this hand-harvest group, the net profit was 37% of total production cost excluding field rent. The farmers who adopted harvest by mowers (double-knife cutter bar, small and large self-propelled mower) system, the costs of harvest were 32.6% (17.1% cutting, 6.2% transport and 9.3% threshing) of total production costs. The costs of cutting, transport and threshing were 52.2%, 19.1% and 28.6% of harvest costs respectively. In this category, the net profit was 96% of total capital without the rent of field. The farmers who harvested the crop by combine, the cost of harvest was 19.9% of total production costs. In this group, the net profit was 120% of total capital without the rent of field.

Table 2.20. Number and percentage of farmers using different harvest systems in Syria and Turkey

Farmer's category (ha)	Hand harvest		Mower-swather or Double-knife cutter bar		Combine harvester	
	No.	%	No.	%	No.	%
< 3	59	94	2	3	2	3
3 - 30	34	39	23	26	30	35
>30	3	14	8	38	10	48

A comparison was made at ICARDA Tel Hadya of the various harvest systems in the 1996/97 and 1997/98 seasons. The systems were: (1) Hand pulling + thresher, (2) Double-Knife cutter bar + thresher, (3) Large self-propelled mower + thresher, and (4) Combine harvester (Table 2.21).

There were significantly greater seed losses from self-propelled mower (24.5%) compared to other harvest systems (Table 2.21). The losses are from two problems: the extreme width 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, although a considerable loss also occurred with self-propelled mower. Minimum loss of seed and straw was obtained from hand harvest.

Table 2.21. The average yields (kg/ha) and losses (as percentage of yield) with different harvest systems in 1996/97 and 1997/98.

	Seed		Straw	
Harvest systems	Yield	% loss	Yield	% loss
Hand-pulling + thresher	1347	11.0	1969	7.8
Double-knife cutter bar + thresher	1160	17.7	1440	17.2
Large self-propelled mower + thresher	1243	24.5	1354	24.2
Combine harvester	1217	17.4	1513	100

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

2.3. International Testing Program

The international testing program on lentil is an instrument for the distribution of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs all over the world. The genetic materials comprise segregating populations in F_3 generation, and elite lines with wide or specific adaptation, special phenotypes, and resistance to common biotic and abiotic stresses. A list of trials supplied in the 1998/99 season is given in Table 2.22.

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 1996/97 international nursery results, received from cooperators are presented here. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

Table 2.22. Distribution of Lentil International Nurseries to cooperators for the 1998/99 season.

International Trial/Nursery	No. of sets
Screening Nursery, Large-Seed LISN-L-99)	43
Screening Nursery, Small-Seed LISN-S-99)	38
Screening Nursery,Southern Latitudes(LISN-SL-99)	26
Screening Nursery,Drought Tolerance (LISN-DT-99)	36
F_3 Nursery, Large Seed (LIF_3N-L-99)	24
F_3 Nursery, Small Seed (LIF_3N-S-99)	15
F_3 Nursery, Early (LIF_3N-SL-99)	11
F_3 Nursery, Cold Tolerance (LIF_3N-CT-99)	10
Cold Tolerance Nursery (LICTN-99)	29
Ascochyta Blight Nursery (LIABN-99)	24
Fusarium Wilt Nursery (LIFWN-99)	29
Rust Nursery (LIRN-99)	16
Total	301

The international testing program for lentil yield trial contemplates two kinds of trials: one for large seed and another for small seed genotypes.

The Lentil International Yield Trial-Large (LIYT-L) was reported from 23 locations in 11 countries. A number of test entries exceeded the local check by a significant margin ($P \leq 0.05$) at Jalalabad in Afghanistan; at Maragheh and Qazvin in Iran; at Caltagirone and Tolentino in Italy; at El Kef in Tunisia; and all locations in Bulgaria, Syria and Turkey. The five highest yielding entries across all the locations were FLIP 95-21L, FLIP 92-3L, FLIP 95-17L, FLIP 96-13L, FLIP 96-2L with seed yields of 994, 961, 951, 941, and 923 kg/ha, respectively. The stability analysis for seed yield revealed that the linear portion of GxE interaction was statistically not significant (Table 2.23). The entries, FLIP 95-17L, FLIP 96-2L, and FLIP 96-13L were relatively suitable for high yielding environments; whereas the entry FLIP 95-20L exhibited specific adaptation to low yielding environments.

Table 2.23. Analysis of variance for stability for seed yields for the entries in LIYT-L and LIYT-S during 1996/97 in different countries.

Sources of variation	LIYT-L d.f.	LIYT-L MS	LIYT-S d.f.	LIYT-S MS
Entry	23	98804**	23	81864**
Entry X Location(Linear)	23	65586n.s.	23	29472n.s.
Pooled deviation	456	44893*	216	42270**
Pooled error	1008	28201	528	26210

For the Lentil International Yield Trial-Small (LIYT-S) data were analyzed for seed yield from 11 locations in 9 countries. At some of the locations including, Caltagiron and Tolentino in Italy, and all locations in Afghanistan, Lebanon, Morocco and Turkey some of the test entries exceeded the respective local check by a significant margin. The five best entries across all locations were FLIP 95-49L, FLIP 89-20L, FLIP 92-28L, FLIP 95-41L and FLIP 95-57L with seed yield of 1264, 1239, 1216, 1214, and 1210 kg/ha, respectively. The stability analysis for seed yield revealed that only the non-linear portion of GxE interaction was significant. The entries, FLIP 95-39L, FLIP 93-1L, and FLIP 92-19L were relatively adaptable across environments. The entries, FLIP 89-20L and FLIP 95-49L were the most adaptable to high yielding environments, whereas the entry FLIP 95-34L was the most suitable for low yielding environment.

The International Yield Trial-Southerly Latitudes (LIYT-SL) data were analyzed for seed yield for two locations in two countries, Mexico and Sudan. At Hubeiba in Sudan three test entries FLIP 89-60L, FLIP 92-52L and FLIP 92-54L exceeded the respective local check in seed yield by a significant margin ($P \leq 0.05$). At Celaya in Mexico, the local check exceeded the yield of most test entries. On the basis of mean across locations the five highest yielding lines are FLIP 89-60L, FLIP 93-42L, FLIP 88-34L, ILL 4403, and FLIP 92-54L with seed yields of 1344, 1182, 1063, 959, and 921 kg/ha, respectively. The entry means over locations for time to flowering varied from 51 to 70 days. The entry FLIP 92-54L was the earliest to flower (51 days) followed by JL-1 (57 days), and ILL 7557 and FLIP 88-43L (59 days)

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 19, 9, 8 and 3 locations, respectively. The analyses of data revealed that at 8 locations in LISN-L (Valdivia in Chile, Ardabil, Qazvin and Sararood in Iran, Rabea in Iraq, Terbol in Lebanon, Hama in Syria, and El Kef in Tunisia); six locations in LISN-S (Terbol in Lebanon, Gelline, Hama, Heimo, Harran and Izra'a in Syria); one location in LISN-SL (Khumaltar in Nepal); and three locations in LISN-DT (Caltagirone and Viterbo in Italy, and Khumaltar in Nepal). Some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). The five best entries on the basis of average over locations are given in Table 2.24.

Table 2.24. The five highest yielding lines across locations in different lentil screening nurseries, 1996/97.

Rank	LISN-L	LISN-S	LISN-SL	LISN-DT
1	Local large	FLIP 96-22L	FLIP 97-32L	FLIP 95-1L
2	FLIP 96-18L	FLIP 96-34L	FLIP 97-31L	FLIP 89-60L
3	FLIP 97-8L	FLIP 97-25L	FLIP 95-69L	FLIP 95-3L
4	FLIP 97-10L	FLIP 95-14L	FLIP 97-33L	FLIP 96-56L
5	FLIP 96-6L	FLIP 96-20L	FLIP 96-50L	FLIP 95-4L

The results of Lentil International F_3-Nursery Large (LIF_3N-L), F_3-Nursery Small (LIF_3N-S), F_3-Nursery Southerly

Latitudes (LIF_3N-SL), and F_3-Nursery Cold Tolerance (LIF_3N-CT) were received from 3, 2, 1 and 1 locations, respectively. The cooperators made individual plant selections for their use from these nurseries.

The results of Lentil International Cold Tolerance Nursery were received from 7 locations. At Annoceor in Morocco all the entries including the susceptible check were rated at 1 (on a 1-9 scale, where 1 = free and 9 = all plant killed). In the remaining other locations but at Hatay, the susceptible check was rated at 7 and above. At Sararood, Kohdasht and Taluqan several entries showed tolerance and resistance reactions. At Ulas and Haymana, where the susceptible check was completely knockdown, all entries were susceptible. At Hatay the response of the check was incongruous. The entries SLL, ILL 780 and SAZAK'91 were those that overall showed the best performances.

The results of Lentil International Ascochyta Blight Nursery were received from 2 locations, Marchouch and Sidiel. However, all the entries including the local susceptible check showed a reaction of 1 (on 1-9 scale, where 1=no infection and 9=all plants killed).

The results of Lentil International Rust Nursery were reported from 1 location, Pantnagar in India. All the test entries showed resistant reaction.

The results of Lentil International Fusarium Wilt Nursery were reported from 4 locations (Hudeiba in Sudan, Pieštǎny in Slovak, Jabalpur in India and Marchouch in Morocco). The local susceptible check was rated one at Marchouch, 3 at Hudeiba, 3 and 5 at Jubalpur and 7 and 9 at Pieštǎny. No entries were rated resistant neither tolerant at Pieštǎny.

(R.S. Malhotra, B. Ocampo, W. Erskine, A. Sarker, NARS Scientists)

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 of 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 third season of the reviewed faba bean programs.

The work plan of 1997/98 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 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.

With these aims the main results in 1997/98 season included:

3.1. Identification of New Resistant Germplasm.

3.1.1. Screening for Cold Tolerance and Ascochyta Resistance.

A nursery of 860 new selected families, previously selected for cold tolerance in Tel Hadya, compared with two checks (ILB 1814 and Giza 4) repeated each ten rows, was planted early (October 16) and exposed to artificial infection with *Ascochyta fabae*.

Results indicated that 191 lines were markedly tolerant to cold (Table 3.1) indicating the efficiency of selection for this character. Meantime 122 families exhibited variable levels of resistance to Ascochyta disease. Seed inspection of individual plants of each selected family showed high level of plants with seeds free from Ascochyta disease, this character was recorded and could be taken into consideration and used as one component of resistance to Ascochyta. In this respect 33 lines (Table 3.2) may have a mechanism to retard or prevent pathogen transmission process to the seed. Regarding this finding of screening the most promising lines represents:

1 line was highly resistant.

6 lines were resistant.

19 lines were moderately resistant.

7 lines combined resistance to Ascochyta and cold tolerance.

Table 3.1. Frequency distribution of selected families tested for cold tolerance at Tel Hadya, 1998.

	Rating for cold damage*					Total
	1	2	3	4	5	
No. of selections	191	202	338	126	3	860
%	22.2	23.5	39.3	14.7	0.4	

* Rating: 1 = high level of cold tolerance; 5 = highly susceptible to cold.
The average of the repeated local check (ILB 1814) = 3.
The average of the repeated susceptible check (Giza 4) = 5.

(S.Khalil, W. Erskine, C. Akem)

3.1.2. Screening for Ascochyta Resistance.

A screening nursery of 60 germplasm accessions was compared for Ascochyta resistance with three checks: Ascott (resistant check), Rebaya 40 (susceptible check) and Giza 4 (susceptible check and repeated each two lines) as disease spreader. The experiment was conducted in a randomized complete block design with three replicates. The tested entries were planted in pots 7 plants each. The plant materials, 75 days old, were subjected to artificial infection with a spore suspension of a single spore isolate of *Ascochyta fabae*. The whole nursery was grown under a plastic tunnel provided with a misting system to maintain high humidity, and avoid frost damage, over night.

Results of statistical analysis revealed highly significant differences among tested germplasm accessions. Six accessions Table 3.3 were rated less than the susceptible checks Rebaya 40 and Giza 4, and reacted similarly to the resistant check Ascott.

Table 3.2. Reaction of the most promising selections to *Ascochyta fabae* disease infection, % of plants with seed free from Ascochyta, and reaction to cold damage.

Selection No.	Pedigree	Origin	Reaction to Asco.	%of* H. Plants	Reaction to cold	
2593-2596/98	90ETA 277	Turkey	4	87.2	2	H.R
906-909/98	VF 123	Iraq	3	66.7	1	R.(A+C)
1094-1097/98	90ETA 266	Turkey	3	71.0	1	R.(A+C)
1909-1912/98	90ETA 400	Turkey	5	65.8	2	R
2126-2128/98	90ETA 207	Turkey	4	63.4	3	R
2427-2430/98	90ETA 218	Turkey	4	61.9	3	R
2801-2804/98	90ETA 333	Turkey	6	66.7	2	R
3195-3198/98	ERESEN 87	Turkey	4	68.4	1	R
3449-3450/98	S.Giant	Spain	5	68.0	3	R
90-93/98	G.2xBPL3437	Egypt	3	45.8	2	M.R
94-99/98	G.2xBPL3876	Egypt	3	54.2	2	M.R
429-433/98	G.2xBPL4640	Egypt	4	44.4	2	M.R
603-604/98	ILB1814	Syria	3	53.3	1	M.R.(A+C)
619-621/98	ILB1814	Syria	3	47.4	1	M.R.(A+C)
651-653/98	ILB1814	Syria	6	41.2	3	M.R
686-688/98	Aquadolce	Spain	4	46.7	1	M.R
760-761/98	Rebaya 40	Egypt	3	45.0	1	M.R.(A+C)
1098-1100/98	90ETA 266	Turkey	5	47.6	3	M.R
1593-1598/98	90ETA 334	Turkey	5	47.2	3	M.R
1770-1772/98	90ETA 400	Turkey	3	44.4	1	M.R.(A+C)
1783-1785/98	90ETA 400	Turkey	3	55.9	2	M.R
1814-1816/98	90ETA 400	Turkey	4	53.3	2	M.R
2020-2023/98	90ETA 400	Turkey	4	40.4	1	M.R
2209-2210/98	90ETA 207	Turkey	4	52.2	3	M.R
2865-2870/98	90ETA 389	Turkey	4	49.0	2	M.R
2959-2962/98	90ETA 389	Turkey	4	54.5	1	M.R
3081-3086/98	ERESEN 87	Turkey	5	43.1	1	M.R
3087-3090/98	ERESEN 87	Turkey	5	58.7	3	M.R
3186-3188/98	ERESEN 87	Turkey	3	51.3	1	M.R (A+C)
3212-3214/98	ERESEN 87	Turkey	5	48.1	2	M.R (A+C)
3260-3265/98	ERESEN 87	Turkey	5	51.3	3	M.R (A+C)
3270-3273/98	CS20DK	Ethiopia	4	41.4	1	M.R (A+C)
3349-3352/98	Aquadolce	Spain	4	42.5	1	M.R (A+C)
ILB1814	Loc.(check)	Syria	7	10.0	4	M.R (A+C)
Giza 4	Sus.check	Egypt	9	Nil.	5	H.S.

* No. of plants with seeds free from Ascochyta x 100
  Total number of plants of the selected family

Scale for Ascochyta, 1-9: where 1=highly resistant, 9=highly susceptible.

Scale of cold, 1-5: where 1=highly tolerant, 5=highly susceptible.

R, MR(A+C): Resistant or moderately resistant to Ascochyta and cold.

Table 3.3. Reaction of the resistant germplasm ascensions to *Ascochyta fabae*, screened under artificial infection under plastic tunnel at Tel-Hadya, 1997/98.

	Date of scoring			
Entry Name	5/4/98	16/4/98	5/5/98	21/5/98
S 96009	1.0	1.3	2.7	3.7
S 96010	1.0	2.0	3.0	3.7
ILB 3763-C	3.3	3.3	3.3	3.7
ILB 5851-B	2.0	2.3	3.3	3.7
ILB 3743-D	2.0	2.0	2.7	3.0
BPL 3011	1.3	2.3	2.3	3.7
Ascott	1.0	1.7	2.7	3.7
ILB 1814	2.0	3.3	4.0	4.3
R. 40	5.3	6.3	6.3	7.0
Giza 4	5.1	6.7	6.7	6.7
LSD .05	1.5	1.8	1.7	1.8
LSD .01	2.1	2.5	2.3	2.4
C.V.	33.9	27.5	22.4	21.3

(S. Khalil, W. Erskine, S. Kemal)

3.1.3. Screening for Bean Leaf Roll Virus (BLRV) Resistance in Faba Bean

During the 1997/98 growing season, 312 faba bean genotypes were evaluated for their reaction to a local isolate of BLRV (SV64-95) using artificial inoculation of the virus with its aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Ten plants of each genotype tested were planted in the field in one row (1.5 m long). Results obtained suggested that nine genotypes were not infected (BPL 1179, ILB 14, ILB 23, ILB 2524, ILB 2550, ILB 2565, ILB 2602, ILB 3596, ILB 4093) and nine genotypes had an infection level of 0.1-10% (ILB 265, ILB 2636, ILB 3396, ILB 3401, ILB 3591, ILB 4246, ILB 4327, ILB 4337, ILB 4344). During the next growing season, the best performing lines will be re-evaluated.

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

3.1.4. Screening for Chocolate Spot Resistance.

A nursery of 49 F_4 populations was grown and evaluated under natural infection with chocolate spot disease at Lattakia compared with one resistant (ICARUS) and one susceptible (Rebaya 40) checks, both repeated each 10 rows. More attention was paid to select individual plants, which combine early maturity with resistance to chocolate spot disease. In this respect a number 139 individual plants were selected on the bases of disease resistance, early maturity and seed characters.

(S. Khalil, M. Kabakibji)

3.1.5. Performance of New Germplasm for Cold Tolerance.

The main objective of this study was to evaluate the original imported breeding material from Turkey (10 entries) and four genetic resources from ICARDA compared with one Syrian local improved accession and one susceptible check to confirm the results of last year's (1996/97) screening.

One trial with 16 entries, in a *randomized complete* block design with four replicates was carried out at Tel Hadya. Planting took place in rows, three meters long with 45 cm between rows. Each plot received 90 seed to ensure 10 plants/m^2. The whole trial was sown twice: One planting in early October (16) and the other sowing late in December (15).

Results revealed highly significantly differences between tested materials. Results of early planting showed that the germplasm accessions "Reinablanca", Seville Giant, and 90 ETA 400 yielded 15.5%, 11.7% and 10% more than the improved Syrian local ILB1814, respectively, with no significant differences. On the other hand all the 15 accessions were highly significantly higher than the susceptible check Giza4. The average seed yield of these accessions was 2.90t/ha and this is in full agreement with that, previously estimated (2.20 t/ha) under heavy frost damage during 1996/97. Therefore these findings are of great importance for identification of new accessions adapted to early planting (mid October) which yielded more than three times of late planting (mid December) (Table 3.4).

Table 3.4. Performance of some faba bean promising accessions tested for cold tolerance at Tel Hadya, 1997/98.

Entry	Yield t/ha		Average
	Early	Late	
90ETA 207	2.52	0.85	1.68
90ETA 218	3.06	0.77	1.91
90ETA 266	3.11	0.97	2.04
90ETA 269	2.55	0.72	1.63
90ETA 277	3.11	0.88	1.99
90ETA 333	2.64	0.76	1.70
90ETA 389	3.05	0.81	1.93
90ETA 397	2.60	0.68	1.64
90ETA 400	3.20	0.67	1.93
90ETA 87	2.74	0.74	1.74
Aquadolce	2.82	0.75	1.78
S. Giant	3.25	0.53	1.89
R. Blanca	3.36	0.67	2.01
N. Mommoth	2.58	0.69	1.63
ILB 1814	2.91	0.94	1.92
Giza 4	0.63	0.10	0.36
Mean	2.76	0.72	1.74
LSD 0.05	0.52	0.18	
LSD 0.01	0.70	0.25	
C.V.	12.97	17.47	
Sowing date	16/10	15/12	

(S. Khalil, W. Erskine)

3.1.6. Regional Adaptation Trial.

The trial is one of five trials sent to Morocco, Tunisia, Egypt, Tajakistan, and Syria, to estimate the range of adaptability of 16 germplasm accessions across different environmental conditions. The experiment was conducted in RCB, with four replicates in Tel Hadya. Each experimental plot comprised 4 rows, 4 meters long and 45 cent between. The plot area was 7.2 m^2 and received 100 seed to ensure 14 plants/m^2. The trial was conducted in Tel Hadya and planted on December 4^{th}.

Results (Table 3.5) revealed highly significant differences. The Syrian local improved accession ILB 1814 ranked first and significantly exceeded all the other tested entries except FLIP 87-22-FB. ILB 1814 yielded 18.38% more than the local check cultivar "Hama 1".

From reviewing the above mentioned results of : early planting (October 16^{th}), regional adaptation trial (planted on December 4^{th}) and late planting trial (planting on Dec. 15^{th}), there are five germplasm accessions: Aquadolce (ILB 1266), New mommoth (ILB 1269), Reinablanca (ILB 1270), Seville Giant (ILB 1933) and ILB 1814, were tested in the three trials across the three sowing dates; it could be concluded that early planting using these cold tolerant accession was very promising (Table 3.6) to increase faba bean production.

Table 3.5. Average seed yield (t/ha), relative yield and ranking order of Faba bean entries evaluated in the regional adaptation trial at Tel Hadya, 1997/98.

Entry	Yield t/ha	Relative yield	Rank
FLIP 82-45-FB	1.79	96.8	6
FLIP 84-59-FB	1.78	96.2	8
FLIP 84-77-FB	1.82	98.4	5
FLIP 84-151-FB	1.79	96.8	7
FLIP 86-35-FB	1.65	89.2	14
FLIP 86-36-FB	1.71	92.4	11
FLIP 87-3-FB	1.49	80.5	15
FLIP 87-16-FB	1.76	95.1	9
FLIP 87-22-FB	1.97	106.5	2
FLIP 87-27-FB	1.83	98.9	4
ILB 1266	1.69	91.3	12
ILB 1269	1.67	90.3	13
ILB 1270	1.42	76.8	16
ILB 1933	1.72	93	10
ILB 1814	2.19	118.4	1
Hama 1 local check	1.85	100	3
Mean	1.76		
L.S.D. 0.05	0.34		
L.S.D. 0.01	0.46		
C.V.%	13.21		
Sowing date	4/12/97		

Table 3.6. Performance of five faba bean cold tolerant germplasm accessions under three different sowing dates Tel Hadya, 1997/98.

Germplasm Accession	Sowing dates			Mean
	Oct. 16	Dec. 4	Dec.15	
Aquadolce (ILB 1266)	2.82	1.69	0.75	1.75
Seville Giant (ILB 1933)	3.25	1.72	0.53	1.83
Reina Blanca (ILB 1270)	3.36	1.42	0.67	1.82
New Mommoth (ILB 1269)	2.58	1.67	0.69	1.65
Improv. S.L.L. (ILB 1814)	2.91	2.19	0.94	2.01
	2.98	1.74	0.72	
Mean	413.9	241.7	100.0	
Relative yield (%)				

(S. Khalil, W. Erskine)

3.2. Population Improvement.

A number of 79 new targeted crosses were remade to increase the frequency of desirable genes for early maturity and resistance to chocolate spot, ascochyta and *Orobanche* in targeted improved populations.

For the same purposes a number of 82 F_1 crosses were grown under the screen houses. By the end of July, the F_1 yield (F_2 seed) of each targeted group were mixed to provide the So seed of the genetic base of the following improved populations for:

a. Early maturity.
b. Resistance to chocolate spot disease.
c. Resistance to chocolate spot, *Orobanche* and ascochyta.
d. *Orobanche* resistance.
e. Autofertility.

(S. Khalil, W. Erskine)

3.3. Seed Multiplication.

Seeds required for the International chocolate spot disease (26 accessions) and *Orobanche* (15 accessions) nurseries were multiplied under the screen houses.

Seeds of 320 FLIPs and ILBs along with 400 determinate type families selected from different genetic resources were multiplied for distribution to NARs on request.

(S. Khalil)

3.4. New Imported Materials

A number of 46 faba bean breeding lines of varieties were imported from China (15), Sudan (6), Libya (8), Ethiopia (4) and Egypt (13), to be used as genetic resources for adaptability.

(S. Khalil)

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 pests. Drought is the major abiotic stress throughout the chickpea growing areas and cold assumes importance in Mediterranean environments and the temperate region especially for winter sowing. The kabuli chickpea is mainly grown as a rainfed crop in the wheat-based farming system in areas receiving between 350 mm and 600 mm annual rainfall in the West Asia and North Africa (WANA) region. In Egypt and Sudan, the crop is only grown with supplemental irrigation and in South Asia, West Asia and Central America, a small part of area is grown with supplemental irrigation.

In WANA, where the crop is currently spring-sown, yield can be increased substantially by advancing sowing date from spring to early winter. Winter sowing results in increased productivity and also allows the crop to be harvested by machine.

Major efforts are underway to stabilize chickpea productivity by breeding cultivars resistant to various stresses, such as the diseases (ascochyta blight and fusarium wilt), insect pest (leaf miner), parasite (cyst nematode), and abiotic stresses (cold and drought). The exploitation of wild *Cicer* species for transfer of genes for resistance to different stresses and widening the genetic base of chickpea are the areas receiving high research priority at the Center. DNA fingerprinting in *Ascochyta rabiei* is being pursued for mapping the pathogen variability in the region.

During 1998, 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. The project on development of kabuli chickpea for the Mediterranean Environments similar to West Australia and Izmir is carried out in collaboration with Aegean Agricultural Research Institute (AARI) Izmir, Turkey and Australian Council of International Agricultural Research (ACIAR) was initiated.

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 1998, 14805 samples of diversified chickpea materials were distributed to NARSs in 44 countries (Table 4.1). These materials included different international nurseries, specific genetic materials for research purposes, and improved elite lines requested by NARSs.

4.1.1.2. On-farm Trials in Syria

On-farm trials were conducted in many countries including Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Morocco, Syria, Tunisia, and Turkey. Some of the high yielding lines were identified for seed increases and registrations. The results of Chickpea On-farm trials in Syria are discussed in this section.

Four improved chickpea lines namely, FLIP 91-63C, FLIP 92-155C, FLIP 92-164C, and FLIP 93-93C, along with the improved check, Ghab 3 were included in the On-Farm trials. The Directorate of Agricultural and Scientific Research, Ministry of Agriculture and Agrarian Reform conducted these trials at 15 environments, during 1997/98. The seed yields at different locations are given in Table 4.2.

The seed yields were very high at Homs and all the entries yielded more than 3.6 tons/ha. Some of the locations including Bashkoy, Izraa, Taftanaz, Tarnab and Tel Hadya all entries gave much lower yields as compared to Al-Ghab, Idleb, Hama, Heimo, Homs, Lattakia, Skailbieh, Tartous and Yahmoul. All the entries gave seed yield in between 2.12 to 2.20 tons/ha but seed size was highest (35g/100 seed) for FLIP 92-164C which exhibited higher level of tolerance to Ascochyta blight and cold.

Table 4.1. Number of entries distributed in the form of international yield trials and specific nurseries in 1997/98.

Country	No. of sets Trial/nursery	No. of Entries	Breeding Lines (No.)	Total no. of Entries
Algeria	14	760	-	760
Australia	10	496	-	496
Azerbaijan	5	243	-	243
Bangladesh	1	63	-	63
Bhutan	4	218	-	218
Brazil	1	35	-	35
Bulgaria	2	76	-	76
Canada	6	266	34	300
Chile	1	35	-	35
China	1	63	-	63
Egypt	7	319	-	319
Ethiopia	11	543	-	543
France	10	496	-	496
Georgia	14	732	-	732
Greece	1	41	-	41
Hungary	5	259	-	259
India	9	405	-	405
Iran	16	872	22	894
Iraq	5	265	-	265
Italy	7	341	-	341
Jordan	4	158	1	159
Kazakhstan	6	278	4	282
Kuwait	1	41	5	46
Kyrghyztan	3	123	-	123
Lebanon	4	206	-	206
Lesotho	3	155	-	155
Libya	9	429	-	429
Mexico	8	414	-	414
Morocco	4	202	-	202
Pakistan	21	889	-	889
Palestine	3	123	-	123
Peru	2	76	-	76
Portugal	3	117	-	117
Romania	5	253	-	253
Russia	3	123	-	123
Saudi Arabia	1	51	-	51
Slovakia	2	126	-	126
South Africa	1	41	-	41
Spain	9	405	30	435
Sudan	3	167	-	167
Syria	31	1673	-	1673
Tunisia	13	653	-	653
Turkey	24	1128	287	1415
Yemen	1	63	-	63
Total	**294**	**14422**	**383**	**1480**

(R.S. Malhotra)

Table 4.2. Seed yield (kg/ha) and other traits of chickpea entries in the on-farm trials conducted jointly with the Directorate of Agriculture and Scientific Research, Syria and ICARDA during 1997/98.

	Seed yield (kg/ha)										
Entry	AlGhab	Bashkoy	Idleb	Hama	Heimo	Homs	Izraa	Izraa S.	Lattakia	Skailbieh	Taftanaz
FLIP 91-63C	3563	1095	2648	2686	2369	3803	1287	1125	2563	2977	965
FLIP 92-155C	3190	1038	2950	2733	2295	3621	1368	994	3026	2180	1189
FLIP 92-164C	3194	949	2657	2669	2450	3698	1330	966	2438	2714	957
FLIP 93-93C	3093	1114	3064	2628	2261	3778	1573	1042	1748	2900	1179
Ghab 3	3539	1064	3379	2582	1836	3669	1569	1201	1900	2447	1119
LSD	1439	353	1895	417	788	382	293	369	543	91	112
C.V. %	15.6	12	23	5.6	12.7	3.7	7.4	12.5	8.4	1.2	3.7

	Seed yield (kg/ha)										
Entry	Tartab	Tartous	Tel-Hadya	Yah-moul	Mean	100-SW(g)	PlHT (cm)	DFLR	DMAT	AB Score	Mean Cold score[a]
FLIP 91-63C	1321	3407	1295	1877	2198	33	61	127	177	5	3
FLIP 92-155C	1550	3200	1238	1988	2170	33	62	129	178	3	3
FLIP 92-164C	1441	3369	1232	1803	2124	35	62	128	177	3	2
FLIP 93-93C	1713	2745	1276	2383	2166	32	65	127	176	3	2
Ghab 3	1325	2911	1184	2087	2121	27	62	124	175	5	3
LSD	1516	1516	351	1517	126						
C.V. %	17	17.5	10	27	2.1						

PLHT = plant height; DFLR = days to flower; DMAT = days to mature; [a] Scale: 1-9, where 1 = free, 9 = killed

The entry, FLIP 91-63C with an overall seed yield of 2198 kg/ha ranked number 1 and was followed by FLIP 92-155C, FLIP 93-93C, and FLIP 92-164C.

As ascochyta blight and cold tolerance are the most important traits for winter-sown chickpea, the new line FLIP 92-164C with a larger seed size and relatively more tolerance to these stresses (Table 4.2). This trial will be conducted for 2 more seasons to have better idea about adaptation of the lines over a period of three years.

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

(NARS Scientists, R.S. Malhotra)

4.1.1.3. Pre-release Multiplication and Release of Cultivars by National Programs

A large number of lines have been chosen by different NARSs during 1997/98 from the chickpea materials supplied from ICARDA for on-farm testing and pre-release multiplication. We supplied small quantities of seeds of some of these lines as per request of NARSs for multi-location or on farm testing.

To date, NARSs in 22 countries have released 77 lines as cultivars from the improved germplasm furnished by ICARDA (Table 4.3).

(NARS Scientists, R.S. Malhotra)

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
	ILC 3279	1996	Blight resistance
Cyprus	Yialousa (ILC 3279)	1984	Tall, blight resistance
	Kyrenia (ILC 464)	1987	Large seeds
Egypt	Giza 88	1994	High yield under irrigation
	Line 195	1995	High yield under irrigation
	Giza 3	1999	High yield under irrigation
France	TS1009 (ILC 482)	1988	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
	Al-Wady (FLIP 86-6C)	1998	High yield, Large seeded
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

Country	Cultivars Released	Year of Release	Specific Features
	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)	1998	High yield, large seeded
	Matama-1 (FLIP 91-77C)	1998	High yield, irrig. conditions
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

4.1.2. Screening for Stress Tolerance

4.1.2.1. Fusarium Wilt

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. It is both soil-borne and seed-transmitted. Breeding for Fusarium wilt-resistance has been one of the main objectives in chickpea improvement. In this effort, the major bottleneck has been the presence of different races of the pathogen.

4.1.2.1.1. Cultivated Species

During 1997/98, 776 new lines were evaluated against Fusarium wilt in Fusarium wilt sick plot at Tel Hadya Syria. The results indicated that only 3 lines were resistant with 2 rating (with < 20% killing) and 11 lines were moderately tolerant with 3 rating on 1 to 5 scale (Table 4.4).

Another 332 lines were evaluated for the second time to confirm their reaction to Fusarium wilt. Out of these 48 lines were free from damage (rating 1), 89 lines were resistant/tolerant (rating 2) and 46 lines were moderately tolerant (rating 3) with 21-40% killing of plants.

The Chickpea International Fusarium Wilt Nursery (CIFWN) with 40 test entries, the fusarium wilt differential with 10 entries, and 599 entries from various preliminary and international yield trials were evaluated in the wilt-sick plot. The Fusarium wilt reaction of entries in CIFWN, wilt differential and yield trials (Table 4.4) showed that 28, 7, and 27 lines, respectively, were resistant (with rating 1 or 2).

Table 4.4. Reaction of chickpea lines to Fusarium wilt in Fusarium wilt sick plot at Tel Hadya, 1997/98.

		Type of material[a]				
Rating Scale	% of plants killed	Lines for reconfir-mation	New germplasm lines	CIFWN	Different-trial lines	PYT lines
1	0	48	0	23	4	2
2	1-20	89	3	5	3	25
3	21-40	46	11	2	0	49
4	41-60	81	42	7	1	94
5	61-100	68	720	3	1	429
Total		332	776	40	9	599

4.1.2.1.2. Segregating Material

The breeding material comprising 27 F_4 bulk populations and 474 F_5 progenies, were grown in wilt-sick plot for evaluation for Fusarium wilt resistance Table (4.5). Out of these 194 progenies in F_5 and 5 bulk populations in F_4 showed resistant reaction. One thousand three hundred and fifty individual plants were selected from F_4 bulks and 82 progenies from F_5 progenies were bulked (Table 4.5) for their increase and evaluation next season.

Table 4.5. Reaction of breeding materials to Fusarium wilt under Fusarium wilt-sick plot at Tel Hadya, 1997/98.

	Reaction on 1-9 scale					
Generation	1	2	3	4	5	Total
F_5 Progenies	0	194	108	111	61	474
F_4 Bulk	0	5	14	8	0	27
Total	0	199	122	119	61	501

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

4.1.2.2. 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 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 damage. 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 when infection is low from the debris.

4.1.2.2.1. Evaluation of Segregating Populations for Resistance to Ascochyta Blight

The reaction of F_2, F_4 and F_5 generations to the existing race populations of Ascochyta blight under field conditions at Tel Hadya is given in Table 4.6.

No progeny was rated 1 or 2. However, 184, 1247, and 1944 F_5 progenies were rated 3, 4 and 5, respectively, on a 1-9 scale with 1= free from damage. On the basis of agronomic traits and Ascochyta blight reaction, 504 progenies were bulked in F_5 for their increase and yield evaluation next season. From F_3 and F_4 bulks the individual resistant plants were selected for further evaluation.

Table 4.6. Reaction of breeding materials in F_2, F_3, F_4 and F_5 generations to Ascochyta blight at Tel Hadya, 1997/98.

	Scale (1-9)									
Generation	1	2	3	4	5	6	7	8	9	Total
F_5 Tall	0	0	0	184	157	45	1	1	1	389
F_5 Large	0	0	2	37	150	470	115	22	4	800
F_5 Early	0	0	23	210	301	429	102	13	2	1080
F_5 general	0	0	159	816	1336	1858	288	37	15	4509
F_4 Bulk	0	0	8	13	12	4	5	0	0	42
F_3 Bulk	0	0	6	17	19	26	14	1	0	83
F_2 Bulk	0	0	5	24	9	12	12	1	0	63
Total	0	0	203	1301	1984	2844	537	75	22	6966

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.

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

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

Seven hundred and seventy two lines included in different yield trials and nurseries were evaluated for reaction to Ascochyta blight in the Ascochyta blight nursery in the field (Table 4.7).

None of the lines exhibited 1 or 2 rating. However, 477 and 75 lines with rating of 3 or 4, were resistant or moderately resistant.

4.1.2.2.3. 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, 9 (FLIP 94-508C, FLIP94-509C, FLIP 94-510C, ICC3912, ICC 3919, ICC 3991, ICC 4475, ICC 12004, ICC 13729, and ICC 149003), 28, 8, and 5 had a rating of 2, 3, 4, and 5, respectively. In general the severity of ascochyta blight infection was much less as compared to the previous year.

Table 4.7. Reaction of elite breeding lines to Ascochyta blight in different trials at Tel Hadya, 1997/98.

	Disease Reaction on 1-9 scale									
Trial Name	1	2	3	4	5	6	7	8	9	Total
CIYT-W-MR	0	0	16	6	0	0	0	0	0	22
CIYT-SPR	0	0	18	4	0	0	0	0	0	22
CIYT-SL1	0	0	15	5	0	2	0	0	0	22
CISN-W	0	0	33	7	1	0	0	0	0	41
CISN-SPR	0	0	40	6	1	0	0	0	0	47
CISN-SL1	0	0	36	3	2	2	0	0	0	43
PYT	0	0	319	44	27	55	75	35	20	575
Total	0	0	477	75	31	59	75	35	20	772

4.1.2.2.4. Reaction of Breeding Materials in the Gene Pyramiding Project

In the gene-pyramiding project to combine sources of resistance to Ascochyta blight, resistant parents with diverse origins were crossed. Nine F_4 progenies, 993 F_5 progenies, and 98 F_7 progenies were grown under field conditions for evaluation for Ascochyta blight reaction. The results (Table 4.8) revealed that 83 progenies in F_7, 492 progenies in F_5, and 7 progenies in F_4 were resistant (with 2 or 3 rating), and another 2 progenies in F_4, 226 in F_5 and 9 in F_7, were tolerant to Ascochyta blight (rating=4).

Table 4.8 Reaction of segregating populations/lines to Ascochyta blight in pyramiding of genes (resistant x resistant crosses) at Tel Hadya, 1997/98.

	Reaction on 1-9 scale									
Generation	1	2	3	4	5	6	7	8	9	Total
F_7 Progenies	0	19	64	9	3	1	0	1	1	98
F_5 Progenies	0	62	430	226	172	88	15	0	0	993
F_4 Progenies	0	0	7	2	0	0	0	0	0	9
Total	0	81	501	237	175	89	15	1	1	1100

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

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

4.1.2.2.5. Screening for Resistance to Pathotype III of Ascochyta Blight Pathogen under Controlled Conditions at Tel Hadya

Research in the ICARDA Biotechnology laboratory has classified *A. rabiei* isolates into 3 groups based on their reactions to a set of differentials. Pathotype-3 is the most virulent of these 3 pathotype groups. Most of the advanced germplasm has been screened only for resistance to the less virulent pathotypes 1 and 2. To identify lines with resistance to pathotype-3, a set of 440 breeding lines selected for their resistant reactions to Ascochyta blight were arranged on benches in a complete randomized design in 3 replications. A row of the susceptible check, ILC 263, was planted after every 5 test-row entries. The 4 weeks old seedlings were spray-inoculated with an isolate of pathotype-3. The pots were then covered with transparent plastic for 48 hours for development of infection. Four weeks after inoculation, the reaction to Ascochyta blight was recorded. Sixty-one lines were selected as moderately resistant to pathotype-3 with ratings between 4 and 5. Among these, the following lines had the least disease reactions: ICC 12004, ICC 4475, FLIP 93-2, FLIP 93-62, ICC 13729, FLIP 94-33 and FLIP 94-67. None of the entries received a rating of less than 4. Most of the lines were highly susceptible. The moderately resistant lines will be confirmed for their reactions in the coming season when more entries are screened for resistance to this aggressive pathotype.

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

4.1.2.3. Cold Tolerance

Cold tolerance is one of the most important pre-requisites for writer-sown chickpea. Even for spring-sown crop cold tolerance at early seedling stage is important. Efforts have been under way since the initiation of chickpea project and breeding for cold tolerance is the integral part of the chickpea improvement work at ICARDA.

4.1.2.3.1. Cultivated Species

During 1997/98 season progenies from interspecific crosses in F4, F5, F6, F7, F8, and F9 generations were grown in autumn for evaluation for cold tolerance under field conditions. The season was very mild with respect to cold and all the breeding material in different generations exhibited cold tolerance with rating ≤ 4.

Forty-seven test entries of different origin were also tested in Chickpea International Cold Tolerance Nursery. The season was mild and the evaluation details were not worth reporting.

4.1.2.3.2. Wild Species

Different accessions from three wild *Cicer* species were grown for confirmation of their tolerance to cold. As the season was mild no useful inferences for cold tolerance were drawn.

(R.S. Malhotra)

4.1.2.4. 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 544 new germplasm lines were evaluated this season, and only 69 of these lines with rating 3 were drought tolerant (Table 4.9). Another 40 lines in Chickpea International Drought-Tolerant Nursery (CIDTN) were evaluated for drought tolerance and 20 lines with rating 3, were drought tolerant.

Two hundred and fifty three lines selected on the visual score during 1997 were evaluated for confirmation of drought tolerance during 1998. Forty-five of these entries were resistant and 177 were moderately tolerant (Table 4.9). Such lines will be used for further exploration for breeding for drought tolerance.

Table 4.9. Evaluation of CIDTN-98 and chickpea germplasm lines for drought tolerance at Tel Hadya, 1998.

Germplasm	Visual score*									Total
	1	2	3	4	5	6	7	8	9	
CIDTN-98	0	0	20	0	19	0	1	0	0	40
Resistant sources	0	0	44	0	177	0	32	0	0	253
Total	0	0	69	0	301	0	149	0	25	544

*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.

(R.S. Malhotra, C. Johansen)

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. Thirty-four test entries along with two checks were tested for biomass yield and other agronomic characters during 1997/98 at Tel Hadya and Terbol. The biomass ranged from 5192 to 7505 kg/ha at Tel Hadya and 4694 kg/ha at Terbol. The results of some of the high yielding entries with high biomass and some other important traits are presented in Table 4.10.

Table 4.10. Seed yield (SYLD), biomass (BYLD), plant height (PTHT), 100-SW, and harvest index (HI) of the high yielding lines in PYT-Biomass at Tel Hadya and Terbol, 1997/98.

		Seed yield (kg/ha)			Biomass yield (kg/ha)					
Entry	Pedigree	Tel Hadya	Terbol	Mean	Tel Hadya	Terbol	Mean	PTHT (cm)	100-SW (g)	HI (%)
S 97042	X94TH157	2805	2184	2495	7162	5531	6347	64	30	39.3
S 97048	X94TH157	2792	2429	2611	7505	6306	6906	66	31	37.8
S 97050	X94TH157	2507	2429	2468	7062	5980	6521	66	31	37.8
S 97051	X94TH158	2527	2939	2733	6543	6490	6517	65	36	41.9
S 97057	X94TH159	2740	2612	2676	6402	5735	6069	57	32	44.1
S 97062	X94TH159	2814	2735	2775	6639	5755	6197	55	34	44.8
S 97063	X94TH159	2709	2694	2701	6871	6143	6507	68	35	41.5
S 97064	X94TH159	2733	2714	2724	6360	5816	6088	59	31	44.7
S 97066	X94TH159	2549	2796	2672	5813	5633	5723	62	32	46.7
S 97068	X94TH159	2965	2931	2948	6904	6441	6673	65	33	44.2
S 97070	X94TH159	2690	3000	2845	6764	6469	6617	66	35	43.0
S 97071	X94TH160	2527	2694	2610	6659	6367	6513	66	39	40.1
S 97073	X94TH160	2616	2510	2563	6715	5918	6317	68	35	40.6
S 97074	X94TH160	2561	2796	2679	6427	6204	6316	67	34	42.4
Mean		2517	2501		6439	5627				
C.V.		8.5	12.6		7.0	9.2				
LSD (at P=0.05)		380.5	640.1		801.3	1053.0				

4.1.3.2. Improvement in Seed Yield in the Cultigen

Four hundred and thirty one newly-bred lines were evaluated in nine preliminary yield trials (PYTs) in winter and 472 lines were evaluated in nine trials in spring at Tel Hadya and Terbol. Several lines were numerically superior to the check-ILC 482 (the check in winter) and ILC 1929 (the check in spring) in seed yield. But the seed yields of only 51 lines at Tel Hadya and 28 lines at Terbol were significantly superior to check in winter. Among the spring-sown trials, 47 lines at Tel Hadya and 3 lines at Terbol, were significantly superior to the check (Table 4.11).

In general, the seed yields were good both for winter and spring planting in 1997/98 season. The winter-sown chickpea produced 88% more seed yield than the spring-sown chickpea at Tel Hadya, and 84% more at Terbol, with an overall increase of 86%. On the basis of overall mean seed yield for these locations for the last fifteen years, winter sowing gave 70% increase over spring sowing (Figure 4.1).

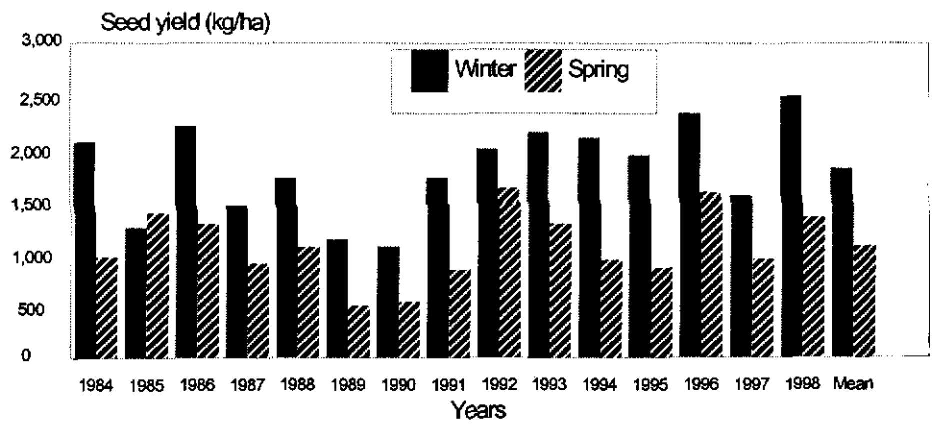


Figure 4.1. Mean seed yield (kg ha^{-1}) of chickpea grown in winter and spring at three locations (Tel Hadya, Jindiress and Terbol) in eleven years (1984-94) and two locations (Tel Hadya and Terbol) in the last four years (1995-98).

(R.S. Malhotra)

Table 4.11. Performance of newly developed lines under winter and spring-sown conditions at Tel Hadya and Terbol, 1997/98.

		No. of entries			Seed yield (kg/ha)		Range for	
Location and season	No. of trials	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	9	431	154	51	2440	3286	9-15	380-655
-Spring	9	472	93	47	1295	2053	12-24	323-541
Terbol								
-Winter	9	431	122	28	2558	3352	10-19	504-879
-Spring	9	472	41	3	1391	1978	8-22	334-645

4.1.3.3. Cyst Nematode Resistance

Earlier studies on evaluation of a large number of accessions of the cultigen for resistance to cyst nematode in collaboration with the Institute of Nematology at Bari, Italy revealed absence of resistance in the cultivated species. The evaluations of wild *Cicer* accessions, however, revealed that 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. Some of the derived lines from these crosses have tolerance to cyst nematode but they have small and dark-colored seeds. Efforts are being made to improve their seed quality.

During 1997/98, 5106 plants in various segregating generations were screened for cyst nematode resistance under controlled conditions in the plastic house at Tel Hadya (Table 4.12). Two hundred and thirty plants in F_3, 167 plants in F_4, 402 plants in F_5, and 579 plants in F_6 that showed resistance behavior (0 to 2 rating) were selected.

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

4.1.3.4. Interspecific Hybridization and Improvement in Cold Tolerance:

A large number of breeding materials in different generations was sown in autumn for evaluation for cold tolerance. As the season was very mild with little cold damage evaluation was not done.

Table 4.12. Reaction of plants from interspecific crosses in F_3, F_4, F_5 and F_6 generations to cyst nematode in the greenhouse at Tel Hadya, 1997/98.

Generation	Cross no.	Parents	Scale[1]						
			0	1	2	3	4	5	Total
F_3	X 96TH127	Sel.95Tr. 35-3-1 X FLIP 84-92C	0	10	28	202	29	4	273
	X 96TH128	Sel.95Tr. 37-1-1 X FLIP 82-150C	4	64	74	602	105	6	855
	X 96TH129	Sel.95Tr. 37-1-4 X FLIP 88-85C	0	5	17	269	96	10	397
	X 96TH130	Sel.95Tr. 47-1-1 X FLIP 93-186C	0	7	21	162	31	13	234
	Total		4	86	140	1235	261	33	1759
F_4	X 95TH112	FLIP 84-92C X ILWC 292	0	8	49	67	12	0	136
	X 95TH113	FLIP 82-150C X ILWC 292	0	19	75	70	0	0	164
	X 95TH114	FLIP 88-85C X ILWC 292	0	1	15	14	0	0	30
	Total		0	28	139	151	12	0	330
F_5 Backcross	X 94TH186	(ILC 482XILWC 292)XILC 482	4	109	278	625	147	15	1178
	X 94TH187	(ILC 482XILWC 292)XILC 482	0	0	11	23	1	0	35
	Total		4	109	289	648	148	15	1213
F_6 Backcross	X 94TH188	(ILC 482XILWC 292)XILC 482	13	211	315	900	279	10	1728
	X 94TH189	(FLIP87-69CXILWC292)XFLIP87-69C	0	8	33	33	2	0	76
	Total		13	219	347	933	281	10	1804

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

4.1.4. 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 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 1998/99 season is given in Table 4.13.

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 1996/97 international nursery results, received from cooperators are presented here. It should be noted that the 1996/97 trials are the most up-to-date data returned by cooperators. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

The Chickpea International Yield Trial-Spring (CIYT-SP) was distributed to 47 locations in 19 countries but the field data were received from 21 locations in nine countries. The trial at three locations was planted in winter thus these locations were excluded from the overall analysis. The grand mean across locations was of 1420 kg/ha. The test entries FLIP 94-61C, FLIP 93-58C, FLIP 94-88C, and FLIP 93-166C, exceeded the local check by 10%. The location mean varied from 227 kg/ha in Sararood (Iran) to 2966 kg/ha in Homs (Syria). In all locations but in

Sararood, Maragheh, and Izraa, there were test entries which statistically outyielded the local check. Eighteen 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 4.14). The entry FLIP 94-61C had above average mean, regression coefficient (b) close to 1, and deviations from regression equal to zero. Thus this entry was generally adapted across environments. However, FLIP 93-182C, FLIP 93-166C, FLIP 93-176C, FLIP 94-8C, and FLIP 93-144C had above average mean seed yield, regression coefficient exceeding unity, and deviation from regression statistically equal to zero, and were thus responsive to high yielding environments. The entry FLIP 94-88C had above average mean seed yield, regression coefficient less than unity, and deviation from regression statistically equal to zero, and thus responsive to poor yielding environments.

Table 4.13. Distribution of Chickpea Nurseries to Cooperators in 1998.

International Trial/Nursery	No. of sets
Screening Nursery Winter (CISN-W-99)	43
Screening Nursery Spring (CISN-Sp-99)	42
Screening Nursery, South. Latitudes-1(CISN-SL1-99)	8
Screening Nursery, South. Latitudes-2(CISN-SL2-99)	7
Screening Nursery, Latin America (CISN-LA-99)	11
F_4 Nursery, Mediterranean Region (CIF_4N-99)	36
Ascochyta Blight Nursery: Kabuli (CIABN-99)	47
Fusarium Wilt Nursery (CIFWN-99)	32
Cold Tolerance Nursery (CICTN-99)	32
Drought Tolerance Nursery (CIDTN-99)	40
Total	298

The Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-WMR) was distributed to 22 countries (57 locations) but field data were received from 12 countries (28 locations). However, the overall seed yield entry means were calculated from 23 locations, as in five locations the trial was not planted in winter. This nursery comprised 23 test entries, one long term check (ILC 482), and one local check. Overall, the grand mean across locations was of 2255 kg/ha. The mean of the long term check was 1838 kg/ha and that of the local check 2108 kg/ha. The test entries FLIP 92-155C, FLIP 93-186C, FLIP 93-174C, FLIP 92-164C, FLIP 93-146C, FLIP 93-181C, FLIP 92-169C, FLIP 93-93C, FLIP 94-100C, FLIP 92-162C, FLIP 94-89C, FLIP 94-35C exceeded the local check by 10%, and FLIP 92-155C (2556 kg/ha), FLIP 93-186C (2532 kg/ha), FLIP 93-174C (2528 kg/ha) by 20%. The location mean varied from 387 kg/ha in Oued Smar (Algeria) to 4789 kg/ha in Homs (Syria). In all locations, but in Sararood, Izraa, Jellin, Homs, Hama, Idleb, and Tartous, there were test entries which statistically outyielded the local check.

The results of the stability analysis revealed that both linear and non-linear portions of entry x environment (GxE) interaction were highly significant (Table 4.14). No entries were found adapted across environments. However, FLIP 92-155C, FLIP 92-164C and FLIP 92-169C had above average mean seed yield, regression coefficient exceeding unity, and deviation from regression approaching to zero, and were 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.

Table 4.14. ANOVA for stability parameters for seed yield for the entries in CIYT-SP and CIYT-W-MR conducted during 1996/97

	CIYT-SP		CIYT-W-MR	
Source of variation	Df	MS(x10)^3	Df	MS(x10)^3
Entry	23	235.143**	23	1073.232 **
Entry x Location (Linear)	23	152.599**	23	473.542 **
Pooled deviation	384	67.687**	504	194.558 **
Pooled error	864	34.154	1104	62.452

** Significant at $P \leq 0.01$

The Chickpea International Yield Trial Southerly Latitudes-1 (CIYT-SL1) was distributed to 7 countries (8 locations). However, field data were received from Ludhiana (India) only, but due to late sowing and heavy wilt infestation this location was not included in the report. This nursery comprised 22 test entries, one improved check FLIP 82-150C, one long term check (ILC 482), and one local check.

The Chickpea International Yield Trial Southerly Latitudes-2 (CIYT-SL2) was distributed to 8 countries (10 locations) but field data were received from Hudeiba (Sudan) and Tel Hadya (Syria). However, only Hudeiba is located in southerly latitude. This nursery comprised 22 test entries, one improved check FLIP 82-150C, one long term check (ILC 482), and one local check. The grand mean was of 1107 kg/ha. The means of the improved check, the long term check and the local check were respectively: 80, 1068, and 1882 kg/ha. All the test entries were outyielded by the local check.

The data on days to flowering varied from 40 to 86 days. Most entries were not adaptable to this location. Overall, the entries with the shortest days to flowering were also the more productive.

The Chickpea International Yield Trial Latin America (CIYT-LA) was distributed to 7 countries (12 locations) but field data were received from Celaya (Mexico) and Tel Hadya (Syria). However, only Celaya is located in Latin America. This nursery comprised 22 test entries, one improved check (FLIP 85-5C), one long term check (ILC 464), and one local check. The grand mean was of 689 kg/ha. The means of the improved check, the long term check and the local check were respectively: 497, 461, and 595 kg/ha. Thirteen test entries exceeded the local check by 10%, and seven by 20%. As regards the trait 100-seed weight, the means of the improved check, the long term check and the local check were respectively: 47, 45, and 36 grams. Nine test entries exceeded the local check by 10%, and five by 20%: ILC 464 (47 g), FLIP 84-15C (47 g), FLIP 85-5C (45 g), FLIP 87-90C (44 g), and FLIP 89-4C (43 g).

The data on seed yield of Chickpea International Screening Nurseries -Winter (CISN-W), -Spring (CISN-SP), -Southerly Latitudes-1 (CISN-SL1), and -Latin America (CISN-LA) were reported from 23, 20, 3, and 2 locations, respectively. Some of the test entries exceeded the local check by significant margins at 10, 8, 1, and 1 locations, in CISN-W, CISN-SP, CISN-SL1, and CISN-LA respectively. The five heaviest yielding entries across locations for these nurseries are given in Table 4.15.

Table 4.15. The five heaviest seed yielding lines across locations in different chickpea international screening nurseries, 1996/97.

Rank	CISN-W	CISN-SP	CISN-SL1	CISN-LA
1	S 95257	S 95307	S 95101	S 95145
2	S 95379	S 95082	S 95407	S 95146
3	S 95345	S 95338	S 95401	F 94-53C
4	F[a] 94-50C	ILC 482	F 94-62C	ILC 464
5	S 95348	F 94-56C	S 95086	F 94-36C

[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 18 and 5 locations. Cooperators from nine locations for CIF_4N-MR, and for one location (New Delhi) for CIF_4N-SL reported the usefulness of these nurseries under their environmental conditions. Overall, all populations have been selected in CIF_4N-MR. In this nursery the most frequently selected populations were in the order: x94TH143, x94TH60, xTH7, xTH55, and xTH56, selected respectively in 9, 8, 7, 7, and 7, locations. In CIF_4N-SL all populations have been selected.

The Chickpea International Ascochyta Blight Nursery-A (CIABN-A) was distributed to 14 countries (29 locations) and scores were received from three countries (three locations). This nursery comprised 40 kabuli type test entries plus one check repeated each two-test entries.

The Chickpea International Ascochyta Blight Nursery-B (CIABN-B) was distributed to 10 countries (21 locations) and results were received from three countries (six locations). This nursery comprised 40 kabuli and 10 desi type test entries plus one susceptible kabuli check repeated each two test entries. None of the entries (kabuli or desi) showed a desirable level of reaction to Ascochyta blight (rating $\leq$ 5 on 1-9 scale) across all locations. Overall, the entry FLIP 92-155C was the best, showing tolerant reaction at six out of seven valid locations (locations were the susceptible check was killed by the fungus), followed by FLIP 91-61C, FLIP 91-196C and FLIP 93-128C. Among chickpea desi entries, FLIP 94-509C was the best showing tolerant reaction at four out of six locations. The differential reaction of lines at various locations suggests variability in the pathogen. This nursery has been very useful in the identification of resistant sources to ascochyta blight.

The Chickpea International Drought Tolerant Nursery (CIDTN) was distributed to 24 countries (42 locations) but results were received from four countries (seven locations). However, valid data were extracted from three locations only. This nursery comprised 40 kabuli test entries plus one susceptible check repeated each two-test entries. Drought tolerance was scored on 1-9 scale (where 1 = free from damage, and 9 = killed or no yield) and the lines with rating ≤ 5 were scored as tolerant. Eleven lines were tolerant to drought at all the locations. The most drought tolerant entries were ILC 2516 and ILC 3832, followed by ILC 2537, FLIP 87-58C and FLIP 87-59C.

The Chickpea International Fusarium Wilt Nursery (CIFWN) was distributed to 17 countries (28 locations) but results were received from four countries (five locations). However, only in Ludhiana and at Tel Hadya the disease was uniformly spread in the experimental area. This nursery comprised 40 kabuli test entries plus one susceptible check repeated each two-test entries. Twelve entries were scored as resistant (≤ 20% plants killed) at all the locations. FLIP 88-1C showed the highest levels resistance, followed by FLIP 92-113C, FLIP 92-140C, FLIP 93-28C, FLIP 93-54C, FLIP 93-55C and ICCV 2.

The Chickpea International Cold Tolerance Nursery was distributed to 17 countries (28 locations) but scores were received from three countries (five locations). However, uniform experimental condition for screening was possible in three locations only. This nursery comprised 50 kabuli test entries plus one susceptible check repeated each two-test entries. Twenty-four entries showed a desirable reaction (5≤ on 1 to 9 scale, where 1 = free, 9 = killed). The most cold tolerant entries were FLIP 93-258C, FLIP 93-259C, FLIP 93-260C and Sel 93TH24416 with an average reaction of less than 3. All the aforementioned lines are derived from hybrids with *C. reticulatum* ILWC 182.

(B. Ocampo, R.S. Malhotra, NARS Scientists)

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

Chickpea (*Cicer arietinum* L.) is an important grain legume, which has a worldwide acceptance as one of the major source of proteins for human as well as for animal consumption. Much of its productivity is adversely affected by damage caused by *Didymella rabiei* and particularly, in some environments, by the Pathotype III. High level of resistance towards this group of isolates is not available in the cultigen. ICARDA-Italy project aimed at (i) studying and characterizing the genetic variability of *D. rabiei;* (ii) identifying new sources of resistance in collection of wild relatives maintained at ICARDA and at transferring them into the cultigen; (iii) transferring these antifungal agents from wild to the cultigen (*C. arietinum*) by genetic transformation.

4.1.5.1. Characterization of Variability of Ascochyta Blight Pathogen

The variation in several biochemical and bio-molecular aspects of a collection of *D. rabiei* isolates was investigated at IspaVe in Italy. A total of 32 single-spore isolates of *D. rabiei*, representing Italy, Syria, Australia, the USA was grouped into three pathotypes, with increasing degrees of virulence: Pathotype I (31%), Pathotype II (41%) and Pathotype III (28%) in the greenhouse. The distribution of the Italian isolates tested within the two mating types was 54% for *MATI-1* and 46% for *MATI-2*, in contrast with previous investigation in which *MATI-2* was very rare.

In order to obtain specific genetic markers for *D. rabiei*, DNA polymorphism of 29 isolates have been determined by RAPD analysis using ten-base primers (Operon-Technologies Inc.). A high degree of genetic variability was observed among isolates of *D. rabiei* population. There was no association between RAPD cluster group and different geographic origins, pathotypes and mating types. The same sets of isolates were characterised by isozyme analysis, and polymorphism was detected in esterase, acid phosphatase, malate dehydrogenase, pectic lyase and xylanase banding patterns. No correlation was found between these biochemical markers and any of the characters examined. In order to explore the intra-specific variability of *D. rabiei* other polymorphic enzymes are under study.

4.1.5.2. Screening for Resistance to Ascochyta Blight

Two hundred and fifty one accessions of *Cicer* species were artificially inoculated by spraying a conidial suspension ($2x10^5 \cdot ml^{-1}$) of the isolates of Pathotype III of *D. rabiei* under controlled conditions at IspaVe in Italy. Highly resistant accessions of *Cicer* were mainly identified within *C. bijugum C. judaicum* and *C. pinnatifidum*. Some of these including, ILWC 76, ILWC 186, and ILWC 150 were also characterized by combined resistance to ascochyta blight and fusarium wilt. Chickpea breeding program could benefit from these results by transferring this resistance into the cultigen. From the compatible interspecific crosses (*C. arietinum* x *C. echinospermum* and *C. arietinum* x *C. reticulatum*, and reciprocals) four F_4 families were grown, under field conditions in Viterbo for evaluation for resistance to Ascochyta blight where no disease was observed. The following numbers of progenies coming from single F_3 plants were selected:

33 from *C. arietinum x C. echinospermum*;
28 from *C. echinospermum x C. arietinum*;
16 from *C. arietinum x C. reticulatum*;
12 from *C. reticulatum x C. arietinum*.

The progenies were analyzed for plant habit and height, flowering and ripening times, flower color, number of pods and seeds/plant, seed weight, aspect of the grain (shape, color, etc.).

4.1.5.3. Reaction of Inter-Specifically Derived Selections to Ascochyta Blight

Advanced lines derived by crossing the chickpea ILC 482 with ILWC 179 (*C. echinospermum*) and ILWC 124 (*C. reticulatum*) which produced higher yield than the cultigen parent were tested for their reaction to ascochyta blight under Italian and Syrian conditions. All were susceptible under Tel Hadya conditions but the progenies from these crosses showed variable response to Italian isolates of 3rd pathogenic group of Ascochyta blight pathogen. Under Italian conditions, a line AE63 from a cross between ILC 482 X ILWC 179 was significantly superior in resistance when compared against ILC 482 (Table 4.16). This might be due to transgressive segregation following interspecific hybridization in *Cicer* species.

Table 4.16. Reaction of Elite Lines Derived by Crossing cultigen with *C. echinospermum* and *C. reticulatum* at ENEA (Rome)

Genotype	No. of plants	Score(scale 0-5)[a]
RA90	14	3,79 + 1,12
AE51	15	3,27 + 0,94
AE126	13	3,00 + 0,41
ILC 482	19	2,08 + 0,56
AE49	12	4,67 + 0,62
AE80	18	3,03 + 0,83
RA53	19	1,68 + 0,89
AE63	18	1,19 + 0,64
RA82	8	2,75 + 0,38
RA86	16	2,03 + 0,53
AE55	19	3,34 + 0,83
AE41	13	3,23 + 0,88

0= no disease, 5= killed.
RA = *C. reticulatum* (ILWC 124) x *C. arietinum* (ILC482).
AE = *C. arietinum* (ILC 482) x *C. echinospermum* (ILWC 179).
a = means and standard deviation.

4.1.5.4. Interspecific Hybridization in Genus *Cicer*

Interspecific hybridization was attempted both at Tel Hadya in Syria and at Italian Institutions. Out of a total of 1,618 hybridizations among *C. arietinum* and wild relatives made in Italy, only 5% produced pods; cross-combinations with *C. echinospermum*, used as bridge species, were also included in this figure. By fluorimetric analyses, incompatibility barriers to interspecific hybridizations were not evident at both stigmatic and stylar level. Pollen grain of incompatible species germinated and penetrated the stigma 24 hrs after pollination and the foreign pollen tube grew down the style. Histological analyses carried out on fertilized ovaries confirmed once more the occurrence of post-zygotic barriers in all hybridization cases. A globular embryo was evident until 6th day, when endosperm degeneration started. Six to eight days after pollination the embryo started collapsing. So far eight different media were tested to rescue embryos but additional effort is still necessary to identify the best conditions for *in vitro* culture of immature embryos. So studies on embryo rescue technique are still in progress.

Interspecific crosses were attempted at ICARDA between three desi lines (GL 769, GLG 84038, and PBG-1), and three accessions from each of the wild *Cicer* species namely *C. bijugum* (ILWC 42, 70 and 260), *C. judaicum* (ILWC 165, 197 and 256), and *C. pinnatifidum* (ILWC 9, 248 and 250). In addition these desi accessions were also crossed with segregating population of a cross between *C. arietinum* x *C. reticulatum*. These accessions of wild *Cicer* species possess valuable traits for the genetic improvement of the cultigen including resistance to ascochyta blight. Out of 1592 pollinations made we succeeded in getting about 182 seeds from the crosses. The highest percentage of putative hybrid seeds was obtained from the crossing between *C. arietinum* and *C. judaicum* (28.9%), and was followed by 9.0% with *C. arietinum* and *C. bijugum*, and 8.1% from and *C. arietinum* X *C. pinnatifidum*. These crossed seeds are being evaluated for confirmation of their hybridity.

4.1.5.5. Polyploidy in Genus *Cicer*

An attempt was made at ICARDA to produce autotetraploids of chickpea cultigen (*C. arietinum*) and three annual wild relatives, *C. bijugum*, *C. judaicum*, and *C. pinnatifidum* to use this material as a bridging species in interspecific hybridization. The plant material used included two accessions each of *C. arietinum* (FLIP 82-150C and FLIP 90-96C), *C. bijugum* (ILWC 42 and ILWC 260), *C. judaicum* (ILWC 174 and ILWC 189), and *C. pinnatifidum* (ILWC 249 and ILWC 153). The seeds were soaked in sterilized distilled water for 2 ½ hrs and were later treated with a 0.05% aqueous colchicine solution with a few drops of a detergent (Tween 100) for five hours. The seeds were then put in petri dishes on a moist filter paper at room temperature for germination. These were later transferred to Jiffy pots and at the seedling stage most of the material was transplanted in the field.

These plants exhibited some morphological aberrations which affected branching (number of primary branches), leave (broader and thicker lamina) and flowers (especially the reproductive organs) and seed set. The variation in seed set may be due to meiotic irregularities. Meiotic analyses indicated the presence of both diploids (2n=2x=16) and autotetraploids plants (Figures 4.2 & 4.3). Meiotic divisions were mostly regular. Bridge formations, laggards and univalents were the most frequent of the meiotic aberrations (Fig 4.2).

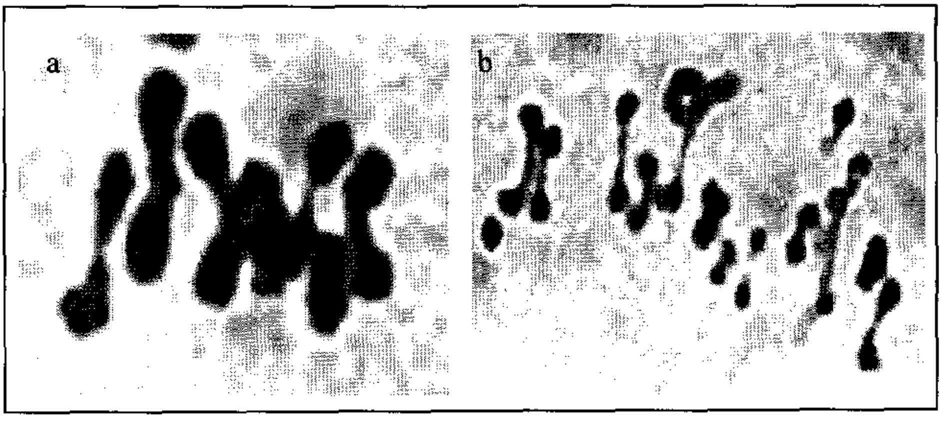


Fig 4.2. Metaphase I of diploid (a) and auto-tetraploid (b) *C. arietinum* FLIP 82-150C

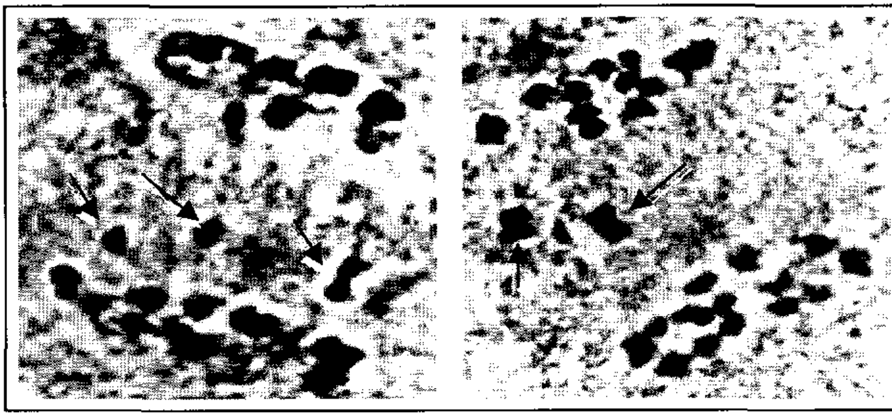


Fig 4.3. Anaphase I of auto-tetraploid *C. arietinum* FLIP 82-150C showing laggards (arrows).

4.1.5.6. Mutation

The seed of three wild *Cicer* species, *C. bijugum*, *C. judaicum*, and *C. pinnatifidum* was irradiated using two different doses of gamma radiation (30- and 45-Kr) at ENEA, Rome, Italy and study was conducted at Tel Hadya, Syria. The main objective of this study was to create variability in wild *Cicer* species for the improvement of compatibility of the interspecific crosses. The individual plants from the M_1 *generation were harvested for growing* M_2 generation in the next year.

4.1.5.7. Genetic Transformation

The main objective of this study was to transfer the anti-fungal agents from wild to the cultigen (*C. arietinum*) by genetic transformation. For genetic transformation experiments, the following anti-fungal genes were utilized: the ThEn-42 gene, isolated from the antagonistic fungus *Trichoderma harzianum* that codifies for an extra-cellular endochitinase, and the osmotin gene from *Nicotiana tabacum*. Both proteins are considered as PR-protein and, in previous experiments, they have shown their effectiveness against several phytopathogenic fungi.

The research work started with the construction of a suitable binary vector carrying the ThEn-42 gene along with the *bar* gene as a marker; the pBIN-based vector was then named pBIN-endo/bar. It was further moved into the AGL1 *Agrobacterium tumefaciens* strain. The chickpea cultivar Semsen (desi type) was used throughout the transformation experiments, since it has been used with success by other scientists in genetic transformation experiments. Kabuli chickpea genotypes were also used in regeneration experiments. Mature chickpea embryos were submitted to co-culture with *A. tumefaciens*. After three days of co-cultivation, explants were transferred onto selection medium (5 mg l^{-1} of phosphinotricine). To induce multiple bud proliferation, the medium was supplemented with different combinations of NAA, BAP and kinetin. After 150 days, shoots surviving the selection were transferred to the rooting medium, in absence of phosphinotricine. Rooted plantlets were then transferred into greenhouse. The transformation frequency was about 0.1% of the co-cultivated embryos.

This figure resulted after more than 8,000 processed chickpea embryos. Putative transformed plants growing in greenhouse were submitted to a further screening *in vivo* based on their resistance to phosphinotricine. Two leaves of each plant were painted using 300 µl l^{-1} of Finale, an herbicide containing phosphinotricine. After one week, plants were scored for their resistance to herbicide.

The T-DNA integration was confirmed by PCR and Southern blot. The expression of the transgene was confirmed through Northern analysis. Modification to this transformation protocol are now in course to increase the frequency of transformed shoots; moreover, results coming from the regeneration experiments have demonstrated that there is enough genetic variability among the tested genotypes suitable to increase the final number of regenerated shoots after the co-culture procedure.

(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)

4.1.6. 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

The production of chickpea in the WANA region is limited by a number of biotic constraints, among which Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. is the most serious. It is particularly severe on the winter crop when low temperatures and continuous rains prevailing during the cropping season that favor crop growth also favor its development. With the increased adoption of winter chickpea in the WANA region, the risk to Ascochyta blight epidemics continues to increase. It is therefore absolutely necessary to control the disease if advantage is to be taken of the winter rains to grow chickpea in winter 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 and in integrated management of the disease.

Fusarium wilt caused by *Fusarium oxysporum* 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 favored by high moisture conditions are important in some areas in Ethiopia and irrigated fields in Egypt and Sudan. Dry root rot (*Rhizoctonia bataticola*) and stem rot (*Sclerotinia sclerotiorum* occur on chickpea in the region but overall, they are less important than Fusarium wilt.

The objectives of the chickpea pathology research in the food legume project are: (1) screen chickpea germplasm to identify sources of resistance to the major diseases under laboratory, greenhouse and field conditions; (2) share the resistant accessions identified, with national programs through international disease nurseries.

4.2.1. Screening for Host Resistance

4.2.1.1. Ascochyta Blight

Host plant resistance is the backbone of Ascochyta blight disease management at ICARDA. Screening for Ascochyta blight resistance is thus a large component of chickpea pathology research at the center. Evaluation of breeding lines and other selected trials begins in the Ascochyta blight field nursery using infected debris collected from the nursery in the previous season and spore suspensions of mixed isolates when infection is low from the debris. Lines selected as resistant to the disease in the field are re-screened under controlled conditions in the plastic house using more virulent isolates of the pathogen. The evaluation details are given in Tables 4.6, 4.7, and 4.8.

4.2.1.1.1. Improving field screening technique

During the 1996/97 cropping season an experiment was conducted to determine the optimum time to spread infested debris in the screening nursery to increase ascochyta blight infection on chickpea. This experiment was repeated during the 1997/98 cropping season. As in the previous season, it consisted of 3 times 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.

Results obtained during the 1997 season were confirmed (Table 4.17). 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 killed. There was very good infection from the January debris inoculation and little infection from the February inoculations. 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 the disease nursery inoculations by spreading infested debris in February produced little disease infection and thus the need to usually supplement with frequent spore sprays. Results from this trial will be incorporated to improve the field screening techniques so as to eliminate the need for spore sprays with conidial suspensions since infested debris when spread early release more inoculum as has been established by detailed epidemiological studies elsewhere.

Conditions were not quite favorable for the development and spread of Ascochyta blight during the 1997/98 season. Infection from the infested debris spread in the nursery in February was quite low by April when severe infection is usually expected. This was partly due to high temperatures at this time of the year and the unusual dry spell prevalent. Thus, by the end of April spore suspensions were spray-inoculated on the entries in the nursery and a mist irrigation system was turned on to increase humidity and aid disease spread. Following these inoculations, good disease development occurred as could be observed by the severe infection of the susceptible checks. Thus, it was possible to distinguish resistant from susceptible reactions.

Table 4.17. Effect of time of debris spread on Ascochyta blight severity (1-9) on chickpea cultivars at Tel Hadya.

Time of debris spread	1997 Crop season		1998 Crop Season		Mean disease score*	
	Ghab1	Ghab3	Ghab1	Ghab3	Ghab 1	Ghab 3
December	9.0	9.0	9.0	9.0	9.0	9.0
January	6.0	4.5	4.7	4.5	5.4	4.5
February	2.7	2.5	3.0	2.5	2.9	2.5
Control	2.5	2.2	3.0	2.5	2.8	2.3
LSD (0.05) = 1.2						
CV (%) = 24.5						

* 1=free, 9=killed.

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

4.2.1.2. Chickpea Fusarium Wilt

Trials evaluated for resistance to chickpea wilt caused by *Fusarium oxysporum* f.sp *ciceris* during the 1997/98 cropping season included: new breeding material in the F_4 - F_5 generation, preliminary yield trials, International

Fusarium Wilt Nursery (CIFWN), and reconfirmation of resistance in selected lines. The evaluations details are given in Tables 4.4 and 4.5. The entries selected in 1997 showing resistance to Fusarium wilt were evaluated for confirmation of their reaction in 1998. About 50% of them showed a highly susceptible reaction. Assuming uniformity of inoculum distribution in the plots as shown by the uniform kill of the susceptible check, it appears there is some shift in the reaction of the cultivars. One reason for this shift in reaction may be the multiplication and spread of other root-rot pathogens in the sick plot. Germination of most of the entries in the trials was poor. Many of the seeds rotted in the ground and isolations from representative samples showed high infection by both *Pythium* spp. and *Rhizoctonia solani*. These pathogens apparently greatly influenced the reaction of the entries in the plots to Fusarium wilt. Precautions will be taken in the next season to treat the seeds with appropriate fungicides to reduce influence of these other root-rot pathogens.

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

4.3. Chickpea Biotechnology

4.3.1. Molecular mapping of resistance to Ascochyta blight

Ascochyta blight is the most important disease in chickpea in WANA. In order to develop molecular markers for resistance genes to this disease, a recombinant inbred line (F_6) population derived from a cross ILC 1272 (susceptible) x ILC 3279 (resistant to Pathotype II) has been developed. Total DNA was isolated from fresh leaves of 120 recombinant inbred lines. Sequence-tagged microsatellite site marker (STMS) analysis was performed. The amplified product was analysed either by ALFexpress DNA sequencer (Pharmacia Biotech) or by denaturing polyacrylamide gel electrophoresis (followed by detection with silver-nitrate). All of the primers analysed so far detected polymorphism between the parents. Linkage analysis of the segregation data of 43 markers resulted in 7 linkage groups. Thirteen markers were not linked to any of the groups. Further screening of the population for Ascochyta blight disease resistance and mapping more markers will facilitate tagging of the genes with these markers.

(S.M. Udupa, M. Baum)

4.3.2. Use of tagged molecular marker for marker assisted selection of Fusarium wilt resistance in chickpea

Studies at Washington State University, Pullman, USA has revealed that resistance to fusarium wilt in chickpea is oligogenic, and at least two different resistance genes against two different races are clustered together in the same linkage group. An allele-specific marker (ASAP; CS-27) linked to susceptible allele of the disease (race 1 of the pathogen) in chickpea has been developed at WSU. To test the feasibility of using this marker for selection, a set of lines (in some cases along with their parents) resistant to different races of fusarium wilt and some lines susceptible to wilt were selected (Table 4.18) and ASAP analysis was performed. The results revealed that the ASAP amplified the desired product (700bp) in both resistant and susceptible cultivars (monomorphic). Therefore, these markers could not be used further for marker assisted selection. Search for a closely linked STMS marker is in progress.

(S.M. Udupa, M. Baum, R.S. Malhotra)

Table 4.18. Reaction of chickpea lines to different races of Fusarium wilt and ASAP marker analysis

			Disease reaction to Fusarium wilt races					
S.#	ILC#	FLIP #	Race 0	Race 5	Fo 8726	Fo 8733	Race 1	ASAP (CS27)
1	5498	84-130C	R	S	S	R	-	p
2	1300		-	-	-	-	-	p
3	1278		-	-	-	-	-	p
4	127		R	S	S	R	-	p
5	5411	84-43C	R	S	M	R	-	p
6	240		R	S	M	R	-	p
7	9786		R	S	-	-	R	p
8	9789		-	-	-	-	-	p
9	256		R	S	R	R	-	p
10	9784		R	R	-	-	R	p
11	7171	87-38C	R	S	-	-	R	p
12	7166	87-33C	R	S	-	-	R	p
13	5407	84-39C	R	S	S	R	-	p
14	5047	82-93C	-	-	-	-	-	p
15	487		R	S	R	R	-	p
16	5037		-	-	-	-	-	p
17	267		-	-	-	-	-	p
18	54		R	S	S	M	-	p
19	**195**		-	-	-	-	-	**p**
20	219		R	S	R	R	-	p
21	237		R	S	S	R	-	p
22	336		R	S	S	R	-	p
23	513		R	S	R	R	-	p
24	4614	81-56W	-	-	-	-	-	p
25	5026	82-72C	-	-	-		S	p
26	5318		-	-	-	-	-	p
27	5433	84-65C	R	S	S	R	-	p
28	5434	84-66C	R	S	S	R	-	p
29	6306	85-130C	R	R	R	M	-	p
30	7115	86-93C	R	-	-	-	R	p

R=Resistant; M=Moderate; S=Susceptible

4.3.3. Interspecific hybridization between cultivated chickpea (*Cicer arietinum* L.) and the wild annual species (*Cicer judaicum* Boiss., *Cicer pinnatifidum* Jaub. & Sp. and *Cicer bijugum* K.H.Rech).

To introduce resistance genes for biotic and abiotic stresses from the wild species into cultivated chickpea, interspecific hybrids between cultivated chickpea (*C. arietinum*) and three wild species (*C. bijugum*, *C. judaicum* and *C. pinnatifidum*) were investigated. Five kabuli-type *C. arietinum* cultivars (ILC 200, ILC 482, ILC 519, Amdoun-1 and FLIP 84-15C) and three desi-types (ICC 12004, ICC13729 and ICC 14903) were crossed with three accessions of each of the wild species (*C. bijugum*, ILWC 32, -62, -79; *C. judaicum*, ILWC 46, -61, -95; and *C. pinnatifidum*, ILWC 171, -236, -250). The wild species were selected according to their known resistance and tolerance for the biotic and a-biotic stresses. The wild species were used as the pollen donor in each cross. The cultivars were emasculated in the morning, pollinated and then treated with hormone solution. Drop of hormone solution I, II and III were applied (one drop at the base of the pistil) in three different time periods, A (every day for the first 10 days), B (every second day till collection) and C (twice a day the first three days). All hormone mixture/time of application combinations were used with all cross combinations. Pods were collected 10-20 days after pollination. Putative fertilized ovules or, if possible, embryos were cultured on different media. Embryos and ovules that regenerated shoots were transferred to ½MS medium. Explants were taken from some putative hybrids to maintain them. Of 3300 pollinations, 1419 (43%) set pods and 423 (12.8%) gave putative fertilized ovules. From 41 of these ovules, embryos could be rescued. Applying hormone solutions after pollination led to ovules from which embryos could be rescued with all treatments. The percentage of pods and ovules developing increased with the amount of hormone applied. This had, however, no effect on the number of embryos developing. An overall improvement of pods, ovules and embryos is visible when hormone regime C is used. Hormone solution II leads to the best germination of the embryos into plantlets (also from ovules) and therefore combination IIA is best to be applied. Ovules and embryos have been cultured on various media. Some developed shoots and roots; on all media roots became necrotic after six weeks. MSZ medium half strength seems to overcome this problem. Medium MSa is most suitable for regenerating shoots. These shoots were transferred to ½ MSZ to regenerate roots. All developing plantlets are being cloned whenever possible.

(B. van Dorrestein, M. Baum, R. S. Malhotra)

4.3.4. Development of a chickpea transformation and regeneration system.

4.3.4.1. Development of a protoplast-based system for somatic hybridization and genetic engineering of chickpea.

A highly reliable and efficient protoplast system for chickpea has been developed, which is applicable also for pea and lentil and suitable for direct DNA-transfer procedures. Although, a highly reliable and efficient protocol for production, culture and also transformation has been established, attempts to induce regeneration failed so far. As in pea and faba-bean, it was intended to induce de-novo shoot organogenesis by application of the phytohormone thidiazuron (TDZ) alone or in combination with auxins. All phytohormone regimes did not result in a morphogenic response. More than 4000 independent callus-lines have been regenerated but none showed shoot- or embryo-development within almost a year of culture.

4.3.4.2. Regeneration and *Agrobacterium*-mediated gene-transfer

The use of transient expression assays (marker-genes *gusA*- and a modified *gfp*-gene)in analysing optimum conditions and susceptibility of chickpea has increased know-how and contributed significantly to the development of an appropriate transformation protocol. In contrast to narb- and faba-bean, de-novo regeneration in chickpea appeared to be quite difficult. Therefore, the applicability of meristem-inoculation techniques as applied in pea were evaluated. The previously described difficulties in retarded shoot development and early shoot tip necrosis have been circumvented by the sequential application of TDZ and kinetin at comparably low concentrations (less than 2 μM). Embryo axis from seeds have been excised and decapitated. However, media composition, culture and selection have been simplified. Numerous shoots develop from the wounded section within a couple of days and *provoke the development of additional axillary shoots in* the following subcultures. The same section also shows substantial gusA-expression following cocultivation with "reporter-strain" EHA101pIBGUS.

The protocol which was recently developed has now been applied for the production of transgenic chickpea lines. This has resulted in transgenic lines for kabuli- and also desi-types as can be concluded from the stable expression of the gusA-marker gene in roots and leaves and resistance against the herbicide BASTA in a so-called "leaf-paint"-assay, carried out already in the greenhouse. At present, no data are available on the progeny of transgenic lines, however, preliminary results from *in-vitro* grown plants suggest a high percentage of fertile regenerants.

Table 4.19. Material, procedure and duration for the production of transgenic chickpea

Material	Procedure	Finalized at day
Mature seeds	Imbibe for at least 4-5 h in sterile water, remove testa, cotyledons and root tip, Remove about one mm of shoot tip	+ 1d
Overnight-culture of *Agrobacterium*	Harvest and resuspend, Inoculate prepared explants,	+ 1d
explants and bacteria	Cocultivate for 2-3 days on SR-medium supplemented with 10 µM TDZ	+ 4d
Inoculated explants	Subculture on TDZ-containing MS-medium	+ 31d
Inoculated explants	Replace TDZ by kinetin and initiate selection by stepwise increase of ppt in the medium	+ 90d*
Regenerated shoots	Grafted (100%) or rooted (60%)	+ 120d*
Grafted shoots	Hardened and transferred into greenhouse	+ 135d*
Regenerated plants	Flowering and seed set	+ 180d*

*there is no synchronous development, shoots are continously produced. The time provides a rough time frame for the development of transgenic chickpea under the current conditions

4.3.4.3. Vector constructs for *Agrobacterium*- and direct DNA-transfer

The vst-gene (encoding the stilbene-synthase gene from *Vitis vinifera*, including regulatory sequences) was subcloned into a pBIN-derived binary vector resulting in pKTV-VST1 harbouring a bar-gene for efficient selection. *Agrobacterium*-strain EHA105 has been transformed with this vector and is currently used for kabuli-chickpea transformation. It is assumed, that the same binary vector can be used for introducing afp-genes.

(H. Kiesecker, A. deKathen, H.J. Jacobsen, B. van Dorrestein, M. Baum)

4.3.5. Development of STMS Markers for Chickpea

A size-selected genomic library comprising 300,000 colonies and representing approximately 20 % of the chickpea genome was screened for $(GA)_n$, $(GAA)_n$ $(CAA)_n$ and $(TAA)_n$ microsatellite-containing clones, of which 440 were sequenced. The majority (~ 75 %) contained perfect repeats. Interrupted, interrupted-compound and compound repeats were present in the range of 6 % to 9 %. (TAA) microsatellites were most abundant and contained the longest repeats with repeat unit numbers from 9 to 131. For 236 loci, primers could be designed and used for the detection of microsatellite length polymorphisms in 6 relevant chickpea breeding cultivars, *C. reticulatum* and *C. echinospermum*, wild intercrossable relatives. A total of 202 primer pairs gave interpretable banding patterns, of which 159 revealed at least 2 alleles on native polyacrylamide gels.

Chickpea-derived STMS markers could also be used to tag agronomically important genes in other species of the genus *Cicer*. To test this possibility, we investigated the conservation of 90 microsatellite-flanking sequences from chickpea within 5 accessions each of 8 annual, and one accession of a perennial species of the genus *Cicer*. The primer sequences successfully amplified microsatellites in the related species, indicating conservation of microsatellite-flanking sequences in relatives of wild chickpea. Conservation of primer sites varied between species depending on their known phylogenetic relationship to chickpea. It ranged from 92.2% in *C. reticulatum*, chickpea's closest relative and potential ancestor, to 50% for *C. cuneatum*. A phylogenetic tree was constructed using the zero-allele information that indicated a closer relationship between chickpea and the other members of its crossability group to the perennial *C. anatolicum* than to other annual species of the genus. Considerable variation in size and number of amplification products between and within species was observed. Sequence analysis of highly divergent amplification products revealed, that variation was either due to large differences in the number of microsatellite repeat units, or to the amplification of another locus unrelated to the one amplified from chickpea. Sequence information and bootstrapping using PAUP suggested that (1) STMS derived from chickpea may efficiently and reliably be used for synteny studies in chickpea's crossability group including *C. anatolicum*, but that (2) care should be taken when applying these markers to other species of the genus. Considering the data presented here and the known historic record, the section *Monocicer* including chickpea is estimated to be between 100,000 and 400,000 years old.

To further expand the usefulness of STMS primers from chickpea across genera, the conservation of intergeneric primer binding sites has been tested in the Leguminosae. One hundred and one chickpea STMS were used to amplify loci in *Lens* and *Pisum*, and of these 46.5% and 38.6% produced amplification products in dry pea and lentil, respectively. Hybridisation of some amplification products from the different genera with the $(TAA)_{10}$ probe showed, that some loci were very well conserved between the genera while others were not. Some STMS markers have detected polymorphisms between cultivars and species of *Lens*. STMS derived from chickpea can be used for the detection of variability between the Leguminosae, but great care should be taken if STMS are used for synteny studies, since results from studies within the genus *Cicer* have shown that a given primer pair may amplify different loci in different species of the same genus.

4.3.6. Genome Mapping and Tagging of Resistance Genes

A total of 120 STMS markers were genetically mapped on recombinant inbred lines from an inter-species cross between a *Fusarium oxysporum* resistant cultivar and chickpeas wild, *Fusarium*-susceptible progenitor *C. reticulatum*. Markers could be arranged in 11 linkage groups (LOD-score: 4) covering 613 cM. Clustering as well as random distribution of loci was observed. Segregation of 46 markers (39 %) deviated significantly (P>0.05) from the expected 1:1 ratio. The majority of these loci (73 %) were located in 3 distinct regions of the genome.

The STMS marker map provides the backbone for the most comprehensive integrated molecular marker map of the chickpea genome available to date. It comprises 292 markers including 120 STMS, 70 AFLP, 48 ISSR, 42 RAPD, 8 isozyme and 3 *Fusarium* resistance loci. At a LOD-score of four 198 (81.2 %) markers cover 1331 cM in 13 linkage groups at an average distance of 5 cM between markers. Clustering of markers in central regions of linkage groups was observed. Markers of the same class except ISSR and RAPD markers tended to generate subclusters. Also, resistance genes against *Fusarium* races 4 and 5 mapped close together and to several types of markers including STMS and a SCAR previously linked to *Fusarium* race 1 resistance, indicating a clustering of *Fusarium* resistance genes around this locus.

Significant deviation from the expected 1:1 segregation ratio was observed for 52 markers (21.3 %, P<0.05). In 68 % of cases segregation was biased towards the wild progenitor's genome. Segregation distortion was almost similar for all marker types except ISSR markers that showed only 8 % aberrant inheritage. Distortedly segregating loci were clustered at 4 chromosomal regions that accounted for 71 % of all aberrantly segregating loci.

Segregation distortion in these clusters affected all types of markers including isozymes.

(P. Winter, T. Pfaff, B. Hüttel, P. C. Sharma, S. Sahi, R. Arreguin, G Kahl, Frankfurt University S. M. Udupa F. Weigand, ICARDA, F. J. Muehlbauer, Washington State University)

5. FORAGE LEGUMES IMPROVEMENT

Introduction

Livestock are an integral part of farming systems where crop production is limited by large seasonal variations in rainfall. These variations lead to a marked seasonality of feed supply, which is a major constraint to livestock production. Annual forage legumes such as vetches (*Vicia* spp.) and chicklings (*lathyrus* spp.) are recognized for their potential to produce extra feed from fallow land, and through the interruption of barley monoculture. These crops can be used for direct grazing during late winter or early spring, harvested for hay in spring either in pure stand or in mixtures with cereals (oat, barley or triticale), or for grain and straw at full maturity. They differ from food legume crops only in the end use. They are mainly used to feed livestock, whereas food legume crops are for human consumption. There is one exceptional case: that is the grasspea (*lathyrus sativus*), which is a popular food and forage crop in Central Asia and African countries (Bangladesh, China, Ethiopia, India, Nepal, and Pakistan), because of its resistance to drought, water-logging and moderate salinity and because of its low requirement for input. When other crops fail under adverse conditions, grasspea can become the only available food source for the poor in the community and sometimes it is survival food during times of drought-induced famine. Although, its seeds are tasty and protein-rich overconsumption can cause an upper motor neurone disease known as 'neurolathyrism', an irreversible paralysis of the lower limbs. The neurotoxic cause of this disease was identified as 3-N-Oxalyl-L-2, 3-diaminopropionic acid (β-ODAP). Its level in the dry seeds varies widely depending on genetic factors and environmental conditions. Efforts are being made to eliminate this antinutritional factor (ANF) by breeding using the available genetic resources and biotechnology.

Flexibility in forage legume crops to meet different types of utilization in different agro-ecological zones is always of great importance in developing new adapted cultivars. Each crop tends to have an ecological niche. For example, grasspea is suitable to low rainfall areas between 200-300 mm, because of its great drought tolerance; wooly-pod vetch and Hungarian vetch are adapted to high elevation cold areas because of their rapid winter growth and cold tolerance.

The introduction of *Vicia* spp. and *Lathyrus* spp. in rotations also increases the production of feed resources and subsequently the carrying capacity of the land in a sustainable manner. This is because of the maintenance of organic matter and nitrogen status of soil, improved soil physical conditions and better control of diseases and pests compared to continuous cereal monoculture.

Forage legume production is also expected to have a positive effect on rangelands by: (a) reducing overgrazing problem and (b) allowing for adoption of proper grazing systems. At present, livestock move into the range at the beginning of the rainy season, causing great damage to newly emerging vegetation through repeated trampling and defoliation.

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* subsp. *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

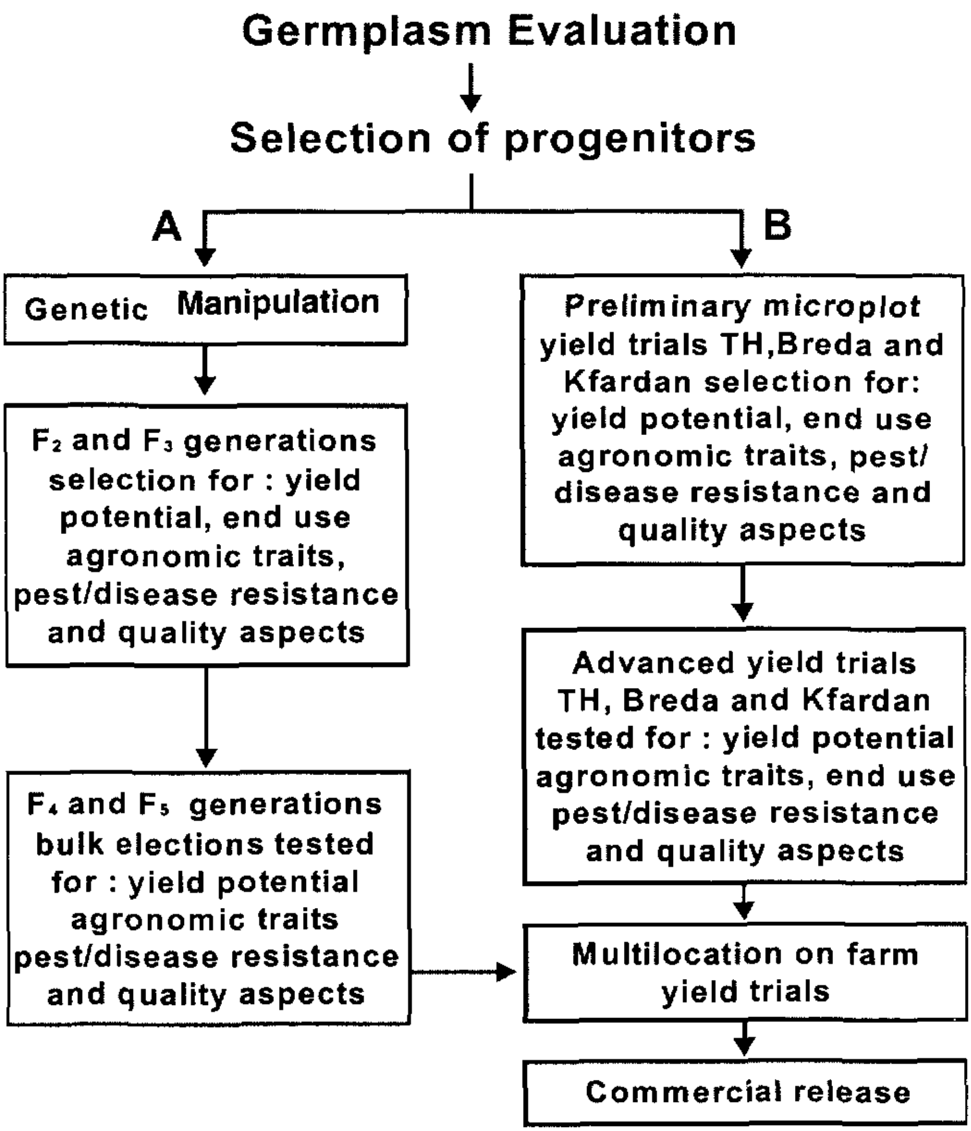


Figure 5.1. Structure of forage legumes breeding program: (A) Hybridization, and (B) Selection.

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.

The forage legumes project emphasizes the need for better understanding of yield limiting factors in different agro-ecological zones, and utilization systems. We cooperate with NRMP in this activity and this information is particularly useful to "tailor", genotypes of each species to fit the targeted environment and farming practices. During the last few years research increasingly turned to less favorable environments, where increased and staple production requires stress tolerant varieties, whose phenology must closely match the temperature and available moisture.

Our forage legumes program was able to gradually adjust its priorities to the changing needs of our clients (Farmers). Over the past five years both as a results of internal assessments, of priorities and of external suggestions a number of activities at Tel Hadya were reduced, such as work on Hungarian vetch and wooly-pod vetch, is now decentralized in Turkey, in collaboration with Turkish national program. Target crosses are being made at Tel Hadya, and the segregated populations are dispatched to Turkey for selection under low-temperature (cold environment). Some activities were more emphasized, such as improving yield potential and quality of grasspea (*Lathyrus sativus*) which is a dependable source of dietary protein for subsistence farmers in collaboration with Ethiopia, Bengladesh, Nepal and India national programs, to contribute to the alleviation of poverty and malnutrition and the reduction of food shortages, through developing and verify lines of grasspea with high-yield potential under low or zero inputs with low neurotoxin, β-ODAP and improved aminoacids complement using conventional breeding and biotechnology e.g. exploitation of somoclonal variation. More attention is also given to common vetch for its versatility and suitability for deferent end uses (grazing, hay, grain and straw), specially, the work that is being done in collaboration with M&M Project. Recently, a new activity has been initiated with central Asian and Caucasian Countries (CAC), to test and evaluate promising lines and populations of vetches and chicklings for spring planting. Works on certain species such as *vicia palaestina* and *Lathyrus ochrus* were reduced at the head-quarter and targeted to areas with mild winter and where broomrape is endamic. The results obtained in 1998 are presented on the following pages and are given by species.

(Ali M. Abd EL Moneim)

5.2.1. Common vetch (*Vicia sativa* L.)

5.2.1.1. Evaluation of Germplasm

During the last three seasons, attention has been paid to the collection and evaluation of native wild types of common vetch. Some showed good cold and drought tolerance as well as early and rapid winter growth, early flowering and maturity. Such genotypes could be of value for developing new cultivars.

In 1997/98, one experiment was conducted to asses 100 accessions of common vetch (*Vicia sativa*) in nursery rows in a cubic lattice design with three replicates (6 rows each). The experiment was fertilized with 40kg/p_2o_5/ha.

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

Table 5.1. Range, Mean, standard error and coefficient of variation (CV%) for 9 characters of common vetch (*Vicia sativa*).

Character	Range	Mean	SE±	CV%
Cold tolerance*	4.0-9.0	6.5	0.76	16.7
Winter growth*	2.9-9.0	6.3	0.84	18.9
Spring growth*	2.0-9.5	7.4	0.63	12.0
Leafiness*	2.6-9.5	7.0	0.70	16.0
Days to flowering	101-123	114	1.4	1.7
Days to maturity	142-173	161	2.4	2.0
Total biological yield (kg/ha)	725-8964	5900	606	15.0
Grain yield (kg/ha)	221-3400	1560	169	15.0
Harvest index (%)	9.0-47	26.5	2.6	14.0

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

A broad variation was observed for the characters 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.

5.2.1.2. Preliminary Evaluation in Microplot Yield Trials (MYT).

The availability of an appropriate genetic base is an indispensable pre-requisite for our breeding program aiming at the development of improved cultivars. Therefore, special attention is given to the material evaluated in observation rows and to the segregated populations for adaptation for the following agronomically important characters: cold tolerance, rapid winter growth, leafiness, erect types, early in flowering and maturity, high herbage and grain yields and resistance to biotic and abiotic stresses. The study of variation in such agronomic characters is of significant practical value. It helps us to establish a suitable breeding program to develop improved 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 elite lines by national programs.

In 1997/98, season a microptol field trial of common vetch was grown at Tel Hadya in 3.5m^2 plots arranged in a triple lattice design. The number of entries was 36, seed rate was 100kg/ha and fertilizer was applied at 40kg P_2O_5/ha. This microplot was divided in two sets, one was harvested at 50% flowering to determine the herbage yield (DM) and its quality, while the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

Out of the thirty-six selections which were tested at Tel Hadya, the top 10 selections which combined both high seed and herbage (DM) production were identified for more critical evaluation (Table 5.2). Herbage yield (DM) at 50% flowering varied from 3800 to 6750 kg/ha (mean of 5053 kg/ha), total biological yield from 3711 to 7937 kg/ha (mean of 6000kg/ha), grain from 1526 to 3115 kg/ha (mean of 2270) and harvest index from 28 to 43% (mean of 37%).

The moderate and high temperature in winter and spring accompanied with high rainfall at Tel-Hadya facilitated the development of foliar diseases such as downey mildew (*Peronospora viciae*), and chocolate spot/blight (*Botrytis fabae*), which caused a severe damage to certain lines. Selected entries showed a high level of natural resistance to the above mentioned diseases are shown in Table 5.2. There are identified for further tests under artificial infection in the disease nurseries.

Table 5.2. Winter growth (WG), herbage (H) biological (B) and grain (G) yields (kg/ha) harvest index (%) and time (days) to flower and mature of the top 10 selections of common vetch in Microplot Yield Trials at Tel Hadya.

IFLVS Sel. #	WG+	Yield kg/ha H	B	G	HI (%)	Time to Flower	Mature
2751	8.0	5300	7000	2790	40	99	148
2755	8.0	5500	6700	2680	40	107	158
2756	8.0	5160	4733	2048	43	103	149
2758	7.0	5470	6100	2560	42	109	150
2759	8.0	5640	5200	2300	43	98	151
2766	7.0	5400	5000	2000	40	100	153
2773	6.0	5520	5900	2300	40	105	155
2774	6.0	6750	5600	2200	40	99	148
2775	8.0	6200	5500	2200	40	99	147
2560 (check)	6.0	4500	5400	1800	33	105	155
Mean++	6.4	5053	6000	2270	37	102	150
S.E. ±	0.5	620	599	297	2.5	0.9	1.9
CV (%)	14	20	17	22	17	1.6	2.0

+ On a scale 1 to 9, where 1 is slow, and 9 is very rapid growth measured on 21 February, 1998.
++ Mean of all 36 entries.

5.2.1.3. Common Vetch Advanced Yield Trials (AYT).

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

An experiment was carried out to test elite promising lines of common vetch at Tel Hadya (TH), Breda (Br), Terbol (T) and Kfardan (Kfr) where the rainfalls during 1997/98 growing season were 433, 230, 495 and 429mm, respectively the total number of frost night was 30, 23, 45 and 31 and respectively, with absolute minimum temperatures of -6.0, 6, -5, and -9C^0, respectively. Materials used in this multi-location yield trial are either progenies of single plants (selections or pure lines), selected from the wild types or selected F_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. This trial was managed in the same way as microplots but had larger plot size (28.0 m^2).

Twenty-five elite lines were tested at Tel-Hadya, Breda, Kfardan and Terbol. The four locations were chosen to sample the environmental conditions of the cereal zone in Syria and Lebanon. There were large variations between lines within the same location and between locations for winter growth, herbage, biological and grain yields.Table5.3.

Table 5.3. Location means of winter growth (WG), herbage (H), biological (B) and grain (G) yields, harvest index (%) and time (days) to flower and mature for 36 elite lines of common vetch in AYT.

		Yield kg/ha			HI	Time to	
Location	WG$^+$	H	B	G	(%)	Flower	Mature
Tel Hadya	7.5	6050	7920	2500	32	106	151
	±0.7	±580	±405	±170	±2.2	±1.0	±1.2
Breda	8.5	4500	4000	1000	25	110	149
	±0.6	±380	±324	±145	±1.9	±1.1	±1.5
Kfardan	8.0	3400	7034	2400	35	104	142
	±0.6	±273	±324	±155	±1.2	±0.7	±0.5
Terbol	7.0	6500	11890	3000	25	120	170
	±1.0	±520	±770	±263	±1.7	±0.9	±1.1

$^+$ On 1 to 9 visual score basis, where 1 = poor and 9 = excellent growth on 24 February, 1998.

The total biological yield was greater at Terbol and Tel-Hadya than Breda and Kfardan. The harvest index did not follow the same pattern. The large variation in both herbage and biological yields between locations was mainly due to the variation among tested lines in their winter and spring growth as indicated by the highly significant correction between winter and spring growth and total biological yield of r=0.71, r=0.65, r=0.55, r=0.69 and r=0.61, r=0.59, r=0.55, r=0.70, at Tel-Hadya, Breda, Kfardan and Terbol, respectively. Table 5.4 shows the most promising and adapted lines at each location. IFLVS # 2487 showed high adaptation and was the most promising across the four locations. Its exploitation in the future breeding program in case of high herbage and grain yields would be most desirable. The local check IFLVS # 2560, was adapted at Tel-Hadya and Kfardan, although its total biological yield was 30% less than IFLVS # 2487. The moderate and high temperatures in winter and spring accompanied with the high rainfall at Tel-Hadya facilitated the development foliar diseases such as downy mildew (*Peronospora vicia*) and powdery mildew (*Erisiphi pisi*), natural infection on leaves led to low herbage and grain yields. Selected lines in Table 5.4. Showed a relatively high level of natural resistance to the above mentioned two diseases.

Table 5.4. The most promising and adapted lines of common vetch at Tel Hadya, Breda, Kfardan and Terbol.

Location	Promising lines IFLVS #							
Tel Hadya	2487*	2484	2637	2628	2499	2484	2614	2560**
Breda	2487	2491	2494	2495	2617	2624	2639	2624
Kfardan	2487	2486	2484	2567	2678	2637	2614	2560**
Terbol	2487	2490	2494	2505	2567	2624	2626	2687

(*) The most adapted lines at the four locations.

(**) # 2560 (check local), adapted at Breda and Kfardan.

5.2.1.4. Improving Seed Retention (Pod-shattering) in Common Vetch (*Vicia sativa*).

Loss of seeds from maturing pods (seed shattering) is common in leguminous forage crops, such as common vetch, and constitutes a serious economic problem, when the crop is used in rotation with cereals. Therefore, an essential character of a grain legume crop and a desirable one in forage legume crop is the ability to retain its seeds long enough to allow mechanical harvesting at full maturity. Pod-shattering in common vetch reduces also its popularity as feed legume crop for fallow replacement. Its seed germinating during the cereal phase of the rotation represent serious "weed problem". Therefore, a breeding program to develop non-shattering cultivars suitable for mechanical harvesting was initiated using natural wild non-shattering mutants with undesirable agronomic traits.

The genetic of pod-shattering was studied using parental (P_1,P_2) foliar generations (F_1,F_2) and backcross (BC_1, BC_2, BC_3, BC_4 and BC_5) generations obtained from crosses between wild non-shattering accessions and promising breeding lines with highly desirable agronomic traits, but with high proportion of pod-shattering. The results revealed that non-shattering trait is conditioned by a single recessive gene. Incorporation of this gene into agronomically promising lines was achieved by backcrossing, selfing and selection for non-shattering trait in erect, large and soft-seeded, leafy and early maturity types. After five backcrosses generations twelve superior lines IFLVS # 2712, 2003, 2711, 2710, 2709, 2723, 2724, 2721, 2556, 2728 and 2558 were selected having 97-99% non-shattering pods as compared to 30-40% in the original breeding lines. The grain yields of these lines is above 2.0 tons/ha under Tel-Hadya and Kfardan conditions.

Developing non-shattering cultivars in common vetch is continuing with the aim to incorporate the erect growth-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 Kfardan stations for distribution to national programs.

The practical benefits of developing non-shattering and erect lines include increased grain yield, reduce problem of volunteers in subsequent cereal crops, improved opportunity for mechanical harvesting and increased flexibility in time of harvest. Increased grain yield results in reducing price of seed and allows farmers to increase the area cultivated with common vetch and so increase livestock production.

5.2.1.5. Improving Cold and Drought Tolerance of Common vetch (*Vicia sativa* subsp. *sativa*) and Herbage Production of Under-ground Vetch (*Vicia sativa* subsp. *amphycarpa*).

In our breeding program, special attention is given to the materials collected from its natural habitats. These materials contain genotypes, which appear useful for the improvement of agronomically important characters, as early flowering and maturity, cold tolerance, and high biomas yield under marginal conditions. It is also generally accepted that the availability of basic genetic materials is indispensable pre-requisite for our breeding program aiming at the creation of important cultivars.

Species and subspecies hybridization: hybridization is an important aspect in feed Legumes breeding, to incorporate useful genes carried out by parental species and also to increase variation for selection. Our studies on underground vetch (*Vicia sativa* subsp. *amphicarpa*), which is grown as wild type in central Anatolia region of Turkey revealed that its ability to produce both aerial and underground pods increases its winter hardiness, drought tolerance and persistence under heavy grazing. The disadvantages of underground podding habit, which may limit its utilization, are its low rate of vegetative growth, shattering of above-ground pods and the dependence of amphicarpy on environmental conditions. In contrast, common vetch (*Vicia sativa*) grows well under favorable conditions, but it is not cold and drought tolerance, and there are some improved lines with non-shattering pods.

To enhance the herbage production of underground vetch and improve the drought and cold tolerance of common vetch, crosses between the two subspecies were made to develop a more agriculturally, valuable feed legume crops from both of them, by transferring the desirable genes from the wild to cultivated species and vice-versa.

The material was derived from crosses of improved lines of common vetch (IFLVS # 715, 2558, 713 and 1448) with two wild accessions of underground vetch (# 2660 from central Anatolia, Turkey and # 2614 originated from Gabal Abd El Aziz area, Syria). High vegetative vigor was observed in the F_1 plants carrying few underground pods near the soil surface.

The F_2 population released enormous variability transcending even the limits of the parents in some traits such as number of underground pods, cold tolerance. Leaf: stem ratio and herbage yield.

Selection was done in F_3 lines descended from F_2 single plant selections of the eight crosses. 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 maintained vigorous growth of common vetch were selected as improved lines of common vetch.

Seeds of improved lines of underground vetch are being used to rehabilitate the marginal lands in Turkey, in collaboration with NRMP. Also, improved lines of common vetch will be used for winter sowing common vetch in Turkey and other high elevation areas in the region.

5.2.2. Narbon Vetch (*Vicia narbonesis*).

5.2.2.1. Advanced yield Trials.

In 1997/98 season, narbon vetch advanced yield trial was sown a four sites (Tel Hadya, Breda in Syria and Kfardan, Terbol in Lebanon). The total number of the tested line was 25 including IFLVN # 2561 (local check).

Winter growth, biological and grain yields and harvest indexes were measured at each location (Table 5.5). There were differences in the performance of the tested lines for all measured traits. Yields were greater at Kfardan and Terbol than Tel-Hadya and Breda, both for biological and grain yields. The harvest index at Tel-Hadya and Kfardan was greater than Terbol and Breda. The low biological and grain yields at Breda was mainly due to the relatively low rainfall (227 mm) which represent 85% of long term average. The high rainfall at Tel Hadya, Kfardan and Terbol, especially late season rains favored the development of downy mildew (*Peronospora viciae*) which caused a severe damage to certain lines. Resistant lines were selected for more critical assessments under artificial conditions to confirm their reaction under natural conditions of 1998. Also, the top 5 lines were selected (Table 5.6) based on early maturity, rapid winter and spring growth, high biological and grain yields and resistance to downy mildew. The local check IFLVN # 2561 was the best in terms of biological and grain yields at Breda, INFLV # 2383 was the best at Tel Hadya, Kfardan and Terbol. All the selected lines produced 15-25% more biological and grain yields than the check at all locations, except at Breda.

Table 5.5. *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.*

		Yield kg/ha			Time to	
Location	WG(+)	B	Gr	HI (%)	Flower	Mature
Tel Hadya	7.7 ±0.8	5100 ±610	1714 ±267	36.6 ±2.4	99 ±1.2	140 ±2.8
Breda	7.0 ±0.5	3900 ±230	950 ±110	24 ±2.7	95 ±1.5	126 ±1.0
Kfardan	5.2 ±0.5	7560 ±280	2700 ±142	36.5 ±2.5	102 ±0.8	144 ±1.7
Terbol	5.0 ±0.6	13600 ±1300	4000 ±310	29.4 ±2.5	110 ±1.3	155 ±2.3

+ On 1 to 9 visual scale basis, where 1 = poor and 9 = excellent growth on 24 February, 1998.

Table 5.6. The most promising and adapted lines of narbon vetch at Tel Hadya, Breda, Kfardan and Terbol.

Location	Promising lines IFLVN #				
Tel Hadya	2383	2384	2385	2387	2389
Breda	2561	2392	2393	2472	2385
Kfardan	2386	2376	2379	2383	2387
Terbol	2386	2391	2392	2466	2383

5.2.3. Bitter Vetch.

5.2.3.1. Bitter vetch Preliminary Evaluation in Microplot Yield Trials (MYT).

Thirty-six selections of bitter vetch (*Vicia ervilia*) were tested at Tel Hadya. Herbage yield varied from 2100 to 3500 kg/ha, biological yield from 1300 to 6300 kg/ha, grain yield from 190 to 2500 kg/ha and harvested index from 14 to 42%. In this trial Bitter vetch showed rapid winter and spring growth as compared to other vetches, and also no systems of downy mildew appeared, but late maturing selections were severely affected by broomrape (*Orobanche crenata*). Table 5.7, shows the top 10 selections, combining early maturity, high herbage and total biological yields. The local check # 2563 produced less biological and grain yields than the rest of the selected entries.

Table 5.7. Winter growth (WG), herbage (H) biological (B), grain (G) yields harvest index and time (days) to flowering and maturity of the top 10 selections of bitter vetch in Microplot Yield Trials (MYT) at Tel Hadya.

		Yield kg/ha				Time to	
IFLVE#	WG+	H	B	G	HI (%)	Flower	Mature
2800	9.0	3000	5400	2300	42	90	146
2798	8.0	3500	5700	2400	42	99	148
2799	9.0	3000	5100	2100	41	92	145
2807	8.0	3100	5100	2000	39	96	145
2802	8.0	3200	6200	2400	38	101	148
2803	9.0	3400	5900	2200	37	96	150
2807	8.0	3500	5100	2000	39	96	145
2801	9.0	3100	5700	2100	36	95	140
2808	8.0	3300	5800	2100	36	99	147
2563 (local)	8.0	3100	4400	1604	36	95	146
Mean++	7.9	2600	5070	1820	36	100	155
S.E. ±	0.7	160	442	244	2.9	1.7	2.3
CV (%)	14.0	18.0	16.0	23.0	17.0	18.0	3.0

+ On a scale 1 to 9, where 1 is poor, and 9 is excellent growth on February 25, 1998.

++ Mean of all 36 entries.

5.2.3.2. Bitter Vetch Advanced Field Trials.

Twenty-five elite lines were tested at Tel Hadya, Kfardan and Terbol. The total biological yield varied from 4400 to 6400 kg/ha at Tel Hadya, from 4300 to 6500 at Kfardan and from 8000 to 12300 kg/ha at Terbol. Biological and grain yields at Terbol were greater than Tel Hadya and Kfardan

(Table 5.8). Bitter vetch showed rapid winter and spring growth accompanied with early flowering. Its yield was relatively better than other vetches, because earliness in flowering and maturity, resulted that the crop escape from the severe attack of broomrape (*Orobanche crenata* Forsk). No symptoms of downy mildew appeared (Table 5.8) the most promising and adapted lines at the three locations.

5.2.4. Wooly pod vetch (*Vicia villosa* subsp. dasycarpa)

5.2.4.1. Advanced Yield Trials (AYT).

Twenty-five promising lines were tested at Tel-Hadya and Kfardan. There were great differences in winter and spring growth, herbage, biological and grain yields, between lines within locations and between locations (Table 5.9). Herbage, biological and grain yields were greater at Tel-Hadya than Kafardan. Low grain yield at kfardan was mainly due to delays in the first appearance of floral buds, and the heat stress that occurred when bud development which caused a large propertion of flower and young-pods drops and the buds development were inhibited by high temperature in the spring.

In contrast to other vetches, wooly-pod vetch characterized by a long flowering period, and high herbage yield. These characters make it the most suitable for grazing or hay making. Early maturity types are needed as it is indicated by the significantly correction between grain yields and days to flowering and maturity. Our results of 1998, when natural conditions favored the severe attack of broomrape (*Orobanche crenata* Frosk), confirmed that wooly pod vetch is resistant to broomrape.

Table 5.8. Biological and grain yields (kg/ha) and time to mature for the top 8 lines of bitter vetch in advanced yield trials at Tel Hadya, Kfardan and Terbol.

	Biological yield (kg/ha)			Grain yield (kg/ha)			Days to mature		
IFLVE #	TH	Kfr.	Tr.	TH	Kfr.	Tr.	TH	Kfr.	Tr.
2509	5870	5700	12300	2500	2000	3600	143	143	150
2511	6000	5600	12200	2500	1900	4100	147	140	151
2512	5900	5800	12500	2300	1800	3400	143	140	149
2513	6400	5800	12100	2600	2200	3450	145	141	152
2516	5300	5400	12000	2200	1900	3400	140	140	150
2522	6400	6500	11600	2700	1800	3500	143	141	155
2649	5600	5600	11000	2400	1900	3400	145	143	150
2652	5400	5600	11200	2100	2200	3500	148	142	151
Mean[+]	5800	5400	11300	2200	1800	3400	149	143	161
SE±	390	291	579	214	130	196	1.2	0.4	0.6
CV(%)	12	10	12	15	13	11	1.5	0.7	0.7

(+) Mean of all 25 lines.

Table 5.10, shows the most promising lines at the two locations. IFLVD # 2562, (the released variety at Quetta, Pakistan under the name of Kuhad 96) was the most promising at the two location. Also, IFLVD # 2441 showed promise at the two location. More emphasis has to be given to reduce young pod abortion, pod shattering, high leaf retention and earliness to flowering and maturity to improve the productivity of wooly pod vetch.

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

	Yield (kg/ha)				Time to	
Location	H	B	G	HI (%)	Flower	Mature
Tel Hadya	7200 ±660	6200 ±900	1200 ±280	19 ±2.7	115 ±1.4	160 ±1.8
Kfardan	4000 ±260	5000 ±250	750 ±80	15 ±1.9	106 ±0.6	151 ±1.6

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

Location	Promising lines IFLVD #				
Tel Hadya	2562	2435	2439	2441	2442
Kfardan	2562	2431	2440	2441	2457

5.2.5. Lathyrus spp. (chicklings)

5.2.5.1. Advanced Yield Trials of Three Lathyrus spp.

Twenty-five promising lines each of common chickling or grasspea (*Lathyrus sativus*) dwarf chickling (*Lathyrus* *cicera*) and ochrus chickling (*Lathyrus ochrus*) were tested at Tel Hadya, Breda and Kfardan. Table 5.11 shows herbage, biological, and grain yields at the three locations. *Lathyrus ochrus* produced the highest herbage yield at Tel Hadya followed by *Lathyrus cicera* and *Lathyrus sativus*; whereas, *L. cicera* produced the highest grain yield at kfardan followed by *Lathyrus ochrus* and *Lathyrus sativus*. The high grain yield of *Lathyrus ochrus* at Tel-Hadya is mainly due to its resistant to *Orobanche crenata* Forsk (broomrape). The relatively low grain yields of *Lathyrus sativus* and *Lathyrus cicera* was mainly due to the severe effect of the broomrape during the pod formation and grain filling stage, especially at Tel-Hadya. Great variability was observed between species and within the same species. The early maturity lines of *Lathyrus sativus* and *Lathyrus cicera* had high grain yields, and the high herbage yield of *L.Ochrus* was due to its rapid and winter growth.

The results of the advanced yield trials of *Vicia* spp. and *Lathyrus* spp., showed great differences between the tested locations and among entries within the same location for the tested traits. Considerable genetic variation exists within each species for attributes indicative of yield and its components. The variations could be exploited by the appropriate breeding procedures to develop high yielding cultivars. These cultivars can contribute significantly to livestock production in rainfed agriculture. There use in rotation with cereals will increase the sustainability of farming systems by acting as a disease and broomrape break, and by contributing to the nitrogen nutrition of cereals.

The utilization of different species varies between region. Consequently characters for selection vary according to respond to local needs. As forage legumes can be used for direct grazing, hay making, straw and grain, we can begin to see how the various species will meet the farmers needs in the prevailing farming systems. The high

Table 5.11. 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).

	Herbage Yield (kg/ha)			Biological Yield (kg/ha)			Grain Yield (kg/ha)		
Species	TH	Br	Kfr	TH	Br	Kfr	TH	Br	Kfr
L. sativus									
Mean +	5200	2500	2700	4100	3100	7000	1400	900	1900
SE	470	195	220	690	320	322	110	85	150
Range	(3200-5900)	(1600-3000)	(1900-3600)	(3200-5200)	(2000-3500)	(6200-8200)	(530-1800)	(430-1200)	(1400-2400)
L. cicera									
Mean	5400	2100	2700	5000	2800	7300	1400	700	2900
SE	410	202	253	430	304	305	206	70	157
Range	(4000-6500)	(1600-3800)	(2000-3500)	(3600-5900)	(1200-3600)	(6700-7900)	(1200-2100)	(200-950)	(2500-3500)
L. ochrus									
Mean	5700	2200	2500	5000	2250	6700	1900	770	2000
SE	360	210	214	560	220	326	300	90	152
Range	(3700-7800)	(700-3200)	(1600-3200)	(3800-6500)	(600-3300)	(6200-7400)	(1000-2300)	(200-950)	(1600-2300)

(+) Mean for all 25 entries, each species.

grain and straw yields, cold tolerance and early maturity of narbon-vetch make it ideal feed legume for producing winter stocks of grain and straw for feeding sheep during the peak of feed demand in winter. It does not lose its leaves following frost, like many other feed legumes or its seeds at maturity stage. Breeding for greater drought tolerance could increase its adaptation. The resistance to birds damage attribute at seedling stage is a major factor in establishment a good stand of narbon vetch. It is easy to establish because of its large seeds. Seeds can be planted deeper than other vetches, which allows placement in a moisture layer on soil. The long flowering period, prostrate to semi-erect growth habit, rapid winter and spring growth, cold tolerance and high herbage production are the most important attribute to make the wooly pod vetch the most suitable for grazing in the cold areas. It has proved to be well adapted to upland of Balochistan conditions and a released variety kuhak 96 is in hand. Common vetch is a versatile feed legume crop. The rapid winter growth types can be used for early grazing, the non shattering erect types can be used to produce grain and straw, and the leafy and rapid spring growth types can be used for hay making. For farmers who require hay or grazing dwarf chickling could be another option in dry areas. The grasspea is susceptible to broomrape, but in dry areas it can still be used for grain and straw. Ochrus chickling can be used in areas with mild winters, and where broomrape is endamic.

5.2.6. Improving Nutritional Quality of Grasspea (*Lathyrus sativus*).

5.2.6.1. Genetic Improvement

Genetic improvement work on *Lathyrus sativus* (grasspea) commenced in 1990 at ICARDA, with emphasis being placed on reducing the neurotoxin 3-(N-Oxalyl)-L-2,3-diominopropionic acid (β-ODAP) concentration through the use of hybridization and recently, the somocolonal variation. In the beginning, a screening program was initiated to explore the possibility of isolating low or toxic-free lines from germplasm collected from different origins. The screening of germplasm continued for three years. Lines having a little as 0.08% to as much as 1.9% were found indicating large variation in β-ODAP content. Five lines IFLLS # 523, 578, 536, 519 and 588 were selected as being significantly low in β-ODAP, with less than 0.1%.

A breeding and selection program has been established to transfer the genes for reduced β-ODAP concentration into high-yielding, adapted lines from Ethiopia, Banghladesh, India, and Pakistan. Some of these lines have been selected for increased seeds per pod and for double-pods per mode. This involves hybridization of selected lines and evaluation of the resulting progenies.

The basic material for this program consisted of thirty-landraces of *L. sativus* representing the available variability for β-ODAP (more than 0.4%) and diversity in agroclimatic conditions among places of their origin. These landraces were crossed with the five lines having low β-ODAP (below 0.1%) as testers and the 150 hybrid combination were obtained. Gene markers such as seed and flower colours were used to eliminate pods, which might have developed from selfing. Selection from F_2 to F_7 was directed for early maturity, small and large seed size and less than

0.1% β-ODAP content. In 1997/98, 85 families were grown under rainfed conditions at Tel Hadya and Breda to assess their yield potential and β-ODAP content. The ten families with lower β-ODAP at Tel Hadya and Breda are shown in Table5.12.

Table 5.12. Grain yield (kg/ha), β-ODAP content (%) and crude protein (cp%) of 10 promising F_7 families of grasspea at Tel Hadya and Breda.

	Tel Hadya				Breda		
IFLLS#	Grain yield (kg/ha)	CP (%)	β-ODAP (%)	IFLLS#	Grain yield (kg/ha)	CP (%)	β-ODAP (%)
709	1800	25.2	0.064	712	990	26.4	0.090
666	1680	24.3	0.063	702	924	27.0	0.092
671	1620	24.6	0.070	705	890	26.9	0.092
652	1560	25.8	0.068	654	850	26.8	0.088
723	1920	25.5	0.072	672	1050	26.6	0.094
731	1570	25.6	0.072	717	860	26.9	0.091
722	1440	24.7	0.073	730	790	26.6	0.096
676	1800	25.2	0.081	689	990	26.9	0.090
679	1920	24.6	0.070	681	1050	26.6	0.095
677	2100	25.7	0.050	677	1150	26.4	0.061
Mean[+]	1320	25.0	0.112		750	26.9	0.140
SE ±	110	0.61	0.010		98	0.5	0.015

(+) Mean of the all 85 tested lines.

From these studies it is apparent that the neurotoxin β-ODAP is much lower than the landraces. Further it is interesting to note that the yield potential of these lines is relatively high when rainfall at Breda was 227mm. The result reported here appear to be highly encouraging to overcome the problem of toxicity of this drought tolerance hardy crop.

(Ali M. Abd El Moneim)

5.2.6.2. Exploitation of Somoclonal Variation.

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

In 1997/98, explants of roots, leaves, internodes and shoots were taken from 15 old seedlings (grown *In vitro*) of five improved lines and ten Ethiopian land races of *Lathyrus sativus*. These explants were cultured on B5L for roots, leaves and internodes or B5L2 for shoots medium. Explants developed into collogenic tissue after few days of culturing and were subcultured on fresh medium every 6 weeks. Explants, which developed roots, were transferred to B5L2 media; explants with shoots but no roots were cultured on MSL+ or on MSL++ (Murashing & Skoog, *Lathyrus*, supplemented with growth regulators). Plants (R_1) with well-developed roots and shoots were hardened and transferred to the plastic house till maturity and seeds obtained. The obtained seeds were planted in the plastic house.

From 3166 explants cultured, 76% developed callus, 4% developed into plantlets Table 5.13. Roots could be regenerated from all tissues analyzed; however, only internodes and shoot meristem and one root explants gave rise to new shoots. Rooting of shoot meristem was only successful when these explants were cultured on MSL++ medium.

In case of Ethiopia landraces only explants of internodes and shoots have been used and the percentage of regenerated between lines varies significantly and seems to be related to the ability to regenerate roots rather than shoots.

Table 5.13. Number and origin of explants to cultured and their regeneration in *Lathyrus sativus*.

IFLLS#	Expl. (NO.)	Expl. as callus (%)	Expl. with roots (%)	Expl. with shoots (%)	Reg. Plants (No.)	Reg. plants (%)
85	470	60	18.3	19.1	12	2.6
482	253	45.1	29.2	19.3	18	6.3
520	180	48.9	23.9	19.4	14	7.8
521	196	62.8	12.8	20.4	8	4.1
589	296	42.2	23.3	25.7	26	8.9
Eth.1	200	28.0	10.0	22.0	20	10.0
Eth.2	195	33.3	4.1	35.4	6	3.1
Eth.3	212	31.6	9.1	23.6	10	4.7
Eth.4	187	29.4	6.4	43.3	6	3.2
Eth.5	221	40.7	8.1	27.6	8	3.6
Eth.6	159	45.9	3.8	32.0	4	2.5
Eth.7	151	47.7	4.6	43.7	3	2.0
Eth.8	162	38.3	0.0	38.3	1	0.6
Eth.9	157	49.0	4.5	33.8	6	3.8
Eth.10	127	29.1	5.5	36.2	1	0.8
Total	3166	44	13.5	21.5	128	4.2

Significant differences between selections analyzed could be observed for regeneration capability. Seedlings of the regenerated plants showed high variation for morphological traits such as flower colour, leaf shape, pod length and shape, number of seeds per pod and pod length as compared to the original lines. The R_2 and R_3 plants are currently developing in the plastic house and individual plant seeds will be analyzed for β-ODAP content.

(B.Van Dorrestein, M. Baum, Ali Abd EL Moneim)

5.3. Zinc effect on β-ODAP content in *Lathyrus sativus*.

It was recently found that plants increase the level of the neurotoxin β-ODAP in their seeds under environmental stress (drought and zinc deficiency). Our observations also indicate that *Lathyrus sativus* landraces collected from Ethiopia, Bengladesh and India are high in their β-ODAP content. The reason may be that soils depleted in micronutrients from flooding by monsoon rains (India subcontinent) or other wise poor in available zinc (Ethiopian vertisols) may be responsible for higher increase in the neurotoxin β-ODAP, and subsequently higher incidence of human lathyrism.

A preliminary greenhouse experiment was conducted in 1998, where three lines IFLLS # 512, 566 and 562 having β-ODAP content 0.156, 0.433, and 0.750, respectively representing low, medium, and high β-ODAP content.

The results of this preliminary experiment demonstrated that *Lathyrus sativus* lines showed significantly seed yield increase with Zinc (Zn^{++}) fertilization to an extent that varied between lines. In the most sensitive zinc, line 512, seed yield was almost doubled by the additional of as little as 5ppm Zn^{++}. The other two lines 562 and 566, showed response to Zn^{++}, particularly of the higher fertilization rate (50 ppm.). The zinc responsive line 512 also showed a consistent increase in seed weight/gram with increasing zinc level. While all lines tended to have reduced zinc concentration with plant age, as evidenced by sampling at different growth stages, plant zinc concentration was higher with zinc fertilization regardless of growth stage. However, the major significance of the study lay in the fact that the increased Zn^{++} concentrations in the tissue were clearly associated with reduced levels of the neurotoxin β-ODAP while all three lines varies in the β-ODAP content, substantial and consistent decreases occurred with added Zn^{++} particularly at the higher level (50 ppm) rate Table5.14.

The break-through findings will be confirmed in the greenhouse where a wider range of Zn^{++} concentrations will be used. Initial field studies will focus on soil

Table 5.14. Effect of soil zinc PPM on 100 seed weight/gr, grain yield/25 plants and β-ODAP.

	100 seed weight/gr				Yield/25 plants				β-ODAP (%)			
Soil Zn^{++} PPM	LS512	LS566	LS562	Mean ± SE	LS512	LS566	LS562	Mean ± SE	LS512	LS566	LS562	Mean ± SE
0	7.4	13.5	11.2	10.7±3.0	29.9	52.3	48.2	43.5±11.9	0.253	0.331	0.288	0.291±0.04
5	9.7	12.2	12.3	11.4±1.5	49.4	51.0	53.9	51.5±2.3	0.199	0.200	0.214	0.200±0.08
50	10.4	13.5	12.2	12±1.6	63.9	70.9	56.8	63.9±7.0	0.151	0.160	0.177	0.163±0.02

application and foliar Zinc sprays to reduce the nuerotoxin β-ODAP. Such findings have a major implications on human health in countries where grasspea seeds are big part of the staple diet.

(Ali Abd EL Moneim (GP), John Ryan (NRMP))

5.4. Nutritional Quality.

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

5.4.1. Hay and Straw Quality of *Vicia* spp. & *Lathyrus* spp.

The quality parameters utilized in forage breeding program are crude protein (CP%), neutral detergent fibers (NDF%), acid detergent fiber (ADF%) and dry matter organic matter digestibility (DMOM%).

Large differences were observed both between and within species. Generally, hays of vetches are more nutritious having higher protein contents than straw (Table 5.15a). Hay of *Vicia dasycarpa* (wooly-pod vetch) has the highest protein content followed by *Vicia sativa* (common-vetch) and *V. ervilia* (bitter vetch). Because of the high proportion of fibers in wooly-pod vetch hay and straw its digestibility is lower than the other vetches. Bitter vetch has low fiber contents that resulted to high digestibility. Hays of *Lathyrus sativus* (grasspea) and *L. cicera* (Dwarf chickling) are higher in protein content and digestibility Table 5.15 b. 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.

Table 5.15a. Mean and range of protein content (%) NDF, ADF, and DOMD for hay and straw of Four *Vicia* spp. Promising lines in advanced yield trials at Tel Hadya.

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
V. sativa								
Mean	18.1	34	24	73	12.1	44	34	56
SE ±	1.2	2.0	1.5	3.5	1.4	2.0	1.6	4.9
Range	14-22	30-46	20-31	66-80	8-16	40-55	30-40	45-68
Vicia ervilia								
Mean	17.2	24	18	79	12.0	34	27	60
SE ±	1.6	2.6	1.5	4.0	1.5	3.0	1.5	6.0
Range	14-22	20-35	15-26	72-85	11-17	30-45	25-34	51-75
Vicia dasycarpa								
Mean	20	36	26	67	10	45	34	52
SE ±	1.8	3.8	2.0	3.5	2.1	4.0	2.6	5.2
Range	17-24	25-46	20-32	57-75	6-13	35-55	30-40	40-70
Vicia narbonensis								
Mean	-	-	-	-	13.5	45	34	53
SE ±	-	-	-	-	1.8	3.9	2.5	5.0
Range	-	-	-	-	9-16	30-50	30-41	44-62

Table 5.15b. Mean and range of protein content (%) NDF, ADF, and DOMD for hay and straw of three *Lathyrus* spp. elite lines in advanced yield trials at Tel Hadya.

	Hay				Straw			
Species	Protein %	NDF %	ADF %	DOMD %	Protein %	NDF %	ADF %	DOMD %
Lathyrus sativus								
Mean	19.5	42	30	74	13.5	55	30	60
SE ±	1.2	4.0	2.7	4.2	1.5	3.0	2.8	4.9
Range	17-23	30-55	22-37	60-80	8-15	40-60	28-44	50-75
Lathyrus cicera								
Mean	19.7	30	-	70	14.0	50	30	59
SE ±	1.6	3.5	-	3.8	1.6	4.9	2.5	4.0
Range	15-25	25-35	-	62-80	10-17	34-60	24-37	45-68
Lathyrus ochrus								
Mean	-	-	-	-	12.5	52	28	61
SE ±	-	-	-	-	0.8	5.7	3.2	4.5
Range	-	-	-	-	8-14	27-70	20-42	50-70

5.4.2. Protein and neurotoxin 3-(N-Oxalyl)-L-2,3-diamino-propionic acid (β-ODAP) in three *Lathyrus* spp. grain at Tel Hadya and Breda.

Protein and neurotoxin β-ODAP for promising lines of *Lathyrus sativus, L. Cicera* and *L.Ochrus* were estimated by a Near-Ifrared Reflectance (NIR) spectroscopy Model NEOTEC 5000, with a wave length setting between 1100 and 2500 mm. Every fifth sample was verified by Micro-Kjeldahl method for crude protein and classical spectrophotometic analysis for β-ODAP. Which gave a correlation of r=0.92 and 95 for β-ODAP and crude protein, respectively. Table 5.16 summarizes the results of crude protein% and β-ODAP% for 25 promising lines each of *L. sativus, L. cicera* and *L. Ochrus* grown at Tel Hadya and Breda with rainfall of 410 and 227mm, respectively. The results indicate that none of the tested lines was β-ODAP free, although some lines were very low below 0.1% (The threshold is 0.2%). Large variation was found between species and between lines within the same species. *Lathyrus ochrus* had the highest protein and β-ODAP, whereas, *L. cicera* had the lowest protein and β-ODAP contents at the two locations. The presence of such variation in protein and β-ODAP suggests that there is a good potential for developing lines of the three tested species with low β-ODAP and high protein contents.

Table 5.16. Mean and range of protein and β-ODAP content of grains of promising lines of three *Lathyrus* spp. at Tel Hadya and Breda.

	Tel Hadya		Breda	
Species	Protein(%)	β-ODAP(%)	Protein(%)	β-ODAP(%)
L. sativus				
Mean	28.0	0.15	30.0	0.21
SE ±	2.0	0.03	1.6	0.05
Range	24-32	0.07-0.2	25-33	0.1-0.3
L. cicera				
Mean	26.0	0.10	28.0	0.17
SE ±	1.4	0.02	1.1	0.02
Range	22-30	0.06-0.14	25-32	0.11-0.2
L. ochrus				
Mean	30.0	0.39	32.0	0.5
SE ±	2.0	0.08	2.1	0.09
Range	27-34	0.25-0.6	24-35	0.3-0.7

5.4.3. Tannins and Protein Contents of Narbon vetch(*Vicia narbonensis*) seed.

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

Non of the twenty-five lines of narbon vetch were tannin-free. Tannin contents of the whole seed varied from 0.03%,in Sel#2388 and 2389 to 0.30% in sel # 2398, whereas, protein content varied from 22.8% in sel # 2472 to 28.0% in Sel # 2385. Lines with very low tannin content were susceptible to downy mildew (*Peronospora viciae*), aphis (*Aphis craccivora*) and pod-borer (*Helicovera* sp.). The presence of moderate levels of tannins in narbon vetch may be a beneficial as a defense against insects and diseases and on animal by reducing the risk of bloat.

In conclusion, the improvement of vetches and chicklings quality is of a paramount importance to the performance of ruminant animals (sheep and goats). A modest increase in protein and digestibility from the development of new elite lines can increase animal performance. Both quantity and quality of the forage consumed contribute to response of the animal. Therefore, progress in breeding for high yield potential is supplemented by improving the quality of the herbage, grain and straw. Forage vetches and chicklings improved in quality were developed by breeding for (a) greater nutritional value, (b) increasing intake and digestibility (c) lower contents and are injurious which reduce the feed intake of toxic properties to animal health. The most useful selection criteria in our breeding program for voluntary intake is the leafiness. Thus, leafiness appears to be an important attribute at the morphological level in the early stage of our breeding program and could help in the improvement of nutritive value of the herbage and straw. Leafness has also been found to be positively correlated with protein content and digestibility.

(Ali M. Abd El Monein, H. Nakkoul)

5.5. Biological Nitrogen Fixation (BNF) in Forage Legumes.

Biological Nitrogen Fixation has been estimated in chicklings (*Lathyrus* spp.), advanced yield trials of 1995/96 season at Tel Hadya, Breda and Kfardan stations with rainfall 404.5, 359.8 and 524.9 mm, respectively using N^{15} dilution method technique. In each entry/treatment, a microplot of 1x1m area was marked after planting, N^{15} fertilizer was added as a solution to the soil equivalent to 10 kg N/ha at 10% enriched amonium sulphate. Similar plots (3 replicates) were planted with non-nodulating chickpea (PM-233) and barley (Arabi Aswad) and within each plot a microplot of 1x1m was marked and received 40kg/ha as 2.5% enriched amonium sulphate. At a physiological maturity stage, 3-5 plant shoots of the middle of each microplot (Legume and reference crop) were collected for the estimations of % N^{15}. Plant samples were dried, ground, sieved and sent for analysis to Europa Scientific and CSIRO laboratories to estimate the average of % N^{15} used to calculate the amount of nitrogen fixed biologically by the legumes.

The results revealed great variability among the three species within the same location and also among the three locations (Table 5.17). At the three locations, the nitrogen derived from fixation was higher in *Lathyrus ochrus* than the other two species. Generally, nitrogen derived from fixation was lower at kfardan than Tel Hadya and Breda. This is mainly due to that the crops were affected by frost that occurred for 69 nights with an absolute minimum temperature of $-6.0^{0}C$.

Table 5.17. Estimation of biological nitrogen fixation as N fixed (kg/ha) in three *lathyrus* spp. grown in Tel Hadya, Breda and Kfardan.

		Location		
Species	No. of entries	Tel Hadya	Breda	Kfardan
L. sativus	25	127±13	131±16	67±12
L. cicera	25	166±16	144±18	93±10
L. ochrus	16	170±18	200±15	107±16

(Fadel Afandi, M.C. Saxena, Ali M. Abd EL Moneim)

5.6. Forage Legume Pathology

Screening and selection for resistance to major stem and leaf diseases of forage legumes is an important selection criteria for developing productive forage legumes suitable for the dry and marginal areas of the WANA region. The main diseases occurring on forage legumes in the WANA region are: Downy mildew *(Peronospora trifoliorum)*, 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: a) monitor the relative importance of these diseases on selected genotypes in on-farm trials, and through periodic disease surveys in the region, b) evaluate and selected genotypes for resistance to the major diseases and obtain information on sources of resistance to individual and multiple diseases from new genetic resources.

5.6.1. Monitoring diseases in on-farm trials

Diseases that were observed on forage legumes included in the 1997/98 on-farm trials in some locations during the 1998 travelling workshop with the Syrian National Program were: stem rots (*Sclerotinia sclerotiotum* and *Botrytis cinerea*); downy mildew (*Peronospora* spp.); cyst nematodes (Heterodera spp.), root rots (*Fusarium* spp.) and broomrape (*Orobanche* spp.).

In general, the incidence and severity of the diseases recorded were low at most locations. However, the severity of stem rot at Hama station on *Vicia ervilia* and *V. sativa* was very high and affected all genotypes (Table 5.18).

Downy mildew was observed on most genotypes of *V. sativa* at Tel Hadya (Table 5.19). Two genotypes (IFLVS # 1716 and IFLVS # 1768) showed the highest severity. At Souran, only the genotype IFLVS # 1887 showed 5% root rot incidence. At Tel Hadya the genotype IFLVE # 2847 showed a 10% root rot incidence. At Himo, the genotype IFLVE 2790 showed 5% root rot incidence. At Tel Hadya, the incidence of cyst nematodes on *Vicia ervilia* was estimated to be 5%. At Himo, the level of downy mildew on common vetch, narbon vetch and chickling was very low. Broomrape infestation was higher on *Vicia ervilia* than on *V. sativa* at Souran.

Table 5.18. Mean percent incidence and severity* of stem rot on bitter vetch (*Vicia ervilia*) and common vetch (*Vicia sativa*) at Hama station, Syria, 1997-98.

Species	Incidence	Severity
Vicia ervilia		
IFLVE #10	60	3
IFLVE #2542	90	4
IFLVE #2847	55	3
IFLVE #199	90	5
IFLVE #2790	70	4
Vicia sativa		
IFLVE #2541	35	2
IFLVE #1768	30	2
IFLVE #1887	40	3
IFLVE #715	35	3
IFLVE #1716	20	2

* Average of two replications.

Table 5.19. Number of entries of narbon vetch and common vetch in different disease reaction categories, Tel Hadya, 1997/98 cropping season.

Nursery	Number of entries in each disease reaction category*					
	1	2	3	4	5	Total
Narbon vetch nursery	0	21	37	5	58	121
Narbon vetch AYT	6	15	3	0	1	25
Common vetch nursery	46	12	13	21	8	100

* 1-5 rating scale where 1 = resistant; and 5 = susceptible.

5.6.2. Screening narbon vetch (*Vicia narbonensis*) for resistance to downy mildew.

A total of 121 accessions obtained from Genetic Resources Unit (GRU) were planted in two replications in randomized complete block design at Tel Hadya. Each accession was planted in two row plots of 2.5-m length and 0.30 m width. After every five accessions, a susceptible genotype was planted as a check and spreader row. In order to maximize disease development, infected narbon vetch debris from the previous season was spread in the plots four weeks after planting. Disease severity was assessed based on 5 point rating scale where 1=highly resistant and 5=highly susceptible. All accessions showing lower than 3 ratings were considered resistant and maintained for further evaluations.

The weather conditions during the 1997/98 cropping season were favorable for downy mildew development at Tel Hadya. None of the narbon vetch accessions was immune to the disease but a total of 21 accessions were found resistant (rating of 2) and the remaining showed moderately to highly susceptible reactions where the latter reactions predominated. Most of the resistant accessions originated from Lebanon, Palestine, Syria, Italy and Turkey. Most of the accessions collected from Syria were susceptible to downy mildew (Table 5.18).

5.6.3. Evaluation of narbon vetch (*V. narbonensis*) promising lines for resistance to downy meldew.

The evaluated material consisted of 25 lines that were grown in the advanced yield trial in the breeding blocks. Downy mildew infection came from natural inoculum. Disease severity was based on percentage leaf infections and the data was subjected to analysis of variance after appropriate transformation.

Significant ($p<0.05$) difference were observed among lines in affecting disease severity. Among the lines, IFLVN # 2651, # 2377, # 2379, # 2381, # 2382, # 2385, # 2469, and # 2601 showed < 15% leaf infections. The most resistant genotype (<5% leaf infection) was IFLVN # 2651. This genotype could be used in the crossing block to develop mildew resistant gene pools.

5.6.4. Screening of Common vetch (*Vicia sativa*) for downy mildew resistance.

a) Disease nursery: A total of 129 genotypes of common vetch were evaluated in the downy mildew disease nursery at Tel Hadya. Each genotype was planted in two row plots with 2.5-m length and 0.3m width in randomized complete block design with two replications. The nursery was inoculated with infected debris collected from the previous season. Disease severity was assessed based on the rating scale described earlier for the narbon vetch nursery.
b) Breeding block: A total of 100 common vetch genotypes originating from Syria, Turkey and Iran were planted in the breeding block. Downy mildew development was initiated from natural inoculum and was severe on the susceptible genotypes.

Disease development in the screening nursery relied mostly on natural inoculum because of late spread of infested debris in the nurseries. The maximum rating was 2 on a few genotypes. This trial will be repeated in the next season. In the breeding block, however, downy mildew development was high and resistant selections could be detected (Table 5.20). Resistance sources were found from the three countries where the genotypes were collected. Half of the genotypes from Iran were highly susceptible but a large number of genotypes collected from Turkey and all genotypes from Afghanistan were resistant to downy mildew.

Table 5.20. Mean percent incidence and severity of downy mildew* on common vetch (*Vicia sativa*) at Tel Hadya, 1997-98.

IFLVS#	Incidence	Severity**
Vicia sativa		
IFLVS# 2541	3	1
IFLVS# 1768	10	4
IFLVS# 1887	3	1
IFLVS# 715	0	1
IFLVS# 1716	25	5
Mean	8.2	2.4

* Average of two replications.
** 1-5 ratings where 1 = resistant and 5 = susceptible.

(S. Kemal, C. Akem, Ali M. Abd EL Moneim)

5.7. Forage Legumes Entomology

5.7.1. Evaluation of *Lathyrus* spp. for resistance to Pea aphid (*Acyrthosiphon pisum Harris*).

Twenty-five accessions each of *Lathyrus sativus, Lathyrus cicera* and *Lathyrus ochrus* of the advanced yield at Tel Hadya were evaluated for resistance to pea aphid, (*Acyrthosiphon pisum Harris*) under natural infestation. The evaluation was done on 14 April, using a visual damage score (VDS) of 1-5, with 1= no damage; 2= slight damage, some curling of the leaves, no honeydew production; 3= moderate damage, obvious curling of the leaves, heavy honeydew production, 4= sever damage, sever curling of the leaves, heavy honeydew production, stunted plants; 5= severe stunting.

Table 5.21. shows that *L. sativus* has the highest number of resistant lines, 7 with a VDS of less than 2.5. Both *L. cicera* and *L. ochrus* has only one line with a VDS of less infestation in 1999 season.

Table 5.21. Selected lines of *Lathyrus* spp. for resistance to Pea aphid, Tel Hadya, 1998.

Lathyrus sativus	VDS[1]	*Lathyrus cicera*	VDS	*Lathyrus ochrus*	VDS
IFLL#554-97	2	IFLLC#494-97	2.33	IFLL#547-97	2.2
IFLLS#564-97	2	IFLLC#574-97	2.6	IFLLO#537-97	2.25
IFLLS#565-97	2	IFLLC#493-97	2.63	IFLLO#540-97	2.55
IFLLS#556-97	2.3			IFLLO#550-97	2.57
IFLLS#560-97	2.3				
IFLLS#561-97	2.3				
IFLLS#535-97	2.3				

[1] Visual Damage Score (VDS), where 1 = no damage and 5 = severe stuning.

(M. EL Bouhssini, Ali Abd EL Moneim)

5.8. International Testing Program

The international testing program on feed legumes is a medium for the diffusion 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 forage legume international trials were initiated from 1991. The genetic materials in forage legume trials comprise elite lines with wide or specific adaptation, special morphological or quality traits, and resistance to common biotic and abiotic stresses. Nurseries are only sent on request and often include germplasm specifically developed for a particular region or a national program. A list of trials supplied in the 1998/99 season is given in Table 5.22.

The testing program helps in identification of genotypes with specific and wide adaptation and help in targeting breeding efforts for specific agro-ecological conditions.

We supplied 144 sets of 4 different types of trials and nurseries (Table 5.22) to various cooperating scientists in 16 countries for conduct during the 1998/99 season.

The prominent features of the 1996/97 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 selections mentioned as having a general or specific adaptation following the stability analysis showed above average yield performance.)

Table 5.22. Distribution of Forage Legume International Nurseries to cooperators for the 1998/99 season.

International Trial/Nursery	No. of sets
Lathyrus Adaptation Trial (ILAT)	
- *Lathyrus sativus* (ILAT-LS-99)	36
Vetch Adaptation Trial (IVAT)	
- *Vicia sativa* (IVAT-VS-99)	42
- *Vicia narbonensis* (IVAT-VN-99)	32
- *Vicia ervilia* (IVAT-VE-99)	34
Total	144

Three International *Lathyrus* Adaptation Trials (ILAT) namely, *Lathyrus sativus* (ILAT-LS), *Lathyrus cicera* (ILAT-LC), and *Lathyrus ochrus* (ILAT-LO); and four International Vetch Adaptation Trials (IVAT) namely, *Vicia sativa* (IVAT-

VS), *Vicia narbonensis* (IVAT-VN), *Vicia ervilia* (IVAT-VE), and *Vicia villosa* ssp *dasycarpa* (IVAT-VD) were supplied to cooperators during 1996/97. In each of these trials, there were 15 test entries and one local check. The results of these trials are discussed as below.

In ILAT-LS the mean seed yield of selections reported from 11 locations of 7 countries varied between 810 and 1504 kg/ha with an average of 1169 kg/ha. Selection #565 showed general adaptation across all locations. Selections #471 and #463 showed adaptation to high yielding environments, whereas selection #563 to low yielding environments. The five best entries across all locations were #559, #453, #456, #471 and #463. The biological yield of *Lathyrus sativus* selections varied between 2291 and 3164 kg/ha with an average of 2671 kg/ha. Selection #563 showed general adaptation. The five best entries across all locations were #456, #563, #471, #565 and #453.

ILAT-LC was reported from 5 locations in 3 countries. The mean seed yield of entries across locations ranged between 815 and 1176 kg/ha with an overall mean of 1024 kg/ha. The selection #487 showed general adaptation. Selections #500 and #569 showed the best adaptation to high yielding environments, whereas selection #572 was the best adapted to low yielding environments. The five best entries across all locations were #500, #572, #569, #570 and #573. The biological yield of *Lathyrus cicera* selections varied between 4787 and 8010 kg/ha with an average of 6554 kg/ha. However, the observed differences were statistically not significant. The selection #572 showed general adaptation. The selection #500 was particularly adapted to favorable environments. The five best entries across all locations were #500, #499, #570, #497 and #569.

The results for ILAT-LO were reported from 6 locations in 3 countries. The mean seed yield of entries across locations ranged between 326 and 542 kg/ha with an overall mean of 442 kg/ha. Most selections showed general adaptation. The selection #185 showed the best adaptation to high yielding environments. The five best entries across all locations were #185, #540, #549, #547 and #541. The biological yield of *Lathyrus ochrus* selections varied between 1270 and 1889 kg/ha with an average of 1586 kg/ha. The selection #548 showed general adaptation across all locations. The selection #185 was particularly adapted to favorable environments. The five best entries across all locations were #548, #185, #540, #549 and #547.

The results of IVAT-VS, IVAT-VN, IVAT-VE and IVAT-VD were reported from 14, 8, 7, and 6 locations, respectively.

In IVAT-VS, the mean seed yield for entries across locations (9 countries) varied between 810 to 1328 kg/ha with an average of 1115 kg/ha. The selection #2680 showed general adaptation. Selection #2495 was the best adapted to high yielding environments, whereas selection #2566 showed the best adaptation to low yielding environments. The five best entries across all locations were #2495, #2073, #2484, #2680 and #2490.

The biological yield of *Vicia sativa* selections varied between 2580 and 3800 kg/ha with an average of 3091 kg/ha. The selections #2083 and #2627 showed general adaptation. Selection #2680 showed the best adaptation to high yielding environments. The five best entries across all locations were #2486, #2680, #2083, #2627 and #2068.

In IVAT-VN, the mean seed yield of selections across environments (four countries) varied between 814 and 1147 kg/ha with an average seed yield of 979 kg/ha. However, the observed seed yield differences were statistically not significant. The regression component of the stability analysis of variance was not significant indicating that all the selections belonging to this trial had average stability. The biological yield of *Vicia narbonensis* selections varied between 3231 and 4514 kg/ha with an average mean of 3918 kg/ha. However, the observed biological yield differences were statistically not significant. Selections #2474 and #2473 showed general adaptation. Selection #2470 showed the best adaptation to high yielding environments, whereas selection #2385 was the best adapted to low yielding environments.

In IVAT-VE, the mean seed yield of selections across environments (three countries) varied between 682 and 956 kg/ha with an average seed yield of 833 kg/ha. The selection #2646 showed general adaptation. Selections #2511 and #2648 showed specifically adaptation to high yielding environments. The five best entries across all locations were #2648, #2649, #2511, #2508 and #2646. The biological yield of *Vicia ervilia* selections varied between 1929 and 2646 kg/ha with an average of 2303 kg/ha. However, the observed differences were statistically not significant. The selection #2563 showed general adaptation. The selection #2646 was the best adapted to high yielding environments, whereas selection #2651 was the best adapted to low yielding environments.

In IVAT-VD, the mean seed yield of selections across environments (six countries) varied between 363 and 510 kg/ha with average seed yield of 443 kg/ha. Selection #2565 showed general adaptation. Selection #2441 was particularly adapted to high yielding environments. The five best entries across all locations were #2441, #2446, #2450, #2424 and #2565. The biological yield of *Vicia dasycarpa* selections varied between 2102 and 2668 kg/ha with an average of 2292 kg/ha. However, the observed differences were statistically not significant. The selection #2438 and #2431 showed general adaptation. The selection #2450 was the best adapted to high yielding environments, whereas selections #2433 and #2562 were the best adapted to low yielding environments.

(R.S. Malhotra, B. Ocampo, A. M. Abd El Moneim, NARS Scientists)

5.9. Use of Forage Legumes by NARS

The Mashreq countries Iraq, Jordan, Lebanon and Syria have an extensive work on farmers' fields to demonstrate the potential of forage legumes, as the best option 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 vetches and chicklings in rotation with cereals (barley or wheat), and their alternative utilization (hay making, direct 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 (Baraka) of 188 grams without supplementary feeding. Results from Iraq showed an average increase in milk production from ewes grazing common vetch variety Baraka (IFLVS#715) of 175 gm/ewe/day. In Lebanon, the released variety of *Lathyrus cicera* (Jaboula) is widely grown in El-Kasr where rainfall is below 250mm.

In Saudi Arabia, at experimental station of king Saud University at Deirab (24-42 ^{0}N, 44-46 ^{0}E) near Ryadh, seventeen lines of *Vicia sativa* and six lines of *Vicia narbonensis* supplied from ICARDA were tested. The best two lines of *V. sativa* were IFLVS#2019 and IFLVS#715 (Baraka), whereas, the best lines of *V. narbonensis* were IFLVS # 2380 and 2383. They are adapted to the central region of Saudi Arabia.

In Criz Alta, Brazil, improved lines of *Vicia sativa*, *V. dasycarpa* and *V. ervilia* were selected from materials supplied by ICARDA in advanced yield trials for their adaptation and yield potential. The most promising lines were IFLVS# 370, 371, 1895 and 3625, IFLVD# 839, 3684, 4139 and IFLVE# 589, 225 and 199. Table at the end of this report (see page 248) shows the cultivars released by national programs in collaboration with ICARDA.

(NARS, ICARDA Scientists)

6. DRY PEA IMPROVEMENT

Although dry peas was domesticated in West Asia and the crop has been cultivated in the ICARDA region for millenia, yields are low because of lack of high yielding and stable cultivars and poor crop management practices. Accordingly, research on dry pea improvement was initiated at ICARDA in 1986. Building on the extensive research on the improvement of dry pea in the developed and also some developing countries, ICARDA identified drypea lines adapted to the farming systems of WANA. Our research on Dry Pea was focused on:

a) assembling enhanced germplasm from institutions in developed and developing countries, and testing their adaptation at ICARDA sites in Syria and Lebanon,
b) increasing the seed of adapted lines and sharing the promising materials with the NARSs in and beyond WANA through Legume International Testing program, and
c) Developing suitable production technology at ICARDA for its transfer to the NARSs for tesing and future use.

Research at ICARDA investigated management practices for pea production under low to medium altitude Mediterranean environments in WANA. Mid-November to early December is the optimum sowing time for peas in the region. Peas fix circa 75 kg N/ha during the season and therefore, are comparable with other cool season food legumes (lentil, fababean and chickpea) in the region. Sowing peas at a population density of 36 plants/m^2 for traditional types and 50 plants/m^2 for semi-leafless types gave optimal high seed yield. The herbicide trials at Tel Hadya revealed that pre-emergence application of a combination Propyzamid (0.5 kg a.i./ha) and Methabenzthiazuron (2.5 kg a.i./ha) or Propyzamid (0.5 kg a.i./ha) plus Cyanazine (0.75 kg a.i./ha) were effective in controlling the weeds.

Cold stress being common during the winter months all the introduced materials were evaluated for cold tolerance under Tel Hadya conditions using a technique followed in chickpea. This technique involves early planting (late September or early October) of pea materials and evaluating it in the month of January or February when the susceptible check cum indicator rows are killed by cold. This technique has resulted in identification of a good number of cold tolerant lines. Some of the lines found tolerant to cold across a number of years are given in Table 6.1.

Table 6.1. Pea lines found tolerant to cold across a number of years at Tel Hadya.

Acc. No.	Name	Origin	Acc. No.	Name	Origin
77	K 129	Greece	199	D-166-1-15-1W	USA
85	506-V2	Afghanistan	205	D-166-1-24-6W	USA
86	603-V2	Afghanistan	206	D-166-1-4-2W	USA
186	D166-3-1	USA	346	PIMOS 12069	USA
190	D166-3-1	USA	354	PIMOS 12077	USA
197	D200-4-3	USA	470	WIR-1878	USA

We have distributed a large number of elite lines to the NARSs through our Legume International Testing Network. The evaluation results of these lines across various countries demonstrated that yield levels of some of the improved cultivars were comparable with other cool season food legumes (including chickpea, lentil and fababean). In some countries the location means for seed yields were high (>2500 kg/ha) in different years.

From these elite cultivars, a large number of lines have been identified by NARSs for multi-location or on-farm testing or pre-release multiplication. Some NARSs have released cultivars namely PS210713 (Contemenous in Cyprus); 061K-2P-2192 (in Ethiopia); Collegian, MG102703, A0149 and Syrian Local (in Sultanate of Oman); and Krema-1 and Ballet (in Sudan) for general cultivation in their countries. The last 12-year results of various experiments on dry-peas have demonstrated that it is a crop with potential in the region that can replace fallow areas (under wheat-fallow or barley-fallow rotation). Research on dry pea was discontinued at ICARDA in 1998 for budgetary reasons.

The salient features of the Dry Pea Improvement work is presented here.

6.1. Germplasm Collection and Evaluation

Forty six germplasm and improved cultivars assembled from Australia (4 lines), Romania (34 lines), France (1 line), India (2 lines), New Zealand (1 line), Sudan (1 line), Sweden (1 line), U.K. (1 line), and USA (1 line) 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 108 to 139 days; days to maturity ranged from 154 to 164 days; plant height ranged from 54 to 96 cm; and the harvest index ranged from 1.3 to 56.3%; seed yield ranged from 63 to 1799 kg/ha, and biological yield ranged from 2281 to 4862 kg/ha (Table 6.2).

Table 6.2. Adjusted seed yield in kg/ha (SYLD) and rank (R), biological yield in kg/ha (BYLD), days to flowering (DFLR), days to maturity (DMAT), plant height (PTHT) and harvest index (HI) of entries in Pea Genetic Evaluation Trial (PGEVT) at Tel Hadya during

Acc.No.	NAME	Origin	DFLR	DMAT	PTHT	BYLD	SYLD	R	HI
160	MG 102469	UK	113	155	84	3195	1799	3	56
173	MG 102703	India	113	154	80	4307	1696	6	39
267	PS 210713	USA	109	154	48	3924	1244	15	32
321	AMAC	France	109	154	50	3543	1577	7	45
380	DMR-8	India	109	154	48	3563	1755	5	49
403	ACC. 1670	New Zealand	111	154	54	3267	1316	14	40
505	590-2-81-82-83	Sudan	108	154	55	2281	973	18	43
507	SV88269	Sweden	126	160	76	3244	358	25	11
545	88 P X00-34	Australia	112	154	70	4206	1556	8	37
633	88P022-6-21	Australia	113	154	80	4594	1782	4	39
895	P200/95	Romania	111	154	51	3115	1404	12	45
897	P212/95	Romania	115	154	55	4164	1832	2	44
898	P164/92	Romania	133	163	73	3733	130	33	4
899	P185/92	Romania	130	162	96	3933	706	20	18
900	P193/92	Romania	122	162	94	3451	174	31	5
901	P281/92	Romania	134	162	91	3494	192	27	6
903	P110/93	Romania	133	162	94	3817	88	42	2
904	P116/93	Romania	134	163	86	4024	127	34	3
905	P122/93	Romania	129	164	93	4181	101	38	2
906	P189/92	Romania	134	163	82	3925	72	45	2
909	P097/94	Romania	139	163	99	3563	76	44	2
913	P119//94	Romania	133	162	78	3310	182	29	6
914	P121/94	Romania	133	162	80	3664	121	35	3
915	P124/94	Romania	134	163	90	3581	93	41	3
973	P92/88	Romania	110	158	90	3723	664	21	18
974	P268/91	Romania	130	163	81	4186	177	30	4
975	P157/92	Romania	138	164	82	2722	62	47	2
976	P286/92	Romania	138	163	94	3855	54	48	1
977	P69/94	Romania	127	162	95	3602	187	28	5
978	P87/94	Romania	114	163	92	3098	521	22	17
979	P121/94	Romania	137	164	82	4386	121	36	3
980	P138/94	Romania	138	164	82	3510	100	39	3
981	P140/94	Romania	138	161	70	3658	49	49	1
982	P151/94	Romania	138	163	81	4296	118	37	3
983	P158/94	Romania	138	163	89	3710	88	43	2
984	P105/95	Romania	137	163	78	3923	139	32	4
985	P108/95	Romania	139	163	77	4257	97	40	2
986	P109/95	Romania	137	161	82	3506	63	46	2
987	P147/95	Romania	115	154	83	4023	1513	10	38
988	P152/95	Romania	114	156	81	4264	1359	13	32
989	P159/95	Romania	119	163	88	4862	307	26	6
990	P160/95	Romania	117	162	93	4608	375	23	8
991	P168/95	Romania	111	158	95	4220	1226	16	29
992	P173/95	Romania	121	161	78	4282	363	24	9
1016	BALESK	Australia	109	154	58	3646	1517	9	42
1017	BLOEY	Australia	109	154	54	3465	1405	11	41
223	SYR.L. Damascus	Syria	112	154	62	2689	950	19	35
224	The Lincoln	Unknown	110	154	43	2254	1091	17	48
225	SYR.L. Aleppo	Syria	115	154	86	5401	1915	1	36
GRAND MEAN		123	159	78	3760	690			
CV			3.7	0.5	11.9	15.8	42.8		
LSD at P=0.05			7.6	1.4	16.4	1058	509		

6.1.1. Evaluation for Cold Tolerance

In cold tolerance nursery 52 accessions were evaluated for confirmation and 248 new dry pea accessions were evaluated for the first time during 1997/98 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 6.3. From the reconfirmation experiment 13 and 19 entries exhibited rating of 3 and 4, respectively (Table 6.4). From the new dry pea accessions 51, 72 and 27 lines exhibited cold tolerance reaction with ratings of 3, 4 and 5, respectively and will be grown for their confirmation next season.

Table 6.3. Frequency distribution for cold tolerance reaction of 300 pea lines evaluated at Tel Hadya during 1997/98.

	Cold tolerance rating (1-9 scale)*									
Experiment	1	2	3	4	5	6	7	8	9	Total
Confirmation	0	0	13	19	10	2	5	3	0	52
New Lines	0	0	38	53	17	6	8	36	90	248
Total	0	0	51	72	27	8	13	39	90	300

* 1 = no cold damage, 9 =100% plants killed.

Table 6.4. Pea accessions with tolerance to cold at Tel Hadya, 1997/98

Rating 3	Acc No.	-86, -158, -190, -195, -197, -243, -244, -247, -339, -342, -343, -344, -346
Rating 4	Acc No.	- 17, - 77, - 80, - 85, -87, -111, -184, -199, -200, -201, -202, -203, -205, -206, -337, -338, -340, -350, -352

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 1997/98 at Tel Hadya and Terbol. Adjusted seed yield for the entries varied from 137 to 2731 kg/ha at Tel Hadya and 1541 to 4889 kg/ha at Terbol. The location means at Tel Hadya and Terbol were 1191 and 3436 kg/ha, respectively. None of the test entries at Tel Hadya and two test entries (Acc. No. 892, and Acc. No. 967) 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 6.5.

6.2.2. Pea International Adaptation Trial (PIAT)

Twenty-three test entries along with two checks were tested in PIAT-98 at Tel Hadya and Terbol during 1997/98. All the test entries at Terbol and 16 test entries at Tel Hadya yielded significantly better than the local check. The mean seed yields at Tel Hadya and Terbol were 1031 and 3432 kg/ha, respectively (Table 6.6). The five highest yielding entries at Tel Hadya included Local Selection 1690, 88P090-5-2, 88P007-2-1, DMR-7, and Syrian Local Aleppo-1; and at Terbol included 88P090-5-21), Local Selection 1690, Syrian Local Aleppo-2, Syrian Local Aleppo-1, 88P001-4-9, and 88P090-5-26.

(R.S. Malhotra)

Table 6.5. 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 (PYT) at Tel Hadya, and Terbol during 1997/98.

		Tel Hadya						Terbol			
Acc. No.	Name	SYLD	R	DFLR	DMAT	Acc. No.	Name	SYLD	R	DFLR	DMAT
884	P84/95	2731	1	114	163	892	P139/95	4889	1	133	173
643	PUSA-10	2324	2	122	168	967	89P150-15-15	4500	2	134	173
650	DDR-14	2049	4	117	165	932	88P084-5-22	4251	3	135	176
971	89P153-9-1	1979	5	119	168	705	88P078-2-22	4249	4	135	176
717	88P103-6-1	1870	6	118	166	947	89P123-2-7	4233	5	124	171
921	88P048-6-10	1820	7	116	163	753	MARINA	4196	6	131	173
891	P134/95	1777	8	114	163	969	89P150-15-19	4169	7	134	174
673	88P034-3-1	1768	9	120	163	640	SPRING PEA 5	4154	8	137	181
647	DDR-11	1750	10	117	163	933	88P084-5-25	4138	9	132	174
734	ORLOVCHANIN 2	1736	11	114	165	719	88P106-2-1	4112	10	135	176
955	89P132-5-18	1736	12	112	162	714	88P090-5-26	4112	11	135	175
708	88P090-5-12	1696	13	119	163	683	88P038-4-3	4000	12	135	174
736	FLAGMAN 5	1673	14	114	165	939	88P089-3-8	4000	13	129	172
683	88P038-4-3	1650	15	119	166	884	P84/95	3984	14	129	173
825	P3/95	1625	16	117	163	681	88P037-5-9	3984	15	135	177
892	P139/95	1615	17	114	166	620	88P106-2-1	3974	16	135	176
735	FLAGMAN	1613	18	116	165	687	88P038-8-9	3959	17	135	175
954	89P132-5-17	1591	19	112	163	642	PUSA-10-1	3904	18	128	172
726	88PX00-11-3	1589	20	115	163	943	88P089-5-2	3891	19	128	173
658	DMR-26	1574	21	118	167	738	FLAGMAN 8	3890	20	130	173
223 (Check1)	SYR.L. Damascus	922	106	117	168	223 (Check1)	SYR.L. Damascus	2054	143	130	177
224 (Check2)	The Lincoln	1515	28	115	163	224 (Check2)	The Lincoln	2359	141	130	171
225 (Check3)	SYR.L. Aleppo	2076	3	121	163	225 (Check3)	SYR.L. Aleppo	3609	54	137	180
Grand Mean		1191		117	165			3436		131	174
S.E. Of Mean		308.51		1.28	1.61			318.13		0.84	1.43
LSD (P=0.05)		855.01		3.56	4.47			881.67		2.34	3.95
C.V. %		36.64		1.55	1.38			13.09		0.91	1.16

Table 6.6. Mean seed yield in kg/ha (SYLD) and rank (R), days to flower (DFLR), and days to maturity (DMAT) of entries at Tel Hadya and Terbol in PIAT-98.

Acc			Tel Hadya				Terbol			
No.	Name	Origin	SYLD	R	DFLR	DMAT	SYLD	R	DFLR	DMAT
8	Syrian Local Aleppo-1	Syria	1537	5	122	164	3963	2	137	178
21	Local Selection 1690	Syria	1816	1	122	164	3931	3	137	179
549	WA 933	Australia	829	17	118	166	3632	12	129	178
611	88P038-10-18	Australia	790	19	119	166	3082	20	135	179
613	88P050-6-9	Australia	829	18	119	163	3753	8	134	172
616	88P090-5-21	Australia	1658	2	119	161	3712	10	135	174
618	88P090-5-26	Australia	1109	11	119	163	3804	5	134	174
621	88P106-2-5	Australia	915	13	119	166	3781	7	135	176
627	88P035-4-4	Australia	846	16	123	166	3534	14	138	178
638	Spring Pea 3	Australia	872	14	117	165	3067	21	128	176
652	DMR-4	India	317	25	118	167	3428	16	130	175
653	DMR-7	India	1602	4	117	165	2615	24	133	175
655	DMR-20	India	1181	10	119	168	3041	22	132	178
661	88P001-4-9	Australia	1332	7	117	164	3919	4	133	175
664	88P007-2-1	Australia	1613	3	116	163	3695	11	132	178
676	88P101-10-2	Australia	862	15	118	165	3408	17	132	178
679	88P035-4-3	Australia	580	22	123	165	3474	15	141	181
709	88P090-5-15	Australia	1357	6	119	163	3795	6	135	174
710	88P090-5-16	Australia	1212	9	118	164	3597	13	134	175
711	88P090-5-21	Australia	1297	8	119	163	3994	1	135	174
715	88P101-10-1	Australia	963	12	119	165	3717	9	135	178
767	P75/87	Romania	709	20	112	163	3100	19	124	170
768	P157/88	Romania	593	21	112	167	3137	18	125	169
775	P80/87	Romania	568	23	112	163	2975	23	124	169
	Local Check*		398	24	117	167	1650	25	134	177
	Grand Mean		1031		118	165	3432		133	176
	S.E. Of Mean		154.7		0.8	1.2	195.7		0.5	0.8
	LSD (P=0.05)		443.5		2.2	3.5	561.2		1.3	2.4
	C.V. %		26.0		1.1	1.3	9.9		0.6	0.8

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

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.

The results of Pea International Adaptation Trial-1997 (PIAT-97) were reported from 16 locations from 13 countries. At 8 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 305 kg/ha at Sararood (Iran) to 3376 kg/ha at Gachsaran (Iran). The mean seed yield across locations was 1420 kg/ha. The ANOVA for stability for seed yield revealed that both linear and non-linear components of GE interaction was significant and important. Six entries namely, 88PX00-11-3 (Acc. No. 623), 88P090-5-21 (Acc. No. 616), 88P038-10-18 (Acc. No. 611), P 397-4 (Acc. No. 501), SPRING PEA 2 (Acc. No 637), 89P111-1 (Acc. No. 557) and gave seed yield of 1460, 1466, 1477, 1481, 1580 and 1648 kg/ha, respectively. These lines were with above average seed yield and non-significant deviations from regression, and were thus adaptable across environments.

(R.S. Malhotra, NARS)

7. PATHOLOGY

7.1. Ascochyta blight of chickpea

Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. is the most serious foliar disease of chickpea in the WANA region. It is particularly severe on the winter crop when low temperatures of 15-25°C and high humidity of up to 100% prevailing during the cropping season favors its initiation and spread. Its annual epidemics are thus usually weather-dependent. A good season for the chickpea crop is often favorable for Ascochyta blight development. With the increased adoption of winter chickpea, the risks of frequent Ascochyta blight epidemics increase. A major emphasis has been given to identify sources of resistance to Ascochyta blight for use by farmers. Because this resistance is often non-durable, emphasis has recently shifted 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 timed foliar sprays, and the manipulation of agronomic practices.

During the 1997/98 cropping season, a set of experiments which 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 was continued. In common to all the packages were 4 cultivars (FLIP 88-85, FLIP 90-96, Ghab 1 and Ghab 3) with different levels of reaction to the disease, seed treatments with fungicides and the variation of one agronomic practice. The experimental design for all the trials was split-split plot with cultivars as main plots, seed treatments as sub plots and a cultural practice as sub-sub plots. The different packages were evaluated at 3 different on-station locations in Syria, in collaboration with NARS scientists.

7.1.1. Timing of Fungicide Applications to Manage Ascochyta Blight of Chickpea

The fungicide Bravo (Chlorothilonil) has been found to be effective as a foliar spray to control Ascochyta blight of chickpea. It was used to determine the optimum time for minimal foliar sprays to control Ascochyta blight on chickpea cultivars. The fungicide was applied once at 4 different growth stages (seedling, vegetative, flowering and podding) on 4 chickpea cultivars with varying levels of reaction to the pathogen. Seeds of all cultivars were treated with the fungicide Tecto (Thiobendozil) except for the control treatment which was not treated and received no foliar spray. Ascochyta blight severity was evaluated on a 1-9 disease rating scale (1= no disease and 9=severe disease) after podding, and yields were measured at the end of the season to determine the effects of the fungicide seed treatments and foliar applications on the disease severity and yield of the chickpea cultivars.

The best disease control on all the 4 cultivars was obtained with fungicide sprays made at the seedling growth stage. Average disease severity ratings with this treatment was 2.3 for the susceptible cultivar, Ghab 1, for example, as compared 6.0 for the untreated controls (Table 7.1). Seed yields were however not significantly different for all the cultivars, for foliar treatments made at this or other growth stages.

7.1.2. Integrating Planting Dates with Seed Treatments and host Resistance to Manage Ascochyta blight.

Winter chickpea can be planted from mid November to mid February, while spring chickpea can be planted from late February to April. Thus, there is a wide range of planting time that can be used during the cropping season depending among other factors on the risk of Ascochyta blight epidemics.

In the second integrated management trial, 5 different planting dates (in November, December, January, February and March) were used to evaluate treated and untreated seed of the 4 chickpea cultivars for reaction to ascochyta blight and to determine the effect of the different planting dates on seed yield. As with other trials, ascochyta disease severity ratings were taken at podding for the winter dates and flowering for the spring dates. Plot seed yields were measured at harvest.

The lowest disease ratings on both treated and untreated seed were recorded with the February and March spring plantings, while the highest was with the first three plantings with treated and untreated seeds (Table 7.2). January plantings gave best results in terms of disease and yields obtained. Fungicide treated seeds did not significantly reduce ascochyta blight severity on the early plantings. The lowest yields were also obtained from the February and March plantings even though they had the lowest disease, probably because of additional factors of low moisture in the plots.

7.1.3. Integrating Row Spacings with Seed Treatments and Host Resistance to Manage Ascochyta blight

Ascochyta blight development is influenced by high relative humidity which tends to increase with dense crop canopy. Plant density between and within rows can be adjusted to reduce the canopy closure and thus lower rapid humidity build up during winter months. Adjustments however, have to be made such that optimum populations are maintained to achieve adequate yields in the absence of the disease. This can easily be achieved through inter-row than intra-row placings

Table 7.1. Effect of time of fungicide application on Ascochyta blight severity and grain yield of chickpea cultivars in Tel Hadya; 1998.

	Disease Severity (1-9)* and Seed yield (Kg/ha)									
	FLIP88-85		FLIP90-96		GHAB 1		GHAB 3		Mean	
Spray Growth stage	Yield	DS	Yield	DS	Yield	DS	Yield	DS	Yield	DS
Seedling	1731	2.3	2390	2.0	1502	2.3	1890	2.0	1878	2.2
Vegetative	1622	2.5	2198	2.2	1364	3.5	1597	2.7	1695	2.7
Flowering	1506	3.8	2261	2.8	1197	5.7	1439	2.7	16001	3.8
Podding	1523	5.0	2138	3.0	1011	5.5	1388	3.5	1515	4.2
Control (No spray)	1407	5.5	1841	3.5	1038	6.0	1390	4.8	1419	4.9
Mean	1558	3.8	2166	2.7	1222	4.6	1541	3.1		
LSD (0.05)	307	1.1	369	0.9	292	0.9	401	1.1		

*Disease Severity scale of 1-9 where 1= no infection and 9= all plants killed.

Table 7.2. Effect of sowing dates on Ascochyta blight severity and seed yield of untreated chickpea cultivars at Tel Hadya; 1998.

	Disease Severity (1-9) and Seed yield (Kg/ha)									
	F-88-85		F-90-96		GHAB 1		GHAB 3		Mean	
Planting Date	DS	Yield	DS	Yield	DS	Yield	DS	Yield	DS	Yield
Nov.	5.0	1813	3.8	2504	5.7	1380	5.0	1685	4.9	1846
Dec.	5.5	1295	3.2	1869	5.2	1117	4.0	805	4.5	1272
Jan.	4.0	1244	2.5	2060	4.0	625	3.2	1055	3.4	1246
Feb.	3.2	813	2.7	1152	2.8	352	2.7	669	2.9	747
Mar.	2.5	695	2.5	981	3.2	491	2.2	775	2.6	736
Mean	4.0	1172	2.9	1713	4.2	793	3.4	998		
LSD (0.05)	1.2	353	1.2	420	1.1	477	1.2	405		

In another experiment, 4 different row spacings (30 cm, 45 cm, 60 cm, and 75 cm) were used to determine the effect of plant populations integrated with seed treatments on the management of ascochyta blight and on the seed yield of the 4 chickpea cultivars. The same 4 cultivars, were used in this trial and disease ratings and seed yields were recorded as in the other trials. The plant populations ranged from 60seeds/m^2 in the closer spacings to 24 seeds/m^2 in the wider spacings.

There were significant differences in disease severity between the closer (30 and 45 cm) and the wider row spacings for both treated and untreated seed (Table 7.3). There were significant yield increases with the 75cm row spacings, contributed largely by increased plant branching (Table 7.3)

7.1.4. Screening of locally available fungicides for use as seed treatments

As a seed treatment, Tecto (Thiobendozil) has been found to be effective in reducing early infections from Ascochyta blight when chickpea is sown under winter conditions. One of the main reasons farmers in the WANA region are not readily using the fungicide to treat their seeds to decrease early infection and increase yields, is the cost and in-availability of the fungicide in the local markets.

To overcome these constraints and to give the farmers an alternatively cheap and readily available fungicide, 4 other fungicides from the local markets were compared with Tecto, for their efficacy as seed treatments on Ascochyta blight development on different chickpea cultivars. None of the fungicides in the trial was significantly better than the untreated check in early disease initiation.

Table 7.3. Effect of row spacings on Ascochyta blight severity and grain yield of chickpea cultivars at Tel Hadya; 1998.

Spacing	Disease Severity (1-9) and Seed yield (Kg/ha)									
	F-88-85		F-90-96		GHAB 1		GHAB 3		Mean	
	DS	Yield	DS	Yield	DS	Yield	DS	Yield	DS	Yield
30cm	6.1	1635	3.5	2353	4.5	1571	3.5	2021	4.4	1895
45 cm	4.0	2270	2.8	2925	4.2	1667	3.3	2001	3.6	2216
60 cm	3.2	2238	2.5	2915	2.8	1563	2.7	1885	2.8	2150
75 cm	3.7	2653	2.5	3436	2.7	2373	2.2	2759	2.8	2805
Mean	4.3	2199	2.8	2907	3.5	1794	2.9	2167		
LSD (0.05)	1.2	619	1.4	791	1.1	816	1.0	725		

The performance of Vitavax, however, was comparable to Tecto on 2 of the cultivars (Table 7.4). Thus, it could be a good substitute for Tecto and is available at an affordable cost.

Table 7.4. Comparison of fungicides as seed treatments to control Ascochyta blight of chickpea cultivars; Tel Hadya 1998.

	Cultivars and Ascochyta blight severity (1-9)				
Fungicides*	F-88-85	F-90-96	Ghab 1	Ghab 3	Mean
Benlate	3.0	2.0	4.0	2.7	2.9
Tecto	3.0	2.3	3.3	3.0	2.9
Vitavax	3.7	3.0	4.0	3.3	3.5
Metothiram	3.7	2.0	4.3	3.3	3.3
Control	4.3	3.3	4.7	4.0	4.1
Mean	3.7	2.5	4.0	3.3	3.4
LSD (0.05) = 1.1;		CV (%). = 15.6			

*All applied at the rate of 3g/kg of seed.

7.1.5. Use of systemic activated resistance to manage Ascochyta blight on chickpea

The compound, BION has been shown to be effective in activating systemic resistance in plants to a number of diseases. It works best when applied before infection is initiated. It has shown some promise in the management of diseases of some crops where resistance is either not available or unstable.

This compound was evaluated for its possible effect on ascochyta blight of chickpea. Ten chickpea lines with varying levels of reaction to ascochyta blight were grown in green house pots. At four weeks old, when they were fully at the vegetative growth stage, the plants were sprayed with the BION solution and covered for 24 or 48 hrs. Two BION concentrations were used. The BION-sprayed plants were then challenge-inoculated with an aggressive isolate of *Ascochyta rabiei* and covered for 24 hrs. Plants were observed for disease symptom development and rated on the 1-9 disease severity scale, 3 weeks after inoculations.

BION sprays at both concentrations significantly reduced the severity of ascochyta blight on all 10 chickpea genotypes (Table 7.5). The effect was more dramatic with the highly susceptible lines, ILC 1929, ILC 190 and FLIP 93-210. There were no significant differences in disease reactions from spray treatments with BION for 24 or 48 hrs at similar or different concentrations. Thus, either concentration and with covering for 24 or 48 hrs was effective in inducing systemic resistance to the pathogen.

When a set of 10 chickpea cultivars with varying levels of reaction to the disease were tested for their effect after spray-treatments with BION under field conditions, no significant differences were noticed from the treated plots and the controls. This was contrary to the greenhouse response, most probably because the spray-treatments were done after infection, as it was difficult to determine the time of initial infection.

7.1.6. Use of cultivar mixtures to manage ascochyta blight

Farmers often use seed of a mixture of varieties rather than pure seed for cultivation, especially in crops where they have different varieties with different characteristics at their disposal. The mixture of cultivars with different reactions to diseases has been shown to be effective as a management tool for several foliar diseases including ascochyta blights in other legume crops, and could also play a role in the integrated management of chickpea ascochyta blight.

Table 7.5. Effect of BION spray on Ascochyta blight severity of chickpea cultivars in the Greenhouse;1998

BION Treatment	Cultivars and Ascochyta blight severity (1-9)										
	Ghab 1	Ghab 3	ILC 1929	ILC 200	ILC 5894	FLIP 88-85	FLIP 90-96	ILC 190	FLIP 93-210	FLIP 93-98	Mean
H 24 hrs	2.3	1.7	3.3	1.7	2.0	2.0	1.7	3.3	3.7	2.7	2.4
L 48 hrs	3.0	2.0	1.7	2.3	2.3	2.7	2.7	3.0	5.0	2.0	2.7
H 48 hrs	2.7	2.3	3.3	2.0	3.3	2.3	2.3	4.0	4.3	3.0	3.0
Control	4.7	3.3	5.3	3.7	4.0	4.0	3.0	5.7	6.7	4.7	4.5
Means	3.2	2.3	3.4	2.4	2.9	2.8	2.4	4.0	5.0	3.1	3.1

LSD(0.05) between treatments = 1.03; CV (%) = 19.5

H 24 = High dosage of 0.08g/l covered for 24 hrs before pathogen inoculation
L 48 = Low dosage of 0.04g/l covered for 48 hrs before pathogen inoculation.

In this trial, 2 chickpea cultivars, ILC 263 (susceptible), and Ghab 3 (resistant), were mixed in different proportions (25:75; 50:50; 75:25) to test the reactions of the mixtures in comparison to the pure cultivars. The three mixture combinations were evaluated in field plots planted in a randomized block design in 3 replications, where disease development depended on infested chickpea debris-spread in the plots at the vegetative stages of plant growth. Disease was controlled in some of the pure cultivar plots with foliar fungicide sprays to determine the mixture effects on the crop yields.

The two test cultivars maintained their reaction positions in the trial as indicated by significant differences in disease reactions in the pure unsprayed plots. The best mixture combination was one with a higher proportion of the resistant to the susceptible component. It gave a significantly lower disease reaction than the unsprayed susceptible control (Table 7.6).

Table 7.6. Effect of cultivar mixtures on Ascochyta blight severity on stems and pods of chickpea

Treatment	Disease Severity (1-9)	Pod infection severity (1-9)
ILC 263/Ghab 3 50/50	4.8	2.7
ILC 263/Ghab 3 75/25	6.0	4.0
ILC 263/Ghab 3 25/75	4.5	2.0
ILC 263 with 3 sprays	3.7	4.3
Ghab 3 with 3 sprays	2.8	2.0
ILC 263 non-spray	6.5	4.3
Ghab 3 non-spray	4.0	3.0
Mean	4.6	3.2
LSD(0.05)	1.2	1.0
S.E.	0.5	0.4
CV (%)	14	18

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

7.2. Fusarium wilt of chickpea

Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ciceris* is the major soil-borne disease of chickpea in the WANA region. It is usually severe on spring-planted chickpea under high temperature and moisture stress conditions. In some areas and fields, it is often found associated with root rots, and sometimes the syndrome is referred to as the wilt/root rot complex. Resistance to fusarium wilt of chickpea is available and its use has been the main strategy of control for the disease. The wilt pathogen, however, is highly variable and many races have been reported in the WANA region. The high pathogenic variability of the pathogen can result in quick shifts in resistant cultivars. In order to delay resistance breakdown in the cultivars, research on other integrated management strategies for the control of the disease has been initiated within the IDM sub-project of the IPM project. This integrated approach utilizes different control components in integrated packages for sustainable yield of spring chickpea even under moisture stress and in fusarium infested fields.

7.2.1. Integration of soil solarization with planting dates and depths to manage fusarium wilt of chickpea

Field experiment: The experiment was conducted in the fusarium wilt sick-plot at Tel Hadya farm, to determine the effect of different control practices on fusarium wilt management of chickpea. The treatments consisted of solarized and non-solarized plots, two sowing dates, two planting depths (5 and 10 cm) and four chickpea genotypes with varying levels of resistance to fusarium wilt. The two sowing dates were mid February to represent early spring and mid March to represent normal spring plantings. The four genotypes were ILC482, (highly susceptible); FLIP 91-218; FLIP 92-28 (moderately resistant) and FLIP 93-192 (resistant).

The experimental design was split-split plot, with solarization as main plot, sowing dates as sub plots and cultivars and seeding depth as sub-sub plots in three replications. Each plot was 2-m long and 0.45-m width and had four rows. In each row was planted with 20 seeds at 10 cm spacing. To prepare plots for solarization, the soil was tilled to fine texture, irrigated to field capacity and then covered with 0.05mm transparent polyethylene film for a period of 9 weeks from July 1 to September 5, 1997.

Plastic house experiment: Soil samples were taken from solarized and non-solarized plots for plastic house experiments. The plastic house experiment consisted of soil solarization, fungicide seed treatment with Benlate-T, and the four chickpea genotypes used in the field experiment. The design was split-split plot with three replications as in the field experiment. Solariation, genotypes and fungicide seed treatments were main, sub and sub-sub plots, respectively. Each replication was represented by a pot planted with 10 seeds.

The parameters measured to evaluate the effect of different treatments in the field and plastic house were percent seedling emergence and percent wilt. In the plastic house, wilt incidence was determined one month after planting. Percentage values were transformed before analysis of variance. Severe pre-emergence damping-off was observed both in the field and in the plastic house mainly caused by *Pythium* spp and *Rhizoctonia solani* and affected seedling emergence.

Field Experiment: Significant differences ($p<0.05$) were observed for soil solarization, genotypes and soil solarization by genotype interactions for percent emergence. On average, soil solarization improved percent seedling emergence by 31% over the non-solarized plots

(Table 7.7). Both sowing date and depth of planting did not affect percent emergence significantly. For percent wilt incidence, significant differences ($p<0.05$) were observed for soil solarization and cultivars. Soil solarization reduced percent wilt incidence by 35% over non-solarized soil.

Table 7.7. Effect of soil solarization on seedling emergence and wilt incidence of chickpea genotypes, Tel Hadya, 1997/98

	Solarized		Non-solarized	
Genotypes	Emergence	Wilt incidence	Emergence	Wilt incidence
ILC 482	57	90	15	95
F91-218	50	20	10	78
F93-28	34	3	15	50
F92-192	4	10	16	35
Mean	45	30	14	65

Emergence: LSD (0.05) Soln =17.5; Genotypes = 5.7
SE Solarization = 4.0; Genotypes = 2.7
F. wilt: LSD (0.05) Soln = 13.4; Genotypes = 17.0
SE Solarization = 3.1; Genotypes = 8.2

Plastic house: Significant differences ($p <0.05$) were observed for soil solarization, genotypes, fungicide seed treatments and genotypes in affecting percent seedling emergence. Moreover, soil solarization by genotype interaction was significant. Soil solarization improved percent emergence by 55% (Table 7.8).

For percent wilt incidence, significant differences ($p <0.5$) were observed for soil solarization, genotypes and solarization by genotype interaction. On the average, soil solarization reduced percent wilt incidence by about 19% over the non-solarized plots (Table 7.8). Fungicide seed treatments did not significantly affect percent wilt incidence.

Table 7.8. Effect of soil solarization on seedling emergence and wilt incidence of chickpea genotypes in plastic house, 1998

	Solarized		Non-solarized	
Genotypes	Emergence	Wilt incidence	Emergence	Wilt incidence
ILC 482	72	10	45	82
F91-218	40	72	5	40
F93-28	87	20	20	50
F92-192	94	20	1	20
Mean	73	29	18	48

Emergence: LSD (0.05) Soln =15.3; Genotypes = 12.7
SE Solarization = 3.5; Genotypes = 5.8
F. wilt: LSD (0.05) Soln = 11.7; Genotypes = 19.3
SE Solarization = 2.7 ; Genotypes = 8.8

(S.Kemal, C.Akem)

7.3. Integrated management of lentil wilt and broomrape

7.3.1. Integration of soil solarization with sowing dates and fungicide seed treatment to manage Fusarium wilt of lentil.

Field experiment: The integration of four components (solarization, cultivars, sowing dates and fungicide seed treatment) for the management of lentil vascular wilt was evaluated under field conditions, in the lentil wilt sick plot at Tel Hadya. A strip of the plot was solarized with polyethylene covering for 3 months during the summer of 1997, after irrigating to field capacity.

Four genotypes, differing in their reactions to wilt (ILL 2130 and ILL 5748, moderately susceptible; ILL 5722 and 5883 highly resistant) were tested. Benlate-T (Benomyl-Thiram) was used for seed treatments at 1g ai/kg of seed. Three sowing dates investigated were Mid November, Mid December 1997 and Mid January 1998. The seeding rate was 250 seeds/m^2. The experiment was a split-split plot design in three replications with solarization as main plots, sowing dates as sub plots and treated or non-treated genotypes with the fungicide, as sub-sub plots. Disease evaluations were taken, by visually estimating the percent of wilted/killed plants, three times at 15 days intervals, starting from 20 April and ending on 20 July 1998.The middle row of each sub- sub plot unit was harvested at maturity, and both biological and seed yields were determined from which the harvest index was calculated. Data were subjected to analyses of variance to determine least significance differences.

Seed treatments with fungicide did not have any effect on lentil vascular wilt and may not be useful in the integrated management of the disease. Overall means indicate that percent terminal wilt (PTW) increased and all yield parameters (biological yield (BYD), seed yield (SYD) and harvest index (HI) decreased, when sowing was delayed from mid Nov. to mid Jan. in both solarized and non-solarized treatments (Table 7.9). Interactions between PTW and sowing dates were significantly different for the two moderately susceptible genotypes and non-significant for the two resistant genotypes. Interactions between PTW and solarization followed similar trends.

BYD was significantly higher, for all genotypes, in date 1 compared with other two dates, and in solarized treatment compared the non-solarized one. However, differences between dates 2 and 3 were non-significant. Also, differences in BYD for the three sowing dates were not significant. Percent increase in BYD in the solarized treatment versus the non-solarized one averaged 65.75 % and ranged between 63-67 % in date 3. SYD followed similar trends to BYD. However, SYD for ILL 2130 was significantly lower in comparison with the other 3 genotypes in the solarized treatment.

Table 7.9. Percent terminal wilt, biological yield g/m2, seed yield g/m2 and harvest index % for genotypes tested in solarized and non-solarized plots*.

	Non =Solarized plots											
	Percent terminal wilt			Biological yield g/m^2			Seed yield g/m^2			Harvest index		
Genotypes	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3
ILL 2130	23 b	36 c	44 c	333 ab	183 a	129 a	81 b	36 a	27 a	29.8 ab	19a	20.3 a
ILL 5722	7 a	8 a	12 a	325 ab	269 a	157 a	92 ab	77 ab	35 a	28.3 ab	24.4 a	19.8 a
ILL 5748	26b	40 c	44 c	210 a	264 a	174 a	53 a	62 a	44 a	26.5 a	21 a	23 a
ILL 5883	4 a	5 a	7 a	454 b	208 a	188 a	136 c	56 a	50 a	29.3 ab	26.5 a	24 a
LSD		10			167			44.9			8.3	

	Solarized plots											
	Percent terminal wilt			Biological yield g/m^2			Seed yield g/m^2			Harvest index		
Genotypes	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3
ILL 2130	13 ab	12 ab	18 b	548 a	434 a	394 a	102 a	98 a	100 a	19.8 a	22.9 a	25.4 a
ILL 5722	4 a	4 a	5 a	568 a	528 a	468 a	166 ab	161 ab	159 ab	29.3 ab	30.5 ab	33.9 ab
ILL 5748	16 b	13 ab	18 b	502 a	489 a	543 a	134 a	150 ab	171 ab	27.5 ab	30.6 ab	31.6 ab
ILL 5883	1 a	2 a	1 a	605 a	555 a	511 a	159 ab	148 ab	175 a	29.2 ab	26.4 ab	34 ab
LSD		10			167			44.9			8.3	

*LSD between solarization treatments are: 12 for percent terminal wilt, 171 for biological yield, 48 for seed yield and 7.9 for harvest index.

Percent increase in SYD in the solarized treatment versus the non-solarized one averaged 73.75 % and ranged between 71-77 % in date 3. HI in the non-solarized plots was higher in date 1 compared to date 3. The opposite was observed in the solarized treatment. However, the differences were non-significant (Table 7.9).

The increase in BYD and SYD in the solarized treatment might be partly explained by the effect of solarization on PTW. Other factors such as the quantity of water available to the plants in the different sowing dates as well as effect of solarization on nutrient availability could also play a part. The relatively low and non consistent seed yield, observed in date 1 and 2 in the solarized treatment for certain genotypes, was also due to the fact that, excessive growth resulted in plant lodging which rendered them to be affected by Botrytis grey mold which was not the case in date 3.

Plastic house experiment: Wilt management through soil solarization (+/-), seed treatment (+/-) and genetic resistance was also investigated under plastic house conditions. The four lentil genotypes as in the field trial, differing in resistance levels to vascular wilt were used. Benomyl-T was also used as seed dressing @ 1 g a.i /kg seed. Seeds were sown in pots in soil collected from solarized and non-solarized strips from the sick plot. The experiment was in split-split design with solarization as main plots, genotypes as sub-plots and fungicides as sub-sub plots with 3 replications. Two months after sowing, plants were scored for wilt reaction using 1-9 scale where 1= plants healthy and 9= completely wilted plants. Biological and seed yields were also taken. Analysis of variance was performed for all parameters recorded.

High significant differences were observed among lines tested for their reaction to lentil wilt in solarized and non-solarized soils, with 5883 being the most resistant. Solarization of fusarium infested soil significantly decreased wilt incidence on moderately resistant lines (Table 7.10). Seed treatment with benomyl had no effect on wilt incidence and severity.

From the above investigation, it can be concluded that an Integrated management of lentil vascular wilt is possible with the integration of moderately resistant accessions, solarization and adjustment of sowing dates. However, the economics of soil solarization needs further investigations. Special attention needs to be given to the control of weeds which are generally more severe in early sowings.

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

7.3.2. Integration of sowing dates, resistance and chemical treatments to manage broomrape in lentil.

Broomrape is a major problem of lentil in the Mediterranean basin, especially in early sowings, and is difficult to control. The integration of some previously tested control measures was made this year, in collaboration with the Syrian Directorate of Agricultural Research, in two sites (Idlib-wet and Tel Hadya-relatively dry).

The IDM package included using two sowing dates: early (29 & 30/11/1997) and normal (15 & 12/1/1998) for Idlib and Tel Hadya sites, respectively; and three cultivars: Hourani (ILL2130), the local (ILL 4400) and an early maturing cultivar adapted to late sowing (ILL 5582). These were integrated with three chemicals: imazethapyr, applied either as pre-emergence treatment, at a rate of 30 ml ai/ha on 11/12/1997 & 22/1/1998 for the first and second sowings, respectively, or as two post emergence treatments, each at a rate of 15 ml ai/ha on 29/12/1997 & 22/1/ 1998 for the first sowing and on 17/2 &22/3/98 for the second sowings for the two sites, respectively; imazaquin as two post-emergence treatments, each at a rate of 7.5 ml ai/ha on 29/12/1997 & 22/1/ 1998 for the first sowing date and on 17/2 &22/3/98 for the second sowings for the two sprays, respectively; or imazapic as post-emergence treatment on Hourani only, for the first sowing only, at a rate of 5 ml ai/h on 22/3 & 1/4/98 for the two sites, respectively. Controls were not treated.

The levels of infestation in the late sowing date were lower (35 -75%) in Idlib and Tel Hadya, respectively (Table 7.11). Number of orobanche shoots was not significantly affected by cultivars in both sowing dates. Chemical treatments reduced orobanche shoots by 61-75% and 22-91% in Idlib and Tel Hadya sites, respectively. Imazethapyr applied as pre-emergence and imazapic as post-emergence treatments gave the best control of orobanche. Seed yield was generally higher in the chemically treated plots. The highest SYD was obtained in the post-emergence treatment of imazapic and the lowest with imazaquin. Differences in biological yield were not significant.

Table 7.10 Wilt score (1-9), biological yield, seed yield and percent increase in both biological and seed yield for four lentil lines grown in pots in non-solarized and solarized soil under plastic house conditions.

	Non-solarized			Solarized			%increase	
Variety	Wilt score	BYD/g/ 10 plants	SYD/g/ 10 plants	Wilt score	BYD/g/ 10 plants	SYD/g/ 10 plants	BYD	SYD
ILL 2130	8.0	5.25	1.26	2.6	18.7	3.19	72	60.5
ILL 4605	9.0	0	0	7.8	4.0	1.93	100	100
ILL 5722	8.6	0.42	0.01	1.9	15.3	5.61	97.3	98.6
ILL 5883	1.5	7.25	1.62	1.0	15.1	4.63	52	65
L.S.D 5%	0.97	2.14	2.30	0.79	2.14	2.30		

Figures presented are means of three replicates

Table 7.11. Summary of statistical analysis of effect of sowing dates, chemical treatments [(*)], and cultivars (ILL 4400 & ILL 5582) on orobanche control, biological (BYD) and seed yield g/m²of lentil in two sites (Idlib & Tel Hadya) during 1997/98 growing seasons

	SOWING 2					SOWING 1				Parameters	Genotypes
LSD	4	3	2	1	5	4	3	2	1		
23	0	0	19	67		66	40	31	104	NO.	
110	400	409	450	444		411	493	417	444	BYD g/m2	ILL 4400
19	17	24	33	12		30	37	42	27	SYD g/m2	
					12				59	NO.	
					505				527	BYD g/m2	ILL 2130
					82				43	SYD g/m2	
	0	0	30	51		60	40	23	103	NO.	
	493	504	436	509		462	491	498	411	BYD g/m2	ILL 5582
	38	50	22	28		38	48	48	32	SYD g/m2	
22	17	0	0	8		1	4	3	24	NO.	
141	250	321	278	283		366	450	378	344	BYD g/m2	ILL 4400
21	29	74	51	71		84	99	68	77	SYD g/m2	
	23	0	0.1	6		2	4	2	24	NO.	
	278	327	311	300		372	350	306	331	BYD g/m2	ILL 5582
	46	85	60	88		84	98	69	88	SYD g/m2	
					0.2				8	NO.	
					267				291	BYD g/m2	ILL 2130
					54				49	SYD g/m2	

[(*)] 1=control (hand weeding), 2= Imazathapyr (pre-emergence), 3= = Imazathapyr (post-emergence), 4= imazaquin (post-emergence), 5= imazapic (post-emergence),

7.3.3. Use of Systemic Activated Resistance to Manage Wilt

The plant activator, BION, was used in different treatments to determine its potential in controlling lentil wilt both under field and plastic house conditions.

Plastic house experiment: Five lentil genotypes (ILL 2130, -4400, -4605, -5722, and -5883), with different reactions to the wilt pathogen were used. Ten seeds of each genotype were sown in plastic pots filled with soil collected from the wilt-sick plot. The treatments used were: seeds either soaked in *BION* for 24 h before planting, soaked in water, or coated with *benlate-T* at 1 g ai/kg of seed, and plants sprayed with *BION* before infection began. Two concentration of *BION* (10 and 20 ppm ai/l) were used for spraying and soaking. The experiment was in a split-plot design, with genotypes as main plots and treatments as sub-plots, in three replicates.

Time of infection (15 days after sowing) was determined based on the isolation of the fungus from an additional set of genotypes grown under the same conditions. Based on this, spraying was performed 2 days before infection. Disease severity was recorded 5 times at weekly intervals, starting from the first appearance of the symptoms.

BION decreased disease incidence on the moderately susceptible cultivars but had no effect on the highly susceptible or the highly resistant cultivars. There were clear interactions between genotypes and treatments.

Field experiment: The experiment was repeated under field conditions, in the wilt-sick plot. The ten genotypes used were: ILL 2126, -2130, -4400, -4401, -4605, -5582, -5883, -5722, -5748, -7012. The experiment was a split plot design, with genotypes as main plots and treatments as sub-plots in 3 replications. The sub plot unit consisted of 3 rows, each 50 cm long and 37.5 cm apart and planted with 40 seeds/row. The treatments were similar to those described above, for the plastic house experiment, except for the time of spraying BION, which was carried out 50 days after sowing, when the first positive isolation of the pathogen from the control treatment was detected. Percent wilted or dead plants per row were recorded four times at weekly intervals, starting from April 20. Data were statistically analyzed.

Overall means for % wilt were significantly lower with spray treatments in scores 3 and 4, and non- significantly with soak treatment Percent % wilted or dead plants were significantly lower with spray treatments for ILL 2130, and ILL 5582 only. All other differences were not significant.

The interactions between genotypes and treatment, observed in the plastic house experiment, were thus confirmed under field conditions. From the two experiments, Bion treatments did not seem to significantly have an effect on lentil vascular wilt.

(B.Bayaa, C Akem)

7.3.4. Studies to determine the movement of wilt pathogen in lentil genotypes.

This experiment was carried out to determine the onset of infection by *F.oxysporum* f.sp. *lentis*, in a susceptible and highly resistant lentil genotype, under field conditions and the time of infection and rate of upper mycelial movement in 5 lentil genotypes, with different levels of reaction to vascular wilt, under laboratory conditions.

Field experiment: Two genotypes ILL 5883, highly resistant (HR) and ILL 4605, highly susceptible (HS) were each planted in 50 rows, each 50 cm long and 37.5 apart, at a rate of 40 seeds per row. Destructive sampling were carried out, at 3-days intervals starting 21 days after sowing, to determine the onset of infection. This was realized by isolating the fungus from the crown region and at different heights in the stem on PDA.

In the highly susceptible genotype (ILL 4605), the first positive isolations of the pathogen were recorded 39 days after sowing. Visual symptoms were first observed 40 days later. Eighty days after sowing, percentage of infection was almost 100%. The fungus was isolated from the stem from a height up to 20 cm. In the highly resistant genotype (ILL 5883), first detection of the pathogen in the stem was recorded 70 days after sowing. Percent wilt infection, based on visual symptoms, did not exceed 5% by May 15. Results of isolation from this genotype at harvest time revealed that the fungus was found in the stem up to a distance of 10 cm above the crown area, in 20% of cases. However, the height reached did not exceed 7.0 cm, in 50% of the cases.

Laboratory experiments: Five lentil genotypes (ILL 5883 (HR); ILL 4605 (HS); ILL 5722: resistant (R); ILL 4401 (MR); and ILL 2126 (MS)) were used. The experiment was carried out in the growth chamber at 19 1 C, 99% relative humidity and 24 hours continuous light. It comprised 3 inoculation methods: 10 day old seedlings artificially inoculated by dipping their roots in an inoculum suspension of *F. oxysporum* f. sp. *lentis* and transferring to Hoagland s nutrient solution in test tubes; seeds sown in cones filled with infested soil collected from the wilt-sick plot mixed with sterilized sand at a ratio of 1/1; or in cones filled with sterilized soil/sand mixture and artificially inoculated with a spore suspension (3ml per cone), of the same isolate. The experiment was a randomized block design in 3 replication.

Destructive sampling was done every 3 days, starting from the second week after sowing. The onset of infection and the height to where the pathogen reached were determined by plating pieces, from crown and from stem at different heights from crown region, on PDA.

In infested soil: In the highly susceptible genotype (ILL 4605), the pathogen was observed, at the crown level 17 days after sowing. Five days later, however, the pathogen was isolated from stem pieces at a height of 10 cm above the crown, indicating a quick vascular invasion. Wilting and chlorosis symptoms were observed on the plants at later stages. In the moderately susceptible (MS) genotype ILL 2126, the pathogen was detected from the crown area 12 to 17 days from sowing. The pathogen was able to move upwards to a height of 6 cm after 22 days from sowing and reached the maximum height tested, 10 cm above the crown, after 27 days from sowing. The movement of pathogen in this genotype was slightly slower than that in genotype ILL 4605 even though the initial infection was detected earlier. Results obtained from the moderately resistant (ILL 4401) and resistant (ILL 5722) genotypes indicate that the onset of infection in these genotypes, compared to the first two, was delayed and the upper movement was slower. The pathogen was detected around 22 days after sowing and it rarely reached levels of 10 cm above the crown in ILL 4401. In ILL 5722 it was detected at this height after around 33 days. Chlorosis without any wilting symptoms was observed on the plants at the end of the experiment. In the highly resistant genotype ILL 5883, the pathogen was first detected around 22 days after sowing. After 27 days, it moved upwards to around 4-6 cm above the crown and remained at these lower levels for around 3 weeks, after which it was isolated from a height of 10 cm above the crown. Throughout the experiment, the plants showed slight chlorosis of lower leaves without apparent wilting.

Artificially inoculated soil: In the highly susceptible (HS) genotypes, ILL 4605, the first isolations of the pathogen were observed 12 days after inoculation, up to 1 cm above the crown. It remained restricted to this level up till 33 days after inoculation. After this period, the pathogen slowly moved upward reaching about 4 cm above the crown at the end of the experiment. Wilting symptoms were observed 40 days after sowing. In the moderately susceptible (MS) genotype ILL 2126, the pathogen was first detected, at the crown level of the stem, 7 days after inoculation. The pathogen remained restricted to around 1 cm above the crown up till 38 days after inoculation, it was thereafter isolated from levels of 3 cm above the crown. Wilting symptoms with slight chlorosis were observed towards the end of the experiment. In the moderately resistant (ILL 4401), resistant (ILL 5722) and highly resistant (ILL 5883) genotypes, the pathogen was detected 7 days after inoculation at crown level and was restricted to the lower 1 cm above the crown till the end of the experiment, 41 days after inoculation. Slight chlorosis was observed only on ILL 4401, with no symptoms on ILL 5722 or on ILL 5883 genotypes.

Artificially inoculated seedlings in nutrient solution
In all genotypes tested, the first isolations of the pathogen, from lower and in some cases from the stem, were observed from few plants 5 days after inoculation. Thirteen days after inoculation, plants tested were invaded up to 10 cm height above the crown in ILL 4605 and to a height of 2 cm in other genotypes. It reached a maximum level of 5 cm in ILL2126 and 1-2 cm in other 3 genotypes, 21 days after inoculation. Severe chlorosis and wilting symptoms were observed on ILL 4605 only. The rapidity of detecting the pathogen, in this experiment, might be explained by the fact that root-wounding facilitates the penetration of the inoculum into the root system of the plant.

(B.Bayaa, C.Akem, Lebanese University)

7.4. Collaboration with NARS

7.4.1. Syria

Collaboration with the Division of Plant Protection, Directorate of Agricultural Research (DSAR), Ministry of Agriculture, Syria was mainly in the conduction of the integrated disease management trials for Ascochyta blight of chickpea. The trials were carried out at 2 locations: Al-Ghab and Heimo research stations. At both locations the 3 IDM packages evaluated for the management of chickpea ascochyta blight at ICARDA research farm in Tel Hadya were evaluated.

Briefly, at the Heimo station for example, a single fungicide spray at seedling stage significantly reduced ascochyta infection on all the cultivars as compared to the untreated controls, in the timing of fungicide application trial. There was also a significant seed yield increase for applications made at the vegetative and flowering stages on the moderately resistant cultivars. In the planting date trial, no disease developed on any of the spring plantings, but the seed yields were also lower than on the winter plantings mainly because of less moisture availability. Seed dressing reduced early infection though not significantly but had virtually no effect in later disease development and spread on all the cultivars. Row spacings apparently had no significant effect on Ascochyta blight severity and closer spacings gave significantly more yields in the resistant and moderately resistant cultivars. The contrast with Tel Hadya results was mainly due to the low disease intensities in these trials, because disease development depended on natural sources, unlike at Tel Hadya where infested debris was used as a source of inoculum.

(C.Akem, Syrian NARS Scientists)

7.4.2. Morocco

Collaboration with INRA Morocco was in the form of disease surveys on faba bean and integrated management of chickpea, lentil and faba bean diseases. These activities were linked to the BMZ supported IDM project in legume and cereal farming systems of WANA.

A survey was conducted in April 1998 in the four major faba bean producing regions of Morocco to determine the distribution and incidence of faba bean diseases in the country. A total of 91 faba bean fields were covered in the survey. Rust was the most prevalent disease occurring in most fields surveyed in all the regions. Ascochyta blight was rarely detected in any of the fields, and chocolate spot was observed only in some fields and at very high intensities when present. Dry root rots were severe in fields and regions that had experienced severe drought at early stages of crop development.

IDM trials on legume diseases were conducted at 3 locations with distinct rainfall characteristics; Douyet station (high rainfall), Marchouch (moderate) and Jaimine Shein (low). Trials at Douyet station focused on the integration of planting dates with limited chemical use for the control of chocolate spot and *Orobanche*.Those at Jaimine Shein were focused on planting dates and row spacings for the management of ascochyta blight of chickpea and planting dates with minimal chemical sprays for the management of lentil rust. At Marchouch, there were 2 sets of trials, the first on the station integrating seed treatments with planting dates for ascochyta and wilt on chickpea and the second set in a farmers field integrating cultivars with planting dates and seed treatments to manage fusarium wilt of chickpea.

Weather conditions at Douyet did not favour the development of chocolate spot on faba beans. Clear differences were observed on *Orobanche* infestation with different rates of glyphosate applications. At Jaimine Shein station, no ascochyta blight developed on the chickpea because of an unusual drought period. Good infection by rust was observed on the local lentil entries and in the IDM trials, planting dates significantly affected rust severity with the earlier plantings having more rust than the later ones. At Marchouch station, no ascochyta developed on the winter plantings due to the prevailing weather conditions, while some wilt developed on the spring plantings but not enough to differentiate treatments.In the farmers field, delayed planting into spring favored the incidence of wilt on the local susceptible entries. Seed treatment with tecto was also showing a significant effect on wilt incidence.

(C. Akem, Moroccan NARS Scientists)

7.4.3. Ethiopia

The Ethiopian national program was also part of the BMZ-supported project on integrated disease management. The legume trials on the project at Ethiopia were focused on the integrated management of chocolate spot and black root rot of faba bean. The packages were evaluated at 3 locations: Holetta, Denbi and Ambo.

The first package consisted of cultivars integrated with sowing dates and fungicide sprays while the second consisted of cultivars integrated with sowing dates and row spacings. In both trials and at all locations, early plantings were highly infected by chocolate spot while the last plantings had the least disease. Fungicide sprays gave good disease protection in the first package while row spacings with 40cm had lower disease than the 20 or 30cm spacings in the second package. There were no cultivar differences in disease reactions among the 3 cultivars used in the trials. Yields were expected to be highest in the first plantings with fungicide spray protections and least in the third planting.

(C.Akem, Ethiopian NARS Scientists)

7.4.4. Nepal

A two-week survey, for diseases of lentil was carried out in the Terai region of Nepal. A total of 52 fields were surveyed. Based on microscopic examination, thirteen fungal genera were recorded on aerial parts of samples collected during the survey. Of these three (*Periconia cookie*, *Alternaria crassa* and *Cercospora canescens*) were the first record on lentil in Nepal. *P.cookie*, *Stemphlium sarcinaeforme* and *Cladosporium oxysporum* were predominant pathogens in the samples. Also reported for the first time were the pycnidial and aecial stages of *Uromyces fabae* (the causal organism of lentil rust).

Isolations from the root systems revealed that *Fusarium* isolates were predominant. Three *Fusarium* spp. were frequently isolated: *F. moniliforme*, *F. solani* and *F. semitectum*. Unexpectedly, Fusarium wilt caused by *F. oxysporum* f. sp. *lentis* was not observed during the survey. *F. solani* was identified and confirmed as the most important component of the complex. Based on the results of this survey, a screening work to identify resistance to *F. solani* has been initiated by the Nepali scientists.

(B.Bayaa, Nepali NARS Scientists)

8. VIROLOGY

Work on legume viruses during the 1997/98 growing season included (i) survey for chickpea and lentil viruses in Ethiopia and Syria, (ii) evaluation of lentil and faba bean genotypes for resistance to faba bean necrotic yellows nanovirus (FBNYV) and bean leaf roll virus (BLRV). 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.

8.1. Survey for Lentil and Chickpea viruses in Ethiopia

A survey to identify virus diseases affecting chickpea and lentil crops in Shewa province of Ethiopia was conducted during November 14-23, 1998. The survey covered randomly selected 33 chickpea and 32 lentil fields. Virus disease incidence was determined on the basis of laboratory testing of 100-200 randomly collected samples from each field against antisera of 12 viruses. In chickpea fields, beet western yellows polerovirus (BWYV) and soybean dwarf virus (SbDV) were the most common. Five chickpea fields had, at the time of the survey a virus disease incidence of 21% or higher (Fig. 8.1). In lentil fields, pea seed-borne mosaic potyvirus (PSbMV) was the most common followed by BWYV and SbDV. Eleven lentil fields (34% of the fields surveyed) had a virus disease incidence of 21% or higher. The highest virus disease incidence in a single field was 58.5% in lentil (PSbMV) and 41.3% in chickpea (BWYV). Other viruses were detected rarely, such as faba bean necrotic yellows nanovirus (FBNYV) and broad bean wilt fabavirus (BBWV) in chickpea and FBNYV, broad bean stain comovirus (BBSV), bean yellow mosaic potyvirus (BYMV) and cucumber mosaic cucumovirus (CMV) in lentil.

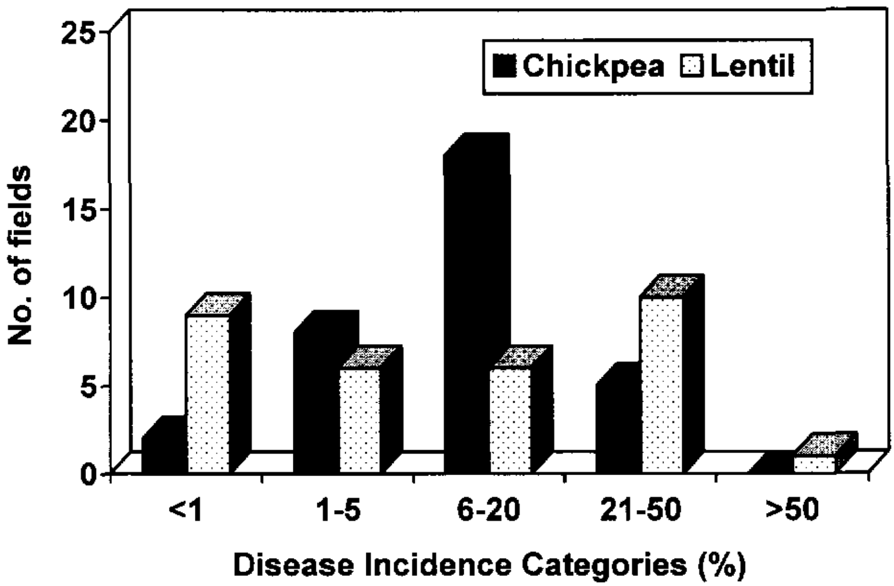


Fig. 8.1 Virus incidence in chickpea and lentil fields based on the results obtained from laboratory testing of randomly collected samples during the survey conducted in Ethiopia, November 14-23, 1998

(K.M. Makkouk and S.G. Kumari (ICARDA), K. Ali, D. Gorfu, A. Yusuf, A. Abraham, A. Lencho, N. Tadesse, M. Ayalew, T. Glmariam, W. Bejiga, D. Tadesse (Ethiopia))

8.2. Status of Pea Enation Mosaic Virus Affecting Lentil in Syria

Symptoms suggestive of virus infection have been observed, in epidemic proportions, in lentil (*Lens culinaris* Medik.) fields in Dara'a in South Syria almost annually since 1994, and were recently observed on many lentil genotypes at the

ICARDA farm near Aleppo as well as in other locations in North Syria during 1998. The symptoms observed included growth reduction and rolling of leaves accompanied by mottling with tip wilting or necrosis. Field symptoms were reproduced on lentil cv. "Syrian Local" upon mechanical inoculation of the plants with inoculum from symptomatic field plants. Transmission tests showed that the disease can be transmitted from lentil to lentil, pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.) plants by the pea aphid (*Acyrthosiphon pisum* Harris) in a persistent manner. More than 500 symptomatic lentil plants were collected and tested for the presence of 14 different viruses by the tissue-blot immunoassay (TBIA). Most samples reacted strongly with the antiserum prepared to a Dutch isolate (E154) of pea enation mosaic virus (PEMV), provided by Dr. L. Bos, Wageningen, The Netherlands. Surveys conducted during the 1997/1998 growing season showed that PEMV was widely distributed in the major lentil growing areas of Syria, and some lentil fields had more than 50% virus incidence.

8.3. Effect of Seed Dressing Insecticide Treatment Imidacloprid (Gaucho®) on Bean Leaf Roll Virus (BLRV) Spread in Faba Bean after Artificial Virus Inoculation with Aphids

The usefulness of seed-dressing with a nitroguanidine group insecticide Imidacloprid (Gaucho®) to reduce spread of the aphid vectored bean leaf roll virus (BLRV) was investigated in a field experiment conducted at Tel Hadya, Aleppo, Syria, using two inoculation times.

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 experiment was carried out in a randomized complete block design with three replicates for each inoculation. Each replicate plot consisted of 4 rows (2 m long), 30 cm apart, with 10 cm between plants within the row. Two and three months after sowing, all plants were artificially inoculated with the virus by using the aphid vector *Acyrthosiphon pisum*.

Virus infection was recorded visually four-five weeks after inoculation based on BLRV characteristic symptoms. Results obtained showed that the spread of BLRV was decreased from 91.6 and 95% (untreated plots) to 0 and 92.5% in plots treated with 4g/kg, and the yield loss was decreased from 88.5 and 73.4% (untreated plots) to 1.27 and 58.8% in plots treated with 4g/kg, when plants were inoculated with the virus two and three months after sowing, respectively (Table 8.1). It was evident that Imidacloprid seed treatment offered the emerging seedlings a two months protection against BLRV spread by aphids, and such protection was drastically reduced few weeks later.

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

Table.8.1 Effect of seed dressing insecticide treatment Gaucho® on bean leaf roll luteovirus (BLRV) incidence in faba bean and on faba bean yield after artificial inoculation with aphids *Acyrthosiphon pisum* two and three months after sowing under field conditions.

Inoculation Time/ after sowing	Treatment Gaucho® (g) /kg faba bean seeds	% of infection based on symptoms	(%) Yield loss
Two months	Untreated	91.6	88.5
	0.5	2.5	14.5
	1	0.8	7.5
	2	0.0	2.1
	4	0.0	1.3
Three months	Untreated	95.0	73.4
	0.5	92.5	61.8
	1	90.0	60.8
	2	90.0	58.8
	4	92.5	58.8

8.4. Testing for Seed-borne Viruses

8.4.1. Cleaning Germplasm in the Gene Bank from Seed-borne Infections

Sixty-six lentil accessions planted in the field for multiplication were purified from seed-borne infections (broad bean stain, pea seed-boren mosaic and bean yellows mosaic viruses) by eliminating infected plants during April (late flowering), and only healthy seeds were harvested to store in the Gene Bank.

One thousand four hundreds and eighty accessions of barley dry seeds were tested for the presence of barley stripe mosaic virus and 77 accessions were found to be infected with the virus. The virus-free accessions will be stored in the Gene Bank, and accessions with virus-infected seeds will be cleaned later.

Fifty-five pea accessions were tested during October for BBSV, BYMV, PSbMV and 30 accessions were found virus-free.

8.4.2. Testing for International Nurseries

During April, 292 of lentil accessions were evaluated in the field by testing fresh leaf samples (400 plants per accessions) for the presence of seed-borne virus infection, and 217 accessions were found to be virus-free. In addition, seed samples of 374 accessions were tested during July-September (400 seeds per accession) and 275 accessions were found virus-free.

149 accessions of faba bean (200 seeds per accession) were tested during September for the presence of BBSV, BYMV, PSbMV and seeds of five accessions only were found to be infected with seed-borne viruses.

Twenty five accessions of lathyrus were tested during June for BBSV, BYMV, PSbMV, AMV, CMV and all accessions were found to be virus-free.

Forty-seven pea accessions were tested during July for BBSV, BYMV, PSbMV and 35 accessions were found to be virus-free.

About 1022 genotypes of barley and wheat were tested for barley stripe mosaic virus during November and 1011 genotypes were found virus-free.

In all above cases, only virus-free accessions were dispatched to collaborators. A summary of the results of laboratory testing for seed-borne viruses is presented in (Table 8.2).

(K.M. Makkouk, N. Attar)

8.5 Distribution of ELISA Kits

ELISA kits or antisera for any of 14 legume viruses available at the Virology Laboratory were sent to collaborators in Algeria, Australia, China, Egypt, Ethiopia, Iraq, Jordan, Pakistan, Turkey and Yemen.

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

Table 8.2. A summary of the results obtained from laboratory testing for seed-borne viruses of legume and cereal crops during 1998.

Source/Crop	No. of accessions tested	No. of accessions found healthy	No. of seeds tested per accession	Testing Period	Seed-borne viruses checked
International Nurseries					
Lentil	666	492	400*	April, July-September	BBSV, BYMV, PSbMV
Faba bean	149	144	200*	September	BBSV, BYMV, PSbMV
Barley and wheat	1022	1011	200**	November	BSMV
Peas	47	35	200*	July	BBSV, BYMV, PSbMV
Lathyrus	25	25	400*	June	BBSV, BYMV, PSbMV, AMV, CMV
Gene Bank					
Lentil	66	13	1000*	April	BBSV, BYMV, PSbMV
	55	30	50*	October	BBSV, BYMV, PSbMV
Barley	1480	1403	200**	May, October-March	BSMV

* Seeds were tested in groups of 25

** Seeds were tested in groups of 50

9. ENTOMOLOGY

9.1.Effect of oil-seed extract from *Melia azederach* on *Sitona* and chickpea leafminer feeding.

Melia azedarach L., a native tree to the Middle East, is widely distributed in Asia, Mediterranean basin, Africa and South America. Leaf and fruit extracts of this tree have been shown to have some anti-feeding characteristics against insects and mites. There are no previous studies on the effect of *Melia* extracts on lentil and chickpea insect pests.

An experiment was carried out in the plastic house at ICARDA in 1997/98 to study the effect of naturally extracted oil of *Melia* on *Sitona crinitus* H. feeding and *Liriomyza cicerena* R. mining. These two insects are the main pests of lentil and chickpea in West Asia and North Africa. Three dosages (0.25%, 0.5, 1%) of *Melia* oil, naturally extracted from dry seeds, were tested in comparison to Mastrin 50% EC (Deltamithrin).

The results showed significant effect ($P<0.05$) of the three dosages of *Melia* on leaflet damage by *Sitona* adults and leaflet mining by leafminer larvae in treated plants compared to untreated plants. There were no significant deference's between plants treated with Deltamithrin and plants treated with the three dosages of *Melia* oil in reducing *Sitona* feeding and leafminer mining. Because of these promising results, further studies will be carried out to determine the effect of *Melia* seed extracts on the major insect pests of legume crops and beneficial insects.

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

9.2. IPM of chickpea leafminer

Chickpea leafminer, *Liriomyza cicerina* Rond. is the major insect pest of chickpea in WANA. Yield losses caused by this pest could go as high as 30%. Efforts are put on developing an IPM package based on host plant resistance, planting date and safe chemicals.

An experiment comparing the effect of planting date (winter vs spring), varieties (local vs improved) and safe chemicals (Neem products vs Deltamithrin) was carried out in the field at Tel Hadya. The experimental design used was a split plot with planting date as the whole plot and variety by insecticide application as the sub plot; 4 replications were used in this experiment. The chickpea cultivars used were a Syrian local and Ghab3, and the treatments used were Neem oil (2ml/l), Neem powder (6g/l) and Deltamithrin (0.25cc/l). Neem formulations were sprayed three times on winter-sown chickpea and four times on spring-sown chickpea starting from the insect appearance at ten days intervals. Deltamithrin was sprayed just one time when the insect appeared in the field. A random sample of 30 leaves from each plot was taken twice a week. The leaves were put in small plastic cages covered with a chesecloth and placed in the rearing room (22°C, 16:H light). The total number of leaves sampled during the season was 6 from winter-sown chickpea and 11 from spring-sown chickpea. The following measurements were taken: number of mining (damaged leaflets), number of pupae, number of adults and number of adult parasitoid, *Opius monilicornis*.

The results showed that winter-sown chickpea had significantly less mining than the spring-sown chickpea (Fig. 9.1). The cultivar Ghab3 also showed significantly less mining than the local Syrian cultivar (Table 9.1). In comparison to the unsprayed check, Neem oil reduced significantly the mining. The level of control provided by Neem oil was about medium compared to the insecticide

Deltamithrin. Neem powder on the other hand was not effective in reducing leafminer infestation (Table 9.1).

Table 9.1. Effect of two Neem formulations and cultivars on leafminer infestation (number of mining), Tel Hadya, 1997/87.

	Ghab 3	Local
Neem oil	589 A/a	730 B/a
Neem powder	759 A/b	933 B/a
Deltamithrin	438 A/c	540 B/c
Check (unsprayed)	783 A/b	984 B/b

The use of Deltamithrin reduced significantly the number of parasitoids, by about 50%, compared to the unsprayed check. Neem oil had a little effect on parasitoid, just about 15% reduction compared to the check. Neem powder on the other hand did not have any negative effect on parasitoids (Fig. 9.2). The same experiment is being carried out in 1999 for confirmation. If these results are confirmed, an IPM package comprising Ghab 3, Neem oil and winter planting date would be on-farm tested against chickpea leafminer in Syria and other countries in WANA.

Means followed by the same letter in horizontal rows (upper case) and in vertical rows (lower case) are not significantly different (P=0.05, LSD test)

(M. El Bouhssini, A. Joubi, K. Mardini, A. Babi (University of Aleppo)).

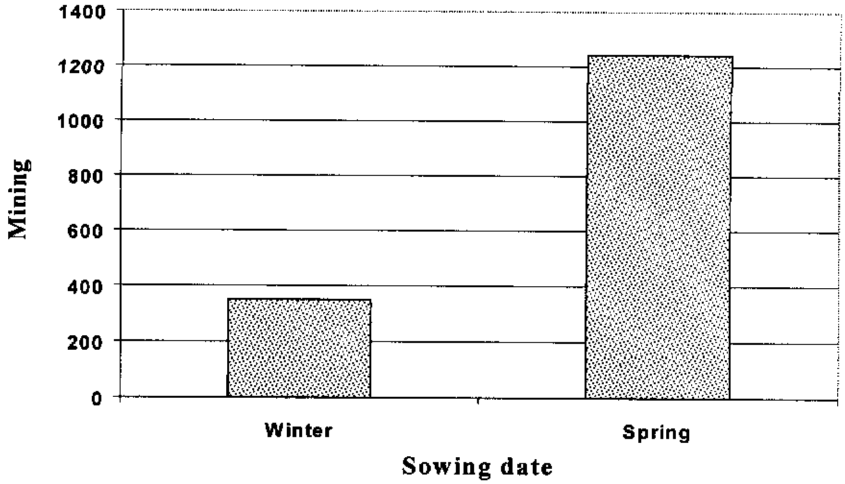


Figure 9.1. Effect of sowing date on chickpea leafminer infestation (number of mining), Tel Hadya, 1998

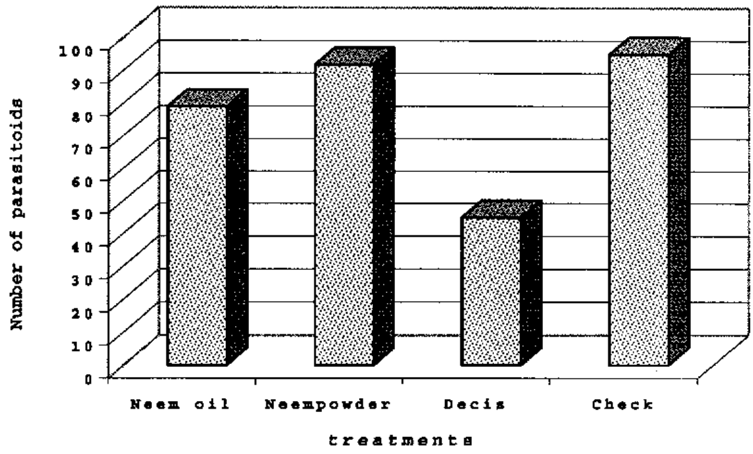


Figure 9.2. Effect of two Neem formulations and Decis on parasitoids of chickpea leafminer, Tel Hadya, 1998.

9.3. Sitona biology

9.3.1. Fecundity of Sitona crinitus

During 1997 season, the first Sitona adult was recorded in the field at Tel Hadya on 23 October. Since then, and at the beginning of each month (November-April), 20 pairs of Sitona were collected from the field and taken to the rearing room (22°C, 16 H light). Each pair was introduced to a small plastic cage (5x2.5 cm) and placed on moist filter paper for egg laying. Fresh lentil plants were added daily to the cages to have enough food for the insects. The number of eggs laid was daily recorded.

The results showed that Sitona started laying eggs about one week from its first appearance in the field by the end of October. The egg-laying period of the female Sitona varied form 6-22 days. However, most of the eggs were laid the first week. Eggs were recorded from early November to the end of April. The highest number of eggs was recorded in February, with an average of 272 eggs/female. During this month, the average number of eggs laid/female/day was 46. However, the maximum number of eggs/female laid during this month was 606 (Fig. 9.3). This high number of eggs shows the potential of *Sitona* populations in building up. Also the fact that the insect lays eggs during a large period of time (November-April) offers the species flexibility to survive through adverse conditions during the season.

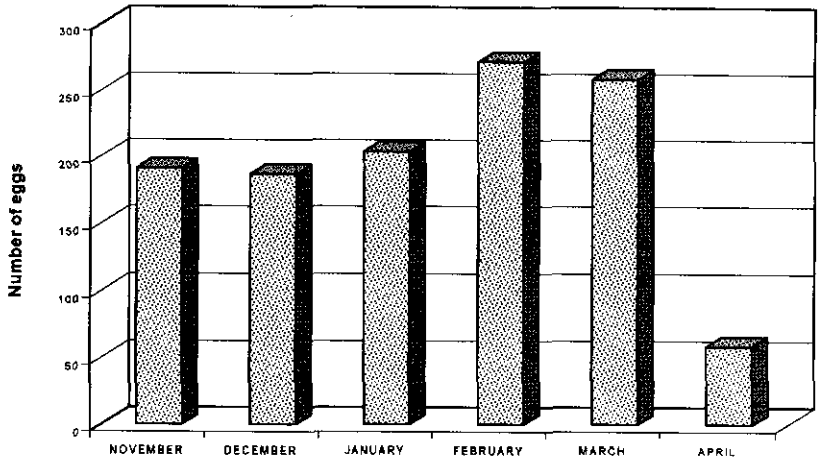


Figure 9.3. S. crinitus fecundity (mean number of eggs per female) under lab. condition during 1997/98 season.

9.3.2. Effect of Temperature on Embryo Development of *Sitona*

The objective of this study was to determine the temperature requirement for embryo development and egg hatch of *S. crinitus*. Eight different temperature regimes (6, 8, 10, 15, 20, 25, 30 and 35°C) were tested. Three petri dishes, each with 25 fresh eggs, were places in one of the compartments of a thermo gradient plate calibrated with one of the temperatures. The paper in the petri dish was moistened daily to allow enough moisture. The number of egg hatch was recorded daily until all the eggs hatched. In the case of the temperature regime 6°C, where there was no egg hatch, the experiment was terminated after three months.

The results showed that there is a negative relationship between temperature and development of egg embryo. As temperature increased, the embryo development period (EDP) decreased. The optimum temperature was between 25-30°C. At 30°C, the EDP was the shortest (7 days), whereas it was the longest at 8°C (69 days) (Fig.9.4). The hatching period was shortest at 30°C (2 days) and longest at 8°C (7 days) (Fig.9.5). At 6°C there was no egg hatch during the three-month period. However, once the eggs were placed under 25°C, they hatched. This may indicate an egg diapause of *S. crinitus* under cold temperature. The temperature 35°C was destructive, as most of the eggs dried up under this regime. These results are useful for rearing *Sitona* in the lab/greenhouse and also for predicting Sitona infestations in the field.

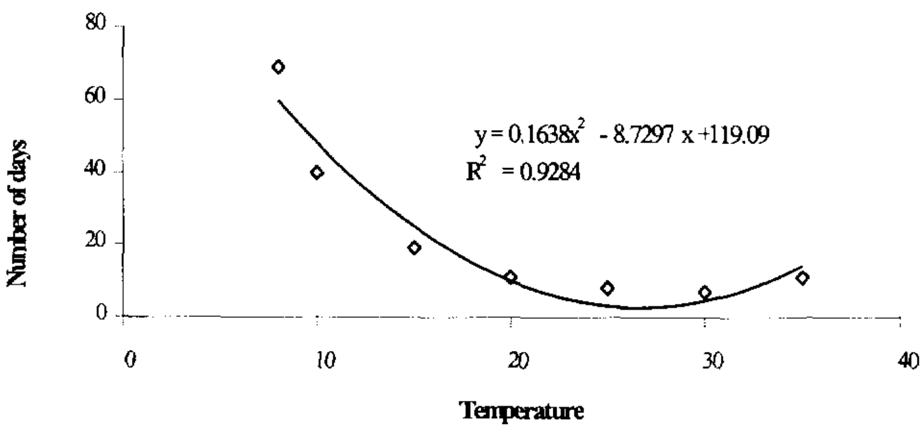


Fig.9.4. Effect of constant temperature on embryo development of *Sitona crinitus*, Tel Hadya, 1998.

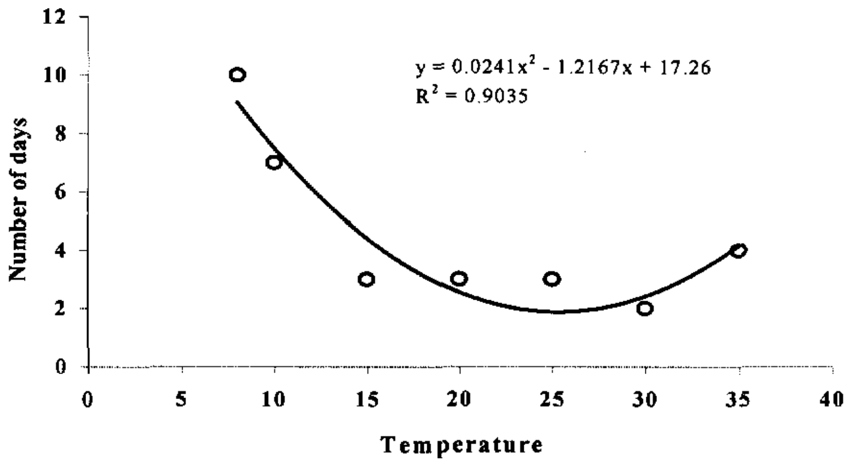


Fig 9.5. Effect of constant temperature on hatching period of *S. crinitus* eggs, Tel Hadya, 1998.

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

10. TRAINING AND VISITS

Training activities in Germplasm Program aim to assist researchers in NARS to develop their competencies in recognizing the problems of cereals and legumes and applying modern techniques to solve these problems. The training in Germplasm Program focused on providing technical training for individual non-degree trainees, conduct and support the research for graduate research students and conduct short-term training courses at ICARDA headquarters and regional, sub-regional and in-country courses. The trainees are taught to design and manage conventional experiments in the various aspects of breeding, hybridization, note taking, disease 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 and in the laboratory as well as some lectures. Round table discussions take place in specialized short-term group training courses. A method for evaluating progress is used to measure the performance of trainees and the impact of their training on agricultural research in their countries.

The following training activities were conducted during 1998.

10.1. Short-Term Courses

10.1.1. Short-Term Courses at ICARDA Headquarters

10.1.1.1. Mechanical Harvesting for Food and Feed Legumes

Food and feed legumes are important crops in WANA region. A legume harvest mechanization short course was organized at Tel Hadya from 24-28 May 1998 jointly conducted by the

Station Operation and Germplasm Program. Ten participants (5 from Syria, 3 from Iran and 2 from Egypt) attended the course. The purpose of the training course was to demonstrate a system of legume production and mechanization that decreases the cost of production. The program included both lectures and practical orientation to harvest machinery. Lectures were on problems of mechanization, breeding, agronomy, and economics of harvest mechanization. The participants evaluated the course as highly successful and useful.

10.1.1.2. DNA Molecular Marker Techniques for Crop Improvement

This course was organized at ICARDA headquarters Tel Hadya (13-24 September 1998), jointly sponsored by ICARDA and International Center for Advanced Mediterranean Agronomic Studies (CIHEAM). Eleven participants from 10 countries attended the course. The lectures covered such topics as the origin and structure of the DNA, gene cloning, DNA marker technologies and statistical analysis of marker data for genetic mapping and biodiversity evaluation. Lectures were given by Prof. Dr. G. Kahl from Frankfurt University and ICARDA biotechnology staff. The course was well received by the trainees and some of the trainees will make use of the demonstrated techniques in their respective national programs.

10.1.2. Regional/Sub-Regional Short-term Training Courses

10.1.2.1. Diagnosis and Control of Diseases of Grain and Pasture Legumes Adapted to Mediterranean Environments

This advanced course was held in Spain from 20-30 April 1998 and sponsored by ICARDA, Center for Legumes in Mediterranean Agriculture (CLIMA) and CIHEAM. Thirty-one participants attended the course (Table 10.1.). The aim of the training course was to increase the knowledge of NARS to identify the diseases of grain and pasture legumes grown in the Mediterranean environments. Drs. K. Makkouk and C. Akem provided input into the course from the ICARDA side.

Table 10.1. Attendance at Diagnosis and Control of Diseases of Grain and Pasture Legumes Adapted to Mediterranean Environments

Country	No. of Participants
Algeria	3
Egypt	2
Morocco	3
Portugal	1
Spain	13
Syria	2
Tunisia	3
Turkey	3
TOTAL	30

10.1.2.2. Computer Application in Breeding Management (AGROBASE)

Germplasm Program and CBSU jointly conducted in-country short-term training course on computer application in breeding management in Cairo, Egypt from 26 February to 03 March 1998. There were 16 participants attended the course. The major emphasis of the course was on designing, and management of breeding trials. The course also covered computer basics, data entry and analysis by AGROBASE. The level of skill achievement was very high.

10.1.2.3. Insect Taxonomy and IPM of Insect Pests

This sort-term course was held in Oman and sponsored by ICARDA and Ministry of Agriculture and Fisheries (S. Oman) from 21 March to 1 April 1998. A total of 21 participants attended the course, (17 participants from S. Oman, 1 from each S. Arabia, Bahrain, Kuwait and UAR). Pre and post-course evaluation showed a big improvement in the entomology knowledge of the participants. All participants were mostly interested in biological control of the insects.

10.1.3 In-Country Short Term Training Courses

10.1.3.1. Introduction to Wilt/Root Rot Diseases

The short-term course was organized by ICARDA and held in Giza, Egypt from 26-31 March 1998. Eight participants attended the course (5 males and 3 females). The program included theoretical, laboratory and field training. Lectures were on wilt root/rot disease, strategies for the identification of resistant sources and integrated management of root/rot diseases. Laboratory and field training focused on the identification, isolation and control of the pathogens.

10.1.3.2. DNA Molecular Marker Techniques for Crop Improvement

A training course on DNA molecular marker techniques was held in Karaj, Iran from 6-19 June 1998. The course was sponsored by ICARDA/Iran project. Ten scientists from Iran participated in this course. Most of the participants had some experience in either breeding or biotechnology. The major aim of the course was to ensure that basic DNA marker technologies could now routinely be used in Iran. Once the basic technology has been established, the Iranian national program can build on this experience and take up new technology. All the trainees expressed their satisfaction with the new knowledge they acquired.

10.2. Individual Training

10.2.1. Individual Non-degree Training

Training in specific areas of techniques in Germplasm Program was provided to 62 researchers from 14 countries (Table 10.2.) who spent periods ranging between 1 week to 3 months in learning different research activities in the program (Table 10.3.). 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 need of NARSs.

Table 10.2. Individual Non-degree Trainees to the Germplasm Program in 1998

Country	No. of Participants
Algeria	1
Bangladesh	3
Egypt	9
Eritrea	1
Ethiopia	1
Iran	6
Iraq	5
Jordan	2
Lebanon	2
Nepal	1
Spain	1
Syria	26
Turkey	3
Yemen	1
TOTAL	62

Table 10.3. Training subjects provided to individual non-degree trainees in the Germplasm Program.

Training Activity	No. of Trainees
Breeding Food Legumes	20
Breeding Legumes for Disease Resistance	2
Breeding Barley	5
Breeding Barley for Disease Resistance	1
Breeding Bread Wheat	2
Breeding Durum Wheat	5
Biotechnology	2
Data Analysis & AGROBASE	3
Entomology in Cereal & Legume	3
Grain Quality	2
IPM in Cereal & Legume	3
Pathology in Cereal & Legume	6
Rhizobium Technology	1
Stress Physiology	2
Viruses in Cereal & Legume	5
TOTAL	62

10.2.2. Graduate Research Training

An important aspects of our training concerns post-graduates. We have in the Germplasm Program a total of 31 students (18 M.Sc. and 13 Ph.D. students). During 1998, a total of ten students (three Ph.D. and seven M.Sc. students) graduated or completed their thesis research, while three new students started their thesis research work at ICARDA (Table 10.4).

Table 10.4. Graduate Research Students at the Germplasm Program during 1998.

	M.Sc. Students		Ph.D. Students	
Country	No.	Graduated in 1998	No.	Graduated in 1998
Algeria	0	0	1	0
Eritrea	1	0	0	0
Germany	0	0	1	1
Iraq	0	0	1	1
Jordan	1	0	0	0
Morocco	0	0	1	0
Netherlands	0	0	1	0
Somalia	1	1	0	0
Sudan	1	0	1	1
Syria	14	6	4	0
Turkey	0	0	2	0
UAE	0	0	1	0
TOTAL	18	7	13	3

10.3. Visitors and Scientific Visits

Visits between the Germplasm Program and NARS are an effective tool for transferring scientific information and research experiences. In 1998, forty-two visitors from Egypt. Algeria, Iran, Iraq, Tunisia, Morocco, Libya, Pakistan, Kazakhstan, Germany, Spain and Turkey visited the Germplasm Program. Most of the visitors were invited for a short periods from one week to one month to had an overviews on breeding activities on the improvement of ICARDA mandate crops, discuss joint projects, selected germplasm, lectures in training courses, discuss graduate student research, or gathered information on Germplasm Program activities and results. In addition, more than 150 farmers and students from Syrian universities visited the program for one day visit.

11. PUBLICATIONS

11.1. Journal Articles

Ahmed, S., C. Akem and Ali M. Abd EL Moneim. Sources of resistance to downy mildew in narbon vetch (*Vicia narbonensis*) and common vetch (*Vicia sativa*) submitted to Genetic Resources and Crop Evolution.

Bayaa, B.; Kumari, S.G.; Akkaya, A.; Erskine, W.; Makkouk, K.M.; Turk, Z.; Ozberk, I. 1998. Survey of major biotic stresses of lentil in South-East Anatolia, Turkey. Phytopathologia Mediterranea 37: 88-95. [En].

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Manschadi, A.M.; Sauerborn, J.; Stutzel, H.; Goebel, W.; Saxena, M.C. 1998. Simulation of faba bean (Vicia faba L.) growth and development under Mediterranean conditions: model adaptation and evaluation. European Journal of Agronomy 9: 273-293. [En].

Ocampo, B.; Robertson, L.D.; Singh, K.B. 1998. Variation in seed protein content in the annual wild Cicer species. Journal of the Science of Food and Agriculture 78: 220-224. [En].

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11.2. Newsletter Articles

Makkouk, K.M. 1998. Virus diseases of legume crops transmitted persistently by sucking insects. Grain Legumes (21): 9-10. [En].

11.3. Book Chapters and Conference Papers

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12. **LEGUME VARIETIES RELEASED BY NATIONAL PROGRAMS**

Crop	Country	Year of release	Variety	Parentage
Faba Bean	Egypt	1994	Gizablanca	Selected from Reina Blanca
Faba Bean	Egypt	1995	Giza 429	Selected from Giza 402
Faba Bean	Egypt	1995	Giza 461	Giza 3 x ILB 938
Faba Bean	Egypt	1995	Giza 643	249/801/80 x NA 83
Faba Bean	Egypt	1995	Giza 674	Giza 402 x BPL 582
Faba Bean	Egypt	1995	Giza 714	462/908 B/83 x 503/453/83
Faba Bean	Egypt	1995	Giza 716	461/842/83 x 503/453/83
Faba Bean	Egypt	1995	Giza 717	503/453/83 x ILB 938
Faba Bean	Egypt	1997	Giza 2	n.a.
Faba Bean	Egypt	1997	Giza 3	n.a.
Faba Bean	Egypt	1998	Giza 40	Landrace, selected from local variety
Faba Bean	Egypt	1998	Giza 843	461/845/83 x 561/2076/85
Faba Bean	Iran	1986	Barkat	ILB 1269
Faba Bean	Portugal	1992	Favel	80S 43977
Faba Bean	Sudan	1990	Sellaim-ML	n.a.
Faba Bean	Sudan	1991	Shambat 104	n.a.
Faba Bean	Sudan	1991	Shambat 75	n.a.
Faba Bean	Sudan	1993	Basabeer	BB7
Faba Bean	Sudan	1993	Hudeiba 93	Bulk1/3
Faba Bean	Sudan	1993	Shambat 616	616
Faba Bean	Syria	1991	Hama 1	Selection from Aquadulce
Faba Bean	Turkey	1998	Yilmaz 98	n.a.
Forage Legumes	Australia	1998	(Lathyrus cicera) Chalus	IFLLC-1279
Forage Legumes	Cyprus	1998	(V. narbonensis) acc. 568	n.a.
Forage Legumes	Jordan	1994	(L. ochrus) IFLLO-185	IFLLO-185
Forage Legumes	Jordan	1994	(V. villosa ssp. dasycarpa) IFLVD 683	IFLVD 683
Forage Legumes	Jordan	1994	(V. sativa) IFLVS - 715	IFLVS - 715
Forage Legumes	Lebanon	1997	(L. cicera) Jaboulah	IFLLC-492

Crop	Country	Year of release	Variety	Parentage
Forage Legumes	Lebanon	1997	(V. sativa) Baraka	IFLVS - 715
Forage Legumes	Morocco	1990	(V. sativa) ILFVS-1812	ILFVS-1812
Forage Legumes	Morocco	1992	(V. villosa ssp. dasycarpa) IVLVD-2053	IVLVD-2053
Forage Legumes	Morocco	1994	(V. narbonensis) IFLVN-2387	IFLVN-2387
Forage Legumes	Morocco	1994	(V. narbonensis) IFLVN-2391	IFLVN-2391
Forage Legumes	Morocco	1994	(V. sativa) IFLVS-709	IFLVS-709
Forage Legumes	Pakistan	1997	(V. villosa ssp. dasycarpa) Kuhak-96	IFLVD-683
Kabuli Chickpea	Algeria	1988	ILC 3279	ILC 3279
Kabuli Chickpea	Algeria	1988	ILC 482	ILC 482
Kabuli Chickpea	Algeria	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Algeria	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	China	1988	ILC 202	ILC 202
Kabuli Chickpea	China	1988	ILC 411	ILC 411
Kabuli Chickpea	China	1993	FLIP 81-40WC	FLIP 81-40WC
Kabuli Chickpea	China	1993	FLIP 81-71C	FLIP 81-71C
Kabuli Chickpea	China	1996	ILC 3279	ILC 3279
Kabuli Chickpea	Cyprus	1984	Yialousa	ILC 3279
Kabuli Chickpea	Cyprus	1987	Kyrenia	ILC 464
Kabuli Chickpea	Egypt	1994	Giza 88	n.a.
Kabuli Chickpea	Egypt	1995	Line 195	ILC 195
Kabuli Chickpea	France	1988	TS1009	ILC 482
Kabuli Chickpea	France	1988	TS1502	FLIP 81-293C
Kabuli Chickpea	France	1992	Roye Rene	F 84-188C
Kabuli Chickpea	India	1996	Pant G88-6	n.a.
Kabuli Chickpea	Iran	1995	FLIP 84-48C	FLIP 84-48C
Kabuli Chickpea	Iran	1995	ILC 3279	ILC 3279
Kabuli Chickpea	Iran	1995	ILC 482	ILC 482
Kabuli Chickpea	Iraq	1991	Dijla	ILC 3279
Kabuli Chickpea	Iraq	1991	Rafidain	ILC 482
Kabuli Chickpea	Italy	1987	Califfo	ILC 72
Kabuli Chickpea	Italy	1987	Sultano	ILC 3279

Crop	Country	Year of release	Variety	Parentage
Kabuli Chickpea	Italy	1995	Pascia	FLIP 86-5C
Kabuli Chickpea	Jordan	1990	Jubeiha 2	ILC 482
Kabuli Chickpea	Jordan	1990	Jubeiha 3	ILC 3279
Kabuli Chickpea	Lebanon	1989	Janta 2	ILC 482
Kabuli Chickpea	Lebanon	1993	Baleela	FLIP 85-5C
Kabuli Chickpea	Lebanon	1998	Al-Wady	FLIP 86-6
Kabuli Chickpea	Libya	1993	ILC 484	ILC 484
Kabuli Chickpea	Morocco	1987	ILC 195	ILC 195
Kabuli Chickpea	Morocco	1987	ILC 482	ILC 482
Kabuli Chickpea	Morocco	1992	Douyet	FLIP 84-92C
Kabuli Chickpea	Morocco	1992	Rizki	FLIP 83-48C
Kabuli Chickpea	Morocco	1995	Farihane	FLIP 84-79C
Kabuli Chickpea	Morocco	1995	Moubarak	FLIP 84-145C
Kabuli Chickpea	Morocco	1995	Zahor	FLIP 84-182C
Kabuli Chickpea	Oman	1988	ILC 237	ILC 237
Kabuli Chickpea	Oman	1995	FLIP 87-45C	FLIP 87-45C
Kabuli Chickpea	Oman	1995	FLIP 89-130C	FLIP 89-130C
Kabuli Chickpea	Pakistan	1992	Noor 91	FLIP 81-293C
Kabuli Chickpea	Portugal	1992	Elmo	ICC 6304
Kabuli Chickpea	Portugal	1992	Elvar	FLIP 85-17C
Kabuli Chickpea	Portugal	1998	Elite	ICC 5035
Kabuli Chickpea	Spain	1985	Alcazaba	ILC 2555
Kabuli Chickpea	Spain	1985	Almena	ILC 2548
Kabuli Chickpea	Spain	1985	Atalaya	ILC 200
Kabuli Chickpea	Spain	1985	Fardan	ILC 72
Kabuli Chickpea	Spain	1985	Zegri	ILC 200
Kabuli Chickpea	Spain	1995	Athenas	ILC 72 x CA2156
Kabuli Chickpea	Spain	1995	Bagda	ILC 72 x CA 2156
Kabuli Chickpea	Spain	1995	Kairo	ILC 72 x CA 2156
Kabuli Chickpea	Sudan	1987	Shendi	ILC 1335
Kabuli Chickpea	Sudan	1994	Jebel Marra-1	ILC 915
Kabuli Chickpea	Sudan	1996	Atmor	ICCV 89509
Kabuli Chickpea	Sudan	1998	Matama-1	FLIP 91-770
Kabuli Chickpea	Sudan	1998	Salawa	ICCV-2
Kabuli Chickpea	Sudan	1998	Wad Hamid	FLIP 89-826
Kabuli Chickpea	Syria	1986	Ghab 1	ILC 482
Kabuli Chickpea	Syria	1986	Ghab 2	ILC 3279

Crop	Country	Year of release	Variety	Parentage
Kabuli Chickpea	Tunisia	1986	Amdoun 1	Be-sel-81-48
Kabuli Chickpea	Tunisia	1987	Chetoui	ILC 3279
Kabuli Chickpea	Tunisia	1987	Kassab	FLIP 83-46C
Kabuli Chickpea	Tunisia	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Tunisia	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	Turkey	1986	Guney Sarisi 482	n.a.
Kabuli Chickpea	Turkey	1986	ILC 195	ILC 195
Kabuli Chickpea	Turkey	1991	Akcin	87AK81115
Kabuli Chickpea	Turkey	1992	Aydin 92	FLIP 82-259C
Kabuli Chickpea	Turkey	1992	Izmir 92	FLIP 85-60C
Kabuli Chickpea	Turkey	1992	Menemen 92	FLIP 85-14C
Kabuli Chickpea	Turkey	1994	Aziziye	FLIP 84-15C
Kabuli Chickpea	Turkey	1994	Damla	FLIP 85-7C
Kabuli Chickpea	Turkey	1997	Gokce	FLIP 87-8C
Kabuli Chickpea	USA	1994	Dwelley	Surutato x FLIP 85-58C
Kabuli Chickpea	USA	1994	Sanford	Surutato x FLIP 85-58C
Lentil	Algeria	1987	Syrie 229	n.a.
Lentil	Algeria	1988	Balkan 755	n.a.
Lentil	Algeria	1988	ILL 4400	ILL 4400
Lentil	Argentina	1991	Arbolito	ILL 4650x-4349
Lentil	Australia	1989	Aldinga	FLIP 84-80L
Lentil	Australia	1993	Cobber	FLIP 84-58L
Lentil	Australia	1993	Digger	FLIP 84-51L
Lentil	Australia	1993	Matilda	FLIP 84-154L
Lentil	Australia	1995	Northfield	78S 26013
Lentil	Australia	1998	Cassab	FLIP 92-35L
Lentil	Australia	1998	Cumra	ILL 590
Lentil	Bangladesh	1993	Barimasur-2	Sel. from ILL 4353xILL 353
Lentil	Bangladesh	1995	Barimasur-4	Sel. from L5 x FLIP84-112L
Lentil	Canada	1989	Indian head	ILL 481
Lentil	Canada	1994	CDC Matador	((Indian head x (Eston x PI 179310))
Lentil	Canada	1994	CDC Redwing	Eston x ILL 5588
Lentil	Chile	1989	Centinela	74TA 470
Lentil	China	1988	FLIP 87-53L	FLIP 87-53L
Lentil	China	1998	C 87	ILL 6980

Crop	Country	Year of release	Variety	Parentage
Lentil	Egypt	1990	Precoz	ILL 4605
Lentil	Egypt	1998	Giza 370	Bulk selection from Egyptian land race 370
Lentil	Egypt	1998	Giza 4	n.a.
Lentil	Egypt	1998	Giza 51	ILL 883 (Iran) x ILL 470 (Syria)
Lentil	Egypt	1998	Sinai 1	Bulk selection from Argentinean variety Precoz
Lentil	Ethiopia	1980	R 186	R 186
Lentil	Ethiopia	1984	Chalew	LL 358
Lentil	Ethiopia	1984	Chikol	NEL 2704
Lentil	Ethiopia	1993	FLIP 84-7L	FLIP 84-7L
Lentil	Ethiopia	1995	Ada'a	FLIP 86-41L
Lentil	Ethiopia	1995	Gudo	FLIP 84-78L
Lentil	Iraq	1994	Baraka	78S 26002
Lentil	Jordan	1990	Jordan 3	78S 26002
Lentil	Lebanon	1988	Talya 2	78S 26013
Lentil	Lebanon	1995	Toula	FLIP 86-2L
Lentil	Lesotho	1998	FLIP 87-21L	FLIP 87-21L
Lentil	Libya	1993	El Safsaf 3	78S26002
Lentil	Morocco	1990	Bakria (Precoz)	ILL 4605
Lentil	Nepal	1989	Sikhar	ILL 4402
Lentil	New Zealand	1992	Rajah	FLIP 87-53L
Lentil	Pakistan	1990	Manserha 89	ILL 4605
Lentil	Pakistan	1995	Masur 95	18-12xILL 4400
Lentil	Pakistan	1996	Shiraz-96	ILL 5865
Lentil	Sudan	1993	Aribo 1	ILL 818
Lentil	Sudan	1993	Rubatab 1 (ILL 813)	ILL 813
Lentil	Sudan	1998	Nedi	ILL 6467
Lentil	Syria	1987	Idleb 1	78S 26002
Lentil	Tunisia	1986	Nefza	ILL 4606
Lentil	Tunisia	1986	Neir	ILL 4400
Lentil	Turkey	1987	Firat 87	75Kf 36062
Lentil	Turkey	1990	Erzurum 89	ILL 942
Lentil	Turkey	1990	Malazgirt 89	ILL1384
Lentil	Turkey	1991	Sazak 91	NEL 854
Lentil	Turkey	1996	Sayran 96	ILL 784

Crop	Country	Year of release	Variety	Parentage
Peas	Cyprus	1994	Kontemenos	PS 210713
Peas	Ethiopia	1994	061K-2P-2192	n.a.
Peas	Lesotho	1997	Local Sel 1690	n.a.
Peas	Lesotho	1997	Mg 102469	n.a.
Peas	Lesotho	1997	Syrian Aleppo	n.a.
Peas	Oman	1995	A 0149 Dry Pea	n.a.
Peas	Oman	1995	Collegian Dry Pea	n.a.
Peas	Oman	1995	MG 102703 Dry Pea	n.a.
Peas	Oman	1995	Syrian Local Dry Pea	n.a.
Peas	Sudan	1989	Krema-1	n.a.
Peas	Sudan	1994	Ballet	n.a.

13. STAFF LIST

1.	Dr William Erskine	Program Leader
2.	Dr Khaled Makkouk	Plant Virologist
3.	Dr Ali Abdel Moneim	Forage/Legume Breeder
4.	Dr Michael Baum	Biotechnologist
5.	Dr Mustapha El-Bouhssini	Entomologist
6.	Dr Chrysantus Akem	Food Legume Pathologist
7.	Dr Rajinder S. Malhotra	International Trials Scientist
8.	Dr Sripada Udupa	Post-Doctoral Fellow
9.	Dr Seid A. Kemal	Post-Doctoral Fellow
10.	Dr Ashutosh Sarker	Post-Doctoral Fellow
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12.	Dr Bruno Ocampo	Research Associate
13.	Mr Gaby Khalaf	Research Associate
14.	Mr Fadel Afandi	Research Associate
15.	Mr Samir Hajjar	Research Associate
16.	Mr George Zakko	Research Assistant
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21.	Dr Imad Eujayl	Research Assistant
22.	Mr Hani Nakkoul	Research Assistant
23.	Mr Hasan El-Hasan	Research Assistant
24.	Mr Abdallah Joubi	Research Assistant
25.	Mrs Widad Ghoulam	Senior Research Technician
26.	Mr Moaiad Lababidi*	Senior Research Technician
27.	Mr Khaled El-Dibl*	Senior Research Technician
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29.	Mr Nidal Kadah	Senior Research Technician
30.	Mr Omar Labban	Senior Research Technician
31.	Mr Pierre Kiwan	Senior Research Technician (Terbol)
32.	Mr Ra'afat Azzo*	Research Technician
33.	Mr Mohamed K.Issa	Research Technician
34.	Mr Bounian Abdel Karim	Research Technician
35.	Mr Diab Ali Raya*	Research Technician
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37.	Ms Setta Ungi	Research Technician
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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-Abdallah	Labourer
44. Mrs Tamar Varvarian	Secretary

Consultants

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

***Left the Program in 1998**