LEGUME PROGRAM

Annual Report for [illegible]

LEGUME PROGRAM
1993 ANNUAL REPORT

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1. INTRODUCTION

1.1. General

Research and training activities during the 1992/93 season were continued with the aim to encourage and support national efforts in the West Asia and North Africa (WANA) region, and other developing countries with similar ecologies, in improving the productivity and yield stability of cool-season food and feed legumes and enhance their role in increasing, in a sustainable manner, the productivity of cereal-based, rainfed farming systems. Research and training were conducted jointly with scientists from other ICARDA programs as well as with those from the national programs in a multidisciplinary team approach. Work on kabuli chickpea was conducted jointly with ICRISAT. Collaboration with relevant institutions in several industrialized countries on basic research continued.

During the season several staff movements occurred. The Senior Microbiologist left the Program to join CIAT, Cali, columbia in 1993. The Principal chickpea Breeder returned from sabbatic leave in September 1993. The post-doctoral fellows/visiting scientists in lentil breeding, forage legume breeding, *Orobanche* control, and crop physiology left the program after completing their respective term appointments. The Senior Entomologist rejoined the Program after maternity leave only to work on half-time basis. The Legume Scientist in North Africa moved away from Morocco to take up the responsibilities of coordinating highland research program being done in collaboration with Turkey.

Research work was mainly centered at Tel Hadya site of ICARDA, but good use was also made of other testing sites in Syria (Breda and Jinderess) and Lebanon (Kfardan and Terbol). Generation advancement of lentil and kabuli chickpea was done at Terbol. Research sites of several national programs were used, jointly with the national scientists, for research on developing breeding material with specific resistance to some key biotic and abiotic stresses because of the presence of ideal screening conditions there.

1.2. Weather Conditions

The weather conditions during the season at Breda, Tel Hadya, Jinderess and Terbol are depicted in Section 11. The long-term average precipitation at these sites is 280, 350, 470 and 600 mm respectively. During the 1992/93 season, the total seasonal precipitation received from Sept 1992 to June 1993 was 283, 277, 402 and 664 mm, respectively. For the third consecutive year rainfall at Tel Hadya was below the long-term average, which was even lower than the rainfall at Breda. Because of higher rainfall at Breda than at Tel Hadya upto mid March, the forage legumes at Breda made better early growth than those at Tel Hadya, and field estimates showed that by 20 March about 1.5t/ha dry matter was already built up by *V. narbonensis*. Higher rainfall, and low temperatures at Breda resulted in development of Ascochyta blight and cold damage in lathyrus nurseries. Although the rainfall at Tel Hadya was low, its uniform distribution resulted in good crop growth. The number of frost events at Breda were 38, compared to 50 and 53 at Tel Hadya and Jinderess. The absolute minimum temperature at Breda was -6.5, at Tel Hadya -8.7, and at Jinderess -8.0. The conditions were, therefore, very favourable for screening for cold tolerance. For example, the cold susceptible check in chickpea cold-tolerance screening got killed by 21 March 1993.

1.3. Achievements

A summary of major achievements in research, training and networking activities during the 1992/93 season is given below.

1.3.1. Kabuli Chickpea

Screening of 2000 new chickpea lines for drought tolerance, using newly developed screening method, revealed that 15 lines were tolerant/moderately tolerant to drought. These will be further evaluated next season. Sources of resistance have also been identified in the cultigen against cold, Ascochyta blight, Fusarium wilt and leaf miner. In the wild *Cicer*, sources of resistance have been identified for all the above five stresses as also for seed beetle and cyst nematode. Multiple-stress resistant sources are more frequently found in the wild *Cicer* species.

Germplasm enhancement work for increased biomass yield, Ascochyta blight resistance, cold tolerance and a combination of blight and cold made considerable progress. Yield levels of newly-bred lines had exceeded the yield of best checks. Yields of newly-bred lines in winter sowing were 2155 kg/ha averaged over three locations, giving a 68.9% increase over the spring-sown ones. Over the period of 10 years (1983/84 to 1992/93), yield of newly bred lines was 62.2% higher when sown in winter than when sown in spring. Use of wild *Cicer* species for chickpea improvement not only enhanced tolerance to target stresses but also increased yield. The seed yield in F_4 and F_5 progenies derived from the interspecific hybridization was >50% higher than the yield of cultigen parent (ILC 482).

During 1993, 17475 chickpea entries were provided to 49 countries through international testing network. Fifty lines have been chosen by 15 NARSs for pre-release multiplication and/or on-farm trials. Six lines were released as cultivars by five countries. Genetic typing of cultivars and assessment of intravarietal variation has been possible by fingerprinting using $(GATA)_4$/EcoRI probe/enzyme combination. A DNA molecular marker for following resistance to Ascochyta blight has been identified. Using this marker, the gene action in a resistant x susceptible cross has been followed. Genetic typing (DNA fingerprinting) of 53 isolates of *Ascochyta rabiei* collected from different parts of Syria has also been done. Studies have been started in developing protocols for *in vitro* culture of embryos so as to enable embryo rescue in the interspecific hybridization.

Survey of chickpea disease situation in different parts of Syria (Dara'a, Hama, Homs, Aleppo, Idleb and Hassakeh provinces) was conducted. Ascochyta blight was devastating in Hassakeh, where excessive rain and conducive temperatures for pathogen in April encouraged the development of severe epiphytotics.

Out of 1615 breeding lines developed between 1981 and 1990, 185 were found promising for Ascochyta blight resistance in field and greenhouse testing in 1991/92. These were again tested during 1992/93 for individual pathotypes in greenhouse and for the mixture of pathotypes in both greenhouse and field. From these evaluations, 12 lines were identified to have broad-based resistance. The role of teliomorphic stage of Ascochyta blight fungus was investigated, as also the development of disease from an infection focus. Progress was made in developing a wilt-sick plot for routine screening of chickpea material for resistance to *Fusarium oxysporum* f.sp. *ciceri*.

Population dynamics of chickpea leafminer and its parasitoides was studied; population of parasitoides followed the same trend as the population of leafminer. Population of pod borers was also monitored. Neem extract effectively reduced the pod-borer damage in chickpea, but it was less effective in controlling leafminer. The resistance of ILC 5901 to leafminer was confirmed.

1.3.2. Lentil

Approximately 250 crosses are made and handled in a bulk pedigree system using off-season generation advancement in Terbol. Segregating populations targeted for different regions are distributed to national programs for selection and cultivar development *in situ*. Progress has been made in increasing yield potential in the breeding material, as reflected by the yield levels in yield trials at Breda, Tel Hadya and Terbol. The lentil international breeding nurseries have evolved in response to the needs of NARSs. There has been increasing number of entries in international trials provide by national programs.

Vascular wilt caused by *Fusarium oxysporum* f.sp. *lentis* being the major disease of lentil in the region, it has received highest attention. Screening for wilt resistance in the 1992/93 season concentrated on adult plant reaction in wilt-sick plot using a range of breeding material and germplasm. Resistance of several lines has been confirmed. A preliminary investigation on biocontrol of wilt using some isolates of *Bacillus* spp. as antagonist has given valuable results.

Screening for resistant to Ascochyta blight, which is a common disease in Ethiopia, Indian sub-continent and some parts of WANA, in trays in plastic house helped in identification of several resistant sources. Sources showing combined resistance to wilt and Ascochyta blight have also been identified.

An effective field screening technique for winter hardiness has been developed and variability in cultivated germplasm examined in collaboration with the Turkish national program. Molecular, chemical and morphological markers for winter hardiness are being studied.

The national programs have made good use of ICARDA enhanced germplasm. Eight cutlivars were released by seven countries during 1993. A large number of lines has been selected for multi-location testing and/or pre-release multiplication in all the major production areas.

A collaborative project with Washington State University is examining the possibility of using DNA-marker (RFLP, PCR) in a system of marker assisted selection for lentil improvement.

Experiments on the control of *Sitona crinitus* to prevent damage to nodules in lentil at Tel Hadya, Jinderess ad Alkamiye confirmed the effectiveness of seed treatment of lentil with Promet at the rate of 12 ml/kg seed. Also, its efficacy was proven in 6 on-farm trials spread in all the major lentil growing areas in Syria. Gaucho insecticide was not effective in preventing nodule damage.

1.3.3. Forage Legumes

Forage-legume improvement covered common vetch (*Vicia sativa*), wooly-pod vetch (*V. villosa* subsp. *dasycarpa*), bitter vetch (*V. ervilia*), Palaestina vetch (*V. palaestina*), Hungarian vetch (*V. panonica*) and narbon vetch (*V. narbonensis*) and common chickling (*Lathyrus sativus*), dwarf chickling (*L. cicera*) and ochrus chickling (*L. ochrus*). Work was also done on amphicarpous vetch (*V. sativa* subsp. *amphicarpa*) and chickling (*L. ciliolatus*). Much of the efforts were devoted to domesticate the wild forms of these species, by selection and hybridization, and enhance their adaptation to different environments and cropping systems in which they are to be grown to augment feed production for livestock. Nutritional quality evaluation was an important component of forage-legume improvement work.

Screening was done of 321 accessions of vetches and 238 accessions of chicklings for reconfirmation of their cold tolerance. Most of the accessions retained their past rating. Fourhundred - and - fortyfive new accessions of chickling were also evaluated and 340 accessions were found tolerant to cold.

Onehundred and eightyfour new selections of seven annual forage legume species were evaluated in microplot trials for green herbage production and seed and straw yield. Several promising selections were identified for promotion to yield trials. Early winter growth of *V. sativa, V. ervilia* and *V. narbonensis* was significantly correlated with dry matter yield of green herbage at flowering and total dry matter yield at maturity.

Genotype x environment study carried out using several advanced selections of different vetch and chickling species helped in the identification of lines with specific adaptation to low and high yielding environments and genotypes with wide adaptation. These entries will be incorporated in the international nurseries. National programs have found these international nurseries very useful. National programs in Iraq, Jordan, Morocco and Syria have identified several lines either for release or for prerelease multiplication. Jordan released a wooly-pod vetch (IFLVD 683), a common vetch (IFLVS 715) and one ochrus chickling (IFLLO 101/185). Scientists in Morocco identified IFLVN 577/2391 and IFLVS 709/2603 for national catalogue trial.

For the routine determination of the seed content of neurotoxin ß-N Oxalyl diamino propianicacid (ODAP) in chicklings, a near-infrared technique was perfected in collaboration with the Canadian Grain Commission grain quality laboratory. Analysis of 116 lines of different chicklings revealed that none was free from ODAP but several had very little content of this free aminoacid. The ODAP content decreased as the moisture supply to the chickling crop was increased. Studies on the reaction of different food and feed legumes to drought, using three discrete levels of moisture supply as well as a continuous range using line source sprinkler system revealed that *Lathyrus sativus* was most drought tolerant crop among the feed legumes and chickpea amongst the grain legumes.

Studies on the seed-bank dynamics of *V. sativa* subsp. *amphicarpa* was continued in the experiment set up in 1989/90, in which effect of different times of grazing was studied. During 1992/93, there was no significant difference between the grazing treatments. Seed softening process was studied: 80% of seeds were hard at the start of the season, but by autumn this decreased to 58%.

Disease survey on forage legumes in on-farm trials in different parts of Syria revealed that wilt caused by *Fusarium oxysporum* was most widespread disease. Ascochyta blight was occasionally found. Disease resistance of different forage legume lines was reconfirmed in greenhouse.

Studies on *Sitona crinitus* control on *V. villosa* subsp. *dasycarpa* confirmed that this is an important pest of this vetch and its control with Promet seed treatment can effectively reduce nodule damage and increase yield.

1.3.4. Dry Pea

New accessions obtained from different cooperators were evaluated in two genetic evaluation trials and promising lines identified for promotion to yield trials. Cold-tolerance evaluation of 36 accessions for reconfirmation and 90 new accessions was completed. Fourteen new lines showing cold tolerance were identified. Twenty-three promising entries were yield tested at Terbol and Tel Hadya to develop international adaptation trial for the 1993/94 season.

1.3.5. International Nurseries

We supplied 1176 sets of 37 different types of trials and nurseries to cooperators in 53 countries, based on their request, for the 1993/94 season. Several cooperators also requested large quantity of seeds of some elite lines, identified by them from earlier international nurseries/trials, for multilocation yield testing and on-farm verification trials. Also *Rhizobium* inoculation was provided.

1.3.6. Training and Networking

Training and networking received priority attention from the Program. Some 207 participants received training in the improvement of lentil, kabuli chickpea, faba bean, pea and annual forage legumes. Training at Aleppo included group courses in legume disease control, insect control, breeding methodologies, harvest mechanization and DNA-molecular marker techniques; individual non-degree training and graduate research. In-country/regional training covered winter chickpea technology, legume seed production, computer use, and general crop production.

Networking in the Nile Valley, North Africa, and West Asia regional programs continued, in which regional trials were designed and executed. These included regional yield testing, integrated disease control, integrated weed control, integrated *Orobanche* control and regional testing of sources of resistant to various diseases and pests. A Global Grain Legume Drought Research Network (GGLDRN) was started in collaboration with ICRISAT and FAO.

For enhancing the adoption of winter sowing of chickpea in the Mediterranean basin, a project planning workshop was organized with FAO at ICARDA in November 1993. National program scientists from Algeria, Morocco, Tunisia, Syria and Turkey participated and contributed to the development of a project proposal to be submitted to potential donors.

To enhance the communication of the results of research conducted at ICARDA base program as well as that done in collaboration with the national programs, 11 books and proceedings, 31 journal articles and 17 articles in other publications were published during 1993. Annual reports, reprints, books and FABIS and LENS newsletters were widely distributed. **M.C. Saxena.**

2. 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 production of the kabuli type. Ascochyta blight and wilt are the two major diseases of chickpea. Leaf miner in the Mediterranean region and pod borer in other regions are 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. 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 and parts of South Asia, West Asia and Central America, the crop 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. With the introduction of winter sowing the chickpea cultivation can be extended to lower rainfall region, say upto 300 mm. There are indications that increasing plant density and reducing row width also increase yield significantly, especially during winter sowing. Winter sowing 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 diseases (ascochyta blight and fusarium wilt), insect pests (leaf miner and pod borer), parasites (cyst nematode and *Orobanche crenata* Forsk.), and physical stresses (mainly cold and drought). Exploitation of wild *Cicer* species for transfer of genes for resistance to different stresses is another area receiving priority. DNA fingerprinting in *Ascochyta rabiei* is being pursued for maping the pathogen variability in the region.

During 1993, several collaborative projects operated. In the project "Development of chickpea germplasm with combined resistance to ascochyta blight and fusarium wilt using wild and cultivated species", four Italian institutions collaborated with ICARDA. The screening for cyst nematode was carried out in association with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. Fusarium wilt resistance screening was also done in collaboration with INRAT, Tunisia and the Departamento de Patologia Vegetal, Cordoba, Spain. Screening for tolerance to cold was done in cooperation with agricultural research institutes in Turkey. A program on mutation breeding was conducted jointly with the Nuclear Institute for Agricultural Biology, Faisalabad, Pakistan. The University of Saskatchewan, Canada is collaborating in studies of genetic diversity in kabuli chickpea. Studies on application of restriction fragment length polymorphism (RFLP) in characterizing chickpea genotypes and *Ascochyta rabiei* isolates are carried out in collaboration with the University of Frankfurt, Germany.

2.1. Chickpea Breeding

Major objectives of the breeding are (1) to produce cultivars and genetic stocks with high and stable yield and to develop segregating populations and materials for crossing programs to support NARSs and (2) to conduct strategic research to support work on germplasm improvement. Specific objectives in the development of improved germplasm for different regions are:

1. Mediterranean region: (a) winter sowing: resistance to ascochyta blight, tolerance of cold, suitability for machine harvesting, medium to large seed size (30% of resources); (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 (30% of resources);

2. 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 (20% of resources);

3. Latin America: resistance to Fusarium wilt, root rot and viruses, large seed size (5% of resources);

4. 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 (15% of resources). **K.B. Singh.**

2.1.1. Use of Improved Germplasm by NARSs

2.1.1.1. International nurseries/trials and other breeding lines

During 1993, 17,475 chickpea entries were furnished to 49 countries. Eighty-six percent of the material went were to developing countries and the remaining 14% to industrialized countries (Table 2.1.1). The nurseries were in demand from all the six continents from Chile to China and from Canada to Australia-New Zealand and 418 sets were furnished. The demand for the finished material continued to increase suggesting that breeders have found them useful for their direct exploitation. The kabuli-chickpea network is well established among chickpea scientists. **K.B. Singh, R.S. Malhotra and M.C. Saxena.**

Table 2.1.1. Number of trials and entries furnished to NARSs during 1993.

Country	Trial and nursery No. of sets of trial/nursery	Trial and nursery No. of entries	Breeding lines (no.)	Total entries (no.)
Algeria	31	1001	61	1062
Argentina	2	72	-	72
Australia	12	437	1	438
Belize	4	128	-	128
Bolivia	2	73	-	73
Brazil	-	-	2	2
Bulgaria	2	65	-	65
Canada	14	529	32	561
Chile	18	699	-	699
China	7	248	-	248
Colombia	2	48	-	48
Cyprus	2	88	-	88
Czechoslovakia	-	-	11	11
Egypt	12	395	10	405
Eritria	3	122	-	122
Ethiopia	12	470	105	575
France	5	168	12	180
Germany	-	-	2	2
Greece	2	88	-	88
Hungary	5	243	-	243
India	37	1259	444	1703
Iran	22	1041	-	1041
Iraq	14	457	4	461
Italy	27	1015	93	1108
Jordan	5	122	-	122
Lebanon	8	343	4	347
Libya	3	72	-	72
Mexico	1	31	-	31
Morocco	11	394	19	413
Nepal	1	31	-	31
New Zealand	2	73	-	73
Oman	4	171	-	171
Pakistan	8	315	6	321
Peru	2	73	-	73
Portugal	7	295	8	303
Qatar	1	24	-	24
Russia	-	-	4	4
Saudi Arabia	11	460	-	460
Spain	10	339	-	339
Srilanka	1	24	-	24
Sudan	6	177	10	187
Syria	45	1896	111	2007
Thailand	1	24	-	24
Tunisia	9	563	514	1077
Turkey	40	1614	-	1614
U.A.E.	1	24	-	24
U.K.	1	48	5	53
U.S.A.	4	129	65	194
Zambia	1	64	-	64
Total	418	15,952	1523	17,475

2.1.1.2. On-farm trials

The Project assisted NARSs in Algeria, Iraq, Jordan, Lebanon, Morocco, Syria, Tunisia and Turkey in the conduct of researcher-managed on-farm trials on winter-sown chickpea. In Syria, the Directorate of Agriculture and Scientific Research of the Ministry of Agriculture conducted on-farm trials in collaboration with ICARDA at 13 sites in different chickpea growing areas. They selected 3 newly developed chickpea lines (FLIP 86-5C, 86-6C and 84-15C) and compared them with the two released cultivars (Ghab 1 and 3). The season was drier than long-term average at most locations. But in north-eastern Syria, the total rainfall was more than 100% higher than the long-term average and much of this was received in early spring in heavy storms encouraging development of serious disease problems of ascochyta blight and root-rots. The new lines were nearly at par with the released cultivars in their yield performance, when averaged over all locations (Table 2.1.2). However, they have 50% larger seed size and taller plants. They could thus be very promising for introduction of winter chickpea in the drier areas of Syria. **Syrian NARSs Scientists and K.B. Singh.**

Table 2.1.2. Seed yield and some other characters of chickpea entries in the on-farm trial conducted jointly by the Directorate of Agriculture and Scientific Research, Syria and ICARDA during 1992/93.

Entry	Seed yield (kg/ha)[1] (g)	100-seed[1] weight (cm)	Plant[1] height (no.)	Days to[2] flower (%)	Protein[3] content score
FLIP 86-5C	2007	45	52	122	18.5
FLIP 86-6C	2002	41	51	120	18.1
FLIP 84-15C	2142	42	48	121	17.8
Ghab 1	2185	28	41	120	17.8
Ghab 3	2039	27	43	124	18.1

1/ Mean of 13 locations, 2/ Mean of 10 locations, 3/ Mean of 7 locations.

2.1.1.3. Pre-release multiplication of cultivars by NARSs

Fifty lines have been chosen in recent years by 15 NARSs from the ICRISAT/ICARDA international trials for the pre-release multiplication and on-farm tests (Table 2.1.3). All the lines are developed through hybridization except two which are selections from germplasm. All the new lines have shown resistance to ascochyta blight and tolerance of cold at ICARDA and they have large seed size. If grown in winter, they can attain a height of at least 40 cm and can thus be harvested by machine. Seeds of some of the promising lines are being multiplied at ICARDA to meet the potential demand of NARSs. **NARSs Scientists.**

Table 2.1.3. Chickpea lines identified for pre-release multiplication and on-farm testing by NARSs in recent years.

Country	Line
Afghanistan	ILC 482, FLIP 81-293C, FLIP 82-150C, FLIP 83-46C, FLIP 84-15C, FLIP 84-92C
Algeria	FLIP 83-49C, FLIP 83-71C, FLIP 84-109C, FLIP 84-145C, FLIP 85-17C, 79TH 101-2, 80TH 177
China	FLIP 86-41C
Cyprus	FLIP 85-10C
Egypt	ILC 202, FLIP 80-36C
France	FLIP 84-188C
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82-169C
Jordan	FLIP 84-15C, FLIP 85-5C
Lebanon	FLIP 86-6C, FLIP 88-85C
Libya	FLIP 84-79C, FLIP 84-93C, FLIP 84-144C
Mexico	ILC 482, FLIP 81-293C
Morocco	FLIP 84-145C, FLIP 84-182C
Syria	FLIP 84-15C, FLIP 86-5C, FLIP 86-6C
Tunisia	FLIP 83-47C
Turkey	FLIP 81-70C, FLIP 82-150C, FLIP 82-74C, FLIP 82-161C, FLIP 82-269C, FLIP 83-31C, FLIP 83-41C, FLIP 83-47C, FLIP 83-77C, FLIP 83-98C, FLIP 84-79C, FLIP 85-13C, FLIP 85-15C, 87AK 71112

2.1.1.4. Release of cultivars by NARSs

During 1993, six cultivars were released by five countries, namely China (FLIP 81-40W, FLIP 81-71C), Egypt (ILC 195), Lebanon (FLIP 85-5C), Libya (ILC 484), and Sudan (ILC 915) (Table 2.1.4.). NARSs in 19 countries have released 54 lines to-date as cultivars from material furnished from ICARDA (Table 2.1.4). Forty-three of them have been released for winter sowing in the Mediterranean region, eight for spring sowing including four in China, three for winter sowing with irrigation in more southerly latitudes, and one in Pakistan. **NARSs Scientists.**

Table 2.1.4. 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 81-40C	1993	High yield
Cyprus	Yialousa (ILC 3279)	1984	Tall, blight resistance
	Kyrenia (ILC 464)	1987	Large seeds
Egypt	ILC 195	1993	Blight, wilt resistance
France	TS1009 (ILC 482)	1988	Blight resistance
	TS1502 (FLIP 81-293C)	1988	Blight resistance
	FLIP 84-188C	1992	Cold, blight resistance
Iraq	ILC 482	1991	Blight resistance, high yield
	ILC 3279	1991	Tall, blight resistance
Italy	Califfo (ILC 72)	1987	Tall, blight resistance
	Sultano (ILC 3279)	1987	Tall, blight resistance
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
	FLIP 85-5C	1993	Green seed consumption
Libya	ILC 484	1993	High yield, blight resistance
Morocco	ILC 195	1987	Tall, blight resistance
	ILC 482	1987	High yield, blight resistance
	Douyet (FLIP 84-92C)	1992	Large seed, blight resistance
	Rizki (FLIP 83-48C)	1992	Large seed, blight resistance
Oman	ILC 237	1988	High yield, irrigated cond.
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
Sudan	Shendi	1987	High yield, irrigated cond.
	Jabal Mera 1 (ILC 915)	1993	For Jabal Mera area
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 res.
	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 89 (FLIP 85-7C)	1990	Blight resistance
	Tasova 89 (FLIP 85-135C)	1990	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

2.1.2. Screening for Stress Tolerance

2.1.2.1. Land races

Screening of germplasm lines was initiated in 1978 for tolerance/ resistance to ascochyta blight (*Ascochyta rabiei* [Pass.] Lab.), in 1979 to cold, in 1981 to leaf miner (*Liriomyza cicerina* Rond.), in 1982 to seed beetle (*Callosobruchus chinensis* L.), in 1986 to cyst nematode (*Heterodera ciceri* Vovlas, Greco et Di Vito), in 1987 for fusarium wilt (*Fusarium oxysporum* Schlecht. emnd Synd f.sp. *ciceri* [Padwick] Snyd. & Hans), and in 1989 to drought. Field screening techniques have been developed for tolerance/resistance to ascochyta blight, leaf miner, cold, and drought. Wilt-sick plot developed near Cordoba, Spain is used for screening resistance against Fusarium wilt. ICARDA is in the process of developing its own wilt-sick plot. Laboratory and greenhouse screening techniques have been developed for seed beetle and cyst nematode, respectively. These techniques have been described in previous annual reports. The number of lines evaluated between 1978 and 1993 for different stresses is shown in Figure 2.1.1 except for seed beetle for which no resistance was found in all 5153 lines evaluated. The 1992/93 evaluations included 1000 lines to fusarium wilt (results awaited from Cordoba, Spain), and 2000 lines to drought. Resistant sources have been identified for ascochyta blight, fusarium wilt, leaf miner, cold, and drought, but no source of resistance was found for seed beetle and cyst nematode. Resistant sources have been freely shared with NARSs and are used in crossing blocks.

Screening germplasm for tolerance to drought continued. This year 2000 new lines were evaluated (Figure 2.1.2). Of these one line, ILC 391, was rated 3, 14 lines rated 4 and 90 lines rated 5 and the remaining 2895 lines were susceptible. These 15 tolerant/moderately tolerant lines would be reevaluated next season. In the same table results of initial evaluation for leaf miner and fusarium wilt are shown. Promising lines will be evaluated next season.

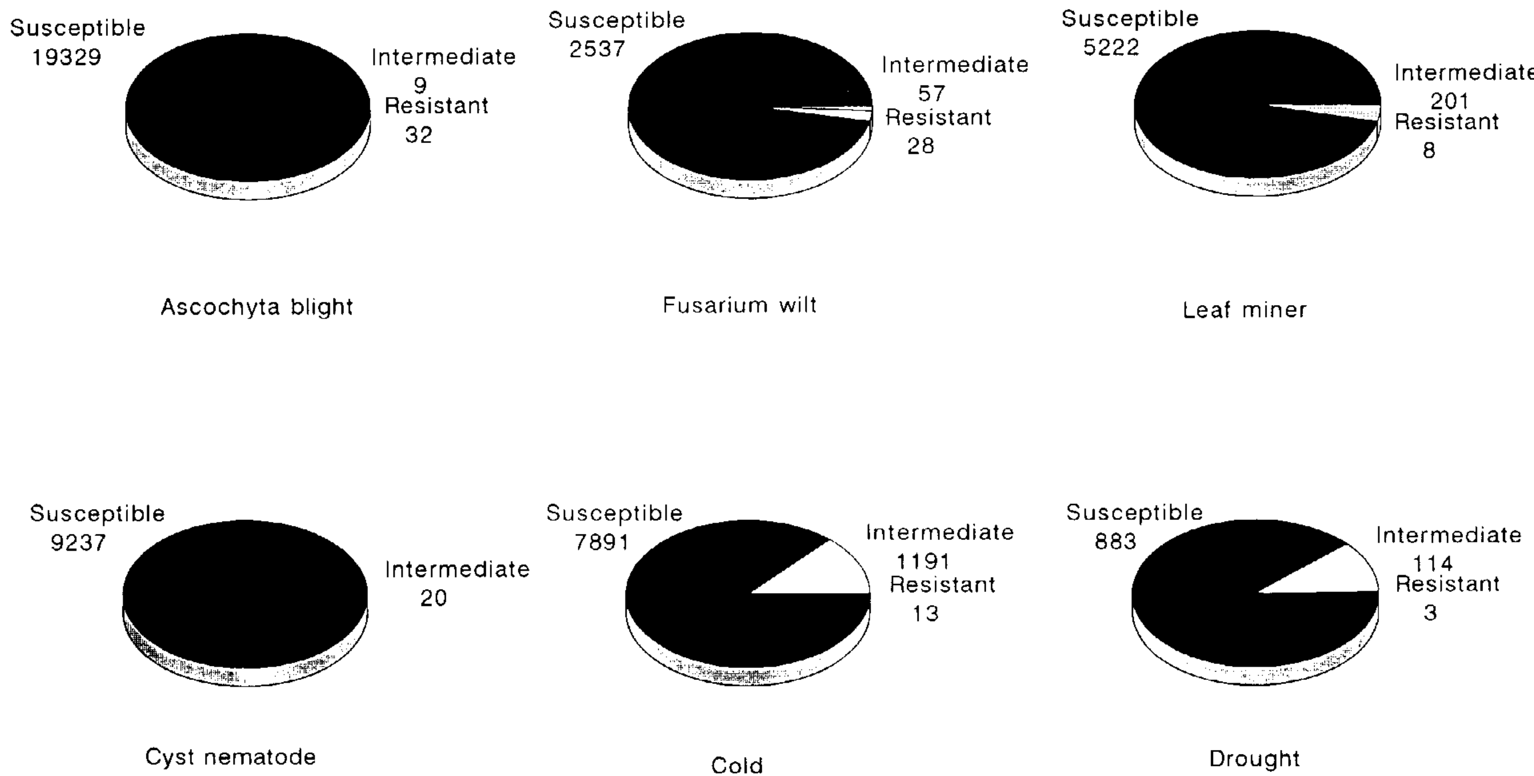


Figure 2.1.1. Reaction of chickpea germplasm to some biotic and abiotic stresses at Tel Hadya, 1978 - 1992.

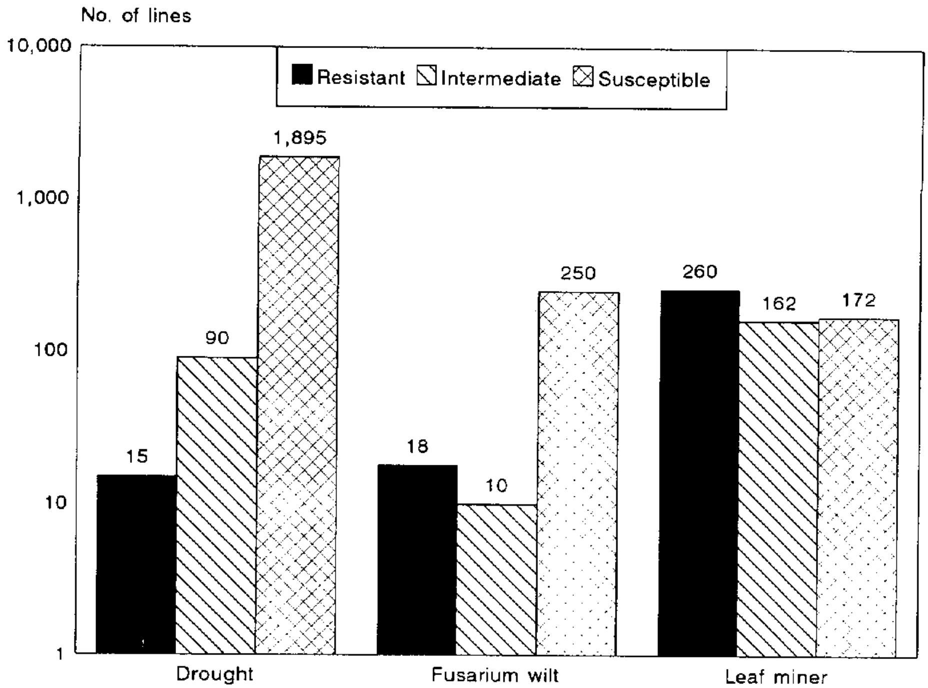


Figure 2.1.2. Preliminary evaluation of germplasm for resistance to leaf miner, fusarium wilt and drought during 1991, 1992, 1993, respectively.

For the past four years, ICARDA has furnished a Chickpea International Fusarium Wilt Nursery (CIFWN) comprising kabuli entries only. While results are awaited from other locations, the results of evaluation of three locations are described here. Three lines, namely FLIP 85-29C, FLIP 85-30C and UC 15, were resistant at Guelma (Algeria) and Hudeiba (Sudan). Another five lines, namely ILC 240, FLIP 85-20C, FLIP 85-35C, FLIP 85-130C and UC 27, were moderately resistant at both locations. These lines were earlier identified resistant at Cordoba (Spain) and can therefore be used in breeding program.

Chickpea International Cold Tolerance Nursery evaluation revealed that out of 47 entries, 3, 31, 10, 2, and 1 entries at Tel Hadya; and 3, 33, 9, 1, and 1 entries at Breda were respectively rated 3, 4, 5, 6 and 7 (on 1 to 9 scale where 1=free, 9=killed). Out of these only two entries (ILC 8262 and ILC 8617) were consistently rated 3 at both sites. Another 28 entries gave moderately tolerant reaction of 4. **K.B. Singh, S. Weigand, M.C. Saxena, R.S. Malhotra, M. Omar (ICARDA), N. Greco, M. Di Vito and A. Porta-Puglia (Italy), R. Jimenez-Diaz (Spain), M.V. Reddy (ICRISAT).**

2.1.2.2. Wild *Cicer* species

Evaluation of eight annual wild *Cicer* species continued for the fifth year to identify sources of resistance to different stresses. The highest susceptibility rating from the five-year evaluation of a line has been taken as the actual rating for that line. The results are summarized in Table 2.1.5. The evaluation during 1992/93 included 43 new accessions for resistance to cold and 197 for drought (Table 2.1.6). One accession *C. bijugum* remained free of damage from cold and another 3 accessions of *C. bijugum* and one *C. reticulatum* had a rating of 2. Hence, additional sources of higher level of cold tolerance in wild *Cicer* species than the cultigen were identified. Only four accessions of *C. reticulatum* were moderately resistant to drought and remaining were susceptible. The evaluation was hampered by delayed and variable germination, a problem that should be resolved. Seed scarification may help.

Sources of resistance were found for ascochyta blight, fusarium wilt, leaf miner, seed beetle, cyst nematode, cold, and drought. Wild species were the only source of resistance so far found for seed beetle and cyst nematode and they had higher level of resistance than the cultivated species for fusarium wilt, leaf miner, and cold. The most important species for resistance to different stress factors was *C. bijugum*, while *C. yamashitae* was the least important. **K.B. Singh, S. Weigand, M.C. Saxena, R.S. Malhotra, M. Omar (ICARDA), M.V. Reddy (ICRISAT, A. Porta-Puglia, N. Greco and M. Di Vito (Italy).**

Table 2.1.5. Reaction of germplasm accessions of *Cicer* spp. to some biotic and abiotic stresses at Tel Hadya, Syria from 1987/88-1992/93.

Scale[a]	Blight		F. wilt[c]		Leaf miner		Seed beetle		Cyst nematode		Cold		Drought	
	No.	species[b]	No.	species	No.	species	No.	species	No.	species	No.	species	No.	Species
1	0	0	72	1,4-7	2	2,6	20	1,3-5,7	3	6	1	1	0	0
2	1	2	0	0	36	1-3,5,6,8	12	1,5-7	1	0	29	1,7	0	0
3	4	1	7	1,5,7	36	1,4-7	4	1,7	17	1,6,7	45	1,4-7	0	0
4	2	5,6	15	1,5-7	33	1,4-7	3	1,6,7	0	1	46	1,3-7	3	7
5	22	5,6	6	5-7	61	1,5-8	3	3,5	28	1,7	21	2,3,5-7	37	1,5-7
6	29	1,5,6	4	5,6	26	1,4-7	8	1,5,7	0	1,8	12	5,6,8	71	1,3-8
7	24	1,4-6	4	6	23	1,4-8	18	2,4,5,7	49	1-5,7,8	11	2,5,6,8	15	1,3,5-7
8	30	4-7	0	0	1	8	52	2,5-8	0	1,5-8	8	5,6,8	20	1,2,4-6,8
9	81	2-8	5	6	3	1,8	10	5,6,8	144	2-8	65	2,3,5-8	42	1-8
Total	193		113		231		130		241		238		188	

[a] Scale: 1 = free; 5 = intermediate; 9 = killed.
[b] Species code: 1 = *C. bijugum*; 2 = *C. chorassanicum*; 3 = *C. cuneatum*; 4 = *C. echinospermum*; 5 = *C. judaicum*; 6 = *C. pinnatifidum*; 7 = *C. reticulatum*; 8 = *C. yamashitae*.
[c] Evaluation for wilt was done at Istituto Sperimentale per la Patologia Vegetale, Rome.

Table 2.1.6. Reaction of different wild *Cicer* species to cold (C) and drought (D) at Tel Hadya, spring 1993. Drought evaluation.

Scale[1]	No. of lines in each *Cicer* species															
	bijugum		yamashitae		judaicum		pinnatifidum		cuneatum		chorassanicum		echinospermum		reticulatum	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3	1	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0
4	0	0	0	0	3	0	3	0	1	0	0	0	2	0	4	4
5	0	4	0	0	4	2	2	8	1	0	1	0	0	0	0	22
6	0	2	0	2	2	29	2	16	0	2	0	0	0	2	0	18
7	0	6	0	0	1	6	2	0	0	0	0	0	0	0	0	1
8	0	3	0	3	0	4	0	4	0	2	0	2	0	2	0	1
9	0	18	0	2	2	6	0	17	0	3	1	4	0	4	0	4
Total	5	33	0	7	12	47	9	45	2	7	2	6	3	8	10	50

[1] Scale: 1 = free; 5 = tolerant; 9 = killed.

2.1.2.3. Sources of resistance

Sources of resistance identified for ascochyta blight, fusarium wilt, leaf miner, cold and drought in cultivated species are listed in Table 2.1.7. and have been used in many breeding programs. Differential disease race-patterns caused some lines to be resistant at ICARDA but susceptible elsewhere. No source of resistance was found for seed beetle and cyst nematode.

Table 2.1.7. Sources of resistance in cultigen to biotic and abiotic stresses identified between 1978 and 1993.

Stress	Source of resistance
Ascochyta blight	ILC 72, ILC 182, ILC 187, ILC 200, ILC 2380, ILC 2506, ILC 2956, ILC 3279, ILC 3856, ILC 4421, ILC 5586, ILC 5902, ILC 5921, ILC 6043, ILC 6090, ILC 6188.
Fusarium wilt	ILC 54, ILC 240, ILC 256, ILC 336, ILC 487, FLIP 85-29C, FLIP 85-30C, UC 15.
Leaf miner	ILC 316, ILC 992, ILC 1003, ILC 1009, ILC 1216, ILC 2622, ILC 5594, ILC 5901.
Cold	ILC 1464, ILC 3287, ILC 3465, ILC 3470, ILC 5638, ILC 5663, ILC 5667, ILC 5947, ILC 5951, ILC 5953, ILC 8262, ILC 8617, ILC 482 (Mut) (M 17033).
Drought	FLIP 87-58C, FLIP 87-59C.

Sources of resistance in wild *Cicer* species for Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, cold, and drought are given in Table 2.1.8. Whereas no line of cultigen was found resistant to two or more stresses, there were several accessions in wild *Cicer* species which were resistant to three or more stresses. Some are shown in Table 2.1.9. These accessions could be more useful in hybridization program for the transfer of genes for resistance if they could be crossable. **K.B. Singh.**

Table 2.1.8. Sources of resistance (rating 1 or 2 on a 1-9 scale) in wild *Cicer* species to biotic and abiotic stresses.

Stress	Source of resistance
Ascochyta blight	*C. judaicum*: ILWC 158, ILWC 161, ILWC 163; *C. pinnatifidum*: ILWC 160.
Fusarium wilt	*C. bijugum*: 20; *C. echinospermum*: 4;*C. judaicum*: 31; *C. pinnatifidum*: 6; *C. reticulatum*: 11. Out of these: *C. bijugum*: ILWC 32, ILWC 75, ILWC 83; *C. echinospermum*: ILWC 39, ILWC 179; *C. judaicum*: ILWC 46, ILWC 57, ILWC 94; *C. pinnatifidum*: ILWC 144, ILWC 149; *C. reticulatum*: ILWC 123, ILWC 183.
Leaf miner	*C. chorassanicum*: ILWC 147; *C. cuneatum*: ILWC 187; *C. judaicum*: ILWC 46, ILWC 56, ILWC 57, ILWC 58, ILWC 95, ILWC 103, ILWC 165, ILWC 175, ILWC 176, ILWC 186, ILWC 192, ILWC 196; *C. yamashitae*: ILWC 55.
Callosobruchus chinensis	*C. bijugum*: ILWC 65, ILWC 67, ILWC 68, ILWC 70, ILWC 73, ILWC 74, ILWC 75, ILWC 83, ILWC 177; *C. cuneatum*: ILWC 187; *C. echinospermum*: ILWC 39, ILWC 179, ILWC 181; *C. judaicum*: ILWC 46, ILWC 54, ILWC 173, ILWC 174, ILWC 176, ILWC 189; *C. reticulatum*: ILWC 104.
Cyst nematode	*C. bijugum*: ILWC 62, ILWC 63, ILWC 64, ILWC 65, ILWC 67, ILWC 68, ILWC 70, ILWC 71, ILWC 73, ILWC 75, ILWC 76, ILWC 77; *C. reticulatum*: ILWC 119; *C. pinnatifidum*: ILWC 212, ILWC 213, ILWC 226, ILWC 236.
Cold tolerance	*C. bijugum*: ILWC 32, ILWC 62, ILWC 63, ILWC 64, ILWC 65, ILWC 67, ILWC 68, ILWC 69, ILWC 70, ILWC 71, ILWC 73, ILWC 74, ILWC 75, ILWC 76, ILWC 77, ILWC 79, ILWC 80, ILWC 84, ILWC 194, ILWC 195.
Drought tolerance	*C. reticulatum*: ILWC 122, ILWC 127, ILWC 142.

Table 2.1.9. Sources of multiple resistance in wild *Cicer* species identified at Tel Hadya, Syria.

Acc. no. (ILWC)	*Cicer* species	Blight	Wilt[a]	Leaf miner	Seed beetle	Cyst nem.	Cold	Drought
32	*bijugum*	S	R	S	R	R	R	S
39	*echinospermum*	S	R	R	R	S	R	S
46	*judaicum*	S	R	R	R	S	S	S
62	*bijugum*	R	R	S	R	R	R	S
73	*bijugum*	R	R	S	R	R	R	S
79	*bijugum*	S	R	R	R	R	R	S
81	*reticulatum*	S	R	R	S	S	R	S
112	*reticulatum*	S	R	S	R	S	R	S
181	*echinospermum*	S	R	S	R	S	R	S
236	*pinnatifidum*	S	NE	R	NE	R	R	S
142	*reticulatum*	S	NE	S	NE	S	R	R

NE = Not evaluated.
[a] Evaluation carried out at Istituto Sperimentale per la Patologia Vegetale, Rome.

2.1.3. Germplasm Enhancement

2.1.3.1. Increased biomass yield

Chickpea seed yield is highly correlated with biomass yield. However, the biomass yield is low in chickpea. Two approaches are being followed at ICARDA to attain this: (a) increase plant height and (b) increase branch number in available tall genotypes. This project was initiated during 1989/90 and the progress is summarized here. During the 1980/90 season six crosses were made between tall genotypes of diverse origin. These crosses were grown in the 1990 off-season and thereafter advanced by bulk method. Three crosses did not produce plants taller than their tall parents and were rejected. The remaining three crosses were advanced to F_6 generation and bulk harvested. More crosses were made in the subsequent years and advanced by the bulk method (Table 2.1.10).

Selection of tall plants started from the 1991/92 season, when we selected 19 plants from F_5 generations which were at least 20% taller than the tall check (ILC 3279). These selections were grown in the progeny rows during the 1992/93 season along with the tall check. Eleven progenies taller than the tall parent were bulk harvested as they were also uniform

(Table 2.1.10). These bulked lines will be evaluated for biomass and seed yield next season. Another 20 F_5 plants which were taller than the tall parent have been selected from the breeding nursery.

Table 2.1.10. Chickpea biomass yield breeding material grown at Tel Hadya, 1992/93.

Generation	No. of developed populations grown	No. of bulk/plants selected
F_0	11	-
F_2	8	7
F_4	2	2
F_5	-	20
F_6	3	3
F_7	19	11

Plant height and branching can be increase through interspecific crosses. Therefore, it is expected that by crossing tall parents of the cultigen with wild *Cicer* both height and biomass yield may increase. With this in mind we made six interspecific crosses including *C. reticulatum* (ILWC 115) x *C. reticulatum* (ILWC 104), *C. arietinum* (ILC 72) x *C. reticulatum* (ILWC 115), *C. arietinum* (FLIP 91-149C) x *C. reticulatum* (ILWC 115), *C. arietinum* (ILC 72) x *C. reticulatum* (ILWC 104), *C. arietinum* (FLIP 91-149C) x *C. reticulatum* (ILWC 104), and *C. arietinum* (ILC 72) x *C. arietinum* (FLIP 91-149C). During the off-season we have produced F_2 seeds and also made five backcrosses. **M. Omar and K.B. Singh.**

2.1.3.2. Ascochyta blight resistance

Ascochyta blight is the major disease of chickpea and its significance after the introduction of winter chickpea in the Mediterranean basin. Without resistance to this disease chickpea cannot be grown during winter. Screening of breeding lines for resistance to blight at ICARDA identified several resistant lines. But, when they were tested across locations and years none of them was found resistant at all locations indicating the presence of physiologic races. Later research at ICARDA indicated that there might be six races in Syria and 13 races in the Mediterranean basin. Therefore, efforts began to combine genes for resistance to ascochyta blight. One approach was to cross resistance sources of diverse origin with the hope that they may have different genes for resistance and by combining them durable resistant lines could be developed. This program was initiated in 1989/90 and materials available at the end of 1992/93 season are shown in Table 2.1.11. During 1992/93 season five additional crosses have been made. Four hundred and seventy-five F_4 and F_5 plants were selected from earlier crosses. All these plants had a rating of 2 on 1-9 scale, where 1 = free from damage and 9 = all plants killed. It is likely that some of them may have true resistance rating. Research in this area will be intensified. **K.B. Singh and M.T. Mmbaga.**

Table 2.1.11. Materials in germplasm enhancement project for ascochyta blight at ICARDA, 1992/93.

Generation	No. of bulks sown	Selection	
		bulk	single plants
F_0	5	-	-
F_2	5	5	-
F_4	3	-	300
F_5	2	-	175

2.1.3.3. Cold tolerance

During 1985/86 four crosses, ILC 3470 X FLIP 81-16C, ILC 3470 X FLIP 82-64C, ILC 3470 X FLIP 81-21C and ILC 3465 X ILC 3861, between tolerant x tolerant lines of diverse origins were made. The F_1 generation was advanced in the off season. The F_2s were grown in the cold nursery and the cold tolerant plants from each of the four crosses were bulk harvested. Subsequently, the material was advanced and 73 cold-tolerant plants were selected in F_6 generations. These tolerant lines were grown along with two tolerant and two susceptible checks in randomized block design with two replications at Tel Hadya and Breda during 1992/93. The plot size was 2 m x 2 rows spaced at 45 cm apart. The observations were recorded on cold tolerance, biomass and seed yield, 100-seed weight, plant height and pod characters. The level of cold tolerance did not improve indicating that the genes for cold tolerance in the original tolerant parents may have been the same. However, there was significant improvement in seed yield (Table 2.1.12). Since better success has been achieved in improving the level of cold tolerance by introgressing genes from wild species, the germplasm enhancement for cold tolerance within cultivated species has been stopped. **K.B. Singh and R.S. Malhotra.**

Table 2.1.12. Performance of selected F_7 cold-tolerant lines for yield and other traits.

S.No.	Entry	Name	CTR	DFLR	DMAT	BYLD	GYLD	100 S.W.	GRHA	PTHT	CAWH	FPOD
1	57	5276-1	3	197	248	1545	537	17	3	61	80	603
2	64	5329-1	3	195	246	1180	468	23	3	56	78	322
3	61	5287-1	3	196	248	1225	433	17	3	58	80	413
6	10	5058-3	3	192	246	1015	387	19	3	54	73	426
10	4	5038-2	3	191	246	1025	371	29	3	55	78	487
12	36	5475-1	3	195	249	860	357	17	3	49	68	573
13	20	5480-1	3	196	251	1125	356	30	3	57	75	394
14	34	5474-1	3	195	247	900	356	16	3	46	65	375
16	3	5038-1	3	189	246	1055	343	18	3	54	78	304
18	22	5464-1	3	191	245	860	337	19	3	52	68	398
28	41	ILC 8262	3	200	249	1100	285	26	3	63	83	316
34	68	ILC 482 C.T	3	210	253	1325	275	27	3	62	78	223
76	1	ILC 533	9	0	0	55	0	12	3	0	0	0
77	56	ILC 1929	9	0	0	95	0	33	3	0	0	0
Mean			3.73	190.11	241.12	728.18	248.77	23.05	2.75	52.81	69.68	315.63
S.E.			0.21	1.21	1.07	147.17	57.65	2.36	0.21	2.58	4.56	82.92
LSD at 5%			0.60	3.42	3.01	414.32	162.31	6.65	0.59	7.25	12.84	233.44
C.V.(%)			8.13	0.90	0.63	28.58	32.77	14.50	10.84	6.90	9.25	37.15

CTR = Cold tolerance rating on 1-9 scale; DFLR = days to flower; DMAT = days to mature; BYLD = biological yield (g/plot); GYLD = grain yield (g/plot); 100 S.W = 100 seed weight (g); GRHA = growth habit (tolerant; 5 = prostrate; PTHT = plant height (cm); CAWH = canopy width (cm); FPOD = filled pods/plot.

2.1.3.4. Combined resistance to cold and Ascochyta blight

A project to combine resistance to cold and Ascochyta blight was started in 1986. The material from this project sown in cold and ascochyta blight nursery in the 1992-93 season is shown in Table 2.1.13. The winter was severe and it destroyed much of material. Of the remaining, many progenies/plants succumbed to ascochyta blight. As a result, none of the progenies was uniformly resistant to both stresses. Only a few plants in some progenies were resistant. A total of 90 plants out of about 7300 plants were selected from F_3 to F_7 progenies. These will be re-evaluated next season. **K.B. Singh, R.S. Malhotra and M.T. Mmbaga.**

Table 2.1.13. Chickpea material evaluated for combined resistance to cold and Ascochyta blight at Tel Hadya, 1992/93.

Generation	Sown	Selected
F_7	8 progenies	16 plants
F_6	5 progenies	10 plants
F_5	18 progenies	25 plants
F_4	1 progenies	6 plants
F_3	5 bulks	33 plants

2.1.4. Improved Germplasm for Wheat-based System

A bulk-pedigree method for breeding cold and Ascochyta blight-resistant chickpeas and another for breeding cold, Ascochyta blight- and drought-tolerant chickpeas, have been used at ICARDA. The first method was described in the 1988 Food Legume Program annual report the second in the 1990 report. Both methods make use of the off-season nursery and cultivars are developed in a period of four years. Following these methods a number of lines have been bred and shared with NARSs.

2.1.4.1. Segregating generations

During the 1992/93 season, 291 crosses were made, F_1s of which (194) were grown in the off-season during 1993. F_2 and F_4 bulks of earlier crosses were grown in the main season and F_3 bulks in the off-season (Table 2.1.14). About 16,600 progeny rows were grown between winter and spring seasons. A total of 458 promising and uniform F_5 and F_6 progenies were bulked. These bulked lines were grown in the off-season and purified seeds have been harvested for multi-location evaluation. Due to an infestation by wilt/root-rot complex, late maturity, and poor growth habit, 139 lines were rejected, leaving only 319 for evaluation in the yield trials next season. The 1992/93 season had a severe winter, hence effective selection for cold tolerance was made. Ascochyta blight developed in epiphytotic form and effective selection was made against this stress as well. **K.B. Singh**.

2.1.4.2. Yield performance of newly bred lines

Three hundred newly-bred lines were evaluated in 14 preliminary yield trials (PYTs) at three locations (Tel Hadya, Jinderess and Terbol) and in two seasons (winter and spring). Several lines were superior in yield over the check, although only a few significantly (Table 2.1.15). The 1992/93 was a relatively dry season, but the rainfall distribution was good. Therefore, the yield in both winter and spring was higher than the previous years. Over the three locations, winter chickpea produced 2155 kg ha^{-1}, giving an increase of 68.9% over spring.

Table 2.1.14. Chickpea breeding material grown at Tel Hadya during winter and spring and at Terbol during off-season, 1992/93.

Generation	No. of bulk/ progeny grown	No. of plants selected	No. of bulked progenies
F_0	291	-	-
F_1	194	-	-
F_2 Bulk	230	146	-
F_3 Bulk	219	1236	-
F_4 Bulk	159	11786	-
F_4 Progeny	684	666	-
F_5 Bulk	2	175	-
F_5 Progeny (Large)	684	-	49
F_5 Progeny (Early)	2109	-	96
F_5 Progeny (Tall)	-	-	95
F_5 Progeny (Others)	12218	-	172
F_6 Bulk Tall	3	-	-
F_6 Progeny (Tall)	-	-	10
F_6 Progeny (Early)	-	-	12
F_6 Progeny (Desi)	12	-	-
F_6 Progeny (Others)	751	230	24
F_7 Progeny	8	16	-
F_7 Progeny (Desi)	101	-	-
Total:			
$F_2/F_3/F_{45}$ Bulks	613	14,255	-
$F_3/F_4/F_5/F_6/F_7$ Progeny		16,567	458

Table 2.1.15. Performance of newly developed lines during winter and spring at Tel Hadya, Jinderess and Terbol, 1992/93.

Location and season	No. of trials	No. of entries			Yield (kg/ha)		Range	
		tested	exceeding check	significantly exceeding check	mean of location	mean of highest yield	C.V. (%)	LSD ($P \leq 0.05$)
<u>Tel Hadya</u>								
Winter	14	324	50	1	2006	2753	9-24	377-953
Spring	13	312	25	2	913	1290	8-16	181-278
<u>Jinderess</u>								
Winter	13	300	62	1	2005	2949	15-36	100-1584
Spring	12	288	4	0	1448	1919	9-17	255-511
<u>Terbol</u>								
Winter	13	300	52	3	2451	2979	7-13	316-655
Spring	12	288	56	2	1468	1954	9-26	290-789
<u>Overall</u>								
Winter	-	-	-	-	2155	-	-	-
Spring	-	-	-	-	1276	-	-	-

Chickpea line FLIP 88-85C had an impressive yield performance in Syria during the 1991/92 ranking first at six out of nine locations as well as in overall performance. It outyielded the best check (Ghab 3) at all the nine locations, and at four locations at significant level, producing 28.8% more seed yield. Its performance in 1992/93 was therefore again examined. The line outyielded Ghab 3 at five out of eight locations, giving 11.9% higher seed yield during 1992/93. The mean yield of this line was 2962 kg ha^{-1} with a range of 2088 to 4204 kg ha^{-1} (Table 2.1.16). These nine locations are spread all over Syria and had divergent agroclimatic conditions. With a 100-seed weight of 35 g, it excelled the check by 20% in seed size. It is highly resistant to both Ascochyta blight and cold. It has been developed from a cross ILC 629 x FLIP 82-144C.

A comparison of spring versus winter sowing has been made over ten years (1983/84 to 1992/93) at three sites (Tel Hadya, Jinderess and Terbol), using common breeding lines (number ranging between 72 and 486 lines). The winters of 1984/85, 1988/89, 1989/90, 1991/92 were more cold than normal and the springs of 1983/84, 1988/89, 1989/90, 1990/91, and 1992/93 (especially at Tel Hadya) were drier than normal.

The seed yield data (Figure 2.1.3) showed that winter-sown trials on average produced 1678 kg/ha against 1032 kg of spring-sown trials, giving 62.2% more yield. The yield differences between winter and spring were larger during dry seasons than in normal seasons. During an abnormally cold year (1984/85), yields of winter-sown trials were lower than spring-sown trials. But this trend was reversed during the later cold years (1988/89, 1989/90 and 1991/92) because of introduction of cold tolerance in selections since 1984/85. The 10% top yielders in winter sowing produced 122.5% or 1264 kg/ha more than the mean yield produced in spring over eight years. Many lines produced more than 4 t/ha seed yield during winter especially in the favourable environment of Terbol.

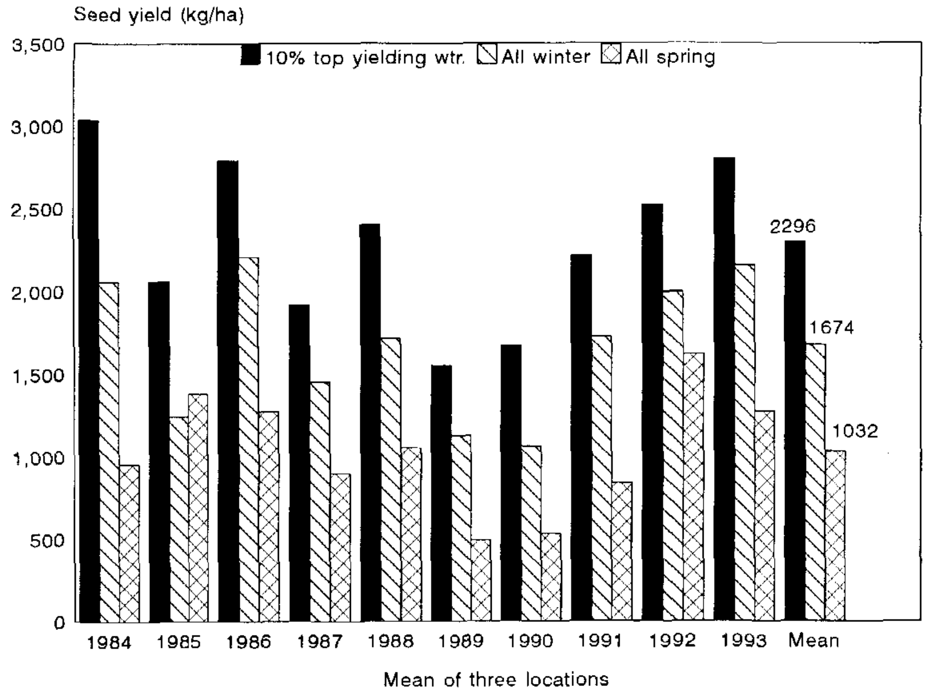


Figure 2.1.3. Mean seed yield (kg ha^{-1}) of chickpea grown in winter and spring at three locations and ten years.

Table 2.1.16. Seed yield (kg/ha, Y) and rank (R) of chickpea line FLIP 88-85C at nine locations in Syria during 1991-92 and 1992-93.

Entry	Tel Hadya		Jinderess		Izraa		Jellin		Homs		Hama		Ghab		Idleb		Heimo		Mean	
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
1991/92																				
FLIP 88-85C	2088	3	2633	3	3306	2	2674	1	3921	1	3825	1	4204	1	3241	1	2122	1	3113	1
Ghab 3	1580	18	1456	24	2204	23	2061	18	3509	5	2894	17	3538	15	2612	7	1889	2	2416	19
1992/93																				
FLIP 88-85C	3372	1	2978	1	2639	1	2495	20	-		3688	4	3021	12	2678	8	1636	4	2813	1
Ghab 3	2294	13	2057	18	2068	11	2671	15	-		3302	7	3184	7	3024	3	1509	9	2513	8
Mean of 24 entries	2009		2152		2400		2450		-		3425		3311		2576		1502			
CV %	13.5		23.4		22.7		14.7				9.3		16.6		21.9		17.5			
SE	341.6		291.2		323.8		209.1		-		162.8		309.9		310.5		151.2			
LSD at 5%	291.6		828.8		521.2		436.3		-		286.6		638.9		609.4		313.6			

Figure 2.1.4 shows the highest yield obtained at the ICARDA and NARS sites for ten years (1980 to 1990). Whereas the highest yields at ICARDA sites ranged between 3 and 5 tonnes per hectare, the highest yields at NARS sites ranged between 5 and 8 tonnes per hectare. Although these are small plot yields and may not be realized on large fields, they are indicative that very high yields could be expected under better management and favorable environments during winter sowing. **K.B. Singh.**

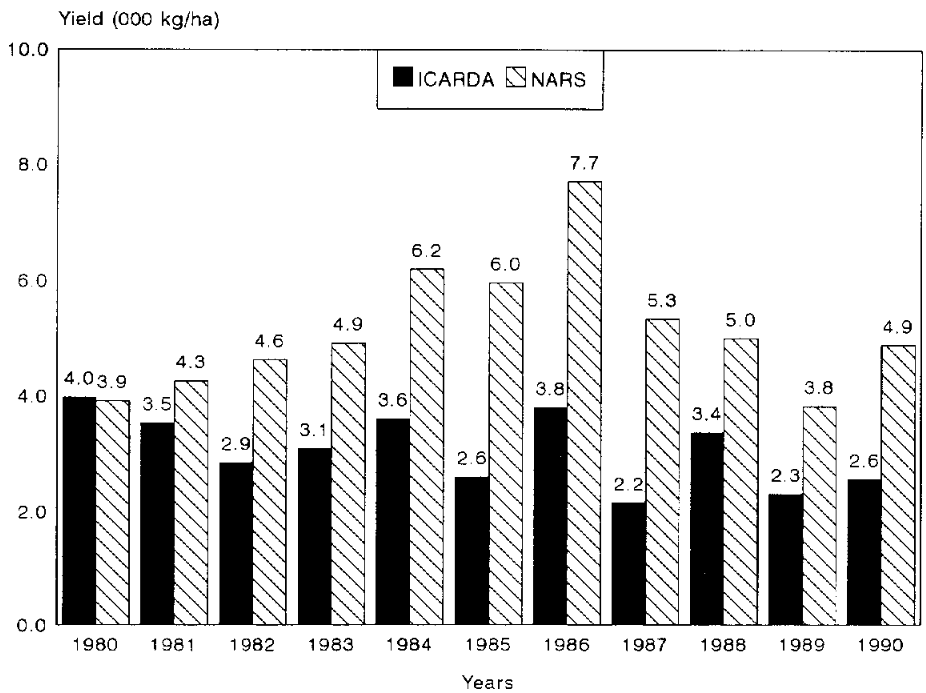


Figure 2.1.4. The highest yield recorded by any line at ICARDA and NARS sites, indicating the yield potential of winter-sown chickpea.

2.1.4.3. Adoption of winter chickpea in the Mediterranean environment

Adoption of winter chickpea by farmers began in Cyprus during the 1984/85 season and by 1990/91 nearly all spring chickpea area was replaced by winter chickpea. Syrian farmers were next to adopt winter chickpea and by 1992/93 an estimated 22,000 ha was sown during winter. All eastern Mediterranean countries including those in West Asia, North Africa and southern Europe have introduced winter sowing. The technology has been accepted, but the major bottleneck in speedy spread of winter chickpea is the non-availability of seed. Occasional set back with a winter-sown chickpea crop can occur under unfavourable weather conditions as were experienced in the north-eastern Syria this season. Development of cultivars with durable resistance to Ascochyta blight is a pre-requisite for introduction of winter chickpea in such areas. **K.B. Singh.**

2.1.5. Strategic Research

2.1.5.1. Mutation breeding for drought tolerance

Five hundred seeds of three diverse genotypes, namely FLIP 84-92C, ILC 5901 and S 90148, were treated with 40, 50 and 60 kr of gamma rays during 1991/92 for inducing mutation, and grown in the field. The germination of these was as shown in Table 2.1.17.

Table 2.1.17. Effect of gamma ray irradiation at different rates on the germination of seeds of three cultivars of chickpea.

Genotype	Dose	Seeds	
		Sown	Germinated
FLIP 84-92C			
	40 kr	500	499
	50 kr	500	478
	60 kr	500	435
ILC 5901			
	40 kr	500	462
	50 kr	500	218
	60 kr	500	68
S 90148			
	40 kr	500	498
	50 kr	500	452
	60 kr	500	169

Plants were harvested individually in early July 1992. Forty seeds from each M_1 plants were grown in drought nursery on 20th March 1993. The material was evaluated on row basis on a 1-9 scale and results are presented in Table 2.1.18. Three progenies were rated 3 and 5 progenies rated 4 as compared to a susceptible rating for the parentals. Another 290 progenies were rated 5 and the remaining 2891 were susceptible. Of the three genotypes, FLIP 84-92C gave more drought-tolerant plants and ILC 5901 produced none. The research will continue to select drought-tolerant mutants. **K.B. Singh.**

2.1.5.2. Development of screening technique for drought tolerance

Efforts continued to develop a reliable, easy screening technique to facilitate evaluation of a large number of germplasm and breeding lines. Thirty previously selected drought-tolerant lines were grown with one drought-tolerant (FLIP 87-59C) and one drought-susceptible (ILC 72) line during the 1993 spring at Tel Hadya & during the 1992/93 winter at Breda.

Table 2.1.18. Evaluation of M_2 generation of three chickpea genotypes for drought tolerance at Tel Hadya during spring 1993.

Genotype	Dose	Number of progenies showing a drought reaction rating of				Total
		3	4	5	6-9	
FLIP 84-92C						
	40 kr	2	2	53	442	499
	50 kr	1	2	50	425	478
	60 kr	0	0	104	331	435
ILC 5901						
	40 kr	0	0	15	447	462
	50 kr	0	0	15	203	218
	60 kr	0	0	3	65	68
S 90148						
	40 kr	0	1	34	463	498
	50 kr	0	0	15	437	452
	60 kr	0	0	1	168	169
Total		3	5	290	2981	3279

Scale: 1 = free from damage; 9 = all plants killed.

At Tel Hadya, two separate trials - one rainfed and other with three supplemental irrigations - were conducted. The plot size was 4 m x 4 rows spaced at 35 cm apart. Randomized block design with three replications was followed for each experiment. The sowing was done on 4 December 1992 at Breda and on 20 March 1993 at Tel Hadya. Entries were rated for drought tolerance visually on 1-9 scale in the rainfed trials. Data on days to flower and seed yield were collected from all trials. The 1992/93 season turned out to be dry as only 286 mm of rainfall at Breda and 283 mm at Tel Hadya were received. Results are presented in Table 2.1.19.

Table 2.1.19. Performance of previously-identified drought-tolerant genotypes under Tel Hadya and Breda conditions, 1993.

Entry	Tel Hadya, spring sown				Breda, winter sown		
	Rainfed			Irrigated	Rainfed		
	Visual score[1]	DFLR	Yield (kg/ha)	Yield (kg/ha)	Visual score	DFLR	Yield (kg/ha)
ILC 142	5	44	1066	3343	5	128	1282
ILC 452	6	50	563	3151	5	137	1237
ILC 477	6	52	532	3425	5	136	1104
ILC 505	6	49	893	3739	7	136	702
ILC 1252	6	51	581	3706	6	136	1041
ILC 2293	5	51	758	3827	6	135	1092
ILC 2739	6	46	679	3239	6	134	839
ILC 2799	6	47	721	3039	6	134	924
ILC 3193	5	48	959	3421	6	135	745
ILC 3512	6	50	537	3230	6	135	1155
ILC 3550	4	45	1079	3528	4	130	1353
ILC 3764	5	51	785	3854	5	134	1157
ILC 3843	4	46	1166	3468	5	129	1269
ILC 4162	6	47	874	3527	6	133	1073
ILC 4236	5	48	881	3434	5	134	1182
ILC 4339	5	42	1189	3743	5	125	1190
ILC 4400	6	57	466	3041	6	136	1196
ILC 4446	6	50	721	3592	5	135	1135
ILC 4463	6	52	801	4051	5	136	1280
ILC 5176	5	47	661	2825	7	138	835
ILC 5371	5	44	1060	3302	7	129	943
ILC 5836	6	50	632	3239	6	134	961
ILC 6023	6	47	841	3199	4	129	1263
ILC 6119	5	39	1098	2849	4	122	1406
ICC 4958	4	46	1174	3106	6	135	978
FLIP 87-51C	6	49	805	4060	5	136	1202
FLIP 87-58C	4	41	1076	3603	5	127	1090
FLIP 87-85C	4	46	1026	3674	6	130	1086
FLIP 88-42C	4	44	1099	2994	6	131	1155
ILC 1929	6	48	798	3828	6	135	1073
ILC 72	9	67	54	2641	6	139	920
FLIP 87-59C	4	42	1243	3733	4	128	1367
Mean			838	3419			1101
C.V. (%)			11.15				9.95
S.E.			113.00				77.49
LSD			486.38				182.49

1 Scale: 1 = free from drought stress; 9 = all plants killed.

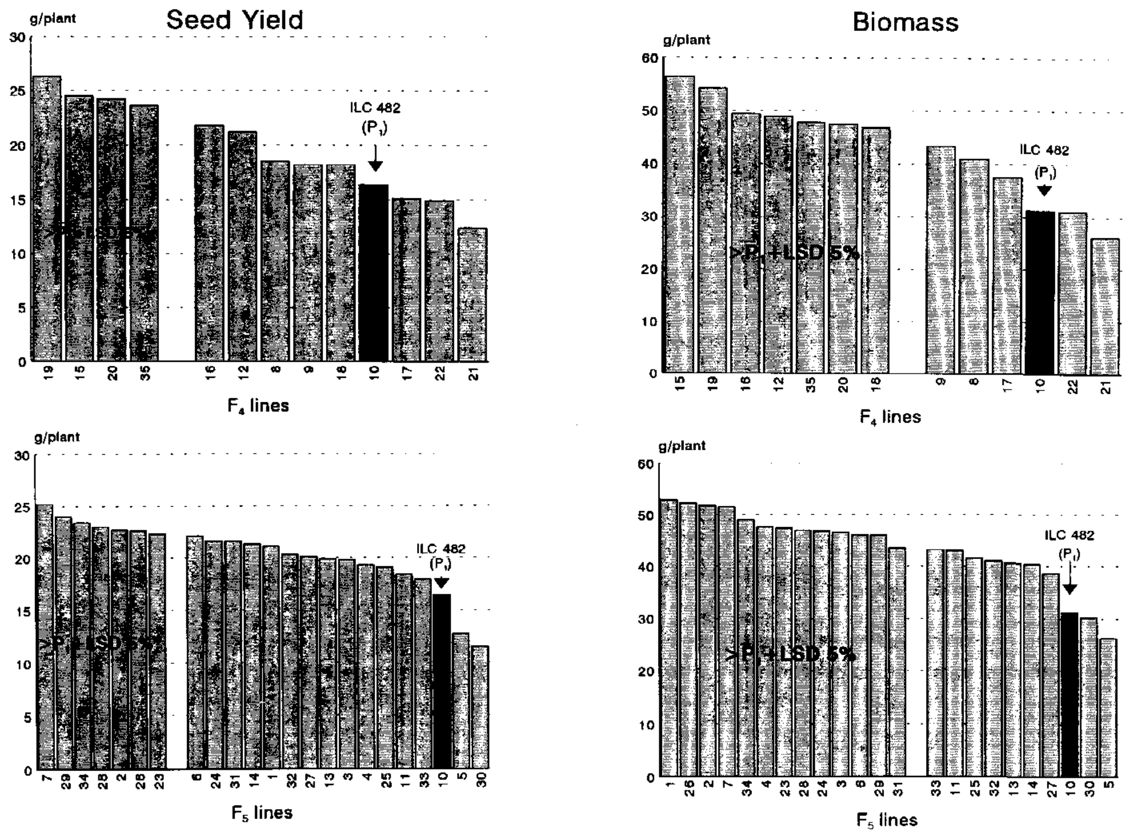


Figure 2.1.5a. Performance of elite F_4 and F_5 lines from the interspecific crosses for seed yield and biomass at Tel Hadya, Syria, 1992/93.

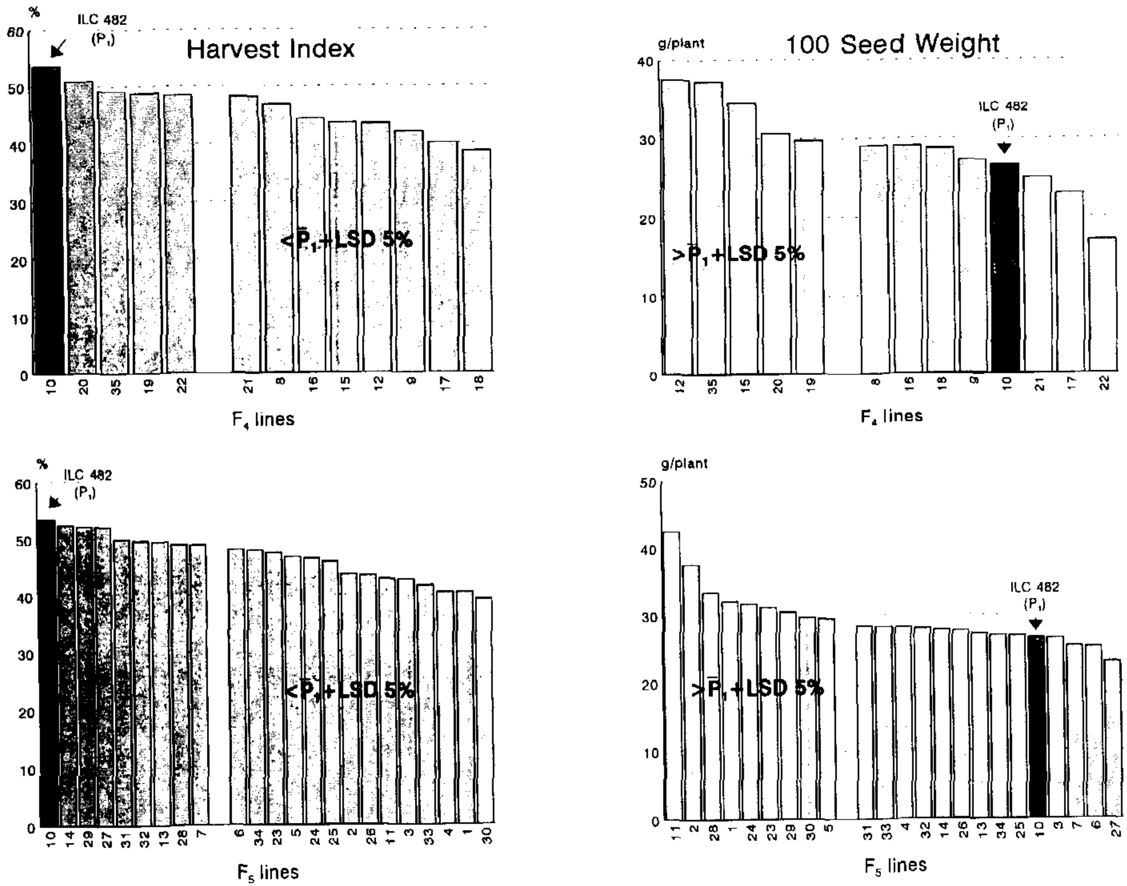


Figure 2.1.5b. Performance of elite F_4 and F_5 lines from the interspecific crosses for harvest index and 100-seed weight at Tel Hadya, Syria, 1992/93.

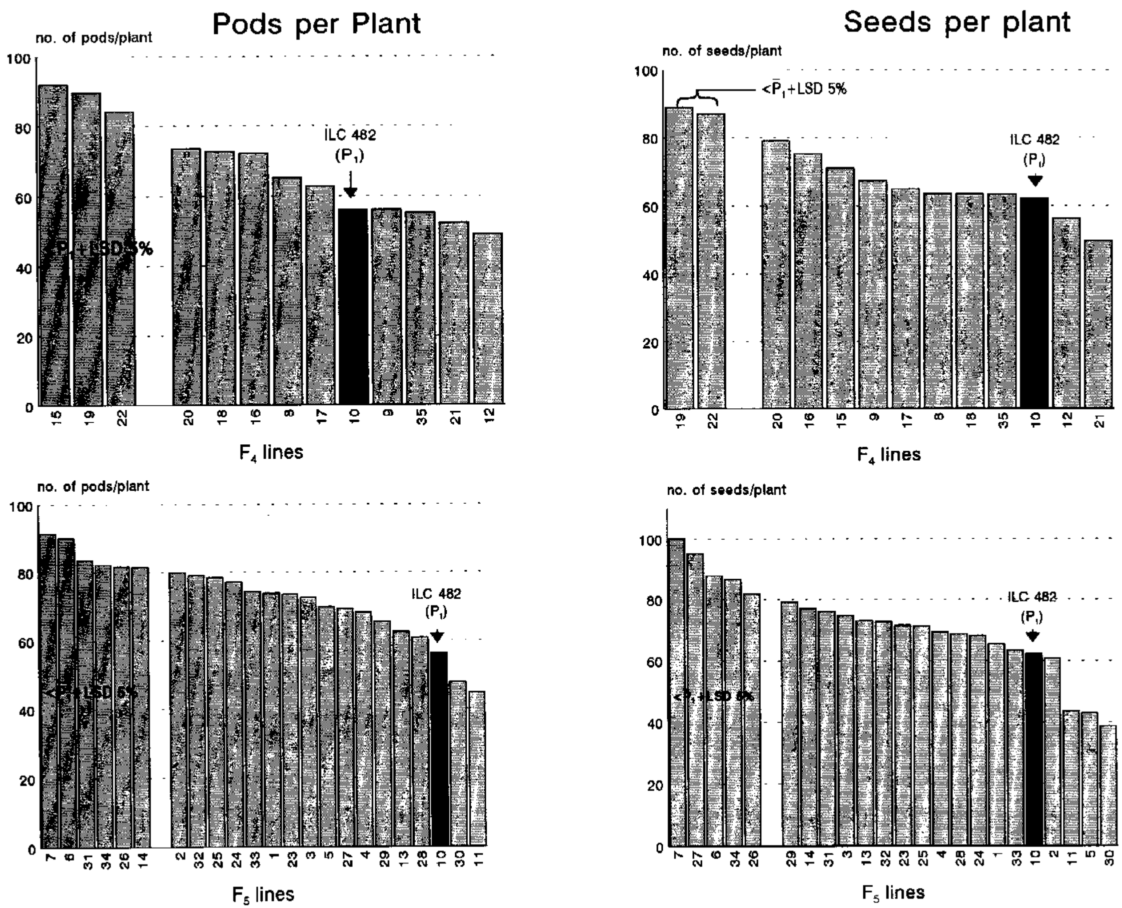


Figure 2.1.5c. Performance of elite F_4 and F_5 lines from the interspecific crosses for plant height and seeds per pod at Tel Hadya, Syria, 1992/93.

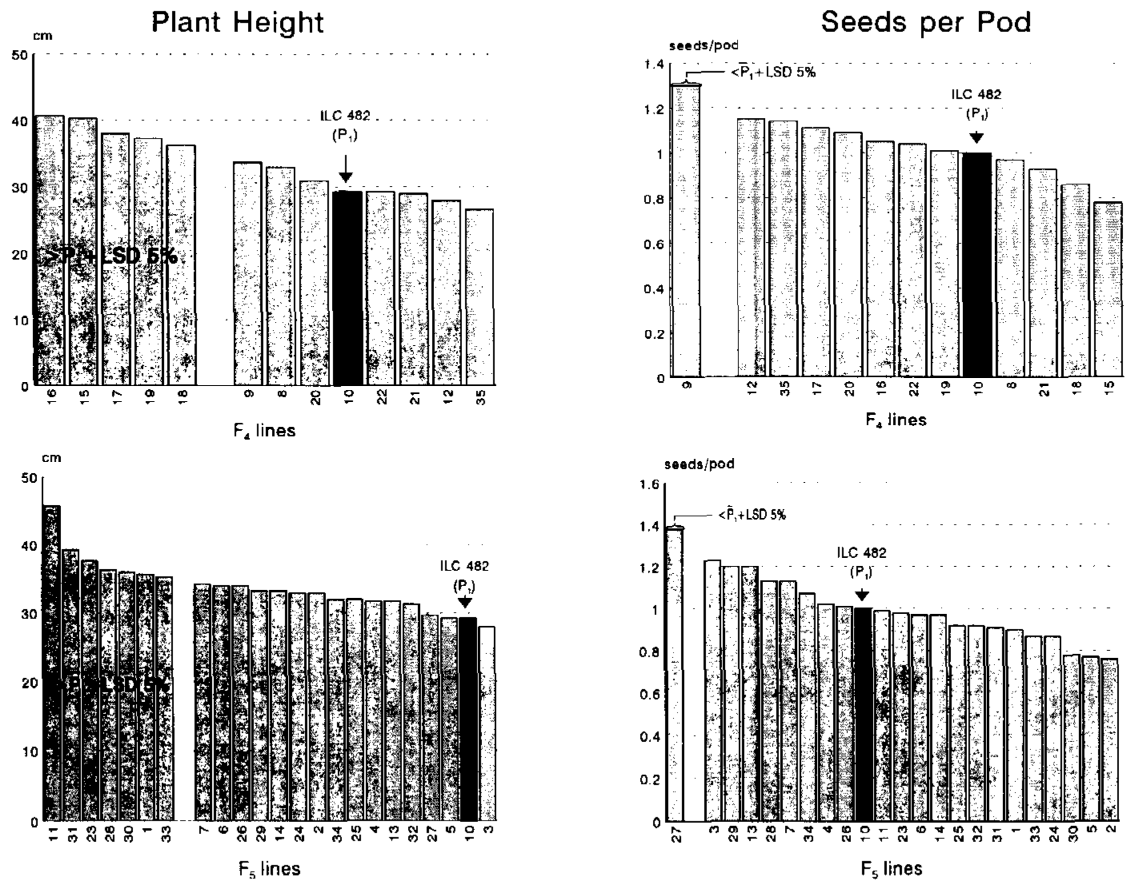


Figure 2.1.5d. Performance of elite F_4 and F_5 lines from the interspecific crosses for pods per plant and seeds per plant at Tel Hadya, Syria, 1992/93.

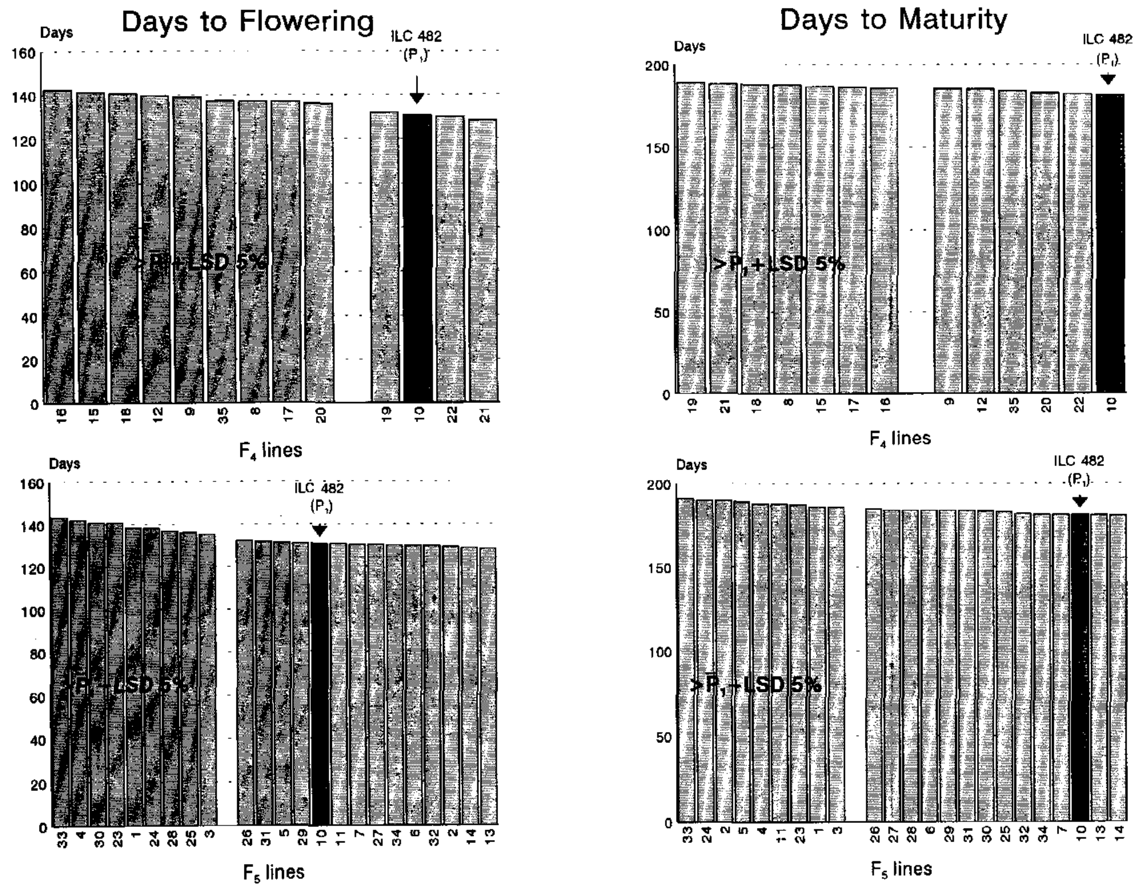


Figure 2.1.5e. Performance of elite F_4 and F_5 lines from the interspecific crosses for days to flowering and days to maturity at Tel Hadya, Syria, 1992/93.

Table 2.1.20. Reaction of plants in F_2, F_4, F_5 and M_4 generations to cyst nematode in the greenhouse at Tel Hadya, 1992/93.

Generation	Cross no.	Parents	Number of progenies in different ratings[1]						
			0	1	2	3	4	5	Total
F_2	X 92TH231	ILWC 119 X ILC 482	1	2	88	381	225	140	837
	X 92TH232	ILWC 119 X FLIP 82-150C	0	4	2	181	336	229	752
	X 92TH233	ILWC 119 X FLIP 83-46C	0	0	0	22	66	116	204
	X 92TH234	ILWC 119 X FLIP 84-93C	0	0	1	152	224	267	644
	Total		1	6	91	936	851	752	2437
F_4	X 91TH214	ILC 846 X ILWC 119	9	34	71	9	-	-	123
	X 91TH215	ILC 863 X ILWC 119	3	30	56	47	2	-	138
	X 91TH318	FLIP 84-92C X ILWC 119	10	45	75	26	-	-	156
	Total		22	109	202	82	2	-	417
F_5	X 90TH571	ILC 482 X ILWC 119	26	167	409	328	110	59	1099
	X 90TH572	FLIP 87-69C X ILWC 119	13	153	542	312	56	12	1088
	Total		39	320	951	640	166	71	2187
M_4	Mutation of ILC 863		1	9	2	120	151	142	425

1/ Scale 0 = no cyst formation on roots, 5 = $\geq$ 50 cysts/plant.

2.1.6.3. Cold tolerance

The level of cold tolerance is higher in wild species than cultivated species. To transfer genes from the wild species to the cultivated species, ten crosses were made between ten cultigens and one accession of *Cicer reticulatum* with a rating of 2 during 1987/88. The F_1s were grown in off-season during 1988. The F_2s were grown in the cold nursery during 1988/89. Each year, we made five interspecific crosses and advanced them. During the 1991/92, F_2, F_3 and F_4 bulks were grown in the cold nursery at Tel Hadya. Ninety-four cold-tolerant plants were selected and harvested individually. These 94 F_3, F_4 and F_5 lines were grown along with their six parents including four cultigens and two *Cicer arietinum* accessions in a randomized block design with two replications at Tel Hadya and Breda during the 1992/93 season. The plot size was 2 m long x 2 rows spaced at 45 cm apart. The crop was sown in early October and irrigated three times for good germinations and early growth so that proper evaluation for cold tolerance could be done. The observations were recorded for cold tolerance (CTR) on 1-9 scale (1 = free from any cold damage and 9 = all plants killed), days to flowering (DFLR) and maturity (DMAT), biomass (BYLD) and seed (GYLD) yield, 100-seed weight (100 S.W.), growth habit (GRHA), plant height (PTHT), the number of filled (FPOD) and empty (EPOD) pods.

The results are presented (Table 2.1.21) for the four most cold-tolerant lines, nine highest yielding progenies and six checks. The cold tolerance rating of four progenies from the interspecific hybridization was 2 and for the remaining nine progenies was 3. The nine highest yielding progenies produced 50 to 100% higher seed yield than the best cultivated check ILC 8262. The two wild species yielded poorly. Seed size and growth habit also improved. Pod dehiscence in the progenies was almost absent. The typical desi and kabuli seed types were recovered. It seems that the genes for cold tolerance from *Cicer reticulatum* have been transferred to the cultivated species. Along with cold tolerance it appears that "yield genes" from the wild species have also been incorporated in the cultigen as is evident from the high yields. The selection pressure has been towards plants closer to either desi or kabuli type starting in F_2 generation. This selection pressure assisted has in elimination of undesirable genes from wild species. **K.B. Singh and R.S. Malhotra.**

2.1.7. Protein Quality

It is our endeavour to develop cultivars having the same or higher protein content than the check cultivar. To meet this objective we analyze all the newly developed lines for protein content. During 1992/93, we had tested 286 newly developed lines at multilocations (Tel Hadya, Jinderess and Terbol) and two seasons (winter and spring). Since earlier studies had

Table 2.1.21. Performance of the elite $F_3/F_4/F_5$ lines at Tel Hadya and Breda during 1992/93.

S.No.	Entry	Name	CTR	DFLR	DMAT	BYLD	GYLD	100 S.W	GRHA	PTHT	FPOD	EPOD
1	85	5936-1	3	204	256	1150	441	26	3	58	236	14
2	37	5848-1	3	179	248	1020	396	27	3	44	285	70
3	17	5814-1	3	202	249	1230	381	24	3	63	181	45
4	94	5968-1	3	184	245	905	364	27	3	49	483	72
5	34	5835-2	3	199	248	1150	360	28	3	62	235	49
6	90	5937-2	3	205	257	1410	356	23	3	56	275	37
8	27	5819-1	3	201	249	1100	336	26	3	62	492	75
9	71	5922-1	3	197	250	1050	336	23	3	58	308	67
10	83	5934-1	3	199	247	1075	336	23	3	58	345	54
33	26	5818-2	2	178	243	705	259	21	3	42	285	28
40	28	5820-1	2	180	249	945	228	22	3	39	250	18
76	2	5803-1	2	187	243	460	102	19	3	28	122	5
82	25	5818-1	2	178	241	400	87	17	4	32	480	79
46	40	ILC 8262	3	200	252	850	210	25	3	60	179	19
81	21	FLIP 87-69C	5	186	246	300	87	35	3	47	66	16
85	1	ILC 482	7	191	245	200	70	29	3	37	189	9
98	70	ILWC 3611	3	185	236	95	3	13	5	15	4	3
99	88	ILWC 239	3	202	236	65	3	10	5	11	1	3
100	56	ILC 1929	9	0	0	120	0	33	3	0	0	0
Mean			3.1	191.3	245.1	693.9	193.4	23.4	3.0	46.8	247.6	32.0
S.E.			0.2	1.2	1.6	157.3	48.3	1.5	0.1	4.3	78.9	17.0
LSD at 5%			0.6	3.5	4.5	440.9	135.6	4.2	0.3	12.2	221.1	47.8
C.V. (%)			9.6	0.9	0.9	32.0	35.3	9.1	6.1	13.1	45.0	75.2

indicated no significant differences in protein content between seasons, we determined the protein content of these newly developed lines grown at Tel Hadya during winter only. The protein content was at par with the check cultivar. **K.B. Singh.**

2.2. Molecular Techniques and Tissue Culture in Chickpea Improvement

2.2.1. Genetic Variation within and between Varieties of Chickpea

Chickpea varieties released for cultivation in Syria viz. Ghab 1, Ghab 2 and Ghab 3 were fingerprinted with several probe/enzyme combinations to know the extent of inter- and intra varietal variation at the DNA level and to identify variety specific fingerprints. The most informative probe/enzyme combination was $(GATA)_4$/EcoRI (Figure 2.2.1). Among the three varieties only 3 bands were in common, indicating a very high degree of inter- varietal variation. Five Ghab 1- specific bands, 5 Ghab 2- specific bands and 4 Ghab 3- specific bands were observed. These bands can be used for variety identification.

Table 2.2.1. Estimation of genetic variation in three chickpea varieties.

Variety	Neis' similarity index			Average number
	Average	Range	SD	of alleles/locus
Ghab 1	0.79	0.55-0.96	0.0987	1.67
Ghab 2	0.79	0.61-0.94	0.0832	1.40
Ghab 3	0.83	0.59-0.97	0.1087	1.69

To estimate the intra- varietal variation Neis' similarity index and number of alleles per locus in a variety were calculated (Table 2.2.1). The range for the Neis' similarity index was 0.55-0.96 for Ghab 1, 0.61-0.94 for Ghab 2 and 0.59-0.97 for Ghab 3 indicating that all the varieties are genetically heterogenous. Standard deviation calculated for individual Neis' index and average number of alleles per locus were highest for Ghab 3, moderate for Ghab 1 and low for Ghab 2, indicating that Ghab 3 is most heterogenous and Ghab 2 the least. **F. Weigand, W. Choumane and S.M. Udupa.**

2.2.2. First DNA Marker for Resistance to Ascochyta Blight in Chickpea

To identify DNA markers which are linked to the gene(s) of resistance to Ascochyta blight, a cross was made between the resistant line ILC 3279 and the susceptible line ILC 1272. The resulting F_1 and F_2 populations were raised and scored for disease resistance against pathotype II (strong) on an individual plant basis.

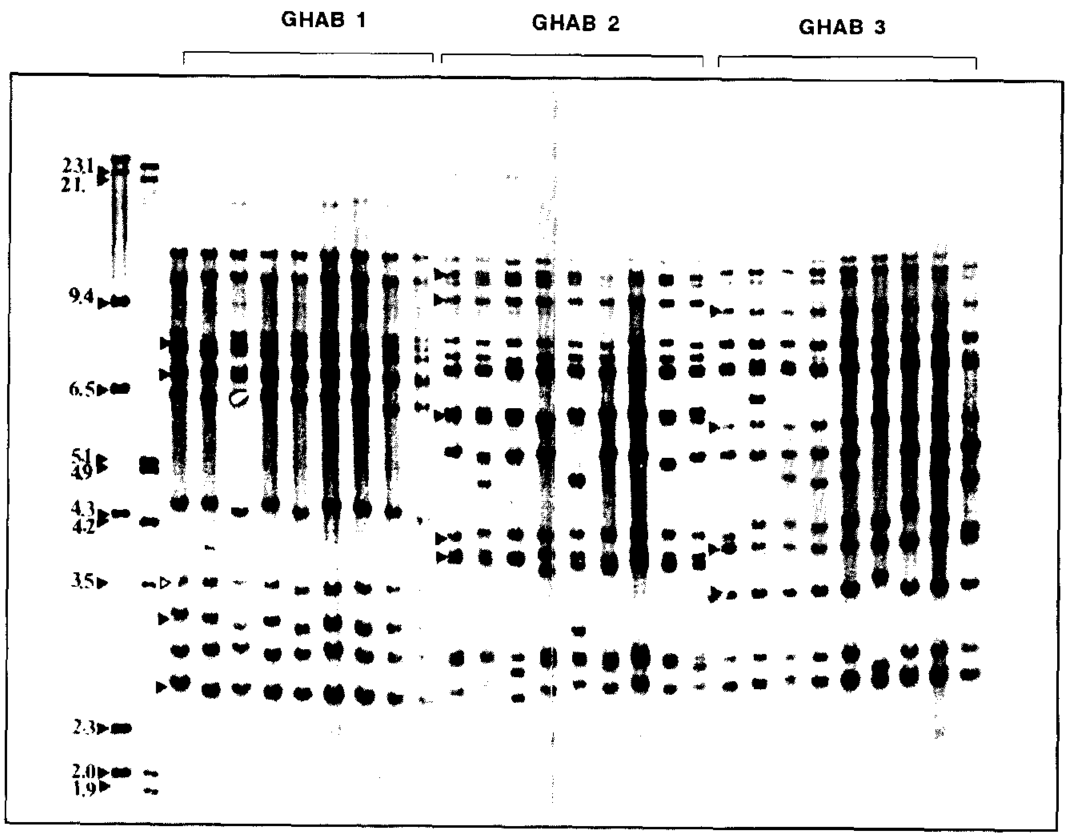


Figure 2.2.1. Genetic typing of Ghab 1, Ghab 2 and Ghab 3 chickpea varieties using the probe/enzyme combination $(GATA)_4$/EcoRI. Each variety is represented by 8 randomly selected individuals sampled from seed multiplication fields. Triangles mark variety-specific bands. Molecular weight markers are shown in kilobases.

The result indicate that resistance is controlled by a single recessive gene. The DNA was extracted from the individual F_2 plants and RFLP analysis was done using 15 oligonucleotide probes. The linkage analysis was performed between the phenotypic trait (resistance) and RFLPs. The probe/enzyme combination $(CAA)_5$/TaqI gave an RFLP which is linked to a resistance locus (linkage distance 13 centimorgans). This RFLP behaves like a dominant genetic marker (i.e. presence/absence type); the DNA fragment is present in ILC 1272 (susceptible) and absent in ILC 3279 (resistant). This DNA marker allows the selection of plants which are homozygous resistant against the pathotype II (strong) with 80% probability in F_2 populations derived from a cross between ILC 1272 and ILC 3279. **F. Weigand and S.M. Udupa (ICARDA); G. Kahl, P. Winter and T. Bünger (University Frankfurt).**

2.2.3. DNA Amplification Fingerprinting of six *Ascochyta rabiei* Isolates from Syria

Forty different primers (10 meres) supplied by Operon Tech., USA, were tested on six isolates of *Ascochyta rabiei*. The primers could detect varying levels of polymorphism (Figure 2.2.2).

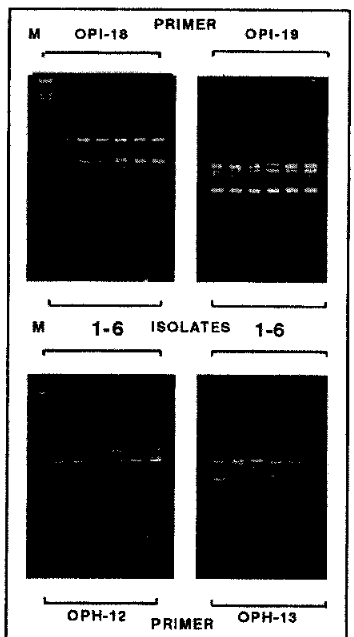


Figure 2.2.2. DNA amplification fingerprinting of *Ascochyta rabiei* isolates (1-6) using the primers OPI-18, OPI-19, OPH-12 and OPH-13. Lane M: molecular weight marker, lambda EcoRI/HindII digest.

The results of 12 polymorphic primers were analyzed to detect phylogenetic relationships (Wagner parsimony method) among the isolates using computer program Phylip, version 3.4. Based on the analysis, six isolates can be grouped into 3 groups (Figure 2.2.3): group 1 comprises isolate No. 1 only, group 2 comprises isolates No. 2, 3 and 5, and group 3 comprises isolates No. 4 and 6.

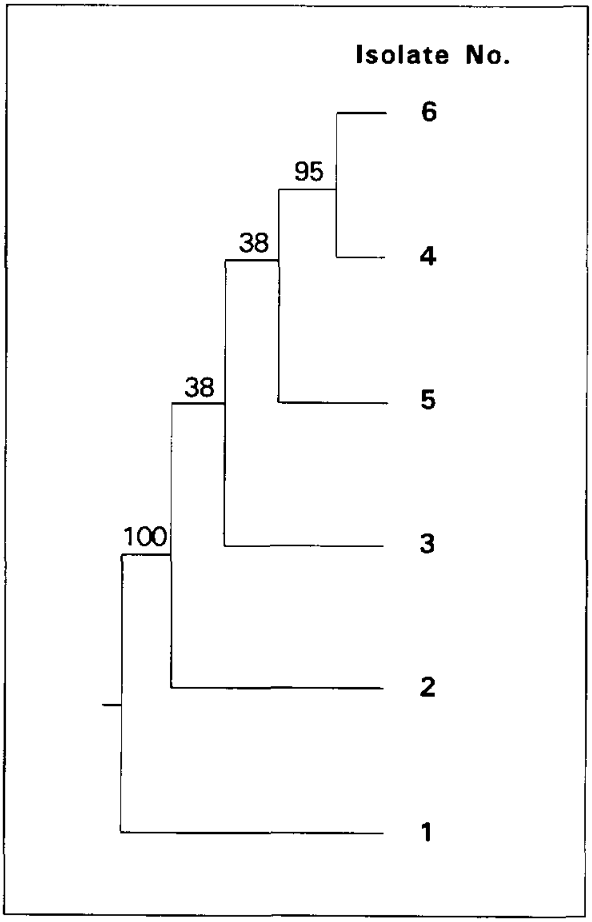


Figure 2.2.3. Phylogenetic relationships among six isolates of *Ascochyta rabiei* based on DNA amplification fingerprinting. The numbers at the forks indicate the number of times the group consisting of the isolates to the right of that fork occurred among the 100 bootstrap replicates.

This grouping based on PCR technique, viz. DNA amplification fingerprinting shows similarity with the groupings based on RFLP technique (DNA fingerprinting) and biological pathotyping (Annual Reports, 1989 and 1991). **F. Weigand and S.M. Udupa.**

2.2.4. Variability in Ascochyta rabiei

Twenty-six isolates of *Ascochyta rabiei* were collected in Syria during 1992 and 15 isolates during 1993. They were purified, single spored and added to the isolate collection, which now stands at 53. Here we are reporting about the genetic typing (DNA fingerprinting) of 53 isolates and biological typing (host- pathogen interaction) of 48 isolates.

For the genetic typing the $(GATA)_4$/TaqI probe/enzyme combination was used. This combination could distinguish between 17 genetic groups (Figure 2.2.4 and Table 2.2.2). Based on the DNA fingerprint pattern we conclude:

1) All isolates collected during 1991, 1992 and 1993 were different from the isolates collected during 1982.

2) Genetic variability exists within and across the chickpea growing regions of Syria.

3) Thirtythree out of the 53 isolates were not distinguishable from each other and represent the most prevalent and homogeneous genetic group occurring in all major chickpea growing regions of Syria.

The experimental setup for the biological typing was further refined during 1993. This improvement allowed us to assign all tested isolates (48) to one of 3 pathotypes. The 3 pathotypes differ in their level of aggressiveness and representative disease development curves are shown in Figure 2.2.5. The three pathotypes are described as super strong (SS), strong (S) and weak (W). As shown in Figure 2.2.4 and Table 2.2.2 the most prevalent and homogenous genetic group as characterized by the DNA fingerprinting (banding pattern H) is expressing the super strong level of aggressiveness and is killing the cultivar with the best level of resistance (ILC 3279) like the most susceptible cultivar (ILC 1929). This super strong pathotype was frequently sampled in the North-East of Syria. **F. Weigand and S.M. Udupa.**

Table 2.2.2. Variability in *Ascochyta rabiei* isolates of Syria with respect to pathotype and DNA-fingerprinting pattern.

Isolate No.	Year of collection	Place of collection	Pathotype[a]	DNA fingerprint pattern
1	1982	Syria/Lebanon	W	A
2	-do-	-do-	W	B
3	-do-	-do-	W	C
4	-do-	-do-	S	D
5	-do-	-do-	W	C
6	-do-	-do-	S	D
7	1991	Ghab	SS	E
8	-do-	Izraa	SS	F
9	-do-	-do-	S	G
10	-do-	Jinderess	SS	H
11	-do-	Tel Hadya	SS	H
12	-do-	-do-	W	I
13	1992	Kamishly	SS	H
14	-do-	-do-	W	J
15	-do-	-do-	W	J
16	-do-	-do-	SS	H
17	-do-	Jinderess	SS	H
18	-do-	-do-	SS	H
19	-do-	-do-	SS	H
20	-do-	Rouge	W	K
21	-do-	-do-	W	L
22	-do-	-do-	W	M
23	-do-	Malkieh	SS	H
24	-do-	-do-	SS	H
25	-do-	-do-	SS	H
26	-do-	-do-	SS	H
27	-do-	-do-	SS	H
28	-do-	-do-	SS	H
29	-do-	-do-	SS	H
30	-do-	-do-	SS	H
31	-do-	-do-	nt	H
32	-do-	-do-	nt	H
33	-do-	-do-	SS	H
34	-do-	-do-	SS	H
35	-do-	-do-	SS	H
36	-do-	-do-	SS	H
37	-do-	-do-	SS	H
38	-do-	Terbol, Leb.	W	N
39	1993	Malkieh	SS	H
40	-do-	-do-	nt	H
41	-do-	-do-	SS	H

Cont'd ...

Cont'd ...

42	-do-	-do-	SS	H
43	-do-	-do-	nt	H
44	-do-	-do-	SS	H
45	-do-	-do-	SS	H
46	-do-	-do-	S	O
47	-do-	-do-	S	O
48	-do-	Kamishly	SS	H
49	-do-	-do-	W	P
50	-do-	-do-	SS	H
51	-do-	-do-	W	Q
52	-do-	Rouge	SS	H
53	-do-	-do-	nt	H

[a] Pathotypes can be distinguished into 3 classes based on analysis of variance and t-test ($P<0.01$). Superstrong = SS, Strong = S and Weak = W. nt =not tested.

[b] DNA fingerprinting was done using $(GATA)_4$/Taq I combination. Capital letters indicates a particular DNA fingerprinting pattern (Figure 1).

2.2.5. Wide Crosses in *Cicer species*

The wild annual *Cicer* species have been screened for biotic and abiotic resistance genes. Some of these species carry: a) resistance genes which cannot be found in cultivated *Cicer*; b) multiple stress resistance; and c) higher resistance level compared to the cultivated species. Sexual hybrids have so far been reported only between *Cicer arietinum* and *C. reticulatum* and *C. arietinum* and *C. echinospermum*. In order to study barriers of the interspecific hybridization two cultivar lines (ILC-482 and FLIP 84-15C), and two lines each of *C. bijugum* (ILWC-32, -62), *C. judaicum* (ILWC-46,-95), and *C. pinnatifidum* (ILWC-236, -171) were chosen for the crosses.

For a first crossing experiment plants from the cultivar lines were crossed with all lines of the wild species. No crossed seeds were obtained. Nevertheless, the time from pollination to flower fall differed in some cross combinations. This may indicate genotypic differences in the lifetime of successfully formed embryos. Different culture media are being tested for their use with *Cicer* species. Immature embryos of *C. arietinum* are cultured to identify the media which allows regeneration for the youngest possible embryos. Media have been identified in other dicot species which allow the regeneration of embryos as young as two days old. **B. van Dorrestein, A. Comeau (Agriculture Canada, Quebec) M. Baum and K.B. Singh.**

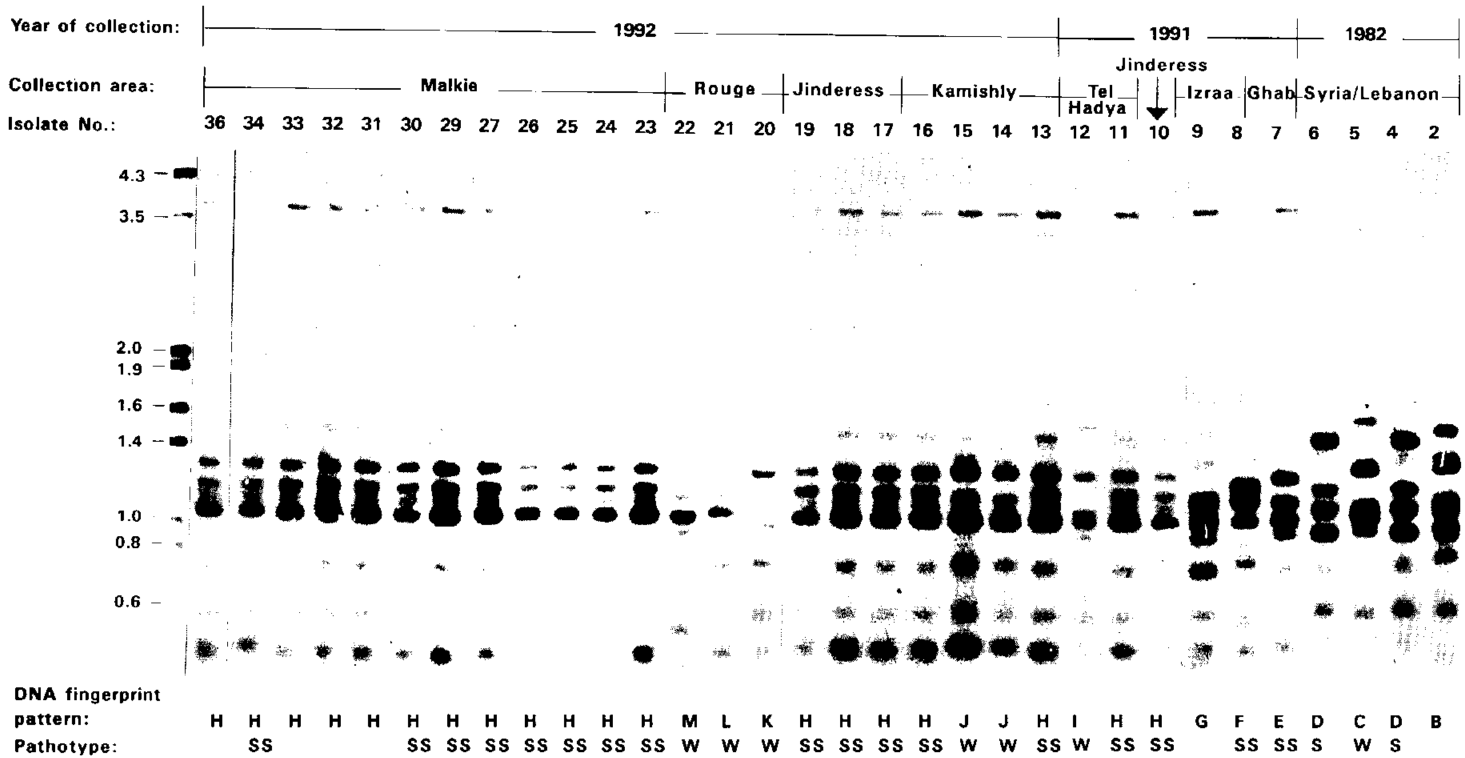


Figure 2.2.4. Genetic typing of *Ascochyta rabiei* isolates of Syria using $(GATA)_4$/TaqI probe/enzyme combination. Molecular weight markers are indicated in kilobases.

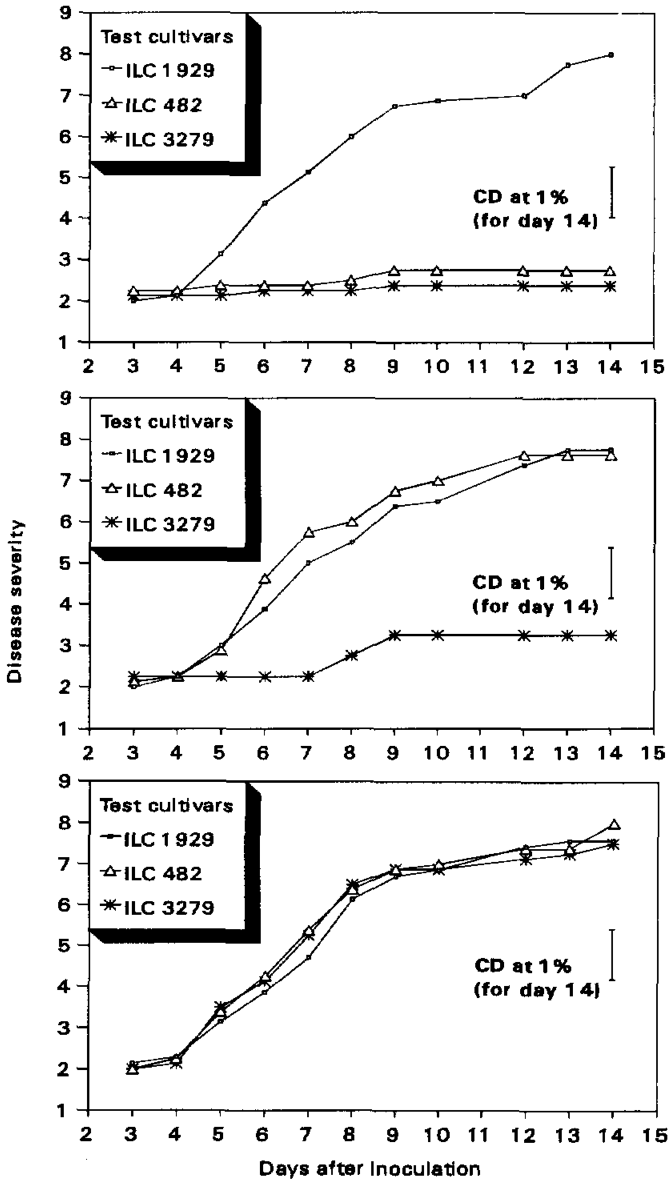


Figure 2.2.5. Typical disease development curves for the 3 *Ascochyta rabiei* pathotypes of Syria.

2.3. Chickpea Pathology

Diseases from a major biotic constraint to the productivity of chickpea and to a large extent, cause instability in chickpea yields. Ascochyta blight caused by *Ascochyta rabiei* is the most serious foliar disease of chickpea, particularly where low temperatures (15-25°C) prevail during the crop season. The occurrence of ascochyta blight in epiphytotic levels is not regular and is weather dependent. However, a good season for the chickpea crop is often favorable to ascochyta blight. Therefore, control of ascochyta blight is essential for increasing chickpea production and yield stability. The use of fungicides as foliar spray and in seed dressing can be of limited success in controlling ascochyta blight and yet high levels of host resistance are not available.

Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ciceri* is the most important soil borne disease. Other soil borne diseases such as dry root rot (*Rhizoctonia bataticola*), black root rot (*Fusarium solani*), wet root rot (*Rhizoctonia solani*), and collar rot (*Sclerotium rolfsii*) have also been reported in the region but economically, they are less important than fusarium wilt. In addition, stem blight caused by *Sclerotinia sclerotiorum* can also be found in areas with high rainfall and cool temperatures.

The objectives of chickpea pathology is to (1) work with chickpea breeder in the development of high-yielding, disease-resistant cultivars and evaluate breeding material for resistance to the major diseases of chickpea; (2) collect information on disease epidemiology and pathogenic variability and develop disease management strategies for ascochyta blight; (3) collect information and monitor disease incidence and severity in the WANA region in collaboration with the national scientists; and (4) develop research collaboration with national programs on diseases management of ascochyta blight and fusarium wilt.

2.3.1. Field Survey of Chickpea Diseases

Disease incidence and severity on chickpea was surveyed in Dara'a, Homs, Hama, Aleppo and Hassakeh provinces in Syria. The objective of this survey was to evaluate the disease situation in chickpea in Syria and to assess disease reaction of two ICARDA developed varieties (Ghab 1 and Ghab 3) and three promising lines (FLIP 84-15, FLIP 86-5 and FLIP 86-6) that were being planted in demonstration plots in farmers fields, on-farm trials and on-station trials.

Results are presented in Figure 2.3.1. Few chickpea farms showed disease symptoms in the Dara'a, Homs, Hama, Idleb and Aleppo provinces. Where disease was observed, fusarium wilt and dry root rot were dominant, but the incidence was usually 5-10% except in Al Ghab and Sqelbieh (Hama) where wilt/root rot and stem blight was 25-50%. Ascochyta blight was observed at only one location in the southern and central provinces.

Fusarium oxysporum, *Rhizoctonia bataticola*, *Sclerotinia sclerotiorum* and *F. solani* were isolated from plants showing wilt/root rot and stem blight symptoms (Table 2.3.1). An *Ascochyta* sp. *Phoma medigaginis* type of fungus was also occasionally associated with root and collar rot and its pathogenicity and taxonomic status is under investigation.

Ascochyta blight was devastating in all chickpea farms in the Hassakeh province, particularly at Malkieh where all the winter and spring planted chickpea sustained heavy loss in yield. This area had unusually high rainfall in April and May at a period when temperatures were cool thereby presenting environmental conditions that are highly favorable to ascochyta blight (Figure 2.3.2). The continuous rainfall and cool temperatures also created excess soil moisture and created water logging that may not be healthy for the plants in general. The root and collar regions sustained much rotting. Field diagnosis of the disease based on symptoms was for ascochyta blight, but isolation of the pathogen from the lesions on the stem showed the presence of four fungi: *Ascochyta rabiei*, *Ascochyta* sp./*Phoma medigaginis*, *Fusarium oxysporum* and *Rhizoctonia bataticola* (Table 2.3.2). The first three occurred in almost equal proportions, but *A. rabiei* was dominant and is believed to be the primary pathogen. However, possible role of the other pathogens in a synergistic interaction can not be ignored and requires further investigations. The taxonomic status of the *Ascochyta/Phoma medigaginis* fungus also needs to be clarified particularly because it closely resembles *A. rabiei* morphologically.

Ghab 2 was the only cultivar that showed some resistance to ascochyta blight at Hassakeh, although it was grown at only one location in a demonstration plot at an area (Hemo station) where the blight came in late and rainfall was not as high as at the hard hit Malkieh area. There is therefore need to intensify the development of several high yielding ascochyta blight resistant cultivars that provide alternatives when resistance in use breaks down. There is also a need to develop a strategy for combining high yield, stable ascochyta blight resistance and acceptable seed size to be used in an integrated disease management system. Identification of blight resistance for Hassakeh will start in 1993/94. Lines that have high resistance to Ascochyta blight have been identified and will be tested in the field at Hassakeh and in the greenhouse at Tel Hadya using field isolates from Hassakeh. Single-spore isolates derived from samples from Hassakeh will be used to determine the pathogenic races(s) of *A. rabiei*. **M.T. Mmbaga, NARS scientists from Syria.**

2.3.2. Ascochyta Blight

A large component of disease management of ascochyta blight depends on host resistance. Screening for blight resistance is, therefore, a large component of chickpea pathology. Evaluation of the resistant lines against individual and multiple races is also essential in identifying durable resistance that can be used in breeding.

Table 2.3.1. Disease incidence on promising chickpea lines grown in on-farm and on-station trials in 1992/93 in Syria.

Province	Location	Zone	Average rainfall (mm)	Trial	Disease names	Incidence	Pathogen isolated	Frequency of isolation (%)
Dara'a	Izra'a	B	266	On-station	Wilt	5%	*F. oxysporum*	100%
	Ghazel	B	-	On-farm	Wilt	5%	*F. oxysporum*	100%
					Virus	1-2%	N/A	N/A
	Jellin	A	356	On-station	Stem blight	25%	*F. oxysporum*	14%
							S. sclerotiorum	78%
					A. blight	5%	*A. rabiei*	33%
							Phoma/*Asc. spp*	20%
	Daael	A	-	On-farm	Root rot	5%	*F. solani*	46%
					Wilt	5%	*F. oxysporum*	40%
					Colar rot	5%	*Phoma/Asc. spp?*	20%
		B	-	5 farms	None	None	None	N/A
Homs	Homs	A	444	On-station	None	None	None	N/A
Hama	Hama	B	376	On-station	None	None	None	N/A
	Al Ghab	A	699	On-station	Wilt/root root	50%	*F. solani*	54%
							Phoma?	80%
							F. oxysporum	30%
					Wilt	25%	*F. oxysporum*	83%
					Stem blight		*S. sclerotiorum*	93%
	Sqelbieh	A	-	On-farm	Wilt/root rot	50%	*F. oxysporum*	100%
							S. sclerotiorum	50%
							R. bataticola	100%
Idleb	Idleb	A	304	On-station	Wilt/root rot	5%	*F. oxysporum*	35%
							Phoma?	38%
	Afess	B	-	On-farm	Wilt/root rot	5%	*F. oxysporum*	60%
							Phoma?	20%
					Stem blight	5%	*S. sclerotiorum*	70%
							F. oxysporum	55%
Aleppo	Kafer Hana	B		On-farm	Cyst nematode	-	*Heterodera* sp	-
	Atareb	B		On-farm	Stem blight	10%	*S. sclerotiorum*	40%
Hassakeh	Hemo	A	576	On-station	A. blight	50%	Phoma?	100%
							A. rabiei	75%
					Wilt/root rot	50%	*F. oxysporum*	82%
							Phoma?	75%
							R. bataticola	40%
	Kamishly	A	-	On-farm	Collar/root rot	50%	Phoma?	47%
							F. oxysporum	100%

* Detailed results for the Hassakeh province are presented on Table 2.3.2.
\+ On-station trials, on-farm trials consisting of Ghab 1, Ghab 3, FLIP 86-5, FLIP 86-6, and FLIP 84-15, N/A = No isolation done.

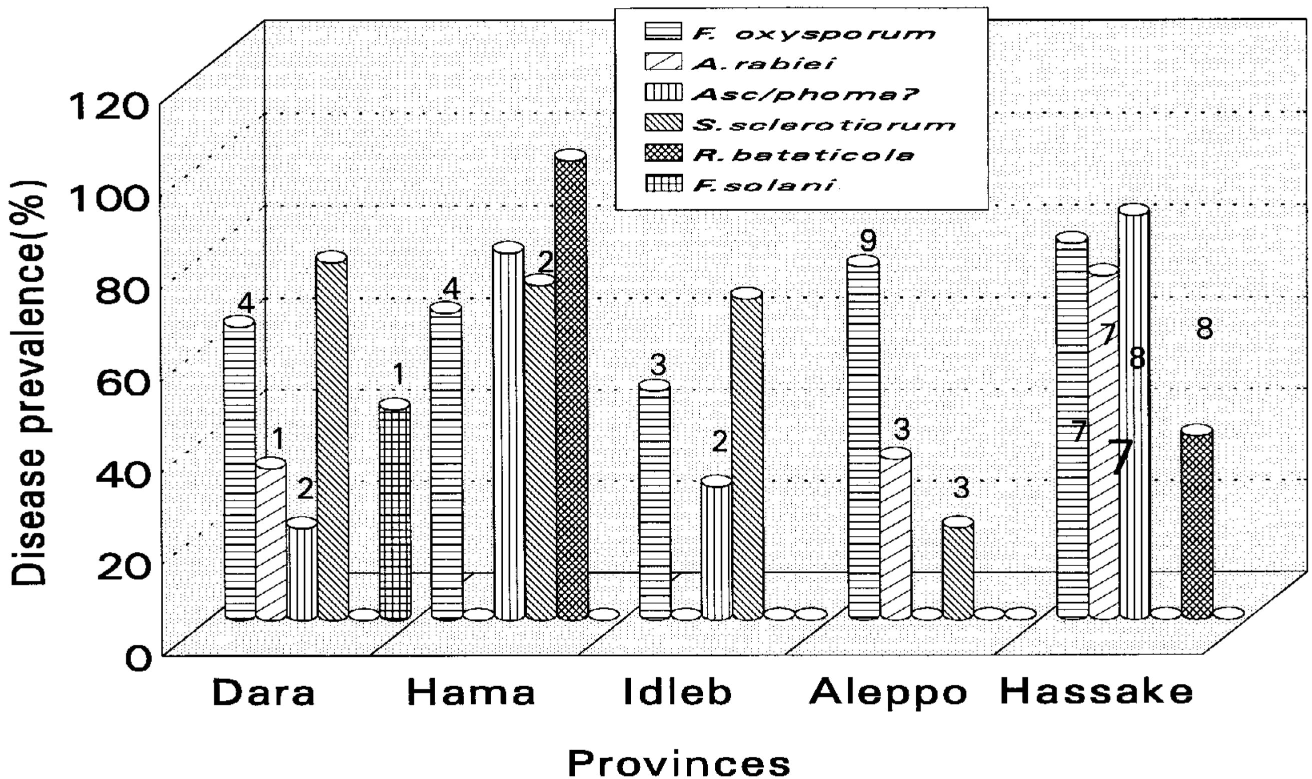


Figure 2.3.1. Mean prevalence of chickpea diseases in Syria 1992/93, in farmers fields, on-farm trials and on-station ICARDA trials. Numbers over bars are frequencies of isolations.

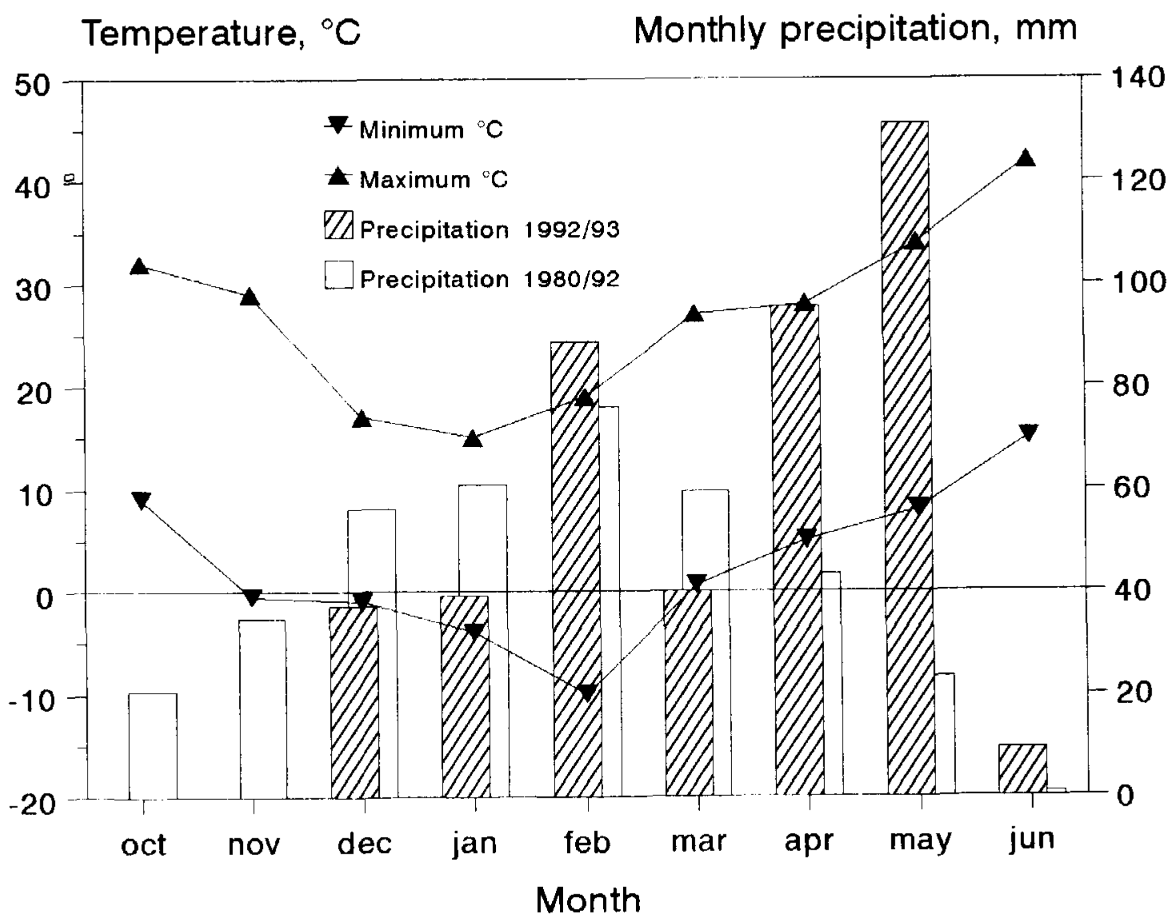


Figure 2.3.2. Weather data for Kamishly, 1992/93.

Table 2.3.2. Disease severity on promising chickpea lines grown in on-farm and on-station trials at Hassakeh provinces, Syria 1992/93.

Chickpea	Disease	No. of fields	Mean severity (1-9 scale)	Pathogen isolated	Mean frequency of isolation (%) stem leaf	pods	collar
Ghab 1	Ascochyta blight, Root/collar rot	6	6	*Ascochyta rabiei*	48	8	22
				Ascochyta sp./*Phoma*?	41	8	25
				Fusarium oxysporum	23	43	-
				Rhizoctonia bataticola	4	0	44
Ghab 2	"	1	4	*A. rabiei* +	0	19	0
				Ascochyta/*Phoma*	0	33	20
				Fusarium oxysporum	0	91	-
				Rizoctonia bataticola	50	0	63
Ghab 3	"	4	6.5	*A. rabiei*	45	0	11
				Ascochyta/*Phoma*	37	0	40
				F. oxysporum	23	0	-
				R. bataticola	28	0	46
FLIP 84-15	"	3	8	*A. rabiei*	63	0	27
				Ascochyta sp./*Phoma*	48	0	0
				F. oxysporum	10	30	-
				R. bataticola	0	0	100
FLIP 86-5	"	3	6.5	*A. rabiei*	48	0	0
				Ascochyta/*Phoma*?	39	0	67
				F. oxysporum	45	30	-
				R. bataticola	0	0	75
FLIP 86-6	"	2	8	*A. rabiei*	35	0	0
				Ascochyta sp/.*Phoma*?	15	0	0
				F. oxysporum	23	50	-
				R. bataticola	25	0	72
Local (winter)	"	3	9	*A. rabiei*	80	-	38
				Ascochyta sp./*Phoma*	48	-	42
				F. oxysporum	31	-	-
Local (spring)	"	2	9	*R. bataticola*	0	-	30

2.3.2.1. Evaluation of breeding lines for resistance to individual and mixed races

Out of 1615 breeding lines developed between 1981 and 1990 and evaluated for resistance in 1991/92, 185 lines had a disease rating of 2-4 in the field and in the greenhouse. These selected lines were again tested against individual and mixed races in the greenhouse, and against a mixture of the same races in the field.

The reaction of the lines to the different races is presented in Figure 2.3.3. Eighty-one percent of the lines were rated 3-4, i.e. resistant (R) to moderate resistant (MR), to the mixture of six races in the green house. Some 88% were R-MR to race 2, but many of these lines were rated 5 or 6 and a few 7 and 8, i.e. intermediate (I) or susceptible (s), to the other individual races, particularly to races 6, 1 and 4. A total of 13% of the lines were rated S and 5% had intermediate reaction in the field. About 43% of the lines expressed rating of 3 and 4. Four of these lines, that had best resistance (rating of 3) in the field (FLIP 88-83, FLIP 90-112, S 91233, and S 91337), were susceptible to several races in the greenhouse. However, 12 lines (FLIP 84-92, 84-93, 90-73, 90-77, 90-109, S 91241; S 91292, S 91345, S 91347, S 91348, S 91377, and S 91400) were R to MR to all the pathotypes included in this study, individually and in a mixture, in the field and in the greenhouse. These lines have the broad-based resistance to all the pathotypes used in this study.

The relatedness of the disease reactions from the mixed races and the individual races was determined by using a multiple regression analysis. The results showed a low coefficient of determination (R^2) value (0.13) and low regression coefficients for all the races. This showed that reaction to the mixed races did not relate with that of any individual race. The results also showed that each race contained in the mixture had a small positive additive effect on the reaction of the mixture. Reactions of the lines in the field were compared to those in the greenhouse by using a multiple regression analysis. Results showed low coefficient of determination (0.02 - 0.06) and very low regression coefficients with all individual and the mixed races.

Even though there was no cross protection between the races, it is hypothesized that the high severity of infection expected from the aggressive races (race 4, 1 and 6) gets modified by the mild races (2 and 3) included in the mixture. It is, therefore, important to use populations of the pathogen derived from field isolates so as to represent the different pathotypes in the same proportions as they occur in nature. It is hypothesized that the original races of *A. rabiei* described in 1984 have changed over the years and the change may have occurred in both culture and in the field. Therefore, the races contained in the debris may be quite different in number and aggressiveness from that maintained in culture. There is need to test these hypothesis. Also pathogenic variability in the screening nursery should be regularly monitored and methods used for storage of culture should be such as would not allow the pathogen to grown or mutate so that the original type cultures are maintained.

2.3.2.2. Evaluation of F_2-F_7 generations

The reaction of the F_2-F_7 segregating populations to ascochyta blight is presented in Table 2.3.3. In the F_2 generation the R X R crosses produced mainly MR (66%) and, I (31%) reactions. The F_2 bulk had 7% MR, 34% I, and 59% S. In the F_4 generation only three F_4 (R x R) bulks were planted and they were R and MR. Of the 143 other F_4 bulks 6% were MR, 32% were I and 62% were S. In the F_5 generation two bulks of (R x R) were planted and they were I and S. In the F_5 progeny <1% were R, 18% were MR, 42% were I and 40% were S. The F_5 progeny of large seeded (winter) had 8% MR, 55% I, and 37% S. The F_5 progeny early winter had 24% MR, 46% I, and 30% S. The F_6 and F_7 progeny (desi) had 16% R, 54% MR and 23% I; no lines were S.

Desi chickpeas had the highest number of R to MR in the F_5 and F_6 progenies. The highest recovery of R to MR in the kabuli F_5 and F_6 progenies was 24% from the winter and early winter material. **M.T. Mmbaga and K.B. Singh.**

2.3.2.3. Confirmation of resistance

Different chickpea lines, that had been selected for ascochyta blight resistance in the 1991/92 season, were planted in the ascochyta blight nursery in 1992/93 for confirmation of the resistance. Results are shown in Table 2.3.4. In general, only 50% of the pre-selected resistant lines were confirmed to be R or MR, 23% rated I and 27% succumbed to the blight with a S rating. **M.T. Mmbaga and K.B. Singh.**

General observations on the nursery revealed that disease symptoms on seedlings were widespread on 1 March before any inoculation with spore suspension was done. Spore suspension was subsequently applied 7 times over a period of about five weeks. Infection increased gradually over the season until the susceptible check was killed and supplemental mist irrigation was stopped in the first week of May. Plant growth continued after mist irrigation was stopped. Scattered pockets of infected plants developed over the entire field in mid May and formed distinct foci of secondary infection, spread on plants that had otherwise appeared healthy. This was because of cool and wet weather in May that favored rapid development of ascochyta blight at the time when plants were at a very susceptible stage (i.e at flowering and early pod). At the time of disease reading, lines that were next to the susceptible checks tended to show more infection than lines away from the susceptible checks. Many lines, including those of advanced generations (i.e. F_6 and F_7), showed both susceptible and resistant reactions on the same line depending on

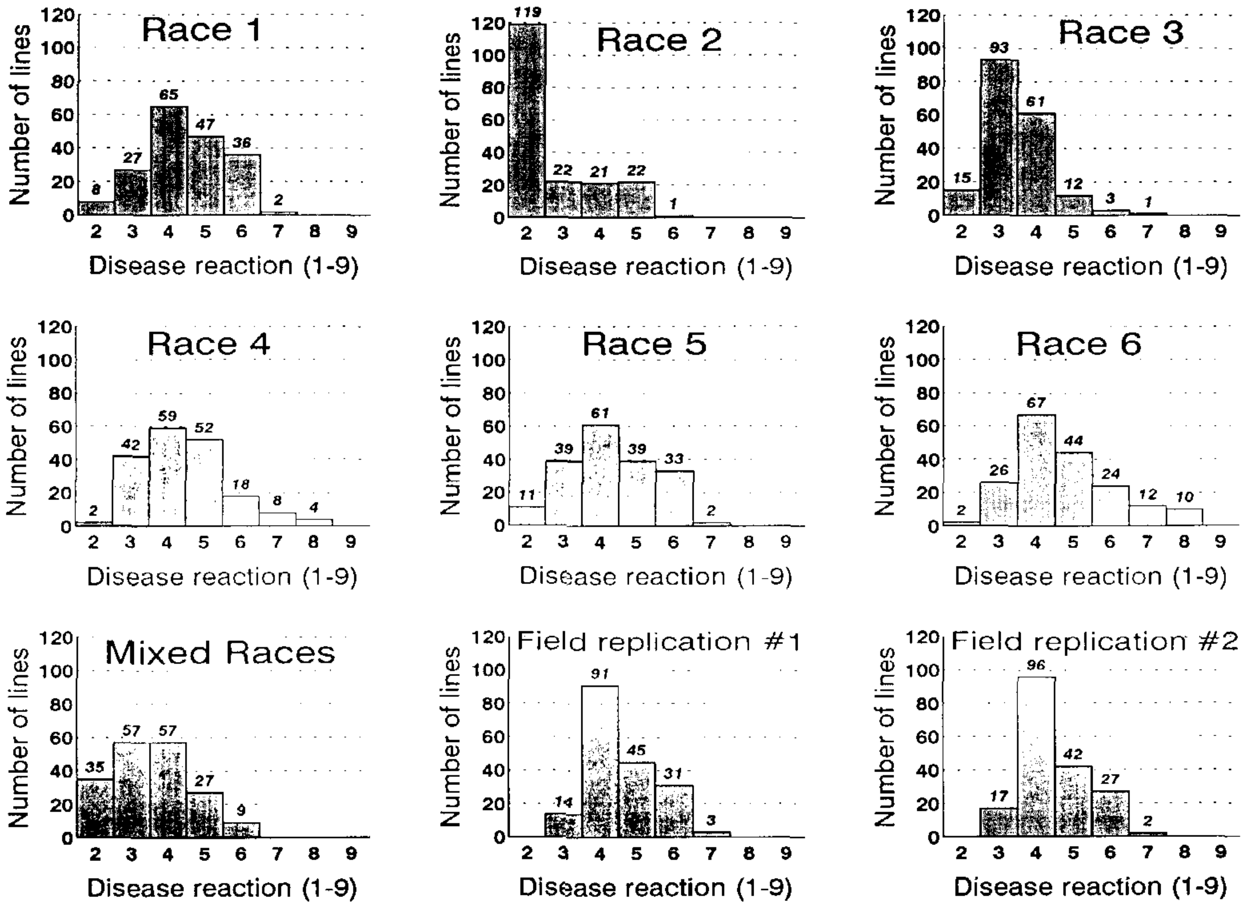


Figure 2.3.3. Reaction of chickpea breeding lines to ascochyta blight in the greenhouse and field, 1992/93.

Table 2.3.3. Reaction of F_2-F_7 generation lines of chickpea to ascochyta blight at Tel Hadya 1992/93.

Generation	Ascochyta blight reaction on 1-9 scale*									Total
	1	2	3	4	5	6	7	8	9	
F_2 (RxR) bulk	0	0	0	84	39	4	0	0	0	127
F_2 bulk	0	0	0	13	64	41	51	18	0	187
F_4 bulk	0	0	0	8	46	66	19	4	0	143
F_4 (RxR) bulk	0	0	2	1	0	0	0	0	0	3
F_5 (RxR) bulk	0	0	0	0	1	1	0	0	0	2
F_5 Prog.	0	0	42	905	2123	1708	293	21	1	5093
F_5 Prog. large, winter	0	0	0	30	206	139	3	0	0	378
F_5 Prog. early, winter	0	0	0	252	497	283	36	6	1	1075
F_6 Prog. winter	0	0	0	69	135	84	2	0	0	290
F_6 & F_7 Prog. (desi)	0	0	18	61	27	6	1	0	0	113
Total	0	0	62	1423	3138	2332	405	49	2	7411

* Disease rating 1-3 = resistant, 4 = moderate resistance, 5 = intermediate, 6 and above = susceptible.

Table 2.3.4. Reaction of pre-selected resistant lines to Ascochyta blight.

Lines	Ascochyta blight reaction on 1 to 9 scale									Total
	1	2	3	4	5	6	7	8	9	
Mutants	0	0	0	0	13	24	28	10	4	88
Demonstration	0	0	0	4	0	0	0	0	1	5
Kabuli* (ICRISAT)	0	0	0	5	1	1	5	0	0	12
Desi* (ICRISAT)	0	0	32	63	12	5	5	0	0	117
FLIP lines	0	0	1	195	97	57	3	0	0	353
PYT	0	0	1	018	77	48	22	21	14	291
CIYT-MR	0	0	0	8	7	3	3	0	0	21
CIYT-Sp	0	0	0	36	18	13	7	6	2	82
CIYT-SL	0	0	0	13	7	1	0	0	0	21
CISN-W	0	0	2	28	17	13	0	0	0	60
CISN-SL	0	0	0	37	7	4	1	0	0	49
CIABN	0	0	5	28	14	3	0	0	0	50
Total	0	0	41	534	270	172	74	37	21	1149

the position and size of the infection foci. Whenever there was no homogeneous disease development on a line, the higher rating was given.

The tendency of plants to recover from infection by new compensatory growth is independent of genetic resistance. It may, however, obscure the rating of damage by diseases and result in the rating of false resistance. In the 1992/93 season, the cool wet weather in mid May favored ascochyta blight development on the compensatory growth and reduced the opportunity for disease escape, but the patchiness of the secondary infection indicates that some disease escapes may have still occurred.

Steps needed to improve the efficiency of resistance screening include: 1) Facilitate disease development at flowering and pod filling. 2) Increase the uniformity of disease spread during flowering by providing uniform inoculum in the form of spore suspension, and increasing the number of lines of susceptible checks between the test entries; and maintaining the susceptible check at a disease rating of about 7 or 8 by increasing the number of check genotypes giving a broader range of disease reaction type so as to provide source of secondary inoculum and reference points for disease reading. (3) Conduct a baseline disease reading at the time the mist irrigation is stopped before compensatory growth occurs. **M.T. Mmbaga.**

2.3.2.4. Pathogenic variability of *A. rabiei*

Pathogenic variability of *A. rabiei* has been frustrating the efforts to control ascochtya blight with host resistance. While quantifying the variability is important, results so far available are not easily comparable and races from different places are not comparable without additional work because they have been differentiated using varied differentials, environmental conditions and disease rating scales. This hampers exchange of information on race-specific resistance and slows down progress on resistance breeding that uses gene pyramiding system.

The objectives of this study were to initiate the standardization of methodology used in race identification and to test the virulence pattern of the ICARDA isolates and races on the available cultivars used by different researchers for race identification. Since studies on pathogenic variability require homogeneity of the differential varieties, single plant selections were done to generate seed source; seed multiplication was done in off-season planting. The available single-spore isolates and new isolates from the 1992/93 collection will be evaluated in the 1993/94 season. This will complement the work on molecular-marker assisted study on variability in the ascochyta blight fungus (section 2.2.4).

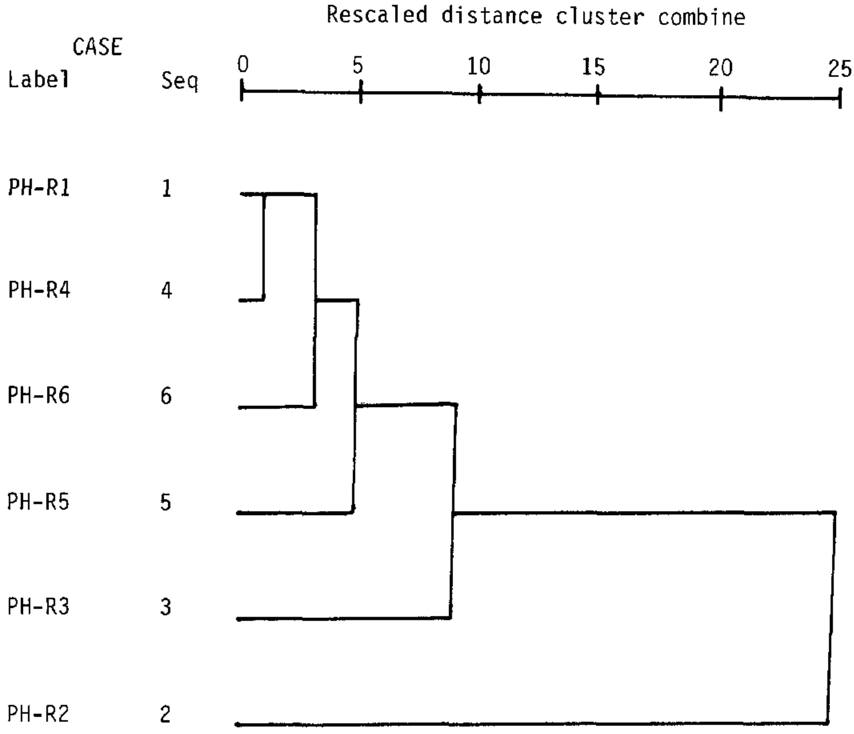
The question whether the isolates of *A. rabiei* differ in form of pathogenic races or in aggressiveness has not been settled and a demonstration of the existence of either races or differences in aggressiveness is important. The six 'races' of *A. rabiei* were used to evaluate resistance of 185 breeding lines in the 1992/93 season. Pathogenetic variability of the six races was demonstrated on many of these lines, and 18 lines gave clear cut differentiation of the 6 races as shown on Table 2.3.5. A cluster analysis was conducted to show the relatedness of the six races in their pathogenicity on the 185 breeding lines and also to show their similarity and dissimilarity.

The relatedness of the individual races is presented in a dendrogram in Figure 2.3.4. Races 1, 4, and 6 and, to some extent, race 5 clustered together. They were similar to one another in their aggressiveness and produced the highest mean disease score on the 185 lines. Race 2 is very mild in pathogenicity and 76% of the 1985 lines rated 2-3 to this race, but many of the same lines rated 6 and a few 7 and 8 to races 6, 1 and 4. Even though races 4, 1 and 6 were similar in their aggressiveness, they differed on the reaction they incited on different lines as shown in Table 2.3.5. These results indicate that the pathotypes in *A. rabiei* can be defined by both their virulence pattern on a set of differential lines i.e. races, and also in their aggressiveness which is demonstrated in Figure 2.3.5. **M.T. Mmbaga and K.B. Singh.**

Table 2.3.5. Disease reaction of eighteen lines of chickpea to 'races' 1 to 6 of *Ascochyta rabiei*.

Chickpea genotype*	Disease reaction (1-9 scale)					
	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6
ILC 72	4	2	4	5	3	4
ILC 187	6	2	3	4	4	6
FLIP 82-97	6	2	3	7	6	7
FLIP 82-243^S	6	6	4	8	6	6
FLIP 83-118	6	5	4	8	2	7
FLIP 84-76	4	2	3	3	3	7
FLIP 84-92^R	4	2	3	4	3	4
FLIP 84-93^R	4	2	4	3	4	4
FLIP 85-99	4	2	2	6	3	2
FLIP 88-83	6	2	3	6	3	8
FLIP 90-97	3	3	4	8	3	3
FLIP 91-235	6	3	2	4	3	3
FLIP 91-257	6	4	3	7	2	4
FLIP 91-281	4	2	2	3	4	6
FLIP 91-316	2	5	3	3	4	4
FLIP 91-335	3	2	3	3	6	3
FLIP 91-354	3	2	3	3	6	6
FLIP 91-380	4	2	4	7	3	4

* R indicates resistant control, S indicates susceptible control.



Average linkage using Euclidean measure.

Figure 2.3.4. Cluster analysis to show the similarity of six 'races' of *Ascochyta rabiei*.

2.3.2.5. The role of teliomorphic stage of *A. rabiei* in Syria

The teliomorphic stage of *A. rabiei* has been reported in Syria, but follow up studies on its role as a source of long-distance movement of primary inoculum or/and source of genetic diversity have not been conducted. The objective of this study was to assess the potential of the teliomorphic stage as a source of primary inoculum and long distance movement of *A. rabiei* in the air.

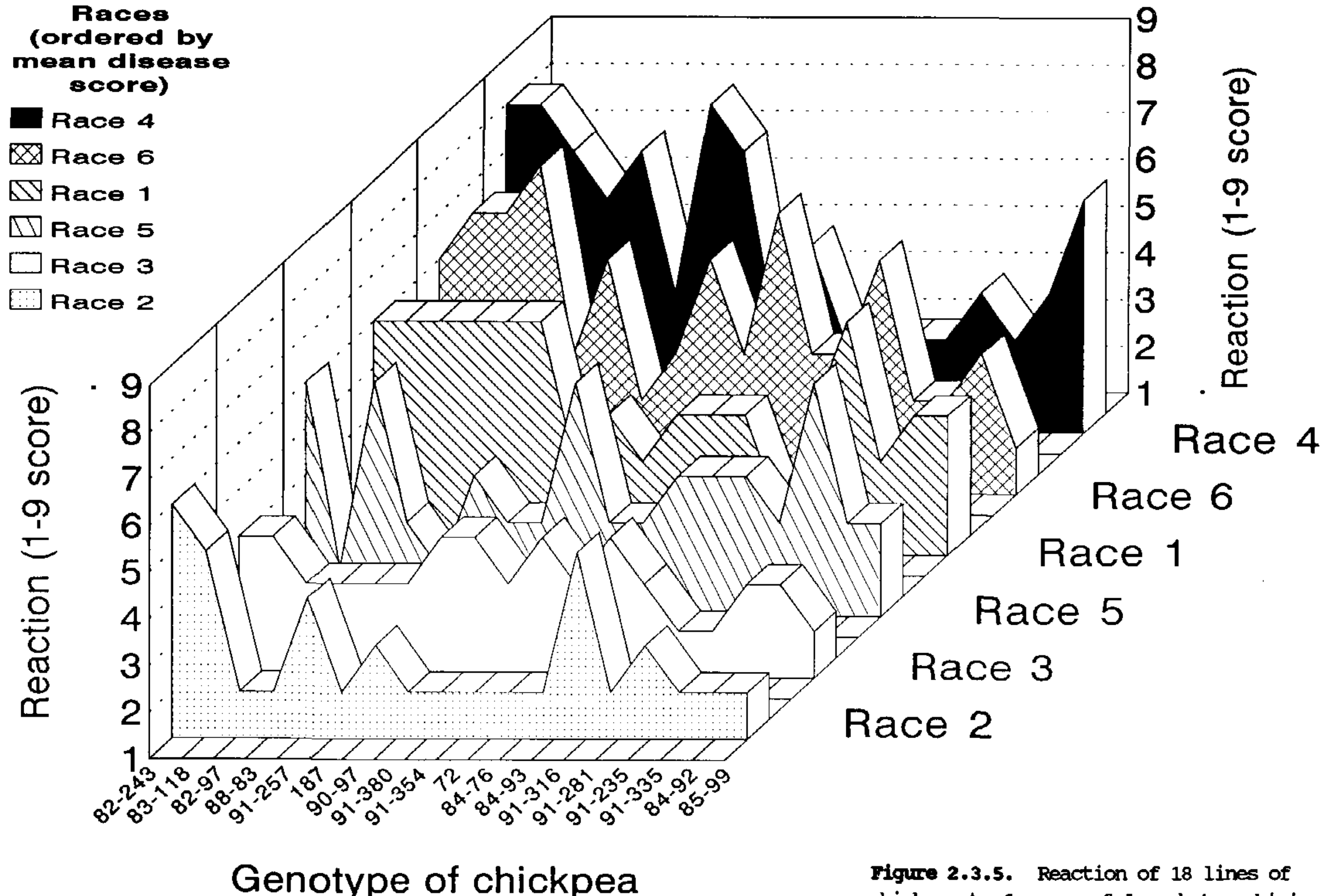


Figure 2.3.5. Reaction of 18 lines of chickpea to 6 races of *Ascochyta rabiei*.

Biological indicators and sticky slides for trapping spores were used to assess the distance of *A. rabiei* movement from chickpea growing areas to areas where chickpea was not grown. Blight infested debris from the previous season was also collected from the field during the months of February to April to look for the presence of ascospores. Ascospores were observed in all debris samples, but they were not fully developed in February. Observations in March and April showed well developed ascospores and some empty perithecia indicating that some escospores had already been released.

Plants placed 15-35 km away from the nearest chickpea fields developed stem lesions of ascochyta blight. Plants placed long distance away from chickpea fields had highest infection incidence during the February and early March exposure and less infection was observed on plants exposed in late March. This could be caused by windy showers in February and early March that would carry the inoculum long distance. The release of ascospores in other areas may have also taken place in February and early March. Ascochyta blight infection was assessed by the percentage of plants that developed typical stem lesions of *A. rabiei*. The disease severity was low and indicated that inoculum density in the air was low and that a longer period of plant exposure to inoculum would give better assessment (Table 2.3.6).

Few ascospores that were morphologically similar to that of *A. rabiei* were observed on trap slides in February only. Other forms of air borne inoculum trapped on slides were (i) minute pieces of debris that were infested with ascochyta, sometimes containing a fruiting structure (pycnidia/perithecia); (ii) large clusters of conidiospore, and (iii) some thick walled mycelia that cleaved at the area of septation and released oidia type of segments on water agar. All these were isolated and purified in culture and gave rise to morphologically typical *A. rabiei* cultures. Pathogenicity tests to complete Koch's postulates will be conducted to confirm their role as sources of air-borne inoculum. **M.T. Mmbaga.**

2.3.2.6. The spread of ascochyta blight from the infection focus

Infested debris and seed are the two most important sources of primary inoculum for ascochtya blight, producing several infection foci from where the disease spreads. The frequency of seed transmission can be very low. Seed transmission ensures a random distribution of the pathogen in a field, that provides many primary infection-foci from which the pathogen can spread. The objectives of this study was to determine the distance of spread of secondary inoculum from the infection focus and to estimate the frequency of infection foci necessary for epiphytotic disease development under the Tel Hadya conditions.

Table 2.3.6. The incidence of ascochyta blight on indicator plants after exposure to open air at different locations and distances from chickpea farms. Fortyfive to 50 plants were exposed in 8-10 pots.

Location	Distance from Chickpea plants	Percentage of plants infected from one week exposure to air-borne inoculum				
		Feb 21-27	Feb 27-March 6	Mar 13-21	Mar 21-27	Mar 27-Apr 14
Tel Hadya (A10)	0	Frost kill	50%	1%	60%	20%
Tel Hadya (A16)	0	Frost kill	50%	16%	74%	24%
Tel Hadya (C)	0	Frost kill	10%	11%	19%	13%
Tel Hadya (Hill top)	0.5km	Frost kill	100%	0	27%	27%
Mohandesin area	15km	Frost kill	10% (leaf)	4%	8%	0
Aleppo	30km	100%	20%	4%	0	0
Aleppo	32km	Frost kill	NT*	7%	3%	0
Aleppo	35km	60%	10%	2%	0	0
Control	0	0	0	0	0	

* NT = Not tested.

Two infection foci, 2m^2 each and 26 m apart, were developed in a 3600 m^2 field planted with a blight susceptible culture ILC 1929. Plants in the marked infection foci areas were inoculated with blight-infested debris and spore suspension of mixed races of *A. rabiei* on March 5. The spread of infection from the infection foci was assessed, twice a week, by following the infection development on non-inoculated plants, and by measuring the direction and distance of conidiospores spread using trap slides. Infection development on non-inoculated plants was first assessed by a preliminary survey of the experimental field to get an overview of the distance and direction of spread. The results are presented in Figure 2.3.6. The infection severity at different radial distances from the infection focus was evaluated using a sampling square that covered 41-45 plants. Percentage of plants that had disease symptoms was counted and severity rating was done on a 1-9 scale. Results are presented on Tables 2.3.7 and 2.3.8, respectively, for plot A and B. All disease spread took place in the month of May.

Temperatures were favorable for disease development (15-25°C) in the last week of March and the whole of April, but disease did not spread from the infection foci because of dry conditions during this period (Figure 2.3.7). Spread of infection to non-inoculated plants was observed ten days after sprinkler irrigation (1 hour daily for 10 days). Infection spread over time included the formation of numerous secondary infection foci that increased in number and size and covered the entire field over a period of one month after which temperatures (>30°C) became limiting (Figure 2.3.6). The number of plants that got killed by blight increased radially from the infection foci and the spread was farthest following the predominant wind direction (Figure 2.3.8).

Conidiospores were dispersed in singlets and in clusters of varying sizes. The number of conidiospore dispersed in singlets was fairly consistent in the different samples taken on the same date (c.v. 15-25%), but the number and size of clusters of conidiospore were highly variable from one slide to another (c.v. >100%) (Tables 2.3.9 and 2.3.10). The distance of spread of clustered and single conidiospore was similar and reached 23 meters from the edge of the field, the farthest distance of sampling. Conidiospore in clusters usually have higher inoculum potential and can spread a longer distance and survive adverse conditions better than spores in singlets.

Plants in the infection foci formed only 0.002% of the plants in the 3600 m^2 experimental plot area, and favorable conditions occurred for only one month of the season when plants were at flowering and early pod formation. If the same percentage of infected plants had resulted from infected seed, the primary infection foci would have been smaller in size, but more numerous and distributed over the entire field. These results indicated that an epiphytotic disease development, similar to what has been presented, could result from only 0.002% infected plants, if a cultivar is susceptible and environmental conditions are similar.

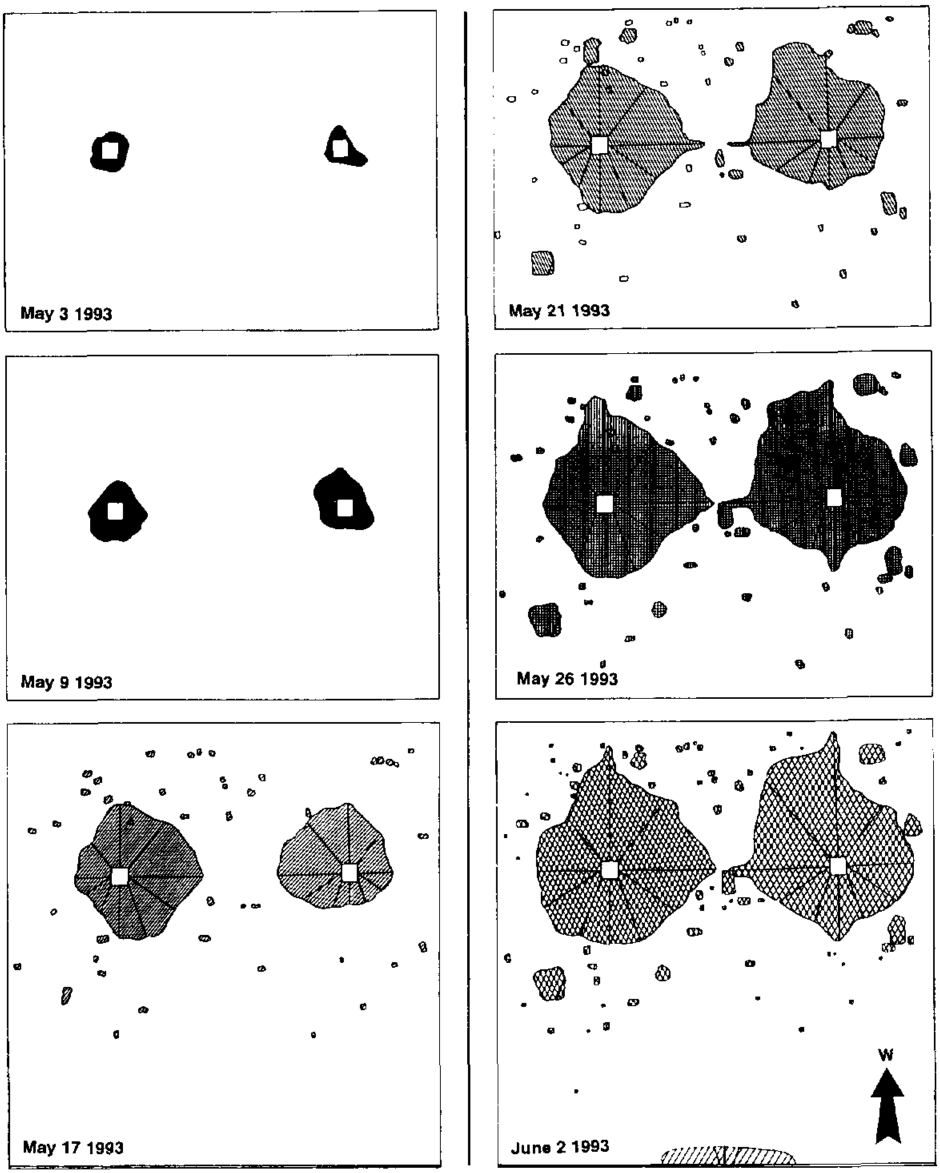


Figure 2.3.6. Spread of Asochyta blight in chickpea field over time, from two infection foci, A and B; Tel Hadya, 1993.

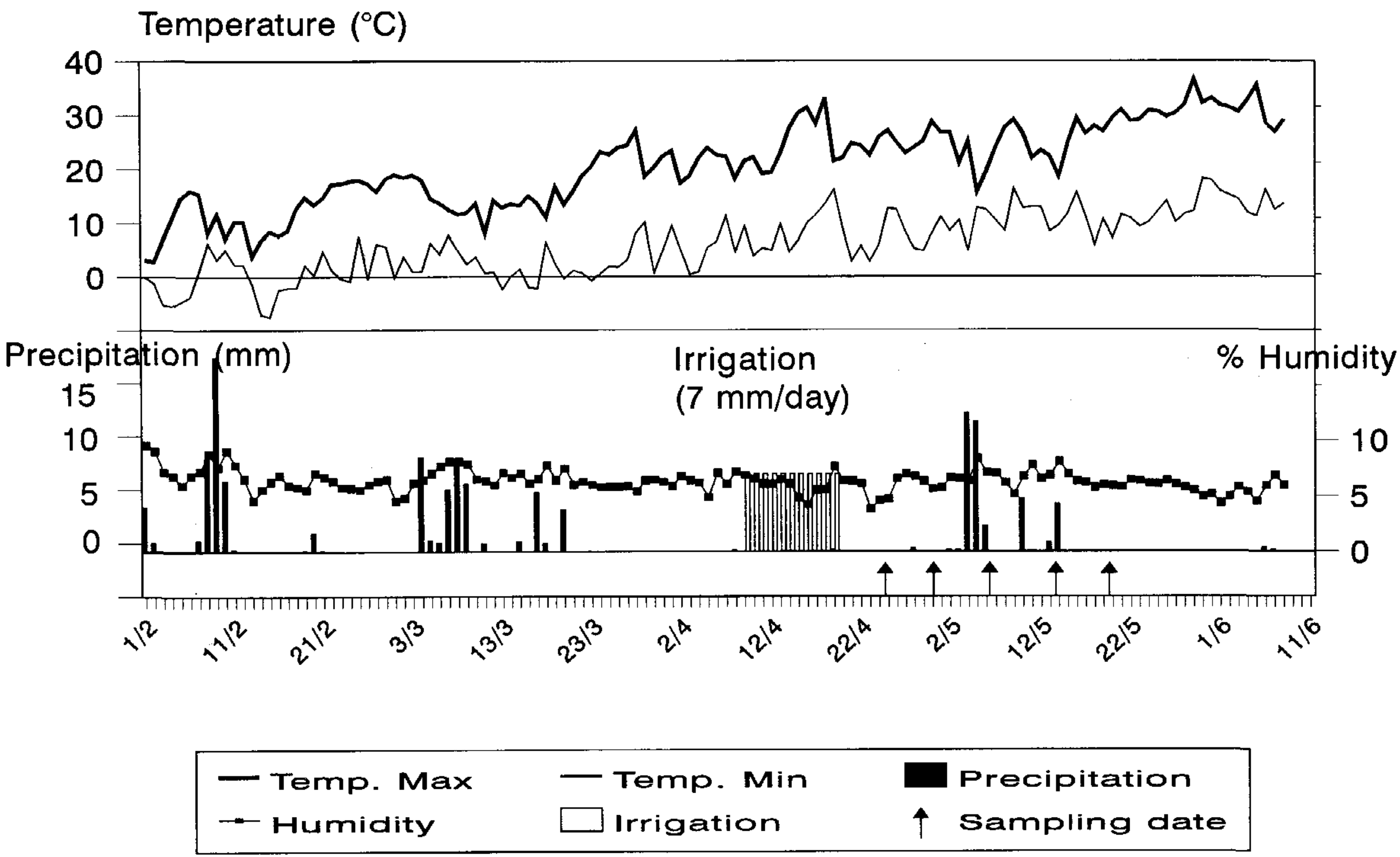
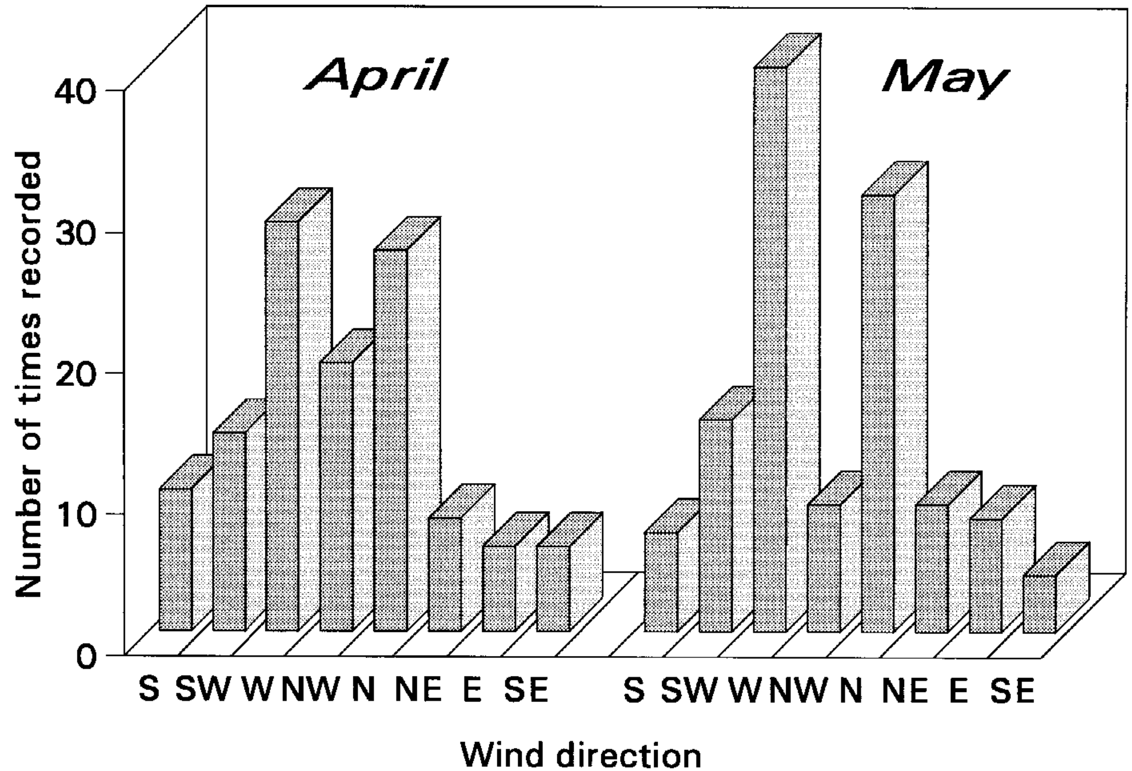


Figure 2.3.7. Tel Hayda weather, 1993.

Table 2.3.7. Spread of ascochyta blight in the field measured by % of plants infected (%INF) and disease severity (DS) on all diseased plants at different distances from infection focus 'A'.

Date of assessment		Distance of spread from the infection focus											
		3m			6m			9m			12m		
		No. of plants	%INF	DS	No. of plants	%INF	DS	No. of plants	%INF	DS	No. of plants	%INF	DS
12.5.1993	Mean	43.67	91.59	3.31	43.33	65.50	2.24	43.33	39.17	1.61	-	-	-
	SE ±	0.27	3.77	0.39	0.27	7.40	0.15	1.52	9.92	0.24	-	-	-
16.5.1993	Mean	42.33	96.01	4.38	41.00	71.31	2.69	42.33	42.12	1.81	-	-	-
	SE ±	0.72	2.33	0.52	0.00	6.23	0.15	0.72	14.51	0.31	-	-	-
23.5.1993	Mean	-	-	-	42.67	84.16	4.10	41.33	64.57	2.30	41.33	56.58	2.28
	SE ±	-	-	-	0.54	5.56	0.68	0.27	7.54	0.34	0.27	13.75	0.59
26.5.1993	Mean	-	-	-	42.33	9.194	4.73	41.00	77.07	2.77	42.67	72.07	2.81
	SE ±	-	-	-	0.72	3.50	0.61	0.47	5.47	0.38	0.54	10.43	0.71



Observations were made at 02:00, 08:00, 14:00 and 20:00 hours each day.

Figure 2.3.8. Frequency of wind directions, April and May 1993. Observations were made at 02:00, 08:00, 14:00 and 20:00 hours each day.

Table 2.3.8. Spread of ascochyta blight in the field measured by % of plants infected (%INF) and disease severity (DS) on all diseased plants at different distances from infection focus 'B'.

Date of assessment		Distance of spread from the infection focus											
		3m			6m			9m			12m		
		No. of plants	%INF	DS	No. of plants	%INF	DS	No. of plants	%INF	DS	No. of plants	%INF	DS
12.5.93	Mean	43.33	88.31	2.66	43.00	68.42	2.10	45.00	46.36	1.70	-	-	-
	SE ±	0.54	5.11	0.24	0.47	6.66	0.18	0.94	6.37	0.21	-	-	-
16.5.1993	Mean	45.33	88.34	3.41	41.33	84.76	2.70	45.00	60.25	3.35	-	-	-
	SE ±	1.36	7.07	0.27	0.27	4.62	0.21	0.82	5.63	1.09	-	-	-
23.5.93	Mean	-	-	-	42.33	90.47	3.47	42.00	64.50	2.47	41.33	28.32	1.3
	SE ±	-	-	-	0.27	5.14	0.61	0.47	8.73	0.40	0.27	12.44	0.1
26.5.1993	Mean	-	-	-	41.67	96.82	4.23	42.33	79.70	3.33	41.33	51.29	1.8
	SE ±	-	-	-	0.72	2.59	0.60	0.27	7.92	0.57	1.09	8.90	0.2

Table 2.3.9. Number of spores trapped on sticky slides placed at different distances from an infection focus.

Date		No. of spores at different distances radial to the infection focus									
		2m	3m	4m	5m	18m	23m	28m	33m	38m	43m
28.4.1993	Mean	24.75	-	23.25	-	-	-	-	-	-	-
	CV%	21.64	-	29.55	-	-	-	-	-	-	-
4/5/1993	Mean	14.00	-	11.25	-	-	-	-	-	-	-
	CV%	16.50	-	24.38	-	-	-	-	-	-	-
10/5/1993	Mean	-	11.42	-	10.33	-	-	-	-	-	-
	CV%	-	22.75	-	29.91	-	-	-	-	-	-
18/5/1993	Mean	-	-	-	-	0.50	12.71	4.50	4.40	5.50	11.0
	CV%	-	-	-	-	100.00	110.01	135.63	58.56	63.64	90.00
25/5/1993	Mean	-	-	-	-	-	-	-	-	-	-

Table 2.3.10. Number of clusters of conidiospores trapped on sticky slides placed at different distances from the infection foci.

Date			No. of spores at different distances radial to the infection focus									
			2m	3m	4m	5m	18m	23m	28m	33m	38m	43m
28/4/1993	Mean	(A)	-	-	-	-	-	-	-	-	-	-
		(B)	-	-	-	-	-	-	-	-	-	-
4/5/1993	Mean	(A)	-	-	-	-	-	-	-	-	-	-
		(B)		0.27	-	0.18	-	-	-	-	-	-
	CV%	(A)	-	-	-	-	-	-	-	-	-	-
		(B)		226.08	-	316.23	-	-	-	-	-	-
10/5/1993	Mean	(A)	-	-	-	-	-	-	-	-		
		(B)	-	1.67	-	0.58	-	-	-	-	-	-
	CV%	(A)	-	-	-	-	-	-	-	-		
		(B)	-	78.74	-	130.15	-	-	-	-	-	-
18/5/1993	Mean	(A)	-	-	-	-	0.50	1.57	0.25	0.60	0.00	0.67
		(B)	-	-	-	-	0.50	4.14	1.00	0.60	0.50	2.67
	CV%	(A)	-	-	-	-	100.00	112.00	173.21	133.33	0.00	70.71
		(B)	-	-	-	-	100.00	144.50	173.21	200.00	100.00	155.92
25/5/1993	Mean	(A)	-	-	-	-	-	-	-	-	-	-
		(B)	-	-	-	-	-	-	-	-	-	-

The percentage of infected plants obtained after seed treatment with benomyl, thiabendazole, captan, calixin, maneb and thiram applied singly and in combinations is often still 1-2%. These results confirm that an integrated approach that reduces the rate of disease spread is necessary to control ascochtya blight. The results also indicate that inoculum can easily move from one to another farm. **M.T. Mmbaga, W. Ka'ade and W. Khoury (Lebanese University).**

2.3.3. The Fusarium Wilt-Sick Plot

In order to be able to screen chickpea germplasm and breeding material for root rot and wilt there was a need to develop a sick plot. Efforts have been underway for last 2 seasons to develop such a plot. Plants that had been inoculated with the chickpea wilt pathogen in Oct 1992 did not develop typical symptoms of vascular wilt, perhaps because the temperatures were too low for Fusarium wilt development. In order to assess the presence and level of *Fusarium oxysporum* f. sp *ciceri* inoculum in the soil, the 2 h sick plot was divided into 5 x 5 plots. About 20 plants that showed mild unclear symptoms and 20 healthy looking plants were uprooted from each section and diagnosed for the presence of *F.* oxysporum in the collar and the stem regions by using culture technique. The maximum incidence of *F. oxysporum* in culture was 38%, mainly from the collar region, from only a small part of the sick plot. *F. oxysporum* was not observed in some areas, while other areas had dry root rot pathogen (*Rhizoctonia bataticola*) well expressed in symptoms and in culture isolation.

Another planting and inoculation were done in Nov 15, 1992 using the same isolate and procedure. Wilt symptoms were expressed very late when the crop was in full podding. The observations suggested that either the inoculum density in the soil was still low, or the isolate in use was not aggressive or the inoculation procedure or the amount of inoculum being added in the new planting did not have much impact.

The sick plot was mapped out according to the status of inoculum present in the soil as shown in Figure 2.3.9. Section A had the highest average amount of wilt pathogen (38%) and only 2% dry root rot. Section B had both wilt (30%) and dry root rot (20%) pathogen. Section C had mainly dry root rot (18%) and only 1% fusarium wilt. Since dry root rot is also a problem in farmers fields, either occurring alone or associated with wilt, it was found unnecessary to eliminate it from the sick plot.

The three sections will be developed in stages, starting with section A, followed by section B and then C. This will reduce the area being inoculated at any one time and will permit to concentrate the development of more uniform inoculum in that section soil. Some overlap of the sections under development will occur during the normal planting season and off-season planting will continue until the entire field has been fully developed.

Highly aggressive isolates of fusarium wilt pathogen were obtained from four fields in Jinderess in May 1993. Pure cultures and infected stem pieces from Jinderess were used to inoculate section A of the sick plot in June 1993. Infecting seed 3-4 h before planting ensures a high wilt incidence that generates infected debris to be plowed back into the soil. Therefore, seed for planting was coated with macerated conidia and mycelia before planting. A mixture of three susceptible varieties (ILC 482, FLIP 83-48 and ILC 1929) in equal proportions by weight were used for planting.

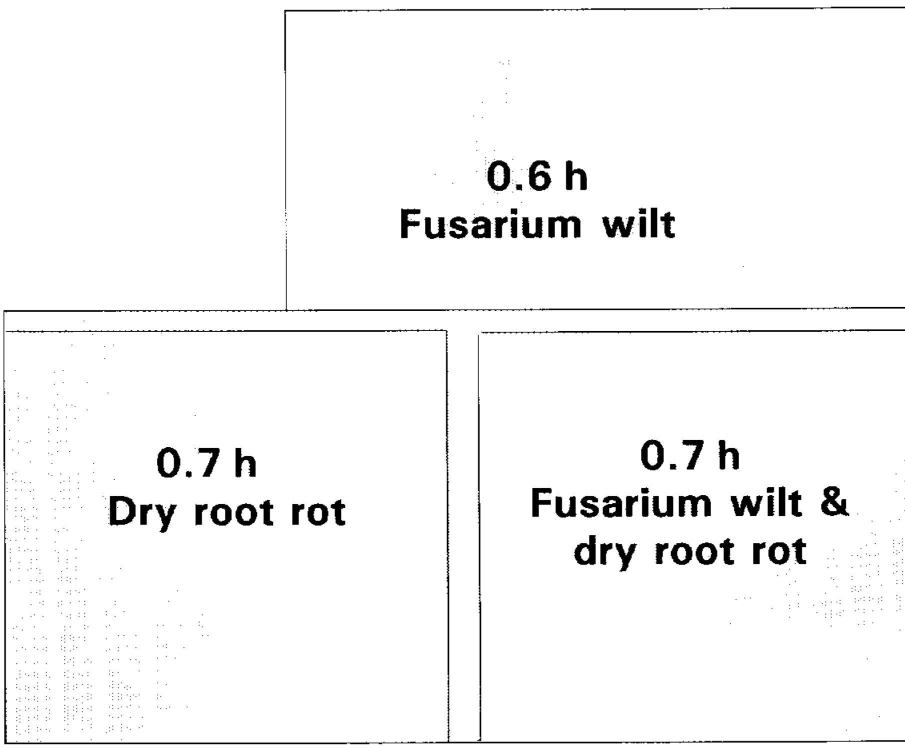


Figure 2.3.9. The wilt and root rot sickplot at Tel Hadya.

Other isolates collected from Kamishly and Hama areas were multiplied in culture and used to inoculate seed for a similar off-season planting done in Oct 1993. The inoculum density and uniformity of inoculum distribution on section A will be assessed using ILC 482 in spring 1994. This procedure generated wilt incidence of about 75% within one month in the June planting. **M.T. Mmbaga and K.B. Singh.**

2.4. Chickpea Entomology

Studies on control methods and host-plant resistance to chickpea leafminer, *Liriomyza cicerina* Rondani, were continued. As for the past 2 years damage by podborer, *Helicoverpa armigera* Hb., has been increasing, all experiments were also evaluated for podborer damage.

2.4.1. Population Dynamics of Chickpea Leafminer and its Parasitoids

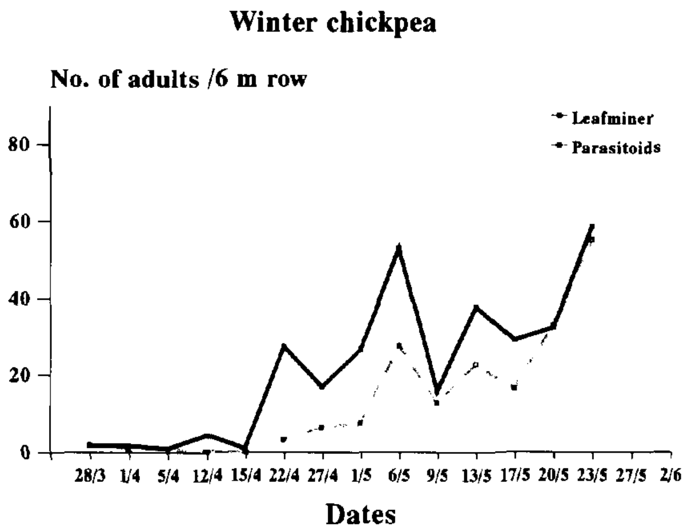
Chickpea leafminer populations were sampled by D-Vac in winter- and spring-sown chickpea plots at Tel Hadya. In winter-sown chickpea leafminer started occurring in early April, reached a first peak in early May and a second in late May before crop maturity (Figure 2.4.1). In spring-sown chickpea leafminer appeared slightly later, in mid April, and did not show two peaks typifying two generations, but rather a continuous build-up reaching a peak in mid May. Population of parasitoids, mainly *Opius monilicornis* and *Diglyphus isaea*, followed the same trend as the population of leafminer (Figure 2.4.1). **S. Weigand and A. Joubi.**

2.4.2. Monitoring of Podborer

Because of the high pod damage in 1992 season monitoring of podborer populations by pheromone traps was continued after chickpea harvest in cotton fields and in 1993 also in tomato crops planted near the previous chickpea fields.

In 1992 the catches in most traps in Tel Hadya were low, except for field B 4 where high numbers were recorded, especially in the beginning of the season (Figure 2.4.2). As this field is closer to the fields planted with summer crops outside the station, the high catches in April/May might reflect the adults moving in from their overwintering sites. In cotton the highest number of podborer were recorded in Tel Hadya village reaching over 1200 moths per trap. In the chickpea fields outside Tel Hadya high podborer numbers were only caught in Al Ghab, but in northern Syria (Alkamiye, Afrin and Jinderess) numbers were low.

In 1993 pheromone catches were similar at Tel Hadya station. In cotton fields around Tel Hadya high numbers of podborer were recorded in Zitan in May and in Banus in September, where populations were low last year (Figure 2.4.3). Banus is located near Tel Hadya, thus the high population recorded in late September can be expected to invade Tel Hadya station after hibernation. In the chickpea fields outside Tel Hadya high numbers of moths were caught in Al Ghab area, especially in Sheikh Yousef, but also in Alkamiye, where numbers were low in 1992.



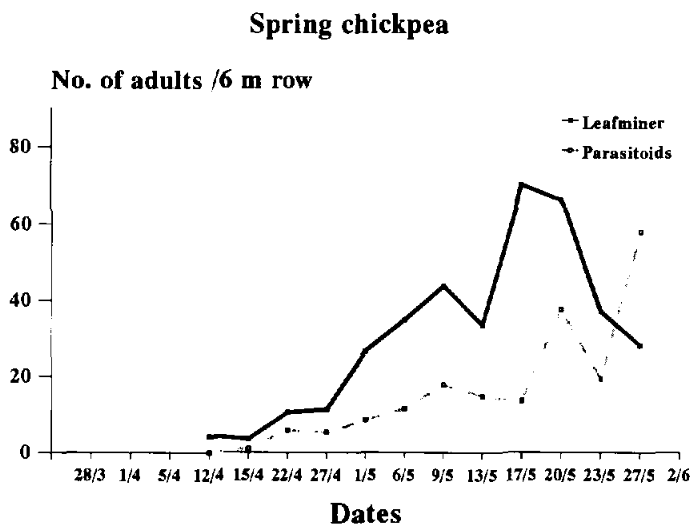


Figure 2.4.1. Development of population of adults of leafminer and parasitoids, as sampled by D-Vac at different sampling dates in winter- and spring-sown chickpea at Tel hadya, 1992/93.

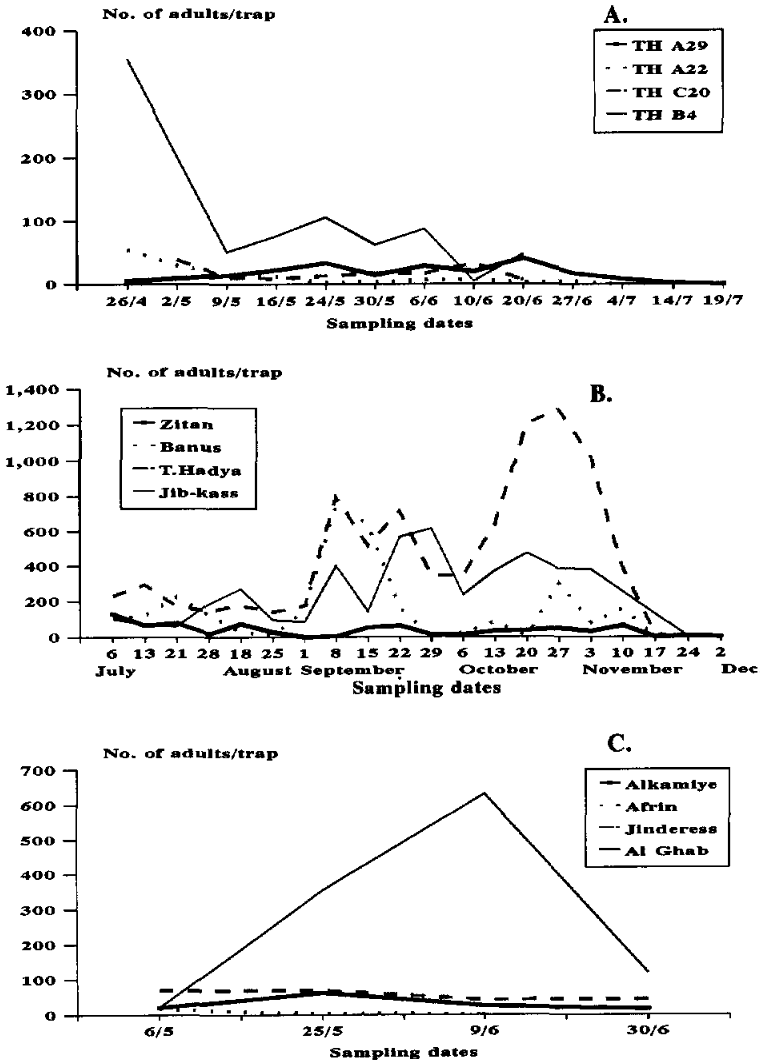


Figure 2.4.2. Pheromone trap catches of podborer, *Helicoverpa charmigera*, in chickpea fields at Tel Hadya station (A), farmers cotton fields around Tel Hadya (B) and chickling on-farm trials (C), 1991.92.

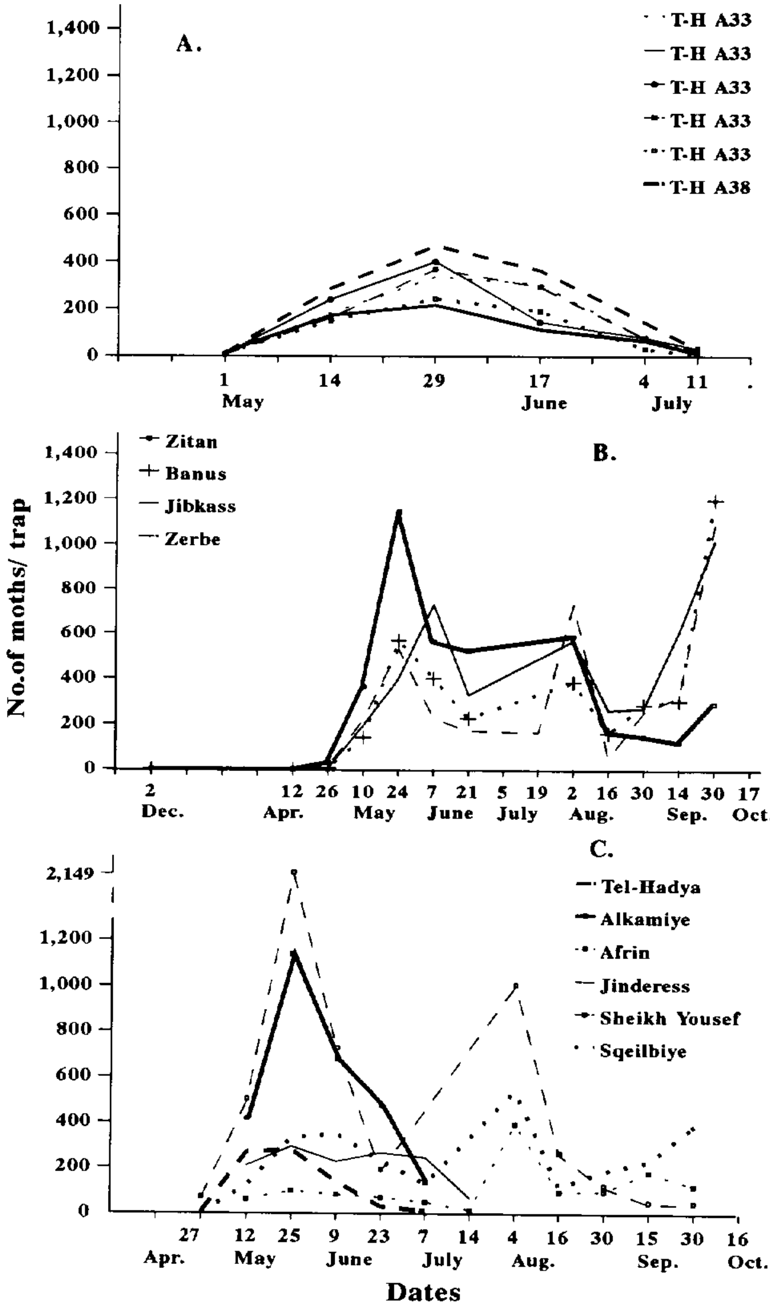


Figure 2.4.3. Pheromone trap catches of podborer, *Helicoverpa charmigera*, in chickpea fields at Tel Hadya station (A), farmers tomato and cotton fields (Banus and Zitan) and cotton fields (Jibkass and Zerbe) around Tel Hadya (B) and chickpea on-farm trials and following cotton fields (C), 1992/93.

The data show the high variation in *H. armigera* populations in regions and years indicating the importance of monitoring. Because of its wide host range management of podborer should be considered in a systems perspective as the damage on chickpea is linked to the surrounding crops. **S. Weigand and A. Joubi.**

2.4.3. Chemical Control of Leafminer and Podborer

The effectiveness of neem (*Azadirachta indica*) seed extract applications as a safe chemical for leafminer and podborer control was further tested in winter- and spring-sown chickpea at Tel Hadya and in spring chickpea at 3 on-farm locations (Afrin, Sqelbiye and Sheikh Yousef). Three sprays consisting of 0.5 kg neem seeds per 10 l water at a rate of 500 l/ha applied in late April, early May and late May were compared with one spray of Thiodan 35 EC (2 cc/l at 500 l/ha) applied in early May. Check plots were sprayed with water (500 l/ha) on the same dates as the neem extract. At Tel Hadya, in addition one spray of Decis 25 (1 cc/l) and one and two sprays of a Bt product in winter- and spring chickpeas, respectively, were tested for podborer control.

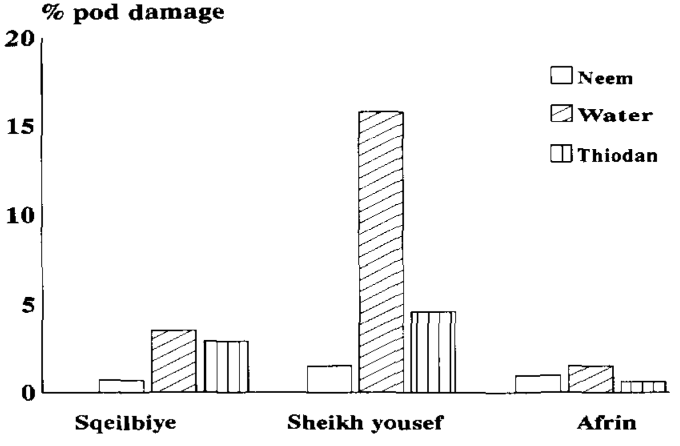
At Tel Hadya, in winter chickpea, the leafminer damage was medium reaching a Visual Damage Score (VDS) rating of 5.3 on a 1 to 9 scale and was reduced significantly only by Decis (Table 2.4.1). Podborer damage was less severe than last year with only 7 % pods damaged in the check, but still significantly reduced by spray of neem only. The Bt spray did not have any effect; Thiodan and Decis slightly reduced the pod damage, but not significantly. Yield differences were not significant.

In spring-sown chickpea leafminer damage was about the same as in winter chickpea (Table 2.4.1). The mining was significantly reduced by Thiodan and Decis, whereas neem and Bt did not have any effect. Although podborer damage was low, it was reduced significantly by all treatments. Seed yield was significantly increased by Thiodan and Decis.

Table 2.4.1. Effect of three applications of neem-seed extract, and one spray of Thiodan 35EC, Decis, and Bt on leafminer infestation (VDS), pod borer damage and seed yield (kg/ha) at Tel Hadya in winter- and spring-sown chickpea, 1992/93.

Treatment	Winter			Spring		
	VDS (17 April)	%pod damage	Seed yield	VDS (2 June)	%pod damage	Seed yield
Neem	4.5	1.8	1741	5.3	0.6	1071
Thiodan	4.5	4.5	1626	2.3	0.3	1150
Water	5.3	7.0	1699	5.3	4.9	1053
Decis	2.8	3.9	1801	2.0	0.6	1173
Dipel (Bt)	5.3	8.7	1758	5.8	3.0	1059
LSD 5%	1.95	5.14	122.5	1.73	1.42	61.4

At the on-farm locations leafminer damage was low at Afrin (VDS 3), relatively high at Squeilbiye and Sheikh Yousef (VDS 5.5 and 6, respectively). At all locations the damage was reduced by neem spray, but differences were not significant. At Sqelbiye and Afrin podborer damage was low (3.5% and 1.5%), but still reduced by neem spray (Figure 2.4.4). Only at Sheikh Yousef pod damage was high with 15.7% and reduced to 1.5% in neem-sprayed plots. Thiodan also reduced pod damage, but less effectively than neem spray. At Sqelbiye seed yield was significantly increased by neem, at Sheikh Yousef by neem and Thiodan, whereas at Afrin yield differences were non-significant.



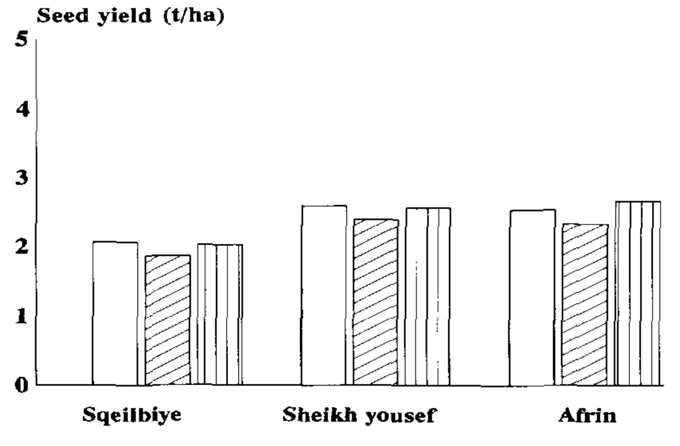


Figure 2.4.4. Effect of 3 applications of neem-seed extract as compared to one spray of Thiodan 35 EC on podborer infestation and seed yield in spring sown chickpea at 3 locations, 1992/93.

These results confirmed the results of the previous two years, that neem extract effectively reduces the percent pod damage in chickpea, but is less effective for control of leafminer. Next season a new commercial synthetic neem product produced in India will be tested, as this would make the application of neem practical in countries where the neem tree cannot be grown.

To study the effect of neem on the leafminer parasitoids leafminer and parasitoid populations were monitored by D-Vac sampling at Tel Hadya. In winter- and spring-sown plots no differences in the number of both leafminer and parasitoids were recorded in the treatments (Figure 2.4.5). However, in this sampling the number of insects was low as compared to the D-Vac sampling in Figure 2.4.1. Most likely, this is due to sampling in different rows each time in border plots for the general population monitoring, whereas in the experiment the same row was sampled each time which would continuously reduce the number of insects. Next season, sampling will be done less frequently and an unsprayed check will be added to the water sprayed one to exclude the possibility that the water sprays reduce leafminer and parasitoid populations. **S. Weigand and A. Joubi.**

2.4.4. Host-Plant Resistance to Leafminer

Of the previously selected 8 promising chickpea lines three (ILC 1216, ILC 3828 and ILC 5901) were grown in winter and spring together with the susceptible check (ILC 1929) without and with one application of Thiodan 35 EC (2 cc/l).

Leafminer infestations were monitored by placing water filled trays between chickpea rows to collect larvae dropping from leaves to soil for pupation and by counting the percent mining in 10 plants per plot. In winter-sown chickpea plots without insecticide application, the number of larvae per tray was highest in ILC 1216 at most sampling dates exceeding the susceptible check, whereas no differences existed between the other 3 lines (Figure 2.4.5). In spite of the high number of larvae, the percent mining in ILC 1216 was low. This was also found last season and is probably due to the late maturity of ILC 1216 which continues vegetative growth when the susceptible ILC 1929 is maturing thereby reducing the percent mined leaves. However, in spring-grown plots the number of larvae and the percent mining was also high in ILC 1216 showing that this line cannot be considered as resistant. In winter- and spring-grown plots ILC 5901 had the lowest number of larvae and percent mining, but only in spring differences were significant. Thus ILC 5901 remains to be the most resistant to chickpea leafminer and will be tested on farmers fields next season.

The percent pod damage was rather low this season, ranging between 5.5 and 7% in winter and 2 and 4 % in spring without significant differences between lines and treatments. Except for ILC 3828 seed yields were higher in winter sowing in all treatments. Significant differences in yield were only found between chickpea lines but not due to insecticide application. Yields of ILC 1929 were significantly higher than of the other three lines. **S. Weigand, K.B. Singh, and A. Joubi.**

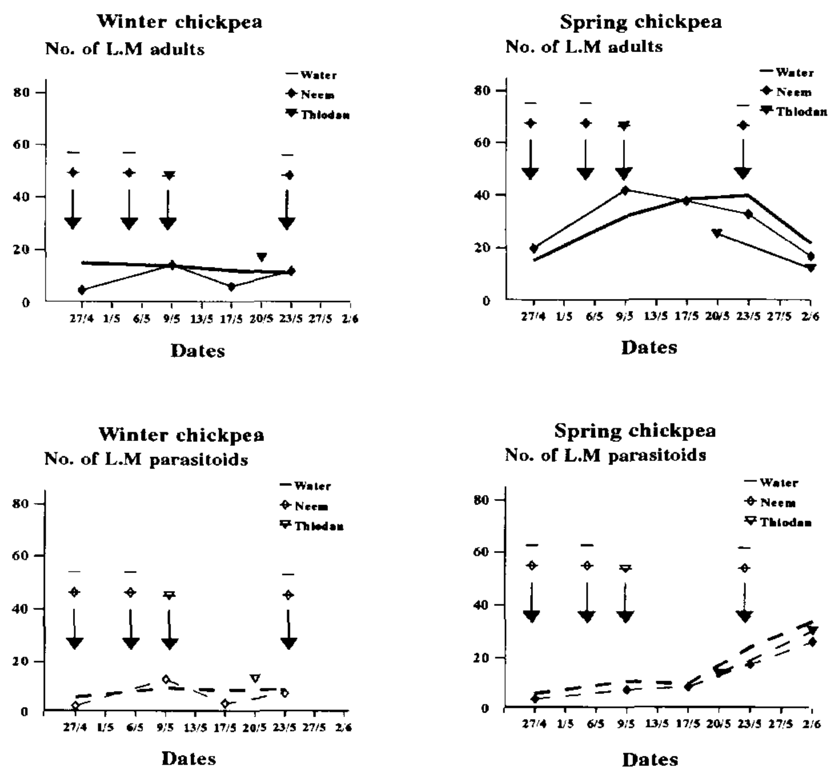


Figure 2.4.5. Effect of 3 applications (arrows show date of spray) of neem-seed extract as compared to one spray of Thiodan 35 EC on leafminer and parasitoid populations in winter- and spring-sown chickpea, Tel Hadya, 1992/93.

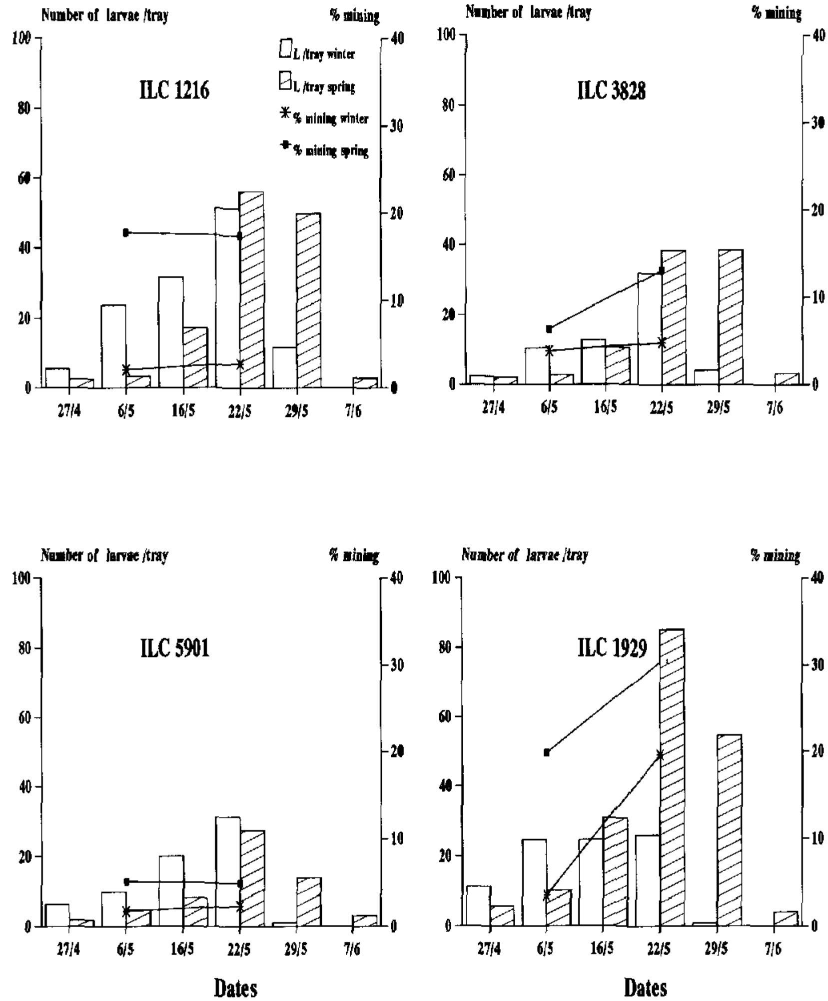


Figure 2.4.6. Development of leafminer larvae population as sampled by water trays and percent mining damage in 4 winter- and spring-sown chickpea lines at Tel Hadya, 1992/93.

3. 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. Agronomic research to develop improved production practices is conducted in coordination with the Farm Resource Management Program, and is extended to the region via the International Testing Network. Increasing the biologically-fixed nitrogen in the wheat-based cropping system is the aim of activities in *Rhizobium* research and *Sitona* weevil control.

3.1. Lentil Breeding

Lentil breeding at ICARDA focuses on three contrasting agro-ecological regions. The importance of the regions in terms of lentil production and the allocation of resources in breeding are summarized together with the respective breeding aims in Table 3.1.1.

Table 3.1.1. Major target agro-ecological regions of production of lentil together with the allocation of resources in breeding and key breeding aims.

Region	% of lentil area in developing countries	% of resources	Key characters for recombination
Mediterranean low to medium elevation	24	75	Biomass (seed + straw), attributes for mechanical harvest, wilt resistance
S. Asia and E. Africa	51	20	Seed yield, early maturity resistance to rust, ascochyta and wilt
High elevation	14	5	Biomass, winter hardiness, attributes for mechanization

3.1.1. Base Program

3.1.1.1. Breeding scheme

The breeding program is divided into three streams directed toward the three target, agro-ecological zones mentioned above. A description of the scheme of breeding was given in the ICARDA Annual Report 1985 (Pages 206).

Approximately 250 crosses are made annually and handled in a bulk-pedigree system using off-season generation advancement. This season we used Terbol Station in Lebanon at 950 m elevation for the summer nursery. Segregating populations targeted for the different regions are distributed through the International Testing Network to national programs for selection and cultivar development *in situ*. Lines with specific characters are distributed in the same manner.

3.1.1.2. Yield trials

Selections from the breeding program for West Asia and North Africa are tested in preliminary and advanced yield trials at three locations varying in their annual average rainfall, namely Breda (long-term average annual rainfall total c. 260 mm) and Tel Hadya (c. 330 mm) in Syria and Terbol (c. 550 mm) in Lebanon. The winter of 1992/93 season was colder than average with 54, 48, and 83 frost nights recorded at Breda, Tel Hadya and Terbol, respectively. The rainfall was below the long-term average in Syria but well distributed, whereas it was above average at Terbol in Lebanon with 285, 276, and 664 mm received to the end of May at Breda, Tel Hadya and Terbol, respectively. Biomass mean yields were 3.4 t/ha at Breda, 4.1 t/ha at Tel Hadya and 6.2 t/ha at Terbol. The same trend was observed for seed yield production with 1.1, 1.6 and 2.5 t/ha realized at Breda, Tel Hadya and Terbol, respectively. A summary of the results of the yield trials is given in Table 3.1.2.

For seed yield the percentages of lines significantly outyielding the best check at P = 0.05 were 12, 2 and 4 % at Terbol, Tel Hadya and Breda, respectively. More test lines merely ranked above the best check for seed yield, representing 16, 15 and 28 % of the total lines tested at Terbol, Tel Hadya and Breda, respectively. The results for biomass follow the same pattern as for seed yield. **W. Erskine.**

3.1.1.3. International nurseries

The lentil international breeding nurseries have evolved in response to the needs of NARSs from the provision of untargeted yield trials to a diversified array of crossing blocks/resistant sources, segregating populations and yield trials for each of the three major target agro-ecological regions of production (Table 3.1.3). Since 1987, for example, we have diversified and targeted the supply of segregating material from two into four different nurseries - Cold Tolerant, Large-seeded, Small-seeded and Early. In the same period, new nurseries of stress resistant material have been launched against rust, Ascochyta blight, Fusarium wilt and cold.

Table 3.1.2. 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 1992/93 season.

Location	Terbol		Tel Hadya		Breda	
	S	B	S	B	S	B
Number of trials	6	6	9	9	7	7
Number of test entries*	132	132	191	191	147	147
% of entries sig. (P<0.05) exceeding best check**	12	2	2	1	4	4
% of entries ranking above best check (excluding above)	16	23	15	11	28	20
Yield of top entry (kg/ha)	2977	7550	2191	4668	1962	5600
Best check yield (kg/ha)	2607	6531	1764	4512	1296	3846
Location mean (kg/ha)	2477	6157	1574	4107	1104	3453
Range in C.V. (%)	6-9	5-9	8-25	7-15	10-24	7-26
Mean advantage of lattice over RBD (%)	2.3	2.2	37.5	40.7	5.2	7.4

* Entries common over locations.

** Large-seeded checks: ILL 4400 long-term, 78S26002 improved; Small-seeded checks: ILL 4401 long-term, ILL 5883 improved.

In the 1993/94 program we have reduced the yield trials for distribution because of low seed multiplication. In addition, in the trials for the Mediterranean target region we have started distributing small seeded lines all of which have resistance to vascular wilt. Thus, all entries in the Lentil International Screening Nursery - Small seeded - 94 have resistance to wilt.

Table 3.1.3. Lentil international breeding nurseries showing target regions and type of nursery in the 1993/94 season.

Type of nursery	Region		
	Mediterranean	Lower latitudes	High elevation
Resis. source/ crossing block	Large-seeded Small-seeded Fusarium wilt*	Early* Rust* Ascochyta blight*	Cold tolerant*
Segregating population	Large-seeded* Small-seeded*	Early	Cold tolerant*
Yield trial		Early	

* Launched since 1987.

In the last two seasons there has been an increase in the number of entries in international trials provided by national programs. It is our aim to increase the input of national programs into the international testing program. Included in 1994 international trials were three lines from Russia, three from Faisalabad, Pakistan and one from Islamabad, Pakistan. Other entries have been supplied by NARSs and are in multiplication for inclusion in next season's trials.

All plant material distributed by ICARDA undergoes strict phytosanitary examination prior to shipment. In lentil among the tests undertaken are ELISA tests for the seed-borne viruses - bean yellow mosaic virus (BYMV), broad bean stain virus (BBSV) and pea seed-borne mosaic virus (Psbmv). The major virus among these is BBSV which is transmitted by *Sitona* weevil. To control the infestation level of BBSV we have planted uninfected seed treated with Promet insecticide to control the vector. As a result of this control strategy, the percentage of lines infected has been reduced from above 25% to c. 10 % (Figure 3.1.1). **W. Erskine, K. Makkouk and R.S. Malhotra.**

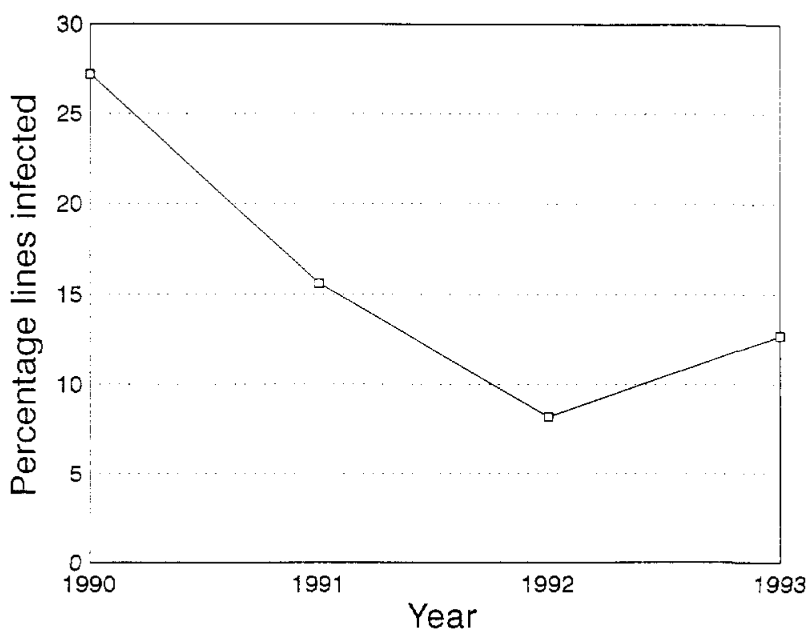


Figure 3.1.1. The percentage of lentil lines infected with virus (BBSV, PsbMV, BYMV) over the period 1990-1993 at Tel Hadya station, Syria.

3.1.1.4. Screening for vascular wilt resistance

Vascular wilt caused by *Fusarium oxysporum* f.sp. *lentis* is the major fungal disease of lentil in the Mediterranean region.

Screening for wilt resistance in the 1992/93 season concentrated on adult plant reaction in infected soil in the field at Tel Hadya. The field sick plot, developed over a three year period, has a high inoculum potential with a relatively uniform distribution (Legume Program Annual Report 1992, Pages 134-6). This, in conjunction with frequently-repeated, susceptible checks (every third row), has minimized disease escape. A range of breeding material and germplasm, both wild and cultivated, were screened in the season. A list of confirmed resistant sources to lentil vascular wilt is given in Table 3.1.4.

Table 3.1.4. Sources of resistance to lentil vascular wilt at Tel Hadya, Syria.

Name	Accession no.	Parentage (ILL)	Origin
162	4403	-	Pakistan
78S26013	5588	-	Jordan
FLIP84-43L	5714	ILL 500 X ILL1719	ICARDA
FLIP85-33L	5871	ILL 176 X ILL 35	ICARDA
81S15	5883	UJL197 X ILL4400	Jordan
FLIP86-38L	6024	ILL 262 X ILL3458	ICARDA
FLIP86-39L	6025	ILL 1 X ILL 936	ICARDA
FLIP87-68L	6258	ILL4353 X ILL4400	ICARDA
FLIP88-3L	6427	ILL5506 X ILL5582	ICARDA
FLIP88-34L	6458	ILL5584 X ILL2501	ICARDA
FLIP89-39L	6797	ILL 223 X 79SH4901	ICARDA
FLIP90-7L	6976	ILL 30 X ILL 851	ICARDA
FLIP90-22L	6991	ILL5588 X ILL 223	ICARDA
FLIP90-36L	7005	ILL 788 X ILL5588	ICARDA
FLIP90-43L	7012	ILL4354 X ILL1880 X ILL813	ICARDA
FLIP92-15L	7180	ILL5588 X ILL5714	ICARDA
FLIP92-27L	7192	ILL5588 X ILL5883	ICARDA
FLIP92-28L	7193	ILL5588 X ILL5883	ICARDA
FLIP92-34L	7199	ILL1939 X ILL5883	ICARDA
FLIP92-39L	7204	ILL5676 X ILL1880	ICARDA

A core collection of 577 accessions from 34 different countries, representative of the ICARDA lentil germplasm collection, was evaluated for resistance to lentil wilt in the sick-plot in the 1992/93 season. Twenty seeds/accession were hill-planted (37.5 cm between hills) in a randomized block design with 3 replicates with a susceptible check (ILL 4605) sown in every third plot. Test entries were scored (% of wilted plants/hill) every three days after April 14 until June 10, when most of the accessions were mature.

Data from three scores (April 14 (1^{st}) and 28 (5^{th}) and 10 May (9^{th}) were analyzed and there were significant differences amongst entries for reaction to wilt at each scoring date (Table 3.1.5). Percentage of wilted plants ranged between 0 - 38% in the 1^{st} score and 0 - 100% by the 5^{th} and 9^{th} scores. Coefficient of correlation between different scores peaked (r= 0.698) between the 5^{th} and 9^{th} scores indicating that evaluation might be done at an intermediate stage of disease development. It was lowest (r=0.285) between the 1^{st} and 9^{th} scores which indicates the unreliability of scoring at an early stage of disease development.

Table 3.1.5. Reaction of germplasm accessions and breeding lines screened for resistance to lentil vascular wilt in the field at Tel Hadya in the 1992/93 season.

Type of material	Number of resistant acc./lines	% of total	Number of susceptible acc./lines	Total number acc./lines
Core germplasm collection	85	14.7	492	577
Breeding lines	130	40.6	116	320

The mismatch between early and late disease scores is caused by different patterns of disease development. Four such types of reaction to wilt were observed in relation to plant growth stage (Figure 3.1.2).

- In Type 1, genotypes were resistant to wilt throughout growth and are represented by the accession ILL 3293 in Figure 3.1.2.
- In Type 2, wilt development started early in the growing season and progressed to maturity. This early-wilting habit is represented by the accession ILL 6535 in Figure 3.1.2.
- In Type 3, wilt developed relatively late and progressed to maturity. The accession ILL 6869 represented this reaction type in Figure 3.1.2.
- In Type 4, wilt development did not start until very late in the growing season. Accessions in this group were rated resistant at 1^{st} and 5th scoring date and susceptible at maturity. This reaction type is represented by ILL 3119 in Figure 3.1.2.

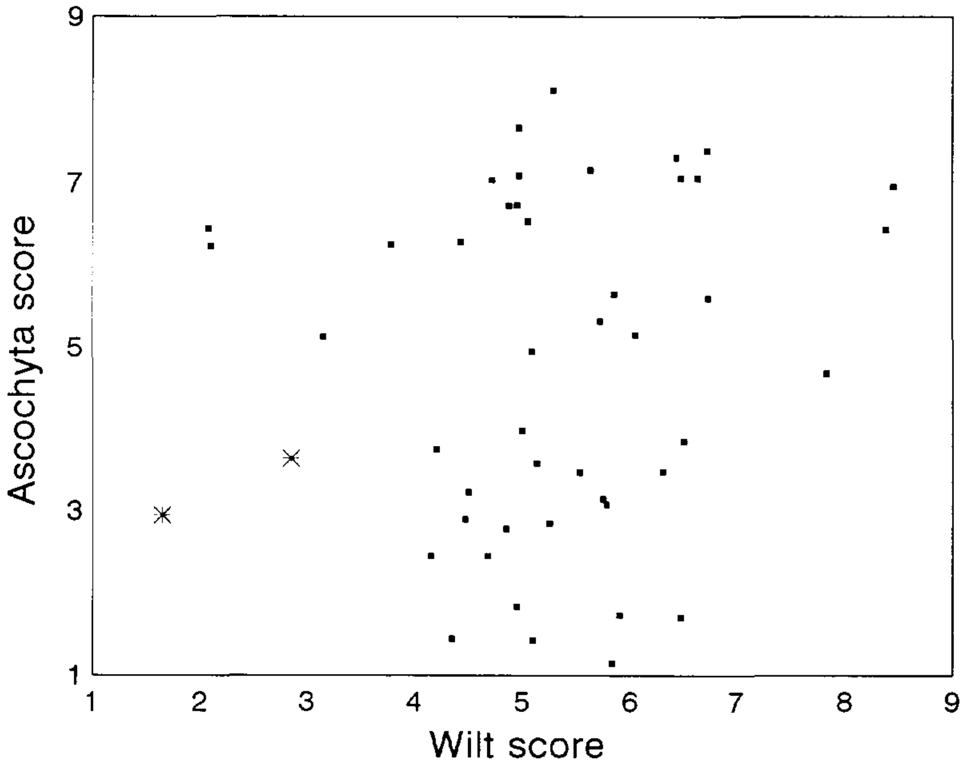


Figure 3.1.2. Disease scores for Ascochyta blight and vascular wilt of lines screened for combined resistance at Tel Hadya in the 1992/93 season. Rating scale 1-9 with 1 = resistant and 9 = susceptible.

Based on the final score, two groups of resistant/tolerant accessions were formed (Table 3.1.5): Group 1 comprised 22 accessions with an average percentage of wilted plants between 0-5%. Group 2 comprised 63 accessions with an average percentage of 15% (0-20%) wilted plants. All 85 resistant accessions will be revaluated next season to confirm their resistance.

In addition to germplasm screening, 320 breeding lines were also screened for wilt resistance in the field in the 1992/93 season (Table 3.1.5). Resistance was found in 130 lines representing 40.6%. The corresponding percentage of resistant accessions in the unimproved germplasm collection was only 14.7 %. The high proportion of resistant material in the breeding material emanates from the previous widespread use of wilt-resistant parental lines in the crossing block.

The screening of wild lentil for resistance to lentil vascular wilt is reported under Section 3.1.1.9.

Preliminary investigations on biocontrol of lentil vascular wilt

Wilt severity was positively correlated with inoculum concentration in laboratory experiments, but the relationship was not maintained in the field (Legume Program Annual Report 1992, Pages 136-9). To investigate this difference, soil samples were collected from sites varying in disease severity within a field. Different media were used to isolate the microorganisms associated with the various soil samples.

Antibiosis was studied *in vitro* by confronting a pathogenic isolate of *Fusarium oxysporum* f.sp. *lentis* with each of the isolated bacteria. This resulted in the identification of nine isolates (*Bacillus* sp.), which inhibited fungal growth from 33 - 62%.

Effects of antagonistic bacteria on seed germination, disease severity, plant height, podding and seed formation were studied in the laboratory and in pots in the plastic house. Lentil seeds treated with 8 of the nine antagonists germinated normally. The remaining isolate reduced germination to 40%.

The isolates which showed maximum inhibitory effect on the fungus *in vitro* were applied to soil in pots in a plastic house either a week before planting (3 weeks before inoculation with the fungus) or at sowing. Adding the antagonist at different concentrations stimulated plant growth (9-28% increase in plant height), podding and seed formation (4 fold compared to the untreated control), and decreased disease severity by 20-23%. These effects were greatest when the antagonist was added before sowing. Also the effect on plant height was pronounced during the first 2 weeks. The exploitation of these microorganisms will be researched next season. **W. Erskine and B. Bayaa (Aleppo University).**

3.1.1.5. Screening for resistance to Ascochyta blight

Ascochyta blight (*Ascochyta fabae* f.sp. *lentis*) is considered to be among the most important biotic stresses affecting crop productivity, particularly in Canada, Ethiopia, parts of the Indian sub-continent and the region of West Asia and North Africa. Losses are not only to the standing crop, but also through reduced seed quality from infection in the swathe. Chemical control is too expensive for practical blight control and host-plant resistance remains the most feasible and environmentally-sound means of disease management.

Screening for resistance to Ascochyta blight was conducted at Tel Hadya in the 1992/93 season. A total of 47 lines were screened in the plastic house using the techniques described in Legume Program Annual Reports 1991 (Pages 99-102) and 1992 (Page 141). Results revealed uniform susceptibility of the check over both trays and replicates and good sources of resistance to Ascochyta blight with 12 lines scoring 1-3 in the final score (1-9 scale). **W. Erskine and B. Bayaa (Aleppo University).**

3.1.1.6. Screening for resistance to rust

Rust caused by *Uromyces fabae* is the major fungal disease affecting lentil in the Indian sub-continent, Ethiopia and Morocco. Systematic screening for resistance was initiated three seasons ago in collaboration with the Moroccan national program in a disease 'hot-spot' at Jemma Sheim. Unfortunately, the winter in Morocco was very dry and screening was not possible this year.

3.1.1.7. Multiple disease resistance

As a result of extensive screening for vascular wilt resistance in the last season at ICARDA Tel Hadya, we have identified several examples of multiple disease resistance within existing breeding material.

For example, the lines screened for resistance to Ascochyta blight (Section 3.1.1.5) were also screened for resistance to vascular wilt. The results show two lines with combined resistance to Ascochyta blight and wilt (Figure 3.1.3).

All the various two-way combinations of resistance to the three diseases - Ascochyta blight, rust and wilt - are available (Table 3.1.6). The rust and Ascochyta screening was done in collaboration with the national programs of Pakistan and Morocco. In addition to the two-disease combinations, examples of multiple resistance to all three diseases have been identified. The line ILL 6258 is resistant to Ascochyta blight and wilt and also moderately resistant to rust. Similarly, ILL 6024 has a high level of resistance to rust and wilt, moderate resistance to Ascochyta and tolerance to Botrytis blight. **W. Erskine, B. Bayaa (Aleppo University) and NARSs.**

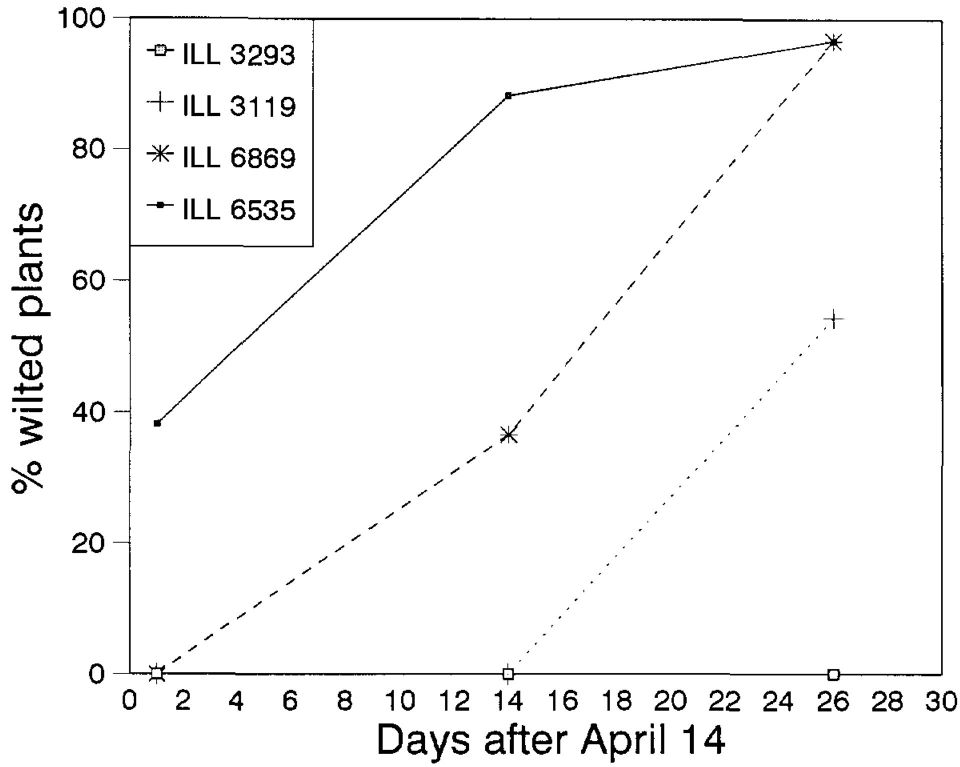


Figure 3.1.3. Contrasting reactions to lentil vascular wilt of four lines (through time (April 1993) in the wilt-sick area, Tel Hadya. (Resistance to wilt throughout growth - Line ILL 3293; early wilter - ILL 6535; medium wilter - ILL 6869; late wilter - ILL 3119.)

Table 3.1.6. Some examples of multiple disease resistance in lentil with combinations of resistance to Ascochyta blight, rust and vascular wilt

Accession no. (ILL)	Ascochyta blight	Rust	Vascular wilt
2439	R	S	R
4605	MR	R	S
5588	R	S	R
5714	R	S	R
5871	R	na	R
5883	T	R	R
6024	MR	R	R
6025	R	S	R
6212	MR	R	S
6258	R	MR	R
6264	na	R	R
6458	R	S	R

R = Resistant, MR = Moderately resistant, T = Tolerant, S = Susceptible
na = Data unavailable.

3.1.1.8. Screening for winter hardiness

Lentil is currently sown in spring in Turkey at elevations above c. 850 m elevation on c. 250 000 ha. Research in Turkey has indicated that yields may be increased by up to 50 % by early sowing in late autumn with winter hardy cultivars. However, the use of such cultivars is not yet widespread in Turkey, because at high elevation the level of winter hardiness is inadequate in cold winters and winter hardiness has not yet been transferred from germplasm sources into acceptable cultivars.

An effective field screening method is needed to select for winter-hardy material, both in segregating and exotic germplasm. In collaboration with the Central Research Institute for Field Crops, studies to develop a field screening method were conducted at Haymana research farm, located south-west of Ankara at an altitude of 1050 m above sea level in the winters of 1991/92 and 1992/93. This location has a long and cold winter season with high snow fall.

The experiment was done in split-plot design with sowing dates as the main-plot factor with a factorial of density x cultivars in sub-plots in three replications. Sowing dates were from early October through mid-November. Two seed densities were 200 seeds/m^2 and 400 seeds/m^2. Eight cultivars, including three winter hardy (Sazak 91, ILL 465, ILL 1918), two winter tolerant (ILL 468, ILL 4400), and three susceptible (ILL 2590, ILL 3493, ILL 5582), were used.

The winter in both seasons (1991/92 & 1992/92) being among the coldest for 20-30 years, the effects and interactions of planting time, seed density and genetic material on winter hardiness became very clear. Combined analysis of two years results revealed the following:

a. Early sowing differentiated winter-hardiness best.
b. Seed density affected the cold tolerance of genetic material. At low plant population levels seedlings were more prone to cold damage than at the high density.
c. Winter-susceptible lines were killed at both seed densities. Moderately winter-hardy lines sown early had no survival at the lower density; and, at the higher seed rate, the plant population was reduced. However, the more winter hardy lines survived at both seed densities with a better crop stand at high seed density.
d. Under the conditions of Haymana and in the absence of early rainfall, irrigation should be used on early sown material to screen for winter-hardiness to initiate germination and vegetative growth before winter.

An isozyme survey using starch gel electrophoresis of these eight lines revealed variation between and within lines for 12 loci namely *Aat-2* (Aspartate Amino Transferase), *Aat-3*, *Acp* (Acid Phosphatase), *Adh-1* (Alcohol Dehydrogenase), *Adh-2*, *Adh-3*, *Idh* (Isocitrate Dehydrogenase), *Lap-1* (Leucine Aminopeptidase), *Mdh-1* (Malate Dehydrogenase, *6Pgd-1* (6-Phosphogluconate Dehydrogenase), *6Pgd-2* and *Prx-1* (Peroxidase). They were monomorphic for the isozymes of Amylase, Diaphorase, Glucose-1-Phosphate Transferase, Glucose Phosphate Isomerase, Glucose-6-Phosphate Dehydrogenase, Phosphoglucomutase and Shikimic Dehydrogenase. Heterozygotes were also observed in the populations for *Adh-1* and *Adh-3*. Analysis of these lines for morphological and chemical traits is also being conducted.

In addition to refining the selection environment for winter-hardiness, the variability for winter-hardiness in cultivated lentil germplasm was examined in the 1991/92 and 1992/93 seasons.

An experiment was conducted at two locations in Turkey, namely, Haymana research farm (elevation 1050 m) and International Winter Cereal Research Center in Konya (elevation 1050 m). A total of 86 randomly-selected accessions of cultivated lentil were used ranging from highly susceptible to winter hardy. A 1-9 scale, with 1= resistant and 9= killed, was used to score for cold tolerance.

In the 1991/92 season winter damage was greater at Hymana than at Konya. The highest score in either replication was taken as the reaction of the entry to cold. The lowest score at Haymana was 4 with only one accession achieving that score (Table 3.1.7). However, the lowest score at Konya was 2 with more than one accession scored as 2. At Haymana only two accessions scored 5 or less, whereas at Konya there were 22. Moreover, most accessions were scored as 9 at Haymana; whereas, at Konya most were scored as 8.

Table 3.1.7. Number of lentil accessions in each reaction group to winter cold at Haymana and Konya.

Cold score	Konya 1991/92	Haymana 1991/92	Haymana 1992/93
1	-	-	-
2	2	-	-
3	5	-	-
4	4	1	-
5	13	1	8
6	6	4	8
7	13	12	12
8	24	11	19
9	19	57	39

In the 1992/93 season germination at Konya was unsatisfactory because of the dry autumn and plants were not scored for winter hardiness. At Haymana germination was facilitated by sprinkler irrigation and the winter was again one of the coldest for 20 years. Scoring for winter hardiness was made in spring after the susceptible check, Malazgirt 89 (ILL 1384), was killed. The number of lines falling into each damage rating is given in Table 3.1.7. The cold scores are taken as average of two replications.

In both years range in reaction to winter cold was clear at Haymana. There was only one line (ILL 662) with cold scores of 5 or less in both seasons at Haymana and the sole season at Konya. There was another line (ILL 1879) with a cold score of 5 in both years at Haymana. In addition, six other lines had a cold score of 5 at Haymana in 1992/93 season and less than 5 at Konya in 1991/92 season.

Highly significant correlations for cold tolerance score were found between Konya 1991/92 and Haymana 1991/92 ($r = 0.68^{**}$), Konya 1991/92 and Haymana 1992/93 ($r = 0.59^{**}$), Haymana 1991/92 and Haymana 1992/93 ($r = 0.62^{**}$). Clearly, variation for winter hardiness in this experiment was due to genotypic differences rather than environmental differences.

Several morphological traits were scored on these lines in a spring planting at Haymana. Some additional chemical analyses are underway. The relationship between winter hardiness and the chemical and morphological traits will be studied. **I. Kusmenoglu (Central Research Institute for Field Crops, Ankara Turkey) and W. Erskine.**

3.1.1.9. Evaluation of wild lentil germplasm

From 1990 to 1993 we conducted a comprehensive evaluation of wild lentil genetic resources for resistance to key stresses. The evaluation has covered winter hardiness and drought tolerance, and resistance to lentil vascular wilt and Ascochyta blight. Additionally we have examined the variation in agronomic characters. Part of this research was reported in Legume Program Annual Reports. But it is appropriate to summarize the results of most of the component parts of the wild lentil evaluation project in one place.

<u>Screening for agronomic characters</u>
An evaluation of wild lentil germplasm for agronomic characters was conducted in the field at Tel Hadya for two seasons on a total of 121 accessions of *Lens* species (1990/91 & 1991/92) (Legume Program Annual Reports 1991 (Pages 105-106) & 1992 (Pages 105-7). For grain yield, straw yield and seed mass, there was no striking variation within the wild species for transfer to the cultigen. However, there were some accessions of *L. culinaris* subsp. *orientalis* that were faster to flower and mature than the earliest cultivated check (ILL 4605) in both seasons. This precocity will be of value to the crop improvement program.

<u>Screening for winter-hardiness</u>
Screening for winter hardiness of 255 accessions of the different subspecies of the genus *Lens*, in addition to three accessions of *Vicia montbretii* (syn. *L. montbretii*), was done at Maadar in Syria and Hymana in Turkey during the 1991-92 season. At Maadar there were 96 frost nights in the growing season and the absolute minimum temperature was -16.0°C, and at Hymana there were 109 frost nights and the absolute minimum temperature was -18.9°C. In both locations the susceptible indicators were killed, indicating that the cold was sufficient for screening. Accessions of *L. culinaris* ssp. *orientalis* showed the highest level of winter hardiness among *Lens* taxa, whereas accessions of *L. nigricans* ssp. *ervoides* were the most susceptible. The most winter-hardy lines and their origins are listed in Table 3.1.8. Correlation showed that winter hardiness was found in accessions originating from high elevation areas. **A. Hamdi, Mr. I. Kusmenoglu (Central Research Institute for Field Crops, Ankara) and W. Erskine.**

Table 3.1.8. Accession number (Acc. no.) and origin of the most winter hardy wild lentil lines at Hymana (Turkey), and Maader (Syria) in 1991-92 season.

Acc. no. (ILWL)	Subspecies	Origin	Winter hardiness	
			Hymana	Maader
6	*orientalis*	Turkey	MT	T
81	*orientalis*	Turkey	T/MT	T
89	*orientalis*	Turkey	INT	T
90	*orientalis*	Turkey	INT	T
91	*orientalis*	Turkey	T/MT	T
97	*orientalis*	Turkey	MT	MT
112	*nigricans*	Turkey	INT	MT
180	*orientalis*	Syria	INT	MT
309	*orientalis*	Turkey	INT	T
312	*orientalis*	Turkey	INT	MT
313	*orientalis*	Turkey	INT	T

INT = Intermediate; MT = Moderately tolerant; T = Tolerant.

Screening for drought tolerance

Susceptibility to moisture stress is a key factor in rainfed lentil production in the Mediterranean region of West Asia and North Africa. We examined the response to drought stress of 121 accessions representative of all subspecies of the genus *Lens* under two moisture regimes (rainfed and rainfed plus supplemental irrigations) at Breda during the 1990-91 (241 mm total seasonal rainfall) and 1991-92 (263 mm total rainfall) seasons.

The cultivated lentils contrasted with their wild relatives in their markedly superior biomass and water use efficiency. Clearly, direct selection of wild lentil germplasm for biomass yield under dry conditions is of little value. However, wild subspecies were more drought resistant than the cultigen with their low relative reduction in yield with drought stress. It may be valuable to transfer this resistance to the cultivated lentil. Among wild subspecies, the most resistant to drought were *L. culinaris* ssp. *odemensis* and *L. nigricans* ssp. *ervoides*. There was, however, considerable variability within subspecies, indicating the possibility of selection for drought resistance within different subspecies.

Time to flower accounted for only 2.4% and 6.8% of the variation in rainfed yield of wild accessions in the two seasons, showing that, in contrast to the cultigen, drought escape was an unimportant resistance mechanism in wild lentil. The drought resistance in wild lentil was almost randomly distributed among collection locations with little relation to collection site aridity, providing further evidence of differences between wild and cultivated lentil in drought response.

In summary, direct selection of wild lentil germplasm for biomass yield under dry conditions is of little value, but it may be valuable to transfer the drought resistance of wild lentil to the cultigen. **A. Hamdi and W. Erskine.**

Screening for resistance to vascular wilt

Wild lentils represent an unexplored potential source for disease resistance. Screening 219 accessions of *Lens* wild species and 2 accessions of *V. montbretii* for resistance to a Syrian isolate of this fungus in the seedling stage was conducted under artificial inoculation in a plastic house. Resistance at the adult stage was confirmed both in a pot trial in a plastic house and in a wilt-sick plot.

Three accessions of *Lens culinaris* ssp. *orientalis*, three accessions of *L. nigricans* ssp. *nigricans* and two accessions of *L. nigricans* ssp. *ervoides* maintained their resistance at the adult stage in the plastic house. All accessions of *L. culinaris* ssp. *odemensis* and both accessions of *Vicia montbretii* were susceptible. In the sick plot, only three accessions maintained resistance (Table 3.1.9). Resistance at the seedling stage was often found in accessions collected at northern and western sites at low elevations. The most resistant accessions in the field at the adult stage were *Lens culinaris* ssp. *orientalis* ILWL 79 and 113 from Turkey and *L. nigricans* ssp. *ervoides* ILWL 138 from Syria.

Screening for resistance to Ascochyta blight

Screening 248 accessions of the ICARDA wild lentil germplasm collection for resistance to a Syrian isolate of this fungus was conducted under artificial inoculation in a plastic house. The reaction of resistant accessions was confirmed in a second trial.

Twenty-four out of 86 accessions of *Lens culinaris* ssp. *orientalis* were resistant, as were 12 of 35 accessions of *L. culinaris* ssp. *odemensis*, 3 of 35 accessions of *L. nigricans* ssp. *nigricans*, 36 of 89 accessions of *L. nigricans* ssp. *ervoides*, and all 3 accessions of *Vicia montbretii* (Table 3.1.10). Sixty-four % of resistant sources were from Syria and southeastern Turkey. Disease reaction was correlated neither with the altitude of collection nor with its annual average rainfall. A significant correlation ($r = 0.281$) between leaflet width and disease reaction was due more to the frequency of the resistant reaction within the narrow-leaved *L. nigricans* ssp. *ervoides* than as a function of small leaf area. Disease reaction was uncorrelated with a range of other morphological traits. **B. Bayaa (University of Aleppo), W. Erskine and A. Hamdi.**

Table 3.1.9. Mean Fusarium wilt score in seedling (trays) and adult (pots) stages and percentage of wilted plants (field) of the most resistant wild lentil accessions with their accession number (ILWL) and country of origin.

Acc. no. (ILWL)	Sub-species	Origin	Wilt score Trays+	Wilt score Pots	% wilted plants
79	*L. culinaris* ssp. *orientalis*	Turkey	1.3	0.9	34
113	*L. culinaris* ssp. *orientalis*	Turkey	2.1	3.2	3
138	*L. nigricans* ssp. *ervoides*	Syria	1.43	2.4	15
SE (±)			1.07		7.1

+ 1-9 scale; 1= highly resistant and 9= highly susceptible.

3.1.1.10. Field evaluation of a model of photothermal flowering responses in a world lentil collection

A model to predict flowering time in diverse lentil genotypes grown under widely different photothermal conditions was developed in controlled environments in collaboration with the University of Reading Plant Environment Laboratory (Food Legume Improvement Program Annual Report 1988 (Pages 80-85). The flowering response was found to be governed by both temperature and photoperiod and to be well described by the relation

$$1/\underline{f} = \underline{a} + \underline{b}\bar{\underline{T}} + \underline{c}\bar{\underline{P}},$$

where $\underline{f}$ is the time from sowing to first flowering, $\bar{\underline{T}}$ and $\bar{\underline{P}}$ are the respective values of mean temperature and photoperiod during that period, and $\underline{a}$, $\underline{b}$ and $\underline{c}$ are genotypic constants.

The present study evaluated the model with a world germplasm collection in the field in Syria and Pakistan. A total of 369 germplasm accessions were evaluated for time to flower at ICARDA, Tel Hadya, Syria and at the National Agriculture Research Centre, Islamabad, Pakistan. The accessions comprised 25 randomly-selected germplasm accessions from the following major lentil-producing countries: Afghanistan, Chile, Egypt, Ethiopia, Greece, India, Iran, Jordan, Lebanon, Pakistan, Syria, Turkey and the former Soviet Union together with elite accessions from the ICARDA breeding program and registered varieties. In Syria, the experiment was sown in a split-plot design with sowing dates of 30 December 1986 and 2 February 1987, as main plots and accessions as sub-plots in two replications. In Pakistan, a randomized block design was used for sowing on 11 November 1986 and on 30 November 1991 in two replications.

Table 3.1.10. Accession number (ILWL*), country of origin and mean disease scores from two screenings for those accessions with disease scores < 3.

ILWL	Origin	Disease score 1	2	ILWL	Origin	Disease score 1	2
Lens culinaris ssp. *orientalis*				*Lens nigricans* ssp. *nigricans*			
4	Turkey	1.0	1.0	110	Turkey	1.3	1.2
7	Turkey	1.0	1.4	190	Turkey	1.6	1.0
69	Uzbekistan	1.6	1.8	311	Turkey	1.0	1.0
77	Unknown	1.0	1.1	*Lens nigricans* ssp. *ervoides*			
80	Turkey	1.0	1.0	41	Turkey	1.2	1.2
84	Turkey	2.2	1.4	45	Yugoslavia	1.0	1.0
86	Turkey	1.6	1.3	50	Yugoslavia	1.5	1.0
88	Turkey	1.6	1.6	58	Turkey	1.0	1.0
93	Turkey	1.0	1.0	63	Turkey	1.0	1.0
94	Turkey	2.0	2.5	123	Syria	1.0	1.0
117	Syria	1.0	1.2	128	Syria	1.0	1.0
118	Syria	1.2	1.5	129	Syria	2.8	1.8
121	Syria	1.0	1.0	130	Syria	1.0	1.0
146	Syria	1.0	1.0	133	Syria	1.0	1.4
180	Syria	1.0	1.0	134	Syria	1.3	1.1
181	Syria	1.2	1.2	136	Syria	1.0	1.0
248	Syria	1.3	1.0	138	Syria	1.0	1.3
257	Syria	1.6	1.0	139	Syria	1.0	1.0
277	Syria	1.6	1.0	141	Syria	1.3	1.0
302	Turkey	1.4	1.9	142	Syria	1.0	1.0
304	Turkey	1.0	1.0	158	Syria	1.0	1.0
315	Turkey	1.0	1.5	184	Syria	1.0	1.0
330	Syria	1.0	1.0	185	Syria	1.0	1.0
331	Syria	1.0	1.1	186	Syria	1.1	1.0
Lens culinaris ssp. *odemensis*				193	Syria	1.2	1.0
20	Unknown	1.4	1.0	206	Yugoslavia	1.8	1.2
116	Syria	1.2	1.1	207	Yugoslavia	1.0	1.4
166	Syria	1.9	1.2	208	Yugoslavia	1.0	1.6
168	Syria	1.0	1.4	259	Turkey	2.1	1.0
170	Syria	1.8	1.0	261	Turkey	1.0	1.1
172	Syria	1.8	1.3	262	Turkey	1.2	1.0
173	Syria	1.0	1.0	263	Turkey	1.4	1.4
174	Syria	1.0	1.0	269	Turkey	1.0	1.0
202	Turkey	1.0	3.0	273	Turkey	1.5	1.1
203	Turkey	2.6	2.1	274	Turkey	1.0	1.1
238	Syria	1.2	1.2	285	Turkey	1.7	1.3
254	Syria	2.5	1.0	294	Turkey	1.3	1.1
300	Turkey	2.9	1.2	303	Turkey	1.0	1.0
Vicia montbretii				318	Turkey	1.0	1.0
12	Turkey	1.0	1.0	323	Turkey	1.0	1.0
107	USSR	1.0	1.0				
283	Turkey	1.0	1.0				

*ILWL : International Legume Wild Lentil.

Islamabad provided the two warmest environments for the vegetative phase of plant growth with mean temperatures prior to flowering of $\bar{T}$ = 13.2°C in 1986/87 and $\bar{T}$ = 12.6°C in 1991/92, to which the greatest contrast was an early sowing at Tel Hadya with a mean temperature of $\bar{T}$ = 9.8°C (Table 3.1.11). There was, however, a striking increase in temperature in Tel Hadya from mid-March (when the mean 7-d temperature was 5.7°C) to mid-May when the corresponding value reached 24.1°C. For mean photoperiod prior to flowering, the shortest daylength regime was in Islamabad in 1986/87 with $\bar{P}$ = 10.5 h d^{1} and the longest days ($\bar{P}$ = 12.1 h d^{1}) were experienced following late sowing in Tel Hadya.

Photoperiod alone accounted for 69% of the variance in $1/f$, the reciprocal of time (d) from sowing to flower. In contrast, temperature alone did not account for a significant proportion of variation in flowering time due to the exposure of plants to supra-optimal temperatures in the late-sown Syrian trial. Using the model, mean pre-flowering values of photoperiod and temperature combined additively to account for 90.3% of the variance of $1/f$ over accessions.

A one-way analysis of variance for time to flower on the basis of country of origin showed significant ($P < 0.001$) differences amongst country means. Early flowering was a characteristic of germplasm from Egypt, Ethiopia and India; accessions from Afghanistan, Iran and Turkey were typically the latest to flower. There were strongly significant differences among countries in the fit of the multiple regression model. Accessions from the former Soviet Union and Turkey showed the poorest fit to the model, whereas accessions from Chile, Ethiopia and Syria showed the best fit. Differences between countries in the mean response to temperature (b), photoperiod (c) and the constant a were substantial ($P < 0.001$; Figure 3.1.4).

Table 3.1.11. Means and standard errors over accessions of different phenological characters at two sowing dates in Tel Hadya, Syria in the 1986/87 season and at Islamabad, Pakistan in the 1986/87 and 1991/92 seasons, together with mean temperature ($\bar{T}$) mean and photoperiod (P) from sowing until the onset of flowering.

Character	Tel Hadya		Islamabad		SE
	Date 1	Date 2	1986/87	1991/92	(±)
Time to 50% flower (d)	121	91	126	120	0.6
Time to first fl. (d)	117	88			1.0
Node no. first flower	9.7	8.6			0.3
Time to maturity (d)	161	131			0.9
Mean temp. ($\bar{T}$) (°C)	9.8	11.0	13.2	12.6	
Mean photoperiod (P) (h d^{1})	11.4	12.1	10.5	10.6	

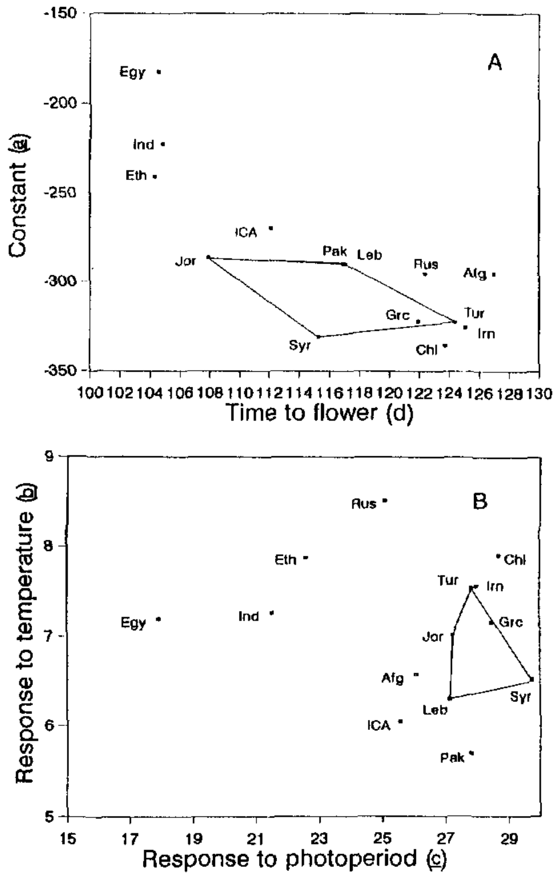


Figure 3.1.4. Mean values for accessions of different countries of origin for time from sowing to flower (d) and the constant (a) ($\times 10^4$) (A) and responses($\times 10^4$) to temperature (b) and photoperiod (c) (B). The respective means for the countries of West Asia are joined in order to illustrate the variation inherent in the region where the crop was domesticated. Country names are abbreviated as follows: Afg = Afghanistan, Chl = Chile, Egy = Egypt, Eth = Ethiopia, Grc = Greece, Ind = India, Irn = Iran, Jor = Jordan, Leb = Lebanon, Pak = Pakistan, Syr = Syria, Tur = Turkey, Rus = Former Soviet Union. (ICA represents ICARDA selections).

The lentil was domesticated in West Asia, from whence it spread. The variation within West Asia for time to flower was relatively high (Diamond in Figure 3.1.4A). The distributions of country means for time to flower and the genotypic constants a, b, and c illustrate the response to selection for adaptation to new ecological environments following the spread of the crop from its centre of origin. Dissemination to lower latitudes such as those in Egypt, India and Ethiopia has been accompanied by an increase in the constant (a) (Figure 3.1.4A) and a reduction in the photoperiodic response (Figure 3.1.4B); sensitivity to photoperiod must have been actively selected against during that spread. Obligate photoperiodic control of the onset of flowering ensures that flowering starts annually in the same calendar period, irrespective of fluctuations in temperature. Consequently, selection against photoperiodic control in a long-day plant such as lentil implies an adaptation to relatively short days, which occur at low latitudes and which would otherwise delay flowering to an unacceptable extent. Under such conditions the crop relies rather more on temperature to ensure that flowering occurs at an ecologically and agronomically appropriate time.

In an earlier study on lentil germplasm from fewer countries, the sensitivity of the crop to photoperiod was found to be related to latitude of origin, i.e. materials from the extreme latitudes were more sensitive to P (FLIP Annual Report 1988). However, it was unclear whether there was a continuous association of photoperiod sensitivity with latitude of provenance or two separate cohorts, namely; Group 1-represented by Mediterranean/temperate germplasm with a strong response to photoperiod, and Group 2, Sub-tropical germplasm with a reduced response. This study gives evidence of two groups contrasting in intrinsic earliness (of which the value a is an approximate guide) and photoperiodic response (c), i.e. Mediterranean/temperate germplasm with large values of both the constant a and sensitivity to photoperiod (b) and a second group of sub-tropical germplasm with a much smaller response to photoperiod and a reduced value of the constant a. There is also evidence that flowering of the sub-tropical group is more temperature sensitive than much of the Mediterranean/temperate group.

The spread of the crop into higher latitudes, for example into the former Soviet Union, has resulted in a small reduction of the photoperiodic response, probably reflecting the change in sowing date from winter to spring.

The major evolutionary force in the spread of the domesticated lentil is known to have been selection pressure for an appropriate phenology. The present study has not only validated a photothermal model over a wide range germplasm in diverse field environments, but has also shown that dissemination of lentil to new environments has caused selection for different regionally-specific balances between photoperiod and temperature sensitivity to control flowering.

This evidence for specific phenological adaptation has led to the adoption of a decentralized breeding program with several different target regions with specific adaptational requirements. **A. Hussain (National Seed Registration Department, Pakistan), M. Tahir, A. Bakhsh (National Agriculture Research Centre, Islamabad, Pakistan), R.H. Ellis, R.J. Summerfield, and E.H. Roberts (Plant Environment Laboratory, University of Reading, UK) & W. Erskine.**

3.1.1.11. Quantitative evaluation of Ethiopian landraces of lentil

As part of back-up research with the Ethiopian program, we assisted in the quantitative evaluation of Ethiopian landraces of lentil. One hundred and fifty-six landrace populations collected from 10 Provinces, spanning the Western, Central, Eastern and Northern Highlands, were evaluated for six quantitative traits at three sites contrasting in altitude in Ethiopia. This collection of germplasm is valuable because of the wide range of sites sampled, spanning ten Provinces and an altitudinal range of 1600 to 4000 m elevation. However, germplasm from the Western region was under-represented and should be collected expeditiously.

Although we found variation within Ethiopian lentil germplasm, this variation did not justify the declaration of Ethiopia as a centre of lentil diversity as, for example, for barley. However, regional differentiation was evident within the material and consistent regional differences among landraces were found for time to flower and maturity, 100-seed weight, number of seeds/pod and plant height.

The overall mean for time to flower was 51 days with the earliest landrace flowering in 45 days (Table 3.1.12). Early flowering was a feature of germplasm from the Western Highlands. For plant height, the range among landraces was wide from 27-49 cm and the early flowering, Western Highlands group were shorter than the other material, on average. Seed size ranged from 2.2-3.2 g/100 seeds over accessions with larger-seeded germplasm originating from the Northern Highlands.

Discriminant analysis confirmed the differences between germplasm from different areas. The canonical variate diagram shows the differentiation between areas (Figure 3.1.5). The x-axis represents 100-seed weight, positively, and time to flower, negatively, and the y-axis represents time to flower and plant height. In the canonical diagram the most distinctive group is that of the Western Highlands, which is early and short in stature. In contrast, the lentils of the Central Highlands were the least distinctive group. The Central Highlands group occupies the middle position both geographically and morphologically, as this germplasm was intermediate for all plant traits and the least distinctive of the regional groups. This implies greatest diversity within germplasm from the Central Highlands and also gene flow between the Central Highlands and the other regions.

Regional differentiation was based, in descending order of importance, on 100-seed weight, time to flower and plant height, which collectively gave a highly significant F-value of 9.20 with 9 and 307 degrees of freedom. The most important character 100-seed weight is a trait affected by human preference and is of low adaptive value. In a previous survey of patterns of morphological variation in lentil germplasm from various countries, plant phenology was the key to adaptation on the macro-geographic scale. On the micro-geographic level of this study, however, time to flower was only the second most important character in differentiation.

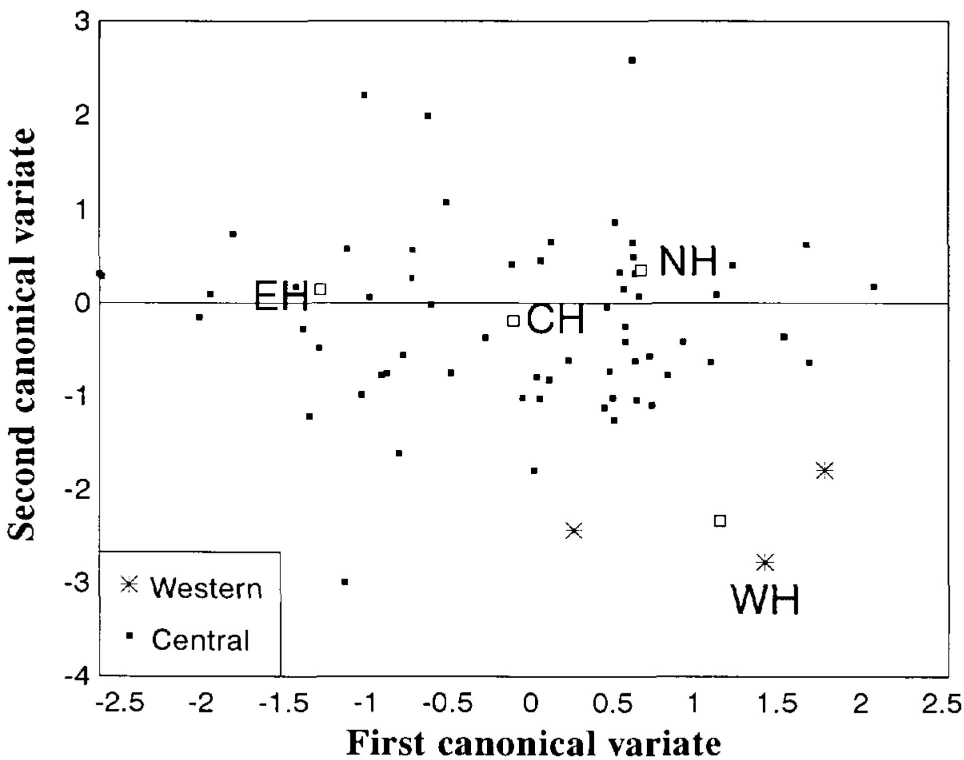


Figure 3.1.5. Scatter diagram of first two canonical variates for the values of the most distinctive (WH) and least distinctive (CH) landrace populations and centroids for the regional groups of Northern Highlands (NH), Eastern Highlands (EH), Western Highlands (WH) and Central Highlands (CH).

The crop growing period was 82 days at the lowland site (elevation 1600 m) and a month longer (113 d) at the highland site (elevation 2450 m), emphasizing the major influence of environment on maturity. The testing environments at different altitudes contrasted primarily in temperature. The major disparity in the length of the growing period at different elevations suggested that times to flower and maturity might be adaptive characters in relation to altitude. However, selections for yield made at sites contrasting in altitude did not differ in their mean time to flower and maturity. Furthermore, correlations between the altitude of collection, on the one hand, and both time to flower and reproductive duration, on the other hand, were non-significant. This shows that, although plant phenology has adaptive value on a regional scale, it is of no value in adaptation to different altitudes within a region. The lack of evidence for selection for altitude/temperature adaptation through plant phenology is probably due to human influence. Sowing date at any location varies seasonally according to the timing of the rains, and seed may be moved to different altitudes within a region. Both these effects dilute selection pressure on the length of the growing period. **G. Bejiga, S. Tsegaye, A. Tullu (Alemaya University of Agriculture, Ethiopia) and W. Erskine.**

Table 3.1.12. Mean (x) and standard errors (SE) of genotypic means overall and by region of origin, together with correlation coefficients with altitude for the characters: time to flower (d), time to maturity (d), plant height (cm), number of seeds per pod and 100-seed weight (g) of Ethiopian lentil germplasm.

Geographic region		Time to flower	Time to maturity	Plant height	Seed no. per pod	100-seed weight
Overall	$\bar{x}$	50.8	95.6	32.7	1.60	2.60
	SE	0.18	0.21	0.26	0.02	0.02
	Range	45.3-57.7	85.3-102.0	27.1-49.3	1.23-2.00	2.17-3.17
Northern	$\bar{x}$	50.9	95.8	32.8	1.6	2.7
Highlands	SE	0.29	0.34	0.43	0.03	0.02
Eastern	$\bar{x}$	51.5	95.8	32.9	1.5	2.5
Highlands	SE	0.45	0.52	0.97	0.04	0.03
Central	$\bar{x}$	50.7	95.6	32.0	1.6	2.6
Highlands	SE	0.25	0.28	0.26	0.02	0.02
Western	$\bar{x}$	46.0	91.7	30.2	1.6	2.5
Highlands	SE	0.33	3.17	1.89	0.11	0.06
Correlation with altitude		0.079	0.009	0.161	0.036	0.323

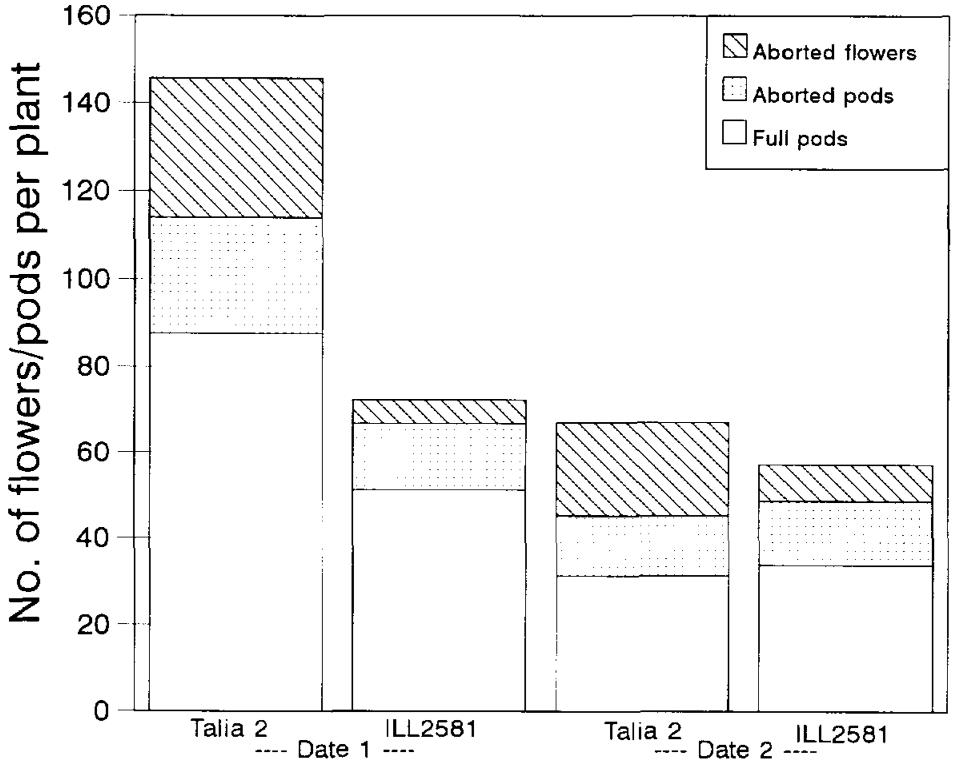


Figure 3.1.6. Average number of aborted flowers, aborted pods and full pods per plant of four treatments, factorial combinations of two lentil genotypes (Talia 2 & ILL 2581) sown on two dates (Nov. 28, 1992 & Feb. 15, 1993), at the American University Farm, Beqa'a valley, Lebanon.

3.1.1.12. Flower and pod abortion in lentil as affected by cultivar and sowing date

The production, nodal position and fate of lentil flowers was studied on two cultivars (Talia-2 and ILL 2581) sown on two dates (Nov. 28, 1992 & Feb. 15, 1993) in a factorial design with three replications at the American University of Beirut Farm, Beqa'a, Lebanon. The study was undertaken as a prelude to a study of the number of flowers per peduncle with the aim of devising a simple sampling method for flower number per peduncle. The number of flowers on a lentil inflorescence varies considerably from one to four flowers per peduncle, with up to seven recorded from the glass-house. This results in different numbers of pods per peduncle at maturity. There is variation within an individual plant in the flower numbers per inflorescence, between plants within a genotype, between genotypes and a strong environmental effect on this trait. This MSc thesis research at the American University of Beirut aims to quantify the variation next season due to these different factors and to understand the significance of this variability to the final yield.

Winter sowing gave significantly more yield than spring sowing (Figure 3.1.6). Cultivar Talia-2 yielded more than ILL 2581 in the winter, but the difference disappeared under spring-sown conditions.

The average number of flowers per plant was 85.5, of which 19.7 % aborted as flowers and 20.7 % aborted as pods leaving 59.6 % to form mature pods. There were significant differences between cultivars in flower abortion and between sowing dates and their interaction with cultivars in pod abortion.

The distribution of flowers among branches within the plants was studied. Overall, primary branches contributed the dominant portion of 62.3 % to final pod yield with the main stem contributing 21.6 % and secondaries contributing 16.1 % (Figure 3.1.7). Although primary branches provide the bulk of flowers, the probability of a flower aborting or a pod aborting was lowest on the main stem and greatest on secondary branches (Figure 3.1.8). Clearly, adjustments to yield from stress after flowering and during pod-filling come primarily from flowers on secondary branches rather than those on the main stem. **H. Tambal, H. Zaiter (American University of Beirut) and W. Erskine.**

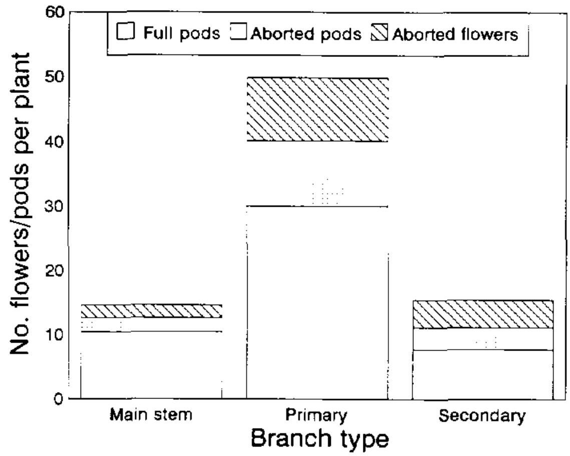


Figure 3.1.7. Average number of aborted flowers, aborted pods and full pods per plant on the main stem, primary branches and secondary branches of two lentil genotypes sown on two dates at the American University Farm, Beqa'a valley, Lebanon in the 1992/93 season.

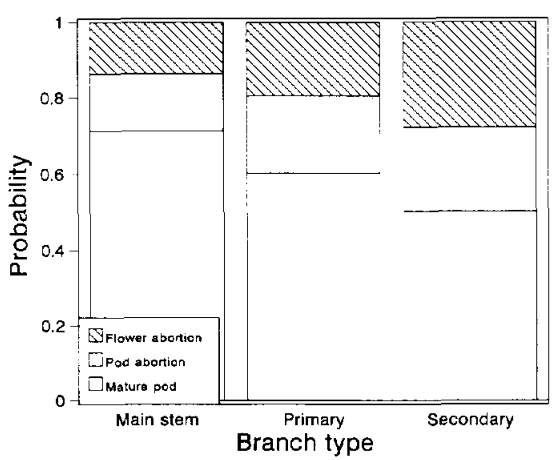


Figure 3.1.8. Probability of flower abortion, pod abortion and mature pod development of flowers formed on the main stem, primary branches and secondary branches over two lentil genotypes sown on two dates at the American University Farm, Beqa'a valley, Lebanon in the 1992/93 season.

3.1.2. Use of Lentil Germplasm by NARSs

3.1.2.1. 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 1000 m around the Mediterranean Sea. To date, more use has been made of lines than segregating populations and few lentil crosses are made outside ICARDA in North Africa and West Asia.

The exploitation of local germplasm within this region has shown unequivocally the similarities in adaptation within this lowland Mediterranean region. For example, selections from Jordanian germplasm have been released in Iraq, Lebanon, Libya and Syria. Selections from Syrian germplasm are released for cultivation in Algeria and Tunisia. Selections from Lebanese and Moroccan germplasm are either released or in registration trials for cultivation in S.E. Anatolia in Turkey.

Table 3.1.13 lists lentil lines released as cultivars and Table 3.1.14 gives those lines selected for pre-release multiplication and/or on-farm trials by NARSs.

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

The line FLIP84-147L (ILL 5816) has been performing well in Jordan and has been identified for large-scale multiplication and on-farm trials in 1993/94.

In Iraq the large-seeded line 78S26002 was registered in 1992. The lentil line - ILL 1939 - has been offered for registration by the South-East Anatolian Research Institute in Turkey and regional trials have shown that ILL 2126 and FLIP86-3L (ILL 5989) perform well in the region.

In North Africa, the lines 78S26002, FLIP84-58L (ILL 5728) FLIP84-114L (ILL 5784) have been identified as high yielding by the national program on the basis of their superior performance in the last three seasons in Tunisia. In Libya the line El Safsaf 3 (78S26002) was released in 1993 for cultivation for the East of the country and FLIP84-51L (ILL 5722) is in large-scale testing for irrigated conditions in Central Libya at Meknosa. Lentil production and area continue to decline in Algeria but the lines ILL 468, NEL45R, LB Redjas and Balkan 755 are in seed increase for future use by farmers. In the National Lentil Yield Trial the Algerian Program found FLIP87-48L (ILL 6238) and FLIP85-7L (ILL 5845) as top-yielders on the coast, FLIP84-145L (ILL 5815) best on the low plateau, and FLIP 87-30L (ILL 6220) and FLIP84-101L (ILL 5671) good for the high plateau.

Table 3.1.13. Lentil cultivars released by national programs

Country	Cultivar name	Year release	Specific features
Algeria	Syrie 229	1987	Yield, seed quality
	Balkan 755	1988	Yield, seed quality
	ILL 4400	1988	Yield, seed quality
Argentina	Arbolito (ILL 4605x-4349)	1991	Yield, tall and early
Australia	ILL 5750	1989	Yield
	FLIP84-51L(ILL 5722)	1993	Yield, red cotyledon
	FLIP84-58L(ILL 5728)	1993	Yield, red cotyledon
	FLIP84-154L(ILL 5823)	1993	Yield, yellow cotyledon
Bangladesh	Falguni (ILL4353x353)	1993	Rust res., yield
Canada	Indianhead (ILL 481)	1989	Green manure
Chile	Centinela (74TA470)	1989	Rust res., yield
China	FLIP87-53L	1988	Yield in Qinghai Province
Ecuador	INIAP-406 (FLIP 84-94L)	1987	Rust res., yield
Egypt	Precoz (ILL4605)	1990	Intercropping in sugarcane
Ethiopia	R 186	1980	Yield
	ILL 358	1984	Rust res., yield
	NEL 2705	1993	Rust res., yield
	FLIP84-7L (ILL5680)	1993	Rust res., yield
Iraq	78S26002	1992	Yield, standing ability
Jordan	Jordan 3(78S 26002)	1990	Yield, standing ability
Lebanon	Talya 2(78S 26013)	1988	Yield, standing ability
Libya	El Safsaf 3(78S26002)	1993	Yield E. Libya, st. ability
Morocco	Precoz (ILL 4605)	1990	Rust res., yield
Nepal	Sikhar (ILL 4402)	1989	Yield
N Zealand	FLIP87-53L (ILL 6243)	1992	Yield, red cotyledon
Pakistan	Manserha 89(ILL 4605)	1990	Ascochyta & rust res.
Sudan	Rubatab 1 (ILL 813)	1993	Yield in Northern areas
	Aribo 1 (ILL 818)	1993	Yield in Jebel Mara
Syria	Idleb 1 (78S 26002)	1987	Yield, reduced lodging
Tunisia	Ncir (ILL 4400)	1986	Large seeds, yield
	Nefza (ILL 4606)	1986	Large seeds, yield
Turkey	Firat 87 (75Kf 36062)	1987	Small seeds, yield
	Erzurum 89 (ILL 942)	1990	Yield in spring sowing
	Malazgirt89(ILL 1384)	1990	Yield in spring sowing
	Sazak 91 (NEL 854)	1991	Winter sowing, red cotyledon
U.S.A.	Crimson (ILL 784)	1991	Yield in dry areas

Table 3.1.14. Lentil lines in pre-release multiplication or on-farm testing by NARSs.

<u>Mediterranean region</u>	
Algeria	ILL 468, ILL 1889
Egypt	FLIP84-51L, FLIP84-112L,
Jordan	FLIP84-147L
Lebanon	FLIP86-2L, FLIP87-56L
Libya	FLIP84-51L
Morocco	FLIP86-15L, FLIP86-16L, FLIP87-19L, FLIP87, 22L
Syria	ILL 5883
Tunisia	78S26002, FLIP 84-58L, FLIP84-114L
Turkey	ILL 1939
<u>High elevation</u>	
Iran	ILL 842, ILL 949
Pakistan FLIP84-4L, FLIP85-7L	
<u>S. Latitudes</u>	
Ethiopia	FLIP86-12L, FLIP86-16L, FLIP86-18L
Nepal	ILL 2578, ILL 4404
Pakistan 7519 from ILL1 x ILL 2573	
Sudan	ILL 818
Yemen	ILL 4605, FLIP84-14L

Morocco suffered severe drought this season. In lentil experiments at Merchouch (200 mm rain received) and Jemaat Shaim (180 mm rain) some yield was achieved by early flowering and maturing lines. Later maturing lines were barren. Several good early lines, with known rust resistance in previous years, were identified for inclusion in Catalog Trials next season. Drought precluded screening for rust this season. The following lines with resistance to rust 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) are in the catalogue trials.

In Egypt the early lines FLIP84-51L (ILL 5722) with small seeds and FLIP84-112L (ILL 5782) with large seeds are both in pre-release multiplication. **National Agricultural Research Systems.**

3.1.2.2. Advances for southern latitude region

This region comprises the sub-continent of India and Ethiopia where an early flowering habit is required together with resistance to rust, ascochyta blight and wilt. The importance of foliar pathogens contrasts with other major areas of lentil production.

There are three strong lentil breeding programs in Pakistan with two in Faisalabad and the remaining program in Islamabad. Over the last five years ICARDA has worked closely with these programs in joint selection as the focus of a thrust to broaden the genetic base of lentils in South Asia. Progress is now apparent and two lines are to be registered shortly and are in 250 on-farm trials/ demonstrations this season. One of them is the early line 87519, selected from a segregating population from ICARDA, opening a new potential cropping niche, because it flowers 18 days before the local, allowing its late sowing (mid-Dec.) in fields vacated by late paddy rice. The new niche can extend the potential area of the crop considerably. It has resistance to rust, Ascochyta and Botrytis. The line is already in our international early trials.

The major production problem in Bangladesh addressable through breeding is rust. 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 in the F_3 generation from this material and a selection from the cross ILL 4353 x ILL 353 was released in 1993.

India has a strong lentil breeding program coordinated under the All India Coordinated Pulse Improvement Project of the Indian Council of Agricultural Research (ICAR). We have good relations with ICAR. During the 1989/90 season ILL 4605 was included in every crossing block in India on the basis of its large seed and combined resistance to rust and Ascochyta blight. During the 1990/91 season there were a total of 60 test entries in the All-India Coordinated lentil trials, of which 12 entries come from crosses with ILL 4605 as a parent. The Indian Agriculture Research Institute, New Delhi has selected two ICARDA lines (LS 362 and LS 2865) for inclusion in the All India trials with large seeds (5.5 g/100 seeds), early flowering and a high yield potential.

Nepal grows more than 120,000 ha of lentil spread from the Terai area adjacent to India to the lower Mid-Hills. The Grain Legume Improvement Program of Nepal has shown that lines from the Pakistani/ICARDA breeding program are excellently adapted to Nepali conditions. For example, the cultivar Sikhar (ILL 4402) originated in Pakistan and the best introduced lines in Nepal come from the joint Pakistan/ICARDA breeding program.

In Ethiopia NEL 2705 and FLIP 84-7L (ILL 5680) were released in 1993. Ada and Akaki are the areas where the released line NEL 358 is becoming very popular and a study on its impact is underway.

In Sudan Rubatab 1 (ILL 813)was released for cultivation in the Northern Province and Aribo 1 (ILL 818) was registered for use in Jebel Mara Region in 1993. **National Agricultural Research Systems.**

3.1.2.3. 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. This season at Ankara the national program of Turkey has again demonstrated that winter-sown lentil has a higher yield potential than the spring-sown crop, provided there is sufficient winter-hardiness in the cultivar. In the Lentil International Cold Tolerance Nursery at Ankara the checks were susceptible to cold and killed and the ILL lines 468, 1918, 465 and 983 were tolerant and selected in descending order of merit.

In Iran the lines ILL 842 and ILL 949 are promising and due for testing on farmers' fields.

The lines FLIP84-4L and FLIP85-7L are in the pre-release stage at the Arid Zone Research Institute, Quetta, Pakistan on the basis of their cold tolerance and larger seed size than the local cultivar. **National Agricultural Research Systems.**

3.1.2.4. Advances in other areas

The New Zealand Institute for Crop and Food Research has registered lentil FLIP87-53L (ILL 6243) as a variety during 1993. It is a red cotyledon line which has out-performed the commercial standard and is well received by the lentil trade for use either whole or split.

In Australia there is now considerable interest in lentil. Prior to the testing of germplasm from ICARDA, lentil assessment in Australia was limited to a few lines representing phenological extremes - extra early and extra late flowering and maturity. ICARDA Mediterranean-adapted material has fitted in well into the vacuum. In Victoria seed of the red lentils FLIP84-51L (ILL 5722) and FLIP84-58L (ILL 5728) and the green lentil FLIP84-154L (ILL 5823) were handed over to a private company for commercialization by the Victorian Institute for Dryland Agriculture on the basis of their consistent yield advantage. It is hoped that these lines will be the basis for a viable lentil industry. In New South Wales the lines FLIP84-51L (ILL 5722) and FLIP86-16L (ILL 6002) are in multi-location testing following their selection at Tamworth over several seasons. The most promising new selection in South Australia is FLIP84-61L (ILL 5731).

The line Crimson (ILL 784) released for the dryland areas of the U.S. Palouse region in 1991 was grown on about 3000 ha last year. Yields have been high at 2-3 t/ha and the area is expected to triple next season as seed becomes available. **National Agricultural Research Systems.**

3.2. Application of Biotechnology

3.2.1. Lentil Mapping Project

This project is a collaborative research program between ICARDA and Washington State University. The objective of this study is to evaluate if new biotechnologies such as the use of DNA-marker (RFLP, PCR) can be used in a system of marker assisted selection to support lentil breeding strategies at ICARDA.

Ascochyta and *Fusarium* diseases cause the most severe biotic stresses in lentils within the region. One parent of the mapping population (ILL 5588) carries resistant gene(s) for *Ascochyta* and *Fusarium*. The mapping populations are being used to develop markers closely linked to the resistance employing both linkage mapping as well as bulk segregation analysis. Once established, the marker(s) can be used to follow up the resistance genes in other crosses of the breeding program. Furthermore, the populations will be used to generate a genetic linkage map for lentils to learn more about the inheritance of both qualitatative and quantitative genes.

3.2.1.1. Development of the mapping population

L692-15-8(F) x L92-7-16 (ILL 5588) cross 1 and L92-17-2 (ILL 5588) x L692-16-1(S) cross 2 were established by Dr. F. Muehlbauer in 1992. ILL 5588 carries resistant gene(s) for *Ascochyta* and *Fusarium* and the other two parents are single plant selections from the same genetic background for slow (S) and fast (F) isozyme alleles. The populations were constructed originally for the use of isozymes. The chosen crossing scheme should ensure that segregation for each isozyme can be recorded in either of the populations.

The populations will be advanced using Single Seed Descent (SSD) to develop homozygous lines for quantitative trait loci (QTL) analysis (Figure 3.2.1). Meanwhile linkage mapping is carried out on F2 populations using RFLP, PCR, isozyme, and morphological markers. The screening for reaction to *Ascochyta* and *Fusarium* will be carried out after seed increases on F3 or F4 families. The resistance reaction can be traced back to the corresponding F2 family. Markers, identified through segregation analysis, which are associated or linked with the resistance have to be verified in the homozygous lines in F7. Additional markers might then also be developed by cloning cosegregating markers with the resistance in bulk segregation analysis. After a seed increase lines will be planted and tested in the field for all available qualitative and quantitative differences. With a statistical QTL analysis using MAPMAKER program traits can then be linked to defined chromosome regions and specified markers.

LENTIL MAPPING PROJECT:ICARDA/WSU

TIME	GENERATION	ACTIVITIES
/91	L-(5588)x L692(S)	Crosses in WSU
	L692(F) x L(5588)	
/92	F1	
04/93	F2	Isozymes, morphology
		RAPD-, RFLP-markers
10/93	SSD F3	RAPD-analysis
01/94	SSD F4	Ascochyta and wilt screening on F3 families
04/94	SSD F5	RAPD-,RFLP-markers
10/94	SSD F6	RAPD-,RFLP-markers
W/95	Field F7 Test	QTL-analysis RAPD-markers

Figure 3.2.1. Development and advancing of the mapping populations to develop homozygous lines for a QTL-analysis.

3.2.1.2. The mapping approach

Within the mapping populations morphological, isozymes and PCR markers are being used to establish a linkage map. Segregation for morphological, isozymes and PCR markers is given for cross 1 below (see Table 3.2.1 and 3.2.2).

Morphological Markers: In cross 1 the epicotyl color segregated according to an expected mendelian ratio of 3 green to 1 red (Table 3.2.2). Even though the cotyledon color and the presence of leaf tendrills varied for the parents, the F2 population did not show segregation.

Table 3.2.1. F2 data file of cross 1 for segregation analysis with the MAPMAKER 1.9 program. A describes a banding pattern homozygous for parent A, B homozygous for parent B, C for not being AA (either AB or BB), D for not being BB (either AB or AA) and - for missing data.

Marker*	Segregation in 38 individual F2 plants
GS (morphol.)	ACCCCCCCCCCCCCCCCCCCCCCCCCCCACCCCAACCC
AAT4 (isozyme)	CCCCCCACACCCCCACA-CCCCCCCCCCCCCCCCCCAA
AAT2 (isozyme)	HHBBAAHAAAABHBHHA-HAHHBHHAAAAHAHAHHHAA
I13 (RAPD)	DBBBBDBDBBBBBDBDBDBDBBBBBDDBBDBBBBDBDB
J18 (RAPD)	DDBDBDDDDDDDBBBDDDDDBDBDBDDDDBDDDDDDDD
ME2a (isozyme)	HHBHHBHBHHHHBBAHA-AHBHBHBHAAABHHHHBB-H
M2a (RAPD)	DDDDDDBDB--DDBBDDD-D-DDB-DDDDDDD-DDDDD
M2b (RAPD)	DDDDDBDBD--DBDDDDD-B-BBB-BBBBBBB-BBBBB
M3a (RAPD)	CAAACCCACCCAACAACCCCACAAAAACCCCCCCCCAC
M3b (RAPD)	DDDDDDDBBBDDDDBDDDBBDDBBBBBBDBDDDDBBBB
M6c (RAPD)	-DDDDDDDDD-DDDDB-D-DBDDDDDBD-DDDDDDBD-
M7a (RAPD)	BBBBBDBDDDDDDDDD-DDD-BBDDBBBBBDDDDDBBB
M7b (RAPD)	ACACACAACCAAAAAC-CAA-CCCAAAAACACAAACAC
M18a (RAPD)	DDDD-D-DB-DBD--D-D-DDDDD-DDDDDDDDDDDDD
M18b (RAPD)	CCCC-A-CC-CCA--CAC-ACACC-CCCACCCCCACAC
X8 (RAPD)	DDDDDDDDB-BDDD-DDBDBBBBBDBBBBDBDDDBBDB
Y11 (RAPD)	CCCCCAACCCACCCCCCCCCCCCCCCCCCCCACCAACA
Y14 (RAPD)	A-CACCCCAACCCCCCCACCCACCCCCCCCACC-ACCA

* GS is epicotyl color, AAT and ME isozymes, and I,J,M,X and Y are RAPD-markers of the Operon kits with the same initials.

Isozymes: For isozyme analysis green plant material was collected from all individual mature plants. Two different gel systems were used, the standard and the histidine gel. At the AAT-locus AAT-2 and AAT-4 (Figure 3.2.2) segregated while at the ME-locus only ME-2 showed variation. The segregation for AAT-2 and ME-2 could be recorded as a 1:2:1 segregation, whereas presence or absence of the isozyme band at the AAT4 locus was recorded as a 3:1 segregation (Table 3.2.2). All three isozyme loci had a skewed segregation, segregation did not fit an expected 3:1 or 1:2:1 mendelian segregation (Table 3.2.2).

Table 3.2.2. X^2-square analysis for the segregation of markers in the F2 population of cross 1.

Marker		Number of individuals for the different classes	X^2-square*
GS	(morphol.)	A=27, C=71,	X^2= 0.51
AAT4	(isozyme)	A=44, C=53,	X^2=20.37**
AAT2	(isozyme)	A=36, H=47, B=14,	X^2=10.07**
ME2	(isozyme)	A=19, H=41, B=36,	X^2= 8.06**
I13	(RAPD)	B=26, D=13	X^2=36.95**
J18	(RAPD)	B= 9, D=29	X^2= 0.03
M2a	(RAPD)	B= 5, D=27	X^2= 2.29
M2b	(RAPD)	A=13, C=19	X2= 5.33**
M3a	(RAPD)	A=15, C=22	X2= 8.98**
M3b	(RAPD)	B=16, D=21	X2= 6.57**
M6c	(RAPD)	B= 4, D=28	X2= 2.67
M7a	(RAPD)	B=16, D=20	X2= 7.26**
M18a	(RAPD)	B= 2, D=28	X2= 6.53**
M18b	(RAPD)	A= 8, C=23	X2= 0.01
X8	(RAPD)	B=16, D=20	X2= 7.26**
Y11	(RAPD)	A= 7, C=31	X2= 0.79
Y14	(RAPD)	A= 9, C=28	X2= 0.01

* Threshold value at a probability of 95% for 1 df (A,C or D,B) = 3.84 and for 2 df (A,H,B) = 5.99; ** indicates markers with skewed segregation.

RAPD-Markers (Random Amplified Polymorphic DNA): DNA was isolated from all F2 individuals according to standard procedures. The RAPD primers (10 mers) are commercially available from Operon Technologies (available at ICARDA kits F to Z). The PCR-amplification protocol was standardized for DNA template and primer concentration, enzyme, nucleotide and Mg^{++} concentration on a Hybrid thermocycler and the Perkin Elmer system 9600. Standard reactions of 50 μl volume, contained 50 ng of DNA, 200 μM of dNTPs, 5μM of primer and 1U of *Taq*-polymerase. The amplification program was 1 cycle for 2 min at 94°C for DNA denaturation, 40 cycles of amplification for 1 min. at 92°C, 1 min at 36°C and 2 min at 72°C and a final step for 5 min at 72°C.

Parent 1 and 2 of cross 1 were screened for polymorphisms with the same primers (Figure 3.2.3). A polymorphism between the parents is supposed to be genetically inherited if the reaction conditions applied

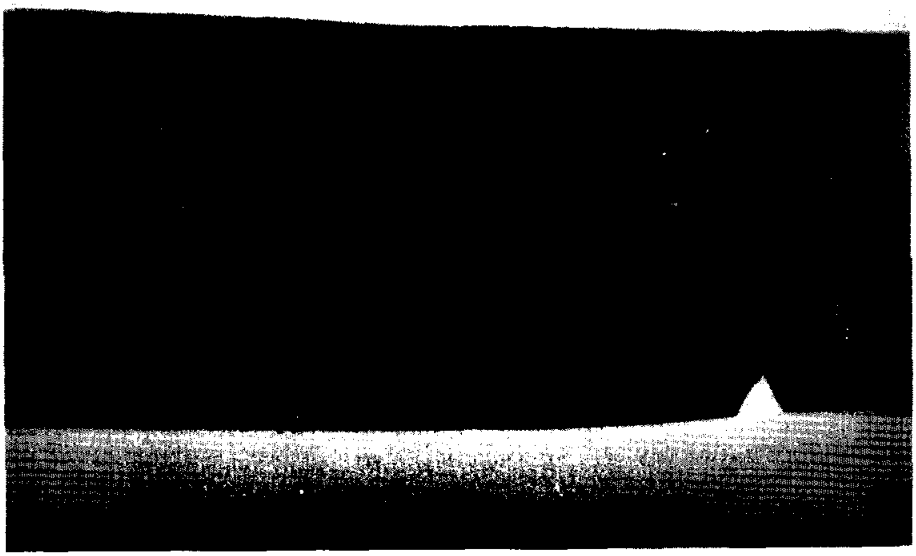


Figure 3.2.2. Segregation at the isozyme locus AAT. The upper band segregates at the AAT-4 locus, the bottom segregation zone segregates for AAT-2/3. From left to right: lane 1 parent 1, lane 2 parent 2, followed by segregation for 18 individuals.

are the same. An identified polymorphic marker is subsequently applied to the segregating population (Figure 3.2.4). RAPD-segregation is recorded as a dominant marker (3:1 segregation), presence and absence of a specific banding pattern. Absence describes homozygosity for one parent (A or B), whereas presence of a band can be either homozygosity for one parent or heterozygosity. Linkage analysis was performed using MAPMARKER. The following linkages were revealed:

M3b - X8	35.7 cM	25.5%
X8 - M2b	28.2 cM	21.6%

Figure 3.2.3. Parental screening for polymorphism with RAPD-markers. From right to left: lane 1 and lane 2 = amplification product of parent 1 and 2 with primer I-13, lane 3 and 4= amplification product of parent 1 and 2 with primer J-18. Following pairs of parents are screened with M-2, M-3, M-7, M-16, M-18, S-3, X-8.

Figure 3.2.4.a Segregation of RAPD-primer M7 in the F2 of cross 1. From right to left: Parent 1 lane 1, parent 2 lane 20, lane 2-19 F2 individuals. The first segregating band from the top of the gel is given the letter a, the marker is M7a. Additional segregating bands below are indicated with continuous following letters b, c etc. The second segregating band is M7b.

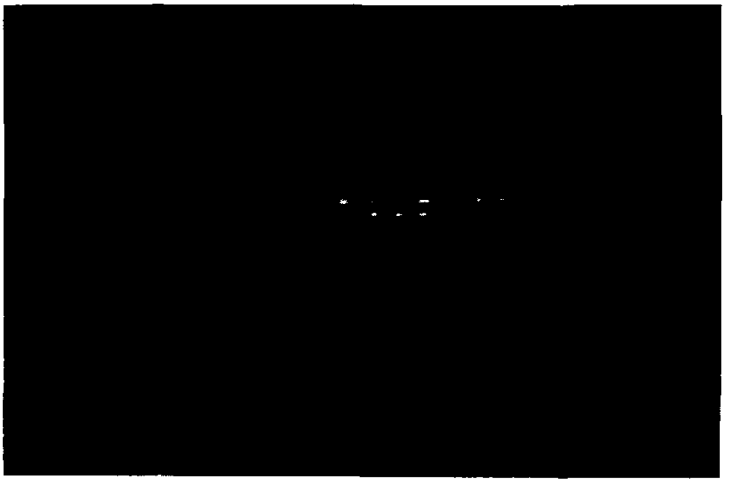


Figure 3.2.4.b. Segregation of RAPD-primer M18 (Explanations see 4a).

The high number of skewed segregation ratios might be due to a) the low number of individuals tested for segregation and/or b) due to a skewed segregation of parental alleles within the population. As the second mapping population is almost the reciprocal cross of the first mapping population, this population will be tested for the segregation of RAPD-markers to determine the quality of the population for linkage mapping. **I. Mahmoud and M. Baum, W. Erskine, B. Bayaa (Aleppo University) and F. Muehlbauer (WSU).**

3.2.2. Genetic Variation and Phylogenetic Relationships among Cold Tolerant Accessions of Lentil

To complement the screening for winter hardiness in lentil (see section 3.1.1.8), 4 cold tolerant (ILL 3516, ILL 1405, ILL 1879 and ILL 630), one cold resistant (ILL 662) and two cold susceptible (ILL 1189 and ILL 485) accessions of lentil were fingerprinted with the $(GGAT)_5$/DraI probe/enzyme combination to study the genetic variation among them (Figure 3.2.5). The data was analyzed using Wagner parsimony method and compared with their geographical origin (Figure 3.2.6). All 7 accessions were grouped into 4 groups, depending on their genetic divergence. Cold tolerant lines from India (ILL 3516) and Iran (ILL 1405) are genetically different from the cold tolerant lines from Turkey (ILL 1879, ILL 630).

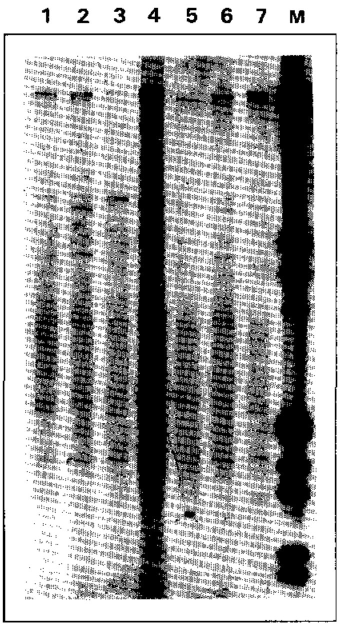


Figure 3.2.5. DNA fingerprint of 7 lentil accessions using $(GGAT)_5$/DraI probe/enzyme combination. Lanes 1-7 show the fingerprints of ILLs 485, 630, 662, 1189, 1405, 1879 and 3516 respectively. Lane 8 contains the molecular weight marker, lambda EcoRI/HindIII digest.

The cold resistant line (ILL 662) coming from Turkey is more closely related to Indian and Iranian cold-tolerant lines than to Turkish cold-tolerant accessions. The two cold susceptible accessions (ILL 1189 from Iran and ILL 485 from Lebanon) are highly divergent. From this observation we could conclude that resistance/tolerance to cold is in different genetic background as confirmed by their different geographic origin. **F. Weigand, S.M. Udupa, W. Erskine and I. Küsmenoglu.**

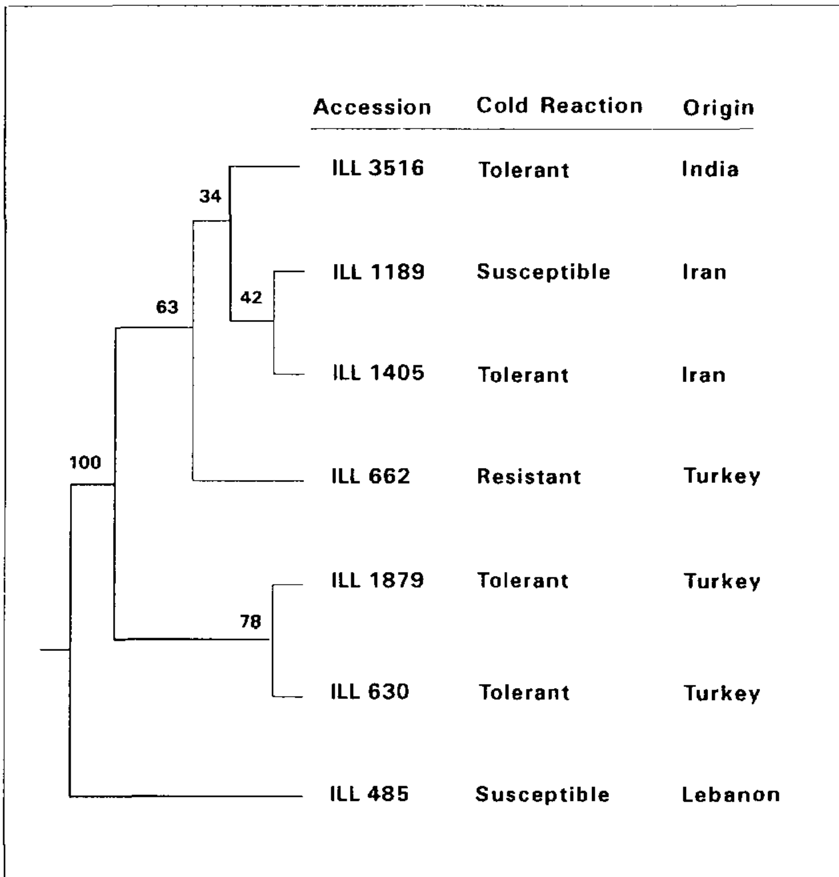


Figure 3.2.6. Phylogenetic relationships among 7 lentil accessions. The numbers at the forks indicate the number of times the group consisting of the accessions to the right of that fork occurred among the 100 bootstrap replicates.

3.3. Lentil Mechanization

3.3.1. Spring-tyne Harrow for Weed Control

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of harvest labour. Systems of mechanization have been developed to decrease the cost of production of the crop (see FLIP and LP Annual Reports 1986-1992).

In Syria the major traditional production areas of lentil were in Aleppo and Idlib Provinces until the end of the 1980s, when harvest mechanization in the Kameshly area lifted the lentil area dramatically. In Kameshly about 80,000 ha of lentil were sown in 1989 and approximately 25 % were harvested by swathe-mower in 1990.

An important aspect of lentil management which is a pre-condition for harvest mechanization is weed control. Considerable research has been conducted on chemical weed control and recommendations for products are available in many countries. Mechanical weed control may be considered as an alternative or as an adjunct to chemical control. As the best plant population levels for lentil production in the Mediterranean basin are above 250 seeds m^2, it is difficult to use inter-row cultivation on lentil. In Canada dryland lentil farmers often supplement their chemical weed control with the use of a spring-tyne harrow when the crop is about 10 cm tall. The operation is done across the whole field uprooting weeds and some lentils. It is only feasible while the weeds are still small and an super-optimal rate of seeding is required to compensate for crop losses.

During 1993 we experimented with mechanical weed control using a spring-tyne harrow on a lentil crop drilled on December 22, 1992 at 440 seeds m^2. The working width of the harrow was 3 m and working speed was c. 8 km($P < 0.05$) h^1. Strips of the field were harrowed on February 28, 1993 and some of these strips were harrowed again on March 5, 1993. There were thus three treatments: 1. No harrow (control), 2. Single pass of the spring-tyne harrow, and 3. Two passes of the spring-tyne harrow. Plant counts of weed and crop density were made in quadrats (0.25 m^2) within each treatment.

The resulting plant counts are shown in Figure 3.3.1. The weed density in the unharrowed lentil was 67 plants m^2 with the dominant species *Sinapis arvensis*. The spring-tyne harrow significantly ($P < 0.05$) reduced both weed and crop density. This reduction was linear and the regression of weed density on to the number of harrow passes was $y = 67 - 27x$. Each harrow pass reduced weed density by 27 plants m^2 or 40 %. Similarly the reduction in the crop density was also linear at $y = 434 - 110x$ and significant at $P < 0.05$. Each harrow pass reduced the crop stand by 110 plants m^2. This has to be compensated in advance at seeding. In this case the initial density of 434 plants m^2 was super-optimal and a single pass of the harrow reduced the weed density by 40 % and reduced the crop density to around the known optimum of 300 plants m^2. Our preliminary observations show that the spring-tyne harrow is promising in this environment and it merits further testing. **J. Diekmann and W. Erskine.**

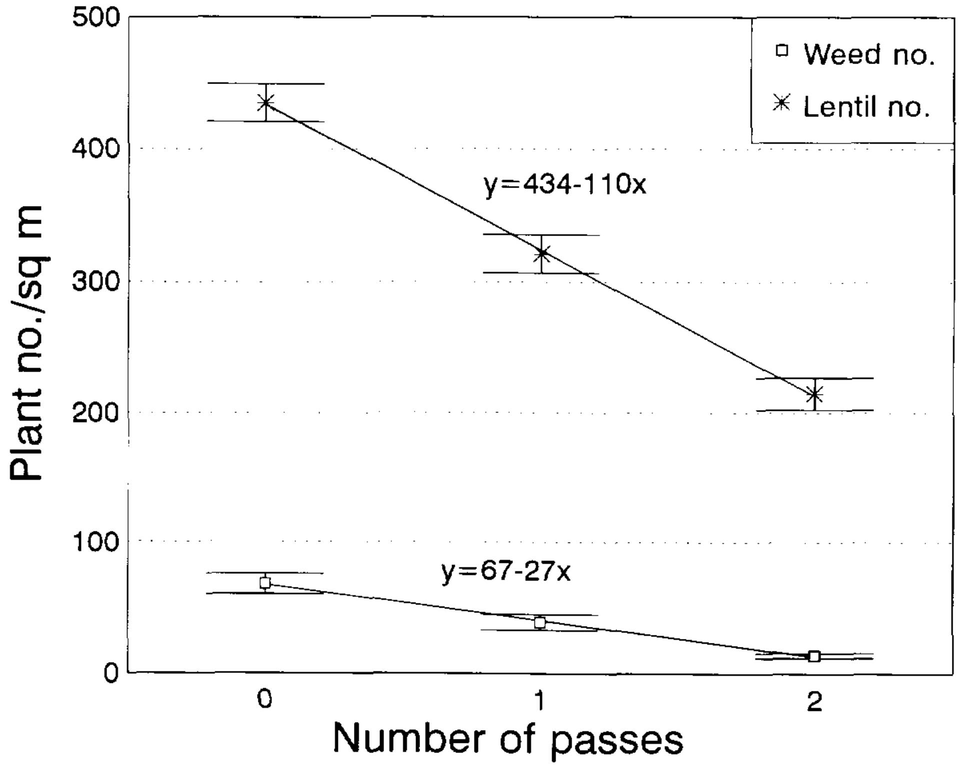


Figure 3.3.1. Plant counts of weed and crop density from 0.25 m^2 quadrats of lentil with different numbers of passes of the spring-tyne harrow for weed control. Standard errors are shown as bars.

3.3.2. Short Course on Legume Harvest Mechanization

A legume harvest mechanization short course was conducted at Tel Hadya from 9 to 20 May 1993 jointly organized by the Legume Program and the Pasture Forage and Livestock Program, including lecturers from Farm Resource Management Program and Station Operations. The course was attended by a total of 8 participants from Algeria, Egypt, Lebanon, Sudan, Syria, Turkey and Yemen. The purpose of the training was to demonstrate various systems of legume production and mechanization in order to decrease production costs.

The program of both lectures and practicals included harvest machinery, particularly different mowers (self-propelled and tractor-drawn) and the combine harvester. Other topics covered were the problems of mechanization, the breeding and agronomy of mechanization for different legumes, seed-bed preparation, economics and techniques for farmer interviews and on-farm trials. In addition, trainees presented the situation of legume production and mechanization in their own countries.

3.4. Lentil Entomology

3.4.1. Effect of *Sitona crinitus* on Lentil Yield

Experiments were conducted at Tel Hadya, Jinderess and one on-farm location, Alkamiye using Promet insecticide at 12 ml/kg lentil seed for *Sitona* control. At all three locations N_{15} technique was used to quantify the effect of insecticide control of *Sitona* on nitrogen fixation.

Oviposition of *Sitona* started in mid February, earlier than last year. At all locations the number of eggs per soil sample was greatly reduced by Promet treatment. The mean nodule damage was low (5%) at Alkamiye at the first sampling date (29 March), when at Tel Hadya and Jinderess already 48% damage was noted. This was observed previously also and is due to lower temperatures at Alkamiye.

At all locations Promet treatment significantly ($P>0.05$) decreased the nodule damage and increased lentil seed and biological yields (Figure 3.4.1).

Plant samples were taken at harvest and analysed for nitrogen content. No significant differences due to treatment were found, although the nodule damage ranged from 60% at Alkamiye to 74% at Jinderess and was significantly reduced by Promet treatment (Table 3.4.1). The nitrogen yields, however, were significantly higher with Promet treatment at all locations, apparently due to crop yield increases. Soil samples from all treatments were also taken and analysed for NH^{+}_{4} and NO_3 and total nitrogen content, but differences were not significant.

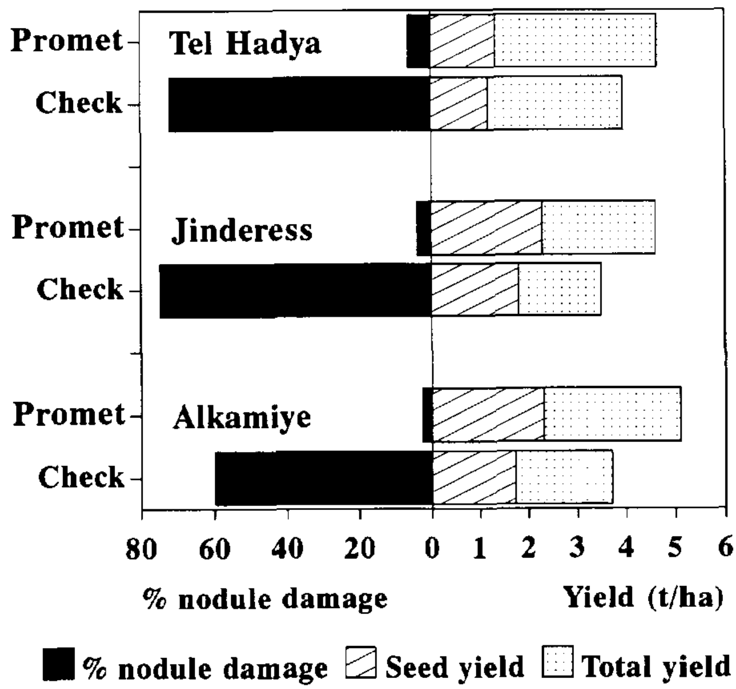


Figure 3.4.1. Effect of application of Promet on lentil seed and biological yield and nodule damage by *Sitona crinitus* at 3 locations, Syria, 1992/93.

Table 3.4.1. Effect of Promet (12 ml/kg seed, P 12) treatment on lentil percent nitrogen content, seed, total and nitrogen yield and nodule damage by *Sitona* at 3 locations in Syria, 1992/93.

Location	Treatment	%N	Lentil yield (kg/ha) Seed	Total	N yield (kg/ha)	% nodule damage on 11 April
Tel Hadya	Check	2.09	1178	3950	82.6	71.8
	P 12	2.15	1338	4647	100.1	6.2
	S.E.M.	0.04	32.6	32.3	2.1	0.1
	LSD 5%	NS	146.6	145.3	9.5	5.9
Jinderess	Check	2.48	1796	3492	85.0	74.6
	P 12	2.47	2288	4606	113.9	3.9
	S.E.M.	0.05	72.1	132.7	4.6	2.8
	LSD 5%	NS	324.6	596.9	20.9	12.5
Alkamiye	Check	2.46	1717	3710	91.1	59.8
	P 12	2.45	2303	5105	124.9	2.6
	S.E.M.	0.03	105.4	167.6	4.5	1.0
	LSD 5%	NS	474.1	754.3	20.2	4.6

This season, Promet treatment for *Sitona* control was evaluated in the lentil on-farm verification trials at 6 locations in some major lentil growing areas of Syria (in the south, middle, northwest, north and northeast). Sampling for nodule damage was carried out twice, in the end of March and early May. At all locations *Sitona* nodule damage was found, but severity differed between locations (Table 3.4.2). In the first sampling (end of March) high nodule damage of more than 70% was recorded in southern and middle Syria (Daraa and Hama areas), whereas in Aleppo and Hassakeh the damage was only about 30 to 45%. These differences in nodule damage resulted in visible plant growth differences. Plants from check plots at high damage sites were smaller and yellowish as compared to plants from Promet treated plots. At the second sampling (early May) differences in nodule damage between locations were less. At all locations Promet treatment significantly reduced nodule damage. Lentil seed and biological yield, however, did not differ significantly between treatments, perhaps because of high residual fertility of the soil.

Table 3.4.2. Effect of Promet (12 ml/kg seed) treatment on lentil seed and total shoot yield and nodule damage by *Sitona* at different locations in Syria, 1992/93.

Location	Treatment	% nodule damage		Lentil yield (kg/ha)	
		28 March	5 May	Seed	Total shoot
Daraa					
Da'el	Check	74.3	87.3	758	1518
	Promet	1.4	31.4	726	2821
Hama					
Souran	Check	70.0	80.0	1491	2929
	Promet	0.3	5.9	1780	2837
Idleb					
Afes	Check	61.8	63.0	2106	3824
	Promet	0.9	7.8	2090	4236
Aleppo					
Kafer Naseh	Check	33.5	84.8	479	1267
	Promet	0.1	9.9	915	1462
Hassakeh					
Om Elrabia	Check	33.9	68.8	n.a.	n.a.
	Promet	0.7	6.2	n.a.	n.a.

These results show that *Sitona* occurs in all the lentil growing areas in Syria but in the southern region damage is severe. In Aleppo and Hasakeh area nodule damage was low in March but had increased to high levels in May. Most likely *Sitona* infestations start later and slower here than in south because of lower temperatures. The experiments also confirmed the effectiveness of Promet treatment for *Sitona* control. **S. Weigand, A. Joubi, and A. Seoud (ARC, Douma).**

3.4.2. Aphid Control in Lentil

Because of relatively low aphid infestation the experiment for economic control using different levels of aphid infestation as threshold could not be carried out as planned. Only the following treatments could be applied: seed treatment with Gaucho 35 (Imidchlorid) at 2.85 ml/kg seed, one spray of Pirimor 50 (0.5g/l) at the lowest infestation level of 50 to 200 aphids per board (20 cm x 50 cm) and weekly spray. The highest number of aphids was recorded in late April, but only reached a mean of 45 aphids per board. The seed treatment with Gaucho did not have a significant effect on the number of aphids. This insecticide has been found to give effective control of aphids in cereals in Egypt and Sudan. The Gaucho treatment is less effective in Syria perhaps because it does not persist for the long period of about 5 months between sowing and aphid infestation in lentil here as compared to only 2 months in cereals in Egypt and Sudan.

Sampling for nodule damage in the plants from this experiment showed that Gaucho does not have an effect on *Sitona*, as the nodule damage was a mean of 82 % with Gaucho and 85 % in the check. This was confirmed in a small greenhouse experiment in which *Sitona* adults were placed on lentil plants at seedling stage treated with Promet, Gaucho and check. Within 24 hours all *Sitona* on Promet treated plants were dead, whereas the ones on Gaucho treated plants continued to survive causing as much feeding damage as the ones on the non treated lentil. **S. Weigand and A. Joubi.**

4. FORAGE LEGUME IMPROVEMENT

Rapidly growing livestock population of the dry areas of West Asia and North Africa has accentuated demand for feed. Earlier, natural range lands provided almost the entire feed supply for animals, but overgrazing during the last three decades has severely degraded the natural vegetation, leading to feed shortage. These shortages are especially acute during late summer and early winter. Growing suitable annual forage-legume crops, such as vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.), can alleviate this problem. These crops are one of the major options to interrupt barley monoculture or to replace fallow in barley-based rotations in dry areas. These annual crops can be used for grazing during winter and early spring and harvested for hay in spring or for grain and straw at full maturity. They differ from food legume crops only in the end use - they are used to feed livestock, whereas food legumes mainly for human consumption.

Although there is a large diversity of species of *Vicia* and *Lathyrus* in the Mediterranean region, only a few have been used as feed crops and these have received little attention in the past by plant breeders and agronomists. Legume program pays particular attention to such annual species of these two genera which could be adapted to areas where seasonal rainfall ranges from 250 to 400 mm.

4.1. Forage Legume Breeding

The general objective of our breeding program is to develop and produce improved cultivars of feed-legume crops and to target these crops to feed livestock in areas with less than 400 mm. It is also desirable to have widely adapted cultivars that can be recommended for different locations with similar agroecological conditions. While attempting to improve yield potential and adaptation to environment, emphasis is laid on ensuring that the palatability, intake and nutritive value of herbage, hay, grain and straw are acceptable. This work is being done in a close collaboration with PFLP.

In vetches, we are dealing with *Vicia sativa* L. (common vetch), *V. villosa* ssp. *dasycarpa* Tan. (wooly-pod vetch), *V. ervilia* L. (bitter vetch), *V. palaestina* R. (Palaestine vetch), and *V. panonica* GR. (Hungarian vetch) to develop improved cultivars. In chicklings, we concentrate on *Lathyrus sativus* L. (common chickling or grasspea), *L. cicera* L. (dwarf chickling) and *L. ochrus* L. (DG) (ochrus vetch). Work is also done on *Vicia sativa* ssp. *amphicarpa* Dorth (underground vetch) and *Lathyrus ciliolatus* L. (underground chickling) which produce pods both underground and aboveground. Two approaches are adopted to develop improved lines of *Vicia* and *Lathyrus* spp. In one, selection is effected in the wild accessions to develop improved cultivated types. In the second, hybridization is done to introgress desirable traits, using the selections from wild accessions. The work is carried out by a multi-disciplinary team involving breeder, physiologist, pathologist, entomologist and animal nutritionist. A description of the scheme of breeding was given in the 1992 Legume Program Annual Report.

In 1992/93, germplasm of *Lathyrus* spp. was evaluated in collaboration with GRU. Promising genotypes (selections) of *Vicia sativa, V. ervilia, V. narbonensis, V. panonica, V. hybrida, V. palaestina* and *Lathyrus sativus* were tested in preliminary microplot field trials at Tel Hadya (seasonal total rainfall 277 mm). Promising lines of *V. villosa* ssp. *dasycarpa* and non-shattering *V. sativa* were tested in Tel Hadya, and promising lines of *V. narbonensis, L. sativus, L. cicera and L. ochrus* were tested at Tel Hadya and Breda (seasonal total rainfall 285). After screening common chickling for low neurotoxine (BOAA) content, a crossing program was initiated in 1990/91 for improving nutritional quality of the crop by breeding. F1 and F2 generations were grown in 1992/93 at Tel Hadya. A study to investigate the potential of subterranean vetch (*V. sativa* ssp. *amphicarpa*) under actual grazing conditions and its effect on the subsequent barley crop and its self-regeneration after barley, was continued. Crosses of *V. sativa* ssp. *sativa* and *V. sativa* ssp. *amphicarpa* were made and F1 and F2 plants were studied. The reaction of promising lines against major foliar and root diseases was monitored. All the breeding work was done under rainfed conditions without suplementary irrigation.

As an international center with major responsibilities for WANA, we aim to serve the national feed improvement programs through:
(1) assembling, classifying, evaluating, maintaining and distributing germplasm;
(2) developing and supplying breeding populations with adequate diversity to be used in different environments; and
(3) co-ordinating international trials to facilitate multilocation testing and identification of widely adapted cultivars.

4.1.1. Germplasm Evaluation

4.1.1.1. Agronomic evaluation of chickling accessions

The appraisal was carried out of 1082 accessions representing 30 species of *Lathyrus* in nursery rows in a trial in collaboration with the Genetic Resources Unit (GRU). A total of 100 entries of *L. sativus, L. cicera* and *L. ochrus* were selected on the basis of visual evaluation of seedling vigour, winter and spring growth, cold effect, leafiness, erect growth habit, and earliness to flower and mature. Further evaluation of their herbage and seed yields, reaction against major foliage and root diseases, and BOAA content will be done in 1993/94. Results of the *Lathyrus* germplasm evaluation are reported in the 1993 Annual Report of GRU. **A.A. El Moneim and L.D. Robertson.**

4.1.1.2. Evaluation of vetches and chicklings for cold tolerance

To compare the tolerance level of various vetch and chickling species and to identify sources of tolerance to cold in each species two experiments were conducted. Two susceptible-cum-indicator checks of common vetch, IFVI 534 and IFVI 708, and two checks of common chickling, IFLA 199 and IFLA 432, were included for screening of the respective species.

The test entries along with the checks were grown in a randomized block design with two replications at Tel Hadya. The plantings were done on 1 Oct 1992 and one irrigation (40 mm) was applied to ensure good germination. The susceptible check was included after every 10 test lines. The crop experienced freezing temperatures for 48 days and the minimum temperature was -8.7°C on 17 Jan 1993. Visual cold tolerance ratings on a 1-9 scale (1= no cold damage, 9= killed by cold) were assigned after the susceptible checks gave a rating of 9. The higher rating of the two replications was considered as the actual cold-tolerance rating of the lines.

Vetches:
Three hundred and twenty one accessions of various vetch species found cold tolerant during 1991/92 were evaluated for reconfirmation of their cold tolerance reaction in the 1992/93 season. Almost all the accessions rated tolerant (rating ≤4) except 1,1,2 and 2 accessions from *V. ervilia, V. hybrida, V. narbonensis* and *V. peregrina*, respectively (Table 4.1.1.) which were rated 5.

Table 4.1.1. Reconfirmation of cold tolerance reaction in germplasm accessions of vetches during 1992/93 season at Tel Hadya.

Species	Cold rating (1-9 scale, 1=free, 9=highly susceptible)									
	1	2	3	4	5	6	7	8	9	Total
V. ervilia	-	-	5	24	1	-	-	-	-	30 (100)
V. hybrida	-	-	58	1	1	-	-	-	-	60 (60)
V. narbonensis	-	-	45	7	2	-	-	-	-	54 (96)
V. peregrina	-	24	13	1	2	-	-	-	-	40 (40)
V. sativa	-	-	28	12	-	-	-	-	-	40 (103)
V. villosa	-	7	89	1	-	-	-	-	-	97 (97)
Total	-	31	238	46	6	1	-	-	-	321 (496)

Values in brackets are the total number of accessions tested for cold tolerance during 1991/92.

Chicklings:
Two hundred and thirty eight accessions found tolerant to cold in 1991/92 season were evaluated for confirmation of their cold-tolerance reaction during 1992/93. All the accessions (except in five accessions where the earlier rating of 4 was increased to 5) were found cold tolerant during 1992/93 season (Table 4.1.2).

Table 4.1.2. Reconfirmation of cold tolerance reaction of 238 accessions of various species of chicklings during 1992/93 season at Tel Hadya.

Species	Cold rating (1-9 scale, 1=free, 9=highly susceptible)									
	1	2	3	4	5	6	7	8	9	Total 1992/93
L. annuus	-	-	21	-	-	-	-	-	-	21 (21)
L. aphaca	-	2	78	1	-	-	-	-	-	81 (85)
L. cicera	-	-	53	9	2	-	-	-	-	64 (70)
L. hierosolimitanus	-	1	44	-	2	-	-	-	-	47 (47)
L. marmuratus	-	-	7	-	-	-	-	-	-	7 (7)
L. ochrus	-	-	-	1	-	-	-	-	-	1 (48)
L. pseudocicera	-	-	13	3	1	-	-	-	-	17 (17)
L. sativus	-	-	-	-	-	-	-	-	-	0 (203)
Total	-	3	216	14	5	-	-	-	-	238 (498)

Values in brackets are the total number of accessions tested for cold tolerance in 1991/92.

In addition to the above mentioned evaluation, 445 new accessions were evaluated for cold tolerance and the results revealed that almost 340 accessions were tolerant (with rating of ≤4). It was interesting to note that out of the new accessions evaluated a few accessions of *L. sativus* and *L. ochrus* also showed tolerant reaction (Table 4.1.3). **R.S. Malhotra, A.A. El Moneim and M.C. Saxena.**

4.1.2. Preliminary Microplot Evaluation

Microplot Yield Trials (MYT) provide the first opportunity for breeders to examine the agronomic characteristics of their selections from germplasm evaluation with the objective of getting high herbage and seed yields, resistance to biotic and abiotic stresses and good nutritive value.

Table 4.1.3. Cold tolerance reaction of new accessions of various chickling species during 1992/93 season at Tel Hadya.

Species	Cold rating (1-9 scale, 1=free, 9=highly susceptible) 1	2	3	4	5	6	7	8	9	Total
L. annuus	-	3	12	-	-	-	-	-	-	15
L. aphaca	-	39	8	-	4	2	-	-	-	53
L. blepharicarpus	-	7	18	-	3	1	-	-	-	29
L. cassius	-	6	-	-	1	-	-	-	-	7
L. cicera	-	10	15	-	1	2	-	-	-	28
L. cilicicus	-	2	-	-	-	-	-	-	-	2
L. clymenum	-	-	1	1	1	1	-	7	3	14
L. gorgoni	-	12	30	2	-	1	1	-	-	46
L. hierosolymitanus	-	15	4	-	-	-	-	-	-	19
L. hirsutus	-	3	1	-	-	-	-	-	-	4
L. incospicuus	-	58	6	3	3	-	-	-	-	70
L. marmoratus	-	2	6	-	-	-	-	-	-	8
L. nissolia	-	2	-	-	-	-	-	-	-	2
L. ochrus	-	1	-	1	4	3	4	2	-	15
L. pseudocicera	-	11	3	1	2	-	-	-	-	17
L. sativus	-	2	-	17	10	12	9	10	2	62
L. sphaericus	-	1	3	-	-	-	-	-	-	4
L. vinealis	-	-	2	-	2	-	-	-	-	4
Other lathyrus species	-	18	12	2	7	6	1	-	-	46
Total	-	192	121	27	38	28	15	19	5	445

In 1992/93 season microplots of six *Vicia* spp. and two *Lathyrus* spp. were planted at Tel Hadya in 3.5 m2 plots arranged in triple lattice design. Numbers of entries for each trial are shown in Table 4.1.4. Seed rate for *Vicia villosa* ssp. *dasycarpa* was 80 kg/ha and for the other species was 100 kg/ha and fertilizers were applied at 40 kg P2O5/ha. These microplot experiments were in two sets. One was harvested at 100% flowering to determine the herbage yield (DM) and the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

4.1.2.1. Common vetch (*Vicia sativa*)

Two sets each of 25 selections of common vetch were tested at Tel Hadya. In the first trial (Trial 1), selections were evaluated for the second time and in the second trial (Trial 2) this was the first evaluation.

Table 4.1.4. Forage legume species and number of entries tested at Tel Hadya 1992/93 in microplot yield trials.

Species	No. of entries (selections)
Vicia sativa Trial 1	25
V. sativa Trial 2	25
V. ervilia	25
V. narbonensis	36
V. panonica	25
V. hybrida	16
V. palaestina	16
Lathyrus sativus	16
Total	184

In Trial 1 the results of the ten most promising lines are shown in Table 4.1.5. The herbage production (DM) at 100% flowering varied from 2623 to 3617 kg/ha, total biological yield at maturity ranged from 3664 to 4682 kg/ha, while the harvest index ranged from 34 to 39%. The high total biological and seed yields of IFLVS 2483 , 2496 and 2504 were attributed to their rapid winter growth, early flowering and maturity and better frost tolerance. IFLVS 2483 is also characterized by high leafiness and leaf:stem ratio, and resistance to lodging.

In Trial 2 the results of the top 12 promising lines are shown in Table 4.1.6. Herbage yield varied from 1783 to 4060 kg/ha, grain yield ranged from 938 to 1710 kg/ha, and the harvest index from 29 to 45%. The relatively low herbage and grain yields were due to low rainfall. Common vetch is adapted to rainfall above 350 mm. Selections in Trial 1 are more adapted to lower rainfall and they underwent selection for two years. Hence yields were higher in Trial 1 than Trial 2.

4.1.2.2. *Vicia ervilia* (Bitter vetch)

Twenty five selections were tested at Tel Hadya. Herbage yield (DM) at 100% flowering varied from 2646 to 4347 kg/ha, total biological yield at maturity ranged for 3619 to 4630 kg/ha, while the grain yield varied from 952 to 2130 kg/ha. Table 4.1.7 shows the performance of 12 top selections. Bitter vetch showed good tolerance to cold with rapid winter and spring growth. Its yields are therefore substantially better than those of common vetch, and it is clear that this neglected species deserves further attention.

Table 4.1.5. Herbage, biological and grain yields, harvest index (%), days to flowering and maturity of the top 10 selections of common vetch (*V. sativa*) in preliminary yield trial 1 at Tel Hadya.

Selection IFLVS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
2483	3346	4682	1779	38	112	146
2484	2959	4317	1511	35	114	148
2486	2924	4466	1563	35	113	151
2487	2632	4186	1549	37	114	148
2488	3014	4247	1529	36	112	146
2489	3092	4014	1485	37	114	149
2490	2974	4130	1528	37	114	149
2496	3113	4329	1645	38	112	147
2501	3167	4297	1504	35	110	146
2504	3170	4453	1692	38	112	147
Grand mean+	3035	4089	1513	37	112	149
SEM±	201	237	88	1.5	0.6	1.0
LSD (P=0.05)	577	679	252	4.4	1.7	2.8
CV (%)	11.4	9.9	10.0	7.3	0.9	1.1

\+ Mean for all 25 selections.

Table 4.1.6. Herbage, biological and grain yields, harvest index (%), days to flowering and maturity of the top 12 selections of common vetch (*V. sativa*) in preliminary yield trial 2 at Tel Hadya.

Selection IFLVS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
2560	3363	3882	1475	38	114	154
2566	3371	3393	1493	44	115	152
2567	3147	3800	1710	45	105	144
2607	3456	3834	1687	44	114	148
2610	4060	3963	1625	41	110	146
2616	3125	3578	1610	45	120	156
2617	3046	3979	1671	42	115	151
2618	3380	3929	1493	38	115	149
2621	2757	3733	1493	40	117	156
2626	3303	3761	1542	41	111	151
2627	3395	3793	1555	41	109	147
2628	3652	3767	1582	42	112	146
Grand mean+	2959	3582	1397	39	116	155
SEM±	226	180	83	1.9	0.6	1.0
LSD (P=0.05)	648	517	239	5.6	1.7	2.8
CV (%)	13.2	8.8	10.3	8.6	0.9	1.1

\+ Mean for all 25 selections.

Table 4.1.7. Herbage, biological and grain yields, and days to flowering and maturity of the top 12 promising lines of bitter vetch (*V. ervilia*) in preliminary yield trials at Tel Hadya.

Selection IFLVE	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Days to flowering	Days to maturity
2563	4085	4543	1999	113	152
2508	4347	4451	2003	112	146
2509	3645	4350	2001	110	147
2510	4138	4317	1986	110	147
2512	4040	4349	1957	111	149
2513	4096	4424	1858	110	149
2516	3949	4630	2130	108	145
2517	4224	4391	1932	110	147
2520	3635	4402	1981	112	151
2522	4078	4489	1975	108	146
2646	3435	3902	1756	116	152
2649	3351	4242	1909	117	158
Grand mean+	3668	4273	1803	114	153
SEM±	205	196	109	0.7	1.2
LSD (P=0.05)	589	556	313	2.1	3.4
CV (%)	9.7	8.0	10.5	1.1	1.3

+ Mean for all 25 selections.

4.1.2.3. Narbon vetch (*Vicia narbonensis*)

Thirty six selections of narbon vetch were tested in microplot field trials at Tel Hadya.The total biological yield varied from 3733 to 4933 kg/ha, grain yield from 1389 to 2072 kg/ha, whereas the harvest index ranged from 36 to 45%. Narbon vetch showed good cold tolerance with rapid winter growth and early maturity. The early genotypes were able to set seeds and form pods before the onset of late spring heat and escape damage from broomrape (*Orobanche crenata* Fosrk.). The total biological yield was therefore negatively correlated with days to flowering and maturity ($r=-0.408$, $P<0.05$ and $r=-0.403$, $P<0.05$). The results indicate the need to search for early maturing genotypes of narbon vetch. The 16 selections which combined high biological and grain yields, high harvest index and early maturity are shown in Table 4.1.8.

Table 4.1.8. Biological and grain yields, and harvest index (%), days to flowering and maturity of the top 16 promising selections of narbon vetch (*V. narbonensis*) grown at Tel Hadya.

Selection IFLVN	Biological yield (kg/ha)	Grain yield (kg/ha)	Harvest yield (kg/ha)	Days to flowering	Days to maturity
2376	4933	2072	42	103	136
2377	4785	1962	41	107	136
2379	4543	1908	42	101	142
2381	4234	1863	44	103	140
2384	4298	1848	43	100	137
2385	4683	1920	41	100	138
2386	4386	1886	43	101	135
2389	4366	1790	41	102	138
2395	4420	1768	40	103	140
2396	4459	1828	41	107	140
2397	4650	2046	44	100	138
2463	4475	1969	44	98	140
2598	4122	1855	45	100	135
2600	4283	1757	41	101	139
2602	3945	1657	42	107	141
2635	3919	1646	42	105	140
Grand mean+	4353	1741	40	112	149
SEM±	262	112	1.2	0.5	0.8
LSD (P=0.05)	739	314	3.3	1.5	2.5
CV (%)	10.5	12	5	0.8	0.9

+ Mean for all 36 entries.

4.1.2.4. Hungarian vetch (*Vicia panonica*)

Twenty five selections were assessed in microplot field trials at Tel Hadya. Herbage yield varied from 1906 to 2719 kg/ha, whereas, grain yield varied from 975 to 1429 kg/ha. Hungarian vetch showed some cold tolerance, had slow winter growth which was followed by rapid spring growth and long flowering period. The low herbage production is due to the low winter growth. Table 4.1.9 shows the performance of top 9 selections for both high herbage and grain yields.

Table 4.1.9. Herbage, biological and grain yields, and days to flowering and maturity of the top 9 selections of *V. panonica* in preliminary yield trials at Tel Hadya.

Selection IFLVP	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Days to flowering	Days to maturity
2653	2719	3547	1135	119	160
2655	2292	3475	1112	119	163
2665	2375	3560	1246	122	162
2667	2091	4124	1402	122	164
2669	2189	4060	1421	123	165
2670	2528	4179	1429	123	165
2672	2110	3970	1310	129	166
2673	2446	4121	1360	121	161
2674	2111	3716	1189	123	164
Grand mean+	2320	3803	1179	121	163
SEM±	176	190	69	0.7	0.7
LSD (P=0.05)	501	544	197	1.9	2.1
CV (%)	13.2	8.7	10.2	0.9	0.8

+ Mean for all 25 selections.

4.1.2.5. Broad-podded vetch (*Vicia hybrida*)

Sixteen selections of this species were tested in microplot field trials at Tel Hadya and the performance of the best six promising selections is shown in Table 4.1.10. Herbage yield varied from 2107 to 2685 kg/ha, total biological yield varied from 2991 to 3881 kg/ha whereas, grain yield varied from 815 to 1128 kg/ha. The crop showed a prostrate and compact growth habit and a slow winter growth followed by a rapid spring growth. This makes the species more suitable for grazing than as a grain crop, although for grazing also it will be inferior to the underground vetch (*Vicia sativa* ssp. *amphicarpa*). Its low harvest index and low grain yield were partly due to the prostrate growth habit that makes seed harvest difficult.

4.1.2.6. Palaestine vetch (*Vicia palaestina*)

Sixteen selections of this species were evaluated in microplot yield trials at Tel Hadya. The biological, herbage and grain yields of the best seven selections are shown in Table 4.1.11. Herbage yield varied from 1733 to 2454 kg/ha, total biological yield from 2739 to 3438 kg/ha, whereas, grain yield varied from 777 to 1284 kg/ha. Although frost susceptible, the crop was able to recover quickly after frost damage. The yields were, however, poor. It grows in areas receiving 250 mm rainfall. It is a sprawling vetch that needs much selection and hybridization before becoming acceptable as a feed legume crop.

Table 4.1.10. Herbage, biological and grain yields, and days to flowering and maturity of the top 6 promising selections of *Vicia hybrida* in preliminary yield trials at Tel Hadya.

Selection IFLVH	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Days to	
				flowering	maturity
2540	2416	2991	1017	108	153
2541	2685	3573	929	109	153
2544	2149	3238	1036	106	150
2546	2672	3723	968	108	154
2547	2223	3300	1089	110	155
2551	2221	3346	937	108	153
Grand mean+	2377	3426	949	109	154
SEM±	161	249	64	0.6	0.8
LSD (P=0.05)	475	733	185	1.7	2.3
CV (%)	11.8	12.5	12.0	0.9	0.9

+ Mean for all 16 selections.

4.1.2.7. Common chickling (*Lathyrus sativus*)

Sixteen selections were tested at Tel Hadya. Results of the top 6 selections are shown in Table 4.1.12. Herbage yield varied from 2147 to 3085 kg/ha, biological yield from 3763 to 5125 kg/ha, whereas, the grain yield from 1618 to 2255 kg/ha. *Lathyrus sativus* was moderately affected by cold in early spring. It is characterized by slow winter growth, rapid growth in the spring and long flowering period. The late rain favoured attack by powdery mildew (*Erisiphe pisi*) when pods were formed.

Table 4.1.11. Herbage, biological and grain yields, and days to flowering and maturity of the best 7 selections of *V. palaestina* in preliminary yield trials at Tel Hadya.

Selection IFLVPa	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Days to flowering	Days to maturity
2523	1928	2912	990	111	149
2525	2027	3438	1272	111	154
2526	2454	3075	1230	109	148
2528	2263	3318	1261	110	153
2529	2064	3008	1143	110	152
2533	2414	3016	1116	108	150
2536	2155	3132	1284	108	147
Grand mean+	2103	3011	1084	111	152
SEM±	198	201	93	0.5	0.9
LSD (P=0.05)	583	590	270	1.4	2.8
CV (%)	16.3	14.2	15.0	0.7	1.1

+ Mean for all 16 selections.

Table 4.1.12. Herbage, biological and grain yields, and days to flowering and maturity of the best 6 promising selections of *Lathyrus sativus* in preliminary microplot yield trials at Tel Hadya.

Selection IFLLS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Days to flowering	Days to maturity
554	2210	4200	1848	116	168
560	2307	5125	2255	117	166
563	2367	4045	1699	115	164
566	2770	4233	1905	115	160
568	2631	3984	1793	117	166
587	3085	4260	1917	113	157
Grand mean+	2523	4370	1879	116	164
SEM±	147	291	131	0.4	0.7
LSD (P=0.05)	433	857	386	1.3	2.1
CV (%)	10.0	12.0	13	0.7	0.8

+ Mean for all 16 selections.

4.1.2.8. Relationship of yield with winter growth and phenology

For cool-season feed-legume species winter growth and early flowering and maturity are important selection criteria. Table 4.1.13 shows the correlation coefficients of total biological yield with some major characters. In *V. sativa, V. ervilia* and *V. narbonensis*, winter growth is significantly correlated with total biological yield. Early winter growth gives a good opportunity for early grazing, providing animals with green fodder in early spring when other feed resources are scarce. Leafy types of *V. sativa* can be grazed in early spring.

Days to flowering and maturity were negatively correlated with total biomass production in *V. sativa, V. ervilia* and *V. narbonensis*. The early genotypes of these species produced more biomass than the late ones. In contrast, in *V. panonica* days to flowering and maturity were positively correlated with total biomass. This is mainly due to its slow winter growth and late maturity (Figure 4.1.1). There is a clear need to continue search for early maturing genotypes of *V. sativa, V. ervilia* and *V. narbonensis* and genotypes with rapid winter growth and early maturity in *V. panonica* for the high elevation cold regions.

Yield levels of *V. sativa, V. ervilia, V. narbonensis* and *L. sativus*, suggest that they could be used by farmers who want straw and grain for winter feeding. *V. sativa* could also be recommended for hay making in the spring, whereas, *V. hybrida* and *V. palaestina* would be suitable
yields.

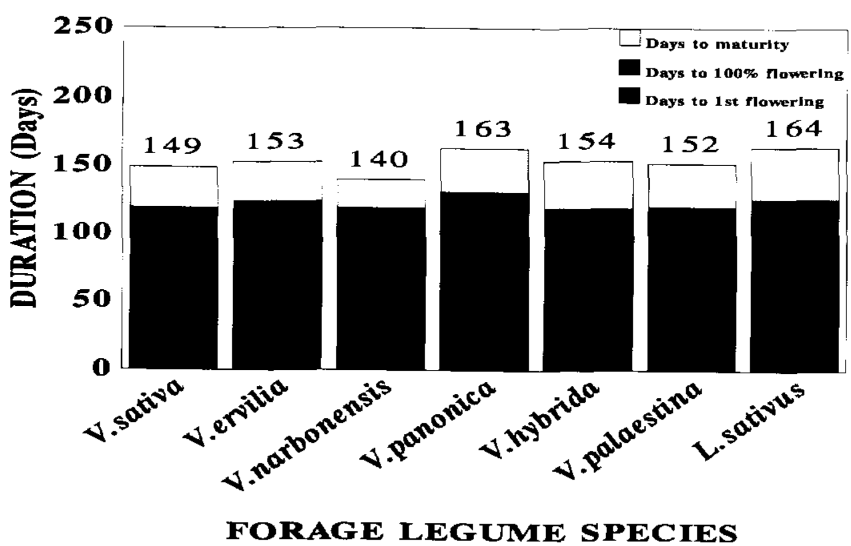


Figure 4.1.1. Variation in Phenology of 6 *Vicia* spp. and 2 *Lathyrus* spp. grown at Tel Hadya 1992/93.

Table 4.1.13. Correlation of total biomass with other agronomic traits in six *Vicia* spp. and one *Lathyrus* spp. in microplot yield trials.

Characters	*Vicia sativa*	*Vicia ervilia*	*Vicia narbonensis*	*Vicia panonica*	*Vicia palaestina*	*Vicia hybrida*	*Lathyrus sativus*
Winter growth	0.465*	0.471*	0.403*	-0.417*	-0.205	-0.148	-0.211
Days to start flowering	-0.514*	-0.725***	-0.518*	0.414*	-0.263	0.166	-0.386
Days to maturity	-0.528**	-0.780***	-0.455*	0.514*	-0.163	-0.084	-0.432*
Total seed yield	0.794***	0.796***	0.770***	0.664***	0.757**	-0.379	0.923***
Straw yield	0.932***	0.334	0.853***	0.865***	0.779**	0.955***	0.953***
Harvest Index	-0.281	0.527**	0.073	0.039	0.332	-0.772**	0.183

* Significant at P = 0.05; ** significant at P = 0.01 and *** significant at P = 0.001.

4.1.3. Advanced Yield Trials

Experiments were carried out to test promising lines of wooly-pod vetch at Tel Hadya and of narbon vetch, common chickling, dwarf chickling and ochrus chickling at Tel Hadya and Breda. These lines were selected on the basis of their performance in microplot yield trials. The trials were sown and managed as microplots but with larger plot size (28 m2).

4.1.3.1. Advanced Yield Trials of wooly-pod vetch at Tel Hadya

Thirty six lines were tested at Tel Hadya. There were great differences in winter growth, days to flowering and maturity, herbage yield at 100% flowering, degree of leaf retention and harvest index. Herbage yield varied from 2533 to 3265 kg/ha and yield from 107 to 555 kg/ha. Seed yield was negatively correlated with days to flowering and maturity (r= -0.795 and -0.685, respectively, P<0.001), although not the herbage yield. The harvest index ranged from 5 to 17%. The best twelve lines (high yield of both herbage and seed) are shown in Table 4.1.14.

Table 4.1.14. Herbage, biological and grain yields, harvest index (%), and days to flowering and maturity for the top 12 lines of wooly-pod vetch grown in AYT at Tel Hadya.

Selection IFLVVD	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
2424	2811	2944	471	16	117	158
2432	2790	3165	538	17	122	160
2435	2564	3265	555	17	121	152
2436	2893	2929	498	17	122	162
2438	2603	3667	550	15	120	162
2439	3163	3199	506	15	120	160
2442	2894	3163	506	16	118	157
2443	2617	2924	497	17	123	161
2450	2867	2906	465	16	120	159
2454	3103	3375	540	16	119	160
2455	2889	3206	545	17	119	158
2457	2881	3100	465	15	118	158
Grand mean+	2817	3175	454	14.3	121	161
SEM±	109	279	53	1.6	0.5	1.0
LSD (P=0.05)	313	792	153	4.6	1.4	2.9
CV (%)	6.7	15.2	20.4	19.4	0.7	1.1

+ Mean for all 36 lines.

Wooly-pod vetch is unaffected by broomrape (*Orobanche crenata* Forsk) and tolerant of cold. It is also characterized by rapid winter growth with a long flowering period. This gives the species the advantage of suitability for early grazing for a long period, even at moderate to high elevations and in broomrape infested lowlands in the WANA region.

4.1.3.2. Advanced yield trials of other vetches and chicklings at Tel Hadya and Breda

Twentyfive promising lines of narbon vetch (*Vicia narbonensis*) and sixteen each of common chickling (*Lathyrus sativus*), dwarf chickling (*L. cicera*) and ochrus chickling (*L. ochrus*) were evaluated under rainfed conditions at two contrasting locations i.e. Tel Hadya and Breda, in three years 1990/91, 1991/92 and 1992/93. The two locations were chosen to sample the environmental conditions of the cereal zone in Syria. Climatic conditions during the three years are described in the corresponding Annual Reports of the Legume Program. The two locations in each of the three years were treated as separate environment to give six environments altogether, with annual rainfall range from 241 to 352 mm.

The experiments were sown in a triple lattice design with three replicates. Plot size was 5 x 5.8 m2. The experiments were sown with an Ojyord experimental drill soon after the first autumn rains.Seeding rate was 100 kg/ha. Field germination was about 95% in all experiments. All plots received a basal dressing of 40 kg P2O5/ha. Observations on disease incidence, parasitic weeds and nematodes were made. Genotype x environment (GxE) interactions were analyzed using linear regression (Perkins & Jinks, 1968).

The study of genotype (line) x environment interactions leads to successful evaluation of stable lines which could be used in future breeding programmes. The "stability" is measured as a linear regression (b value) of line mean yield on the average of all lines in each environment. It is a measure of the response of a particular line to changes in environment. Any significant deviation from the average response (b=1.0) is because of the genotype (line) x environment interaction. In addition to the regression coefficient, deviation around regression lines (S_b) is considered as a measure of stability. The best line is one which has high mean yield across environments along with regression coefficient not significantly different from 1.0 and the least deviation from regression (S_b). Coefficients of determination (r^2 values) are also computed from linear regression analysis as a measure of goodness of fit.

Results of narbon vetch:
Mean total biological and grain yields and three stability parameters i.e. regression coefficient (b), deviation around regression lines (S_b) and coefficient of determination (r^2) are given in Table 4.1.15.

Table 4.1.15. Mean total biological and seed yields and estimates of stability parameters for 25 lines of narbon vetch based on six environments.

Lines IFLVN	Total biological yield (kg/ha)				Seed yield (kg/ha)			
	X	b	$\pm S_b$	r^2	X	b	$\pm S_b$	r^2
2561	4007	1.08	0.25	0.83	1362	0.86*	0.13	0.91
2380	3958	1.06	0.12	0.95	1567	1.05	0.10	0.96
2383	4211	1.06	0.07	0.98	1599	1.01	0.05	0.98
2387	3618	1.04	0.11	0.95	1514	1.04	0.01	0.96
2388	3949	1.02	0.09	0.97	1406	0.86*	0.07	0.96
2390	3828	0.86*	0.21	0.95	1415	0.84*	0.19	0.92
2391	3685	0.96	0.11	0.95	1369	0.84*	0.14	0.89
2392	4119	1.16*	0.19	0.95	1543	1.19*	0.18	0.90
2393	3818	0.94	0.07	0.97	1443	1.05	0.05	0.98
2461	4051	1.03	0.13	0.94	1438	1.07	0.14	0.93
2462	3968	0.92	0.12	0.94	1433	1.07	0.09	0.96
2464	3960	0.80*	0.17	0.84	1328	0.81*	0.15	0.88
2465	3952	0.95	0.09	0.96	1367	1.05	0.10	0.96
2466	3694	0.93	0.13	0.93	1279	1.04	0.12	0.94
2467	4068	1.01	0.09	0.97	1428	1.06	0.10	0.96
2468	4008	1.14*	0.16	0.92	1377	0.92	0.10	0.95
2469	4004	1.04	0.07	0.98	1444	1.04	0.09	0.97
2470	3956	0.99	0.10	0.96	1363	0.99	0.12	0.94
2471	3982	1.02	0.12	0.94	1437	1.03	0.09	0.96
2473	4117	1.00	0.11	0.95	1476	1.07	0.10	0.96
2474	3966	1.20*	0.21	0.96	1455	1.22*	0.25	0.96
2475	3908	0.95	0.08	0.98	1487	1.04	0.06	0.98
2476	3821	0.86*	0.17	0.97	1436	0.91	0.07	0.97
2477	4149	0.92	0.02	0.94	1631	0.92	0.05	0.98
2478	4127	1.08	0.05	0.99	1446	1.10	0.09	0.95
Grand mean	3957				1442			
SEM±	297				124			
LSD (P=0.05)	582				242			

* Significantly different from 1.0 at 0.05 probability level.

Differences among the 25 lines for both biological and grain yields were significant. Total biological yield ranged from 3618 to 4211 kg/ha, while grain yield ranged from 1279 to 1631 kg/ha. On the basis of environmental mean values (Table 4.1.16), variations among environments were significant. Mean biological yield varied from 1929 kg/ha at environment 4 to 5358 kg/ha at environment 2, while grain yield varied from 677 kg/ha at environment 6 to 2052 kg/ha at environment 1. Mean performance was high at both Tel Hadya and Breda in 1992/93, when rainfall was 277 and 285 mm and total number of frost days was 59 and 54, respectively. This indicates that narbon vetch could be adapted to lower rainfall areas with <300 mm and it tolerates the frost spells occurring during winter and early spring. Narbon vetch is also characterized by rapid winter growth and early maturity.

Table 4.1.16. Mean total biological yields and seed yields (kg/ha) in *Vicia narbonensis* for the six environments.

Envir. No.	Loc.	Year	Rain (mm)	No. of frost days	Biological yield		Seed yield	
					Yield	Rank	Yield	Rank
1	TH	1990/91	290	35	3724	4	1237	5
2	TH	1991/92	352	57	5358	1	2052	1
3	TH	1992/93	277	59	4810	2	1844	2
4	BR	1990/91	241	35	1929	6	677	6
5	BR	1991/92	264	73	3225	5	1282	4
6	BR	1992/93	285	54	4716	3	1564	3
	Mean				3957		1443	
	LSD (5%)				823		343	

Pooled analysis of variance showed that the mean differences between lines and environments were significant at ($P<0.05$). The genotype (lines) x environment interaction component was found to be significant. A large portion of this was accounted for by the linear component.

Considering the two complex characters, biological yield and grain yield, lines IFLVN 2383, 2473, 2477 and 2478 had high mean yields, regression coefficients not significant from unity and low (S_b) values. They would thus be considered as the most stable lines across environments. From our previous observations, these lines showed greater cold tolerance and seedling vigour and early maturity. Their full exploitation in future breeding program would be beneficial. Lines IFLVN 2392 and 2474 had high mean yields, had regression coefficients significantly above unity and greater deviation from regression suggesting that these lines are adapted specifically to favourable environments. In contrast, lines IFLVN 2390 and 2464, had relatively high yields along with regression coefficient significantly below 1.0 and greater deviation from regression revealing that these lines are adapted specifically to unfavourable environmental conditions. Their exploitation would prove to be very useful under poor environments.

Results of common chickling:

Mean total biological and grain yields across environments and three stability parameters are given in Table 4.1.17. Differences among the 16 lines for both biological and grain yields were significant. The biological yield varied from 2440 to 2950 kg/ha, whereas, the grain yield

Table 4.1.17. Mean total biological and seed yields and estimates of stability parameters for 16 lines of common chickling based on six environments.

Lines IFLLS	Total biological yield (kg/ha)				Seed yield (kg/ha)			
	X	b	$\pm S_b$	r^2	X	b	$\pm S_b$	r^2
587	2892	0.74*	0.22	0.74	975	0.72*	0.14	0.86
504	2789	1.07	0.09	0.97	980	1.02	0.04	0.99
505	2547	1.06	0.09	0.97	814	0.98	0.08	0.97
508	2775	1.07	0.05	0.95	953	1.03	0.03	0.94
510	2914	1.21*	0.13	0.96	1050	1.29*	0.13	0.94
516	2695	0.92	0.15	0.90	806	0.96	0.10	0.95
519	2835	1.20*	0.15	0.94	832	1.19*	0.08	0.98
520	2665	1.05	0.13	0.94	804	1.05	0.07	0.98
522	2766	0.91	0.07	0.97	888	0.83*	0.04	0.99
527	2666	1.20*	0.09	0.98	930	1.22*	0.17	0.98
528	2440	0.93	0.07	0.98	900	0.90	0.05	0.98
529	2880	0.82*	0.12	0.92	962	0.86*	0.03	0.99
530	2638	0.97	0.09	0.96	782	1.00	0.06	0.98
531	2648	0.74*	0.09	0.94	822	0.78*	0.09	0.94
533	2511	1.11	0.15	0.93	847	1.1	0.09	0.97
535	2950	0.97	0.07	0.88	900	1.04	0.07	0.98
Grand mean	2726				892			
SEM±	236				115			
LSD (P=0.05)	462				225			

* Significantly different from 1.0 at 0.05 probability level.

ranged from 782 to 1050 kg/ha. On the basis of the environmental mean values, environment 2 (Tel Hadya 1991/92) gave the highest biological and grain yields, while the lowest biological yield was in environment 4 (Breda 1990/91) and the lowest grain yield was environment 1, (Tel Hadya 1990/91) (Table 4.1.18). Mean performance was relatively high at both Tel Hadya and Breda in 1992/93. Relatively high rainfall and conducive temperatures at Breda in 1992/93 encouraged development of diseases such as Ascochyta blight (caused by *Ascochyta pisi*. f.sp. *lathyri*) on common chickling. Therefore, common chickling produced lower biological and grain yields at Breda than at Tel Hadya during 1992/93 (Table 4.1.18).

Table 4.1.18. Mean total biological yields and seed yields (kg/ha) in *Lathyrus sativus* for the six environments.

Envir. No.	Loc.	Year	Rain (mm)	No. of frost days	Biological yield		Seed yield	
					Yield	Rank	Yield	Rank
1	TH	1990/91	290	35	2433	4	310	6
2	TH	1991/92	352	57	3744	1	1464	1
3	TH	1992/93	277	59	3366	2	1311	2
4	BR	1990/91	241	35	1335	6	344	5
5	BR	1991/92	264	73	2584	5	950	4
6	BR	1992/93	285	54	2894	3	973	3
	Mean				2726		892	
	LSD (5%)				653		318	

The pooled analysis of variance showed that genotype (line) x environment interaction was significant and great portion of this was accounted for by the linear component.

Lines IFLLS 504, 508 and 535 had high mean yields across environments and b values not significantly different from 1.0, and low deviation around regression lines (S_b), suggests that these lines are stable with wide adaptation. IFLLS 510 and 527 were found to be high yielding, showing linear response to the changes in environmental conditions. These two lines could be recommended for the improved and favourable environments. Two lines IFLLS 587 and 531 were found to be high yielding but less responsive to changes in the environments and thus could be exploited for poor environmental conditions. Inclusion of both these lines in future breeding programmes under unfavourable conditions would be highly desirable.

Results of dwarf chickling:
Differences among lines for biological and grain yields were not significant (Table 4.1.19). Mean total biological yields across environments for the 16 lines ranged from 2987 to 3364 kg/ha, and for

Table 4.1.19. Mean total biological and seed yields and estimates of stability parameters for 16 lines of dwarf chickling based on six environments.

Lines IFLLC	Total biological yield (kg/ha)				Seed yield (kg/ha)			
	X	b	$\pm S_b$	r^2	X	b	$\pm S_b$	r^2
501	3153	1.20*	0.17	0.97	1109	1.25*	0.18	0.90
486	3311	1.17*	0.06	0.99	1191	1.00	0.12	0.94
487	3272	0.96	0.02	0.99	1240	1.05	0.03	0.99
488	3069	1.03	0.12	0.94	1124	0.89*	0.14	0.90
489	3214	1.06	0.14	0.94	1223	1.14	0.10	0.96
490	2987	1.00	0.03	0.99	1152	1.10	0.06	0.98
491	3084	0.87*	0.06	0.98	1207	0.98	0.08	0.96
492	3198	0.80*	0.02	0.94	1163	0.82*	0.07	0.92
493	3240	0.98	0.03	0.99	1194	0.97	0.03	0.99
494	3268	1.08	0.12	0.95	1218	1.13	0.10	0.96
495	3201	0.99	0.11	0.95	1177	0.97	0.07	0.97
496	2993	0.89	0.09	0.95	1140	0.89	0.05	0.98
497	3179	0.98	0.18	0.87	1215	0.89	0.09	0.95
498	3255	1.02	0.11	0.96	1148	0.90	0.09	0.95
499	3164	0.93	0.06	0.98	1132	0.97	0.07	0.98
500	3364	1.03	0.05	0.99	1239	1.20*	0.04	0.99
Grand mean	3183				1179			
SEM±	215				96			
LSD (P=0.05)	422				188			

* Significantly different from 1.0 at 0.05 probability level.

grain yields from 1109 to 1240 kg/ha. Variations among environments were significantly different (Table 4.1.20). Mean biological yields ranged from 1819 kg/ha at Breda 1990/91 to 3895 kg/ha at Breda 1992/93, whereas, seed yields ranged from 680 kg/ha at Breda 1990/91 to 1685 kg/ha at Breda 1992/93. Breda 1992/93 gave the highest biological and grain yields, while Breda 1990/91 gave the lowest yields. Statistically non-significant values were found for line x environment (linear) interaction for both biological and grain yields, indicating that differences among most of the 16 lines regression coefficients were not present. This reflects the narrow genetic diversity of the material under study. This was not the case in narbon vetch and common chickling. The little variation in the regression coefficients indicated that most of the 16 lines did not have different environmental response. Two lines IFLLC 491 and 492, showed high mean yields with regression coefficient significantly below unity and low deviation from its regression line, revealing that they are specifically adapted to unfavourable conditions. IFLLC 501 and 486 were found to be high yielding, showing linear response to the changes in the environmental conditions. These lines could be recommended for the favourable environments. Inclusion of both these lines in future breeding programmes aiming at developing high yielding lines of dwarf chickling would be useful.

Table 4.1.20. Mean total biological yields and seed yields (kg/ha) in *Lathyrus cicera* for the six environments.

Envir. No.	Loc.	Year	Rain (mm)	No. of frost days	Biological yield		Seed yield	
					Yield	Rank	Yield	Rank
1	TH	1990/91	290	35	2789	4	536	5
2	TH	1991/92	352	57	3819	2	1539	3
3	TH	1992/93	277	59	3740	3	1552	2
4	BR	1990/91	241	35	1819	6	680	6
5	BR	1991/92	264	73	3036	5	1082	4
6	BR	1992/93	285	54	3895	1	1685	1
	Mean				3183		1179	
	LSD (5%)				597		265	

Results of ochrus chickling:
Variation among environments was significant (P<0.05) for mean biological and grain yields (Table 4.1.21). Mean yields ranged from 546 (Breda 1990/91) to 3270 kg/ha (Tel Hadya 1992/93), and from 150 kg/ha (Breda 1990/91) to 1202 kg/ha (Tel Hadya 1992/93) for biological and grain yields, respectively. 'Tel Hadya 1992/93' was the highest yielding environment for both biological and grain yields.

Table 4.1.21. Mean total biological yields and seed yields (kg/ha) in *Lathyrus ochrus* for the six environments.

Envir. No.	Loc.	Year	Rain (mm)	No. of frost days	Biological yield		Seed yield	
					Yield	Rank	Yield	Rank
1	TH	1990/91	290	35	1841	5	386	5
2	TH	1991/92	352	57	1967	4	714	4
3	TH	1992/93	277	59	3270	1	1202	1
4	BR	1990/91	241	35	546	6	150	6
5	BR	1991/92	264	73	2568	3	772	3
6	BR	1992/93	285	54	2732	2	1139	2
	Mean				2154		727	
	LSD (5%)				609		243	

Differences among the 16 genotypes (lines) for biological and grain yields were significant (Table 4.1.22). Biological yield ranged from 856 to 1892 kg/ha, while grain yield ranged from 625 to 856 kg/ha. The highest yielding line was IFLLO 548. This line had better tolerance to cold and drought compared with other lines. It has high yields across environments with regression coefficients significantly different from unity and low deviations from regression. It could be recommended for poor environments with low rainfall and frequent cold spells.

The development of forage legume cultivars from different species which maintain a high level of performance over a range of environments is our main goal. Therefore, assessment of genotype (line) x environment interaction is important in forage legumes breeding program for evaluating promising lines for their adaptability. The use of two contrasting sites in three years could help us to identify adapted lines for specific environment.

In depicting "poor" and "good" environment, it seems reasonable that for biological and grain yields the environment should be precisely described for each species. For example, ochrus chickling is adapted to low rainfall areas and can grow on soil infested with Orobanche because of its resistance, but is poorly adapted to areas with high frequency of frosts. In contrast, narbon vetch and dwarf chickling are susceptible to Orobanche, drought, and frost spells at early spring. Therefore, in our studies ochrus chickling was the lowest yielding species, whereas, narbon vetch and dwarf chickling were the highest yielders (Figure 4.1.2).

Table 4.1.22. Mean total biological and seed yields and estimates of stability parameters for 16 lines of ochrus chickling based on six environments.

Lines IFLLO	Total biological yield (kg/ha)				Seed yield (kg/ha)			
	X	b	$\pm S_b$	r^2	X	b	$\pm S_b$	r^2
185	2278	0.94	0.10	0.95	734	1.00	0.12	0.94
537	2285	1.02	0.04	0.99	850	1.10	0.06	0.98
538	2328	1.10	0.06	0.99	625	1.12*	0.03	0.99
539	2095	0.83*	0.09	0.95	745	0.89	0.09	0.95
540	2308	0.93	0.06	0.98	791	0.99	0.03	0.99
541	2181	1.02	0.20	0.87	737	0.88*	0.13	0.92
542	1915	0.94	0.16	0.89	730	1.00	0.16	0.90
543	1892	1.09	0.14	0.90	699	1.07	0.08	0.97
545	2047	1.09	0.18	0.90	715	1.07	0.16	0.91
546	2153	0.99	0.14	0.92	691	1.07	0.11	0.96
547	2014	0.90	0.12	0.94	730	0.91	0.09	0.96
548	2400	0.86*	0.07	0.97	856	0.88*	0.06	0.98
549	2099	1.01	0.09	0.97	652	0.98	0.08	0.97
550	2172	1.11	0.10	0.97	656	1.03	0.10	0.96
551	2142	1.06	0.07	0.98	685	1.03	0.04	0.99
104	2198	1.10	0.14	0.94	738	0.99	0.06	0.96
Grand mean	2154				727			
SEM±	220				88			
LSD (P=0.05)	430				172			

* Significantly different from 1.0 at 0.05 probability level.

On the basis of the extensive testing reported here, serious considerations will be given to release the most adapted lines in collaboration with national programs. In future, emphasis will be laid on antinutritional factors such as BOAA in *Lathyrus* spp., enhancement of cold tolerance in ochrus chickling, increased leaf retention and high L/S ratio in common vetch and wooly-pod vetch, early winter growth, pod shattering and disease resistance in all species.

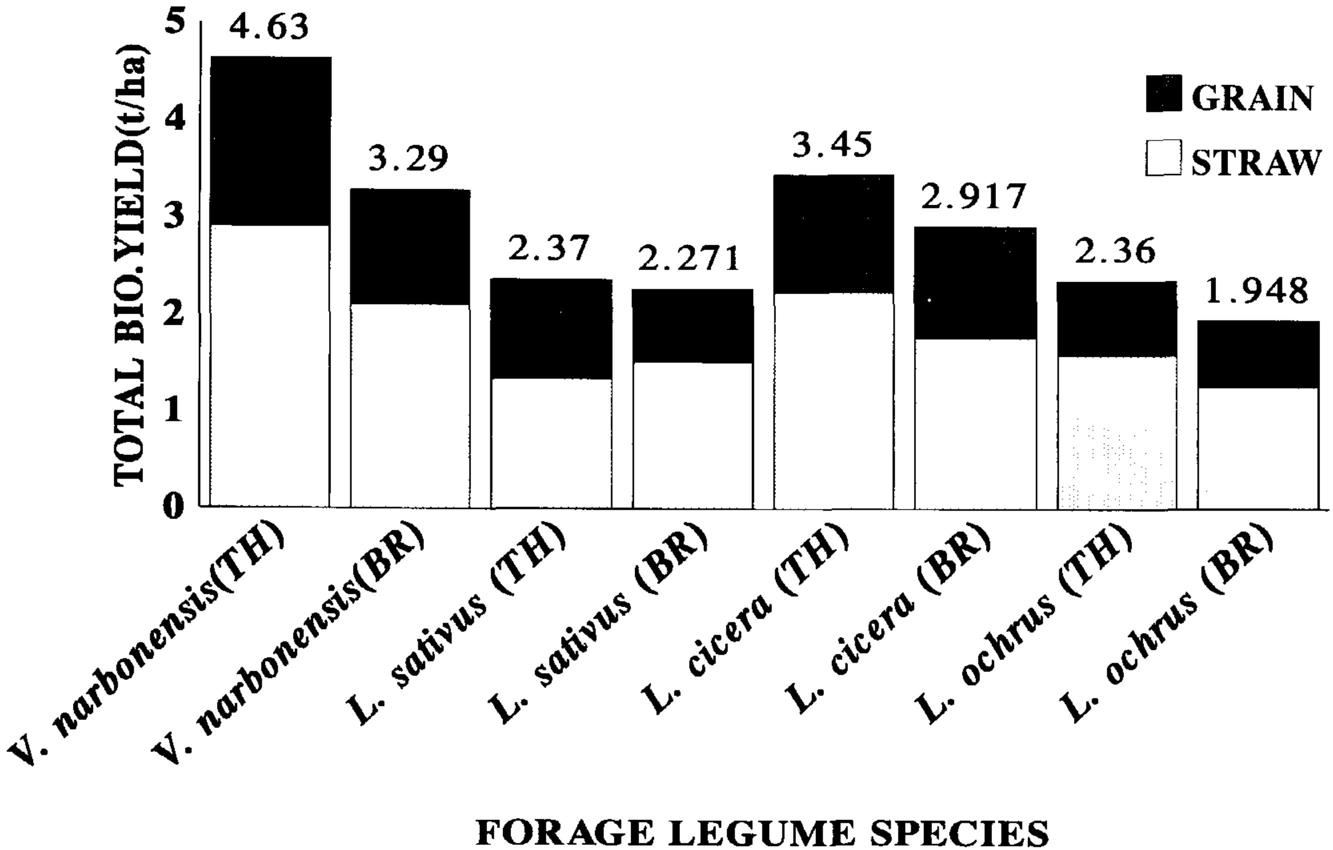


Figure 4.1.2. Average performance of feed legume species at Tel Hadya and Breda over three years 1990/91, 1991/92 and 1992/93.

4.1.4. Nutritional Quality in Chicklings

Chicklings (*Lathyrus* spp.) are a drought tolerant, protein rich food and feed legume in areas with less than 350 mm rainfall. *Lathyrus sativus* is particularly adapted to dry conditions. It was the major component of human diets and animal feed in the times of drought induced famines in Asia and Africa. One of the drawbacks of *L. sativus*, however, is that its excessive consumption causes "Lathyrism", a nervous disorder resulting in incurable paralysis of the lower limbs of human being or domestic animals, which is attributed to the presence of the free amino acid B-N-Oxalylamino alanin (BOAA) in seed. One of our main objectives in breeding chicklings is to develop lines nearly free from the neurotoxin (BOAA) and adapted to low rainfall areas and investigate the possible association of neurotoxin with agronomical and morphological characters of the genotypes and their reaction against insects and diseases. The chemical estimation of BOAA is quite laborious and expensive and this puts a limit on screening and further identification of low BOAA lines. ICARDA, in collaboration with the Grain Research Laboratory of Winnipeg, Manitoba, Canada, has developed a rapid method using near infrared reflectance (NIR).

4.1.4.1. Evaluation of BOAA content in new selections of *Lathyrus* spp. at Manitoba

One hundred and sixteen samples, representing 70 lines of *Lathyrus sativus*, 24 of *L. cicera* and 22 of *L. ochrus* were assessed for their BOAA content using NIR. The results indicated that none of the *Lathyrus* spp. lines was BOAA-free, although several of them were quite low in BOAA. Samples of *L. cicera* showed a range from 0.01 to 0.22% with a mean of 0.16%. *L. sativus*, showed the biggest range from 0.16 to 0.74% with a mean of 0.48%, while *L. ochrus* lines were highest in BOAA, ranging from 0.46 to 0.67% with a mean of 0.57%. Presence of such a range in BOAA content in available lines suggests that there is a good potential for breeding *L. sativus* and *L. cicera* lines with low BOAA content. **Aboud El-Salih (Der El-Zour Faculty of Agriculture), Phillip Williams (Grain Research Laboratory, Winnipeg, Manitoba, Canada) and A.A. El Moneim**

4.1.4.2. Evaluation of crude protein and BOAA content in AYT entries at ICARDA

The sixteen promising lines of *L. sativus*, *L. cicera* and *L. ochrus*, which were evaluated at Tel Hadya and Breda in 1992/93, were assessed for protein and BOAA contents using NIR (NEOTEC Model 5000) at ICARDA. Every tenth sample was verified by Macro-Kjeldahl method for crude protein content, and by the conventional chemical method of Briggs *et al* (1983) for BOAA content. Results are shown in Tables 4.1.20a, b, and c.

Table 4.1.23a. Crude protein (CP%) and BOAA content (%) in 16 lines of *Lathyrus sativus* at Tel Hadya and Breda, 1992/93.

Line IFLLS	CP(%) TH	CP(%) Br	BOAA(%) TH	BOAA(%) Br
587	26.2	27.4	0.465	0.413
504	25.2	27.3	0.347	0.363
505	25.2	27.5	0.280	0.395
508	25.0	27.4	0.274	0.412
510	25.0	27.5	0.345	0.415
516	25.6	27.6	0.272	0.436
519	25.6	27.3	0.287	0.372
520	25.3	27.3	0.282	0.439
522	25.7	27.4	0.335	0.469
527	26.1	27.5	0.310	0.391
528	26.3	26.0	0.260	0.393
529	24.4	27.2	0.369	0.397
530	24.7	25.7	0.263	0.380
531	24.2	27.5	0.294	0.468
533	24.7	27.1	0.349	0.436
535	24.1	26.5	0.401	0.403
Mean	25.2	27.1	0.320	0.410
SEM±	0.69	0.57	0.06	0.03

In *L. sativus*, the protein content ranged from 24.1 to 26.2% at Tel Hadya and from 25.7 to 27.6% at Breda. BOAA content varied from 0.26 to 0.47% at Tel Hadya and from 0.36 to 0.47% at Breda. *Lathyrus cicera* showed the lowest BOAA content which varied from 0.077 to 0.344% at Tel Hadya and from 0.135 to 0.40% at Breda. *L. ochrus* lines had the highest BOAA content which varied from 0.456 to 0.716% at Tel Hadya and from 0.587 to 0.775% at Breda. These results confirm the interspecific and intraspecific differences in BOAA content obtained from NIR analysis at Manitoba, Canada with other selections of the three species.

Our observations demonstrate that lines with early maturity, and smaller seeds of light cream colour contain low concentrations of BOAA. These characters can serve as markers for selecting low BOAA lines and would be of particular significance in our breeding program. These characters will be given high attention in selecting high potential lines with low BOAA content in F3 families in 1993/94. **A.A. El Moneim, M.C. Saxena and Hani Nakoul.**

Table 4.1.23b. Crude protein (CP%) and BOAA content (%) in 16 lines of *Lathyrus cicera* at Tel Hadya and Breda, 1992/93.

Line IFLLC	CP(%) TH	CP(%) Br	BOAA(%) TH	BOAA(%) Br
501	23.2	27.1	0.140	0.282
586	28.8	27.1	0.340	0.363
587	24.1	26.0	0.196	0.232
588	24.5	25.7	0.186	0.214
589	24.2	26.3	0.344	0.341
590	24.5	24.9	0.148	0.198
591	24.0	25.8	0.238	0.220
592	24.2	26.0	0.096	0.176
593	26.2	26.6	0.159	0.174
594	25.9	25.8	0.173	0.167
595	24.1	26.8	0.077	0.135
596	25.2	27.7	0.262	0.221
597	24.7	26.7	0.239	0.291
598	24.6	25.2	0.342	0.400
599	25.2	26.0	0.266	0.258
500	32.2	24.7	0.142	0.317
Mean	24.60	26.15	0.210	0.250
SEM±	0.87	0.80	0.09	0.08

Table 4.1.23c. Crude protein (CP%) and BOAA content (%) in 16 lines of *Lathyrus ochrus* at Tel Hadya and Breda, 1992/93.

Line IFLLO	CP(%) TH	CP(%) Br	BOAA(%) TH	BOAA(%) Br
185	26.5	27.7	0.535	0.611
537	25.4	27.7	0.652	0.756
538	25.6	25.9	0.572	0.658
539	26.0	27.2	0.716	0.741
540	25.9	26.9	0.600	0.742
541	26.4	27.2	0.598	0.661
542	24.4	25.6	0.589	0.587
543	24.9	26.8	0.651	0.775
545	25.0	27.3	0.456	0.608
546	26.0	28.5	0.556	0.695
547	26.0	27.9	0.545	0.704
548	25.9	27.7	0.549	0.639
549	27.8	27.6	0.558	0.612
550	26.4	27.9	0.534	0.578
551	26.7	27.2	0.490	0.587
104	26.8	27.9	0.599	0.702
Mean	25.98	27.31	0.580	0.670
SEM±	0.82	0.74	0.06	0.07

4.1.5. Genetic Studies

4.1.5.1. Seed retention in common vetch

An essential characteristic of a grain legume crop, and a desirable one in a forage legume crop is the ability to retain its seeds long enough to allow mechanical harvesting at full maturity. Pod shattering in common vetch reduces its popularity as a forage legume crop for fallow replacements. The vetch seeds germinating during the cereal phase of the rotation represent a serious "weed" problem. Therefore, a breeding programme to develop non-shattering cultivars suitable for mechanical harvesting was initiated in 1985, using three natural wild non-shattering mutants, with undesirable agronomic traits.

The genetics of pod-shattering of common vetch was studied by using P1, P2, F1, F2, BC1, BC2, BC3, BC4 and BC5 generations obtained from crosses between non-shattering wild types 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 and selection for non-shattering trait in erect, leafy and early types. Six superior families, IFLVS (NS) 2565, 2558, 2557, 2014, 1448 and 715, were selected having 95-97% non-shattering pods as opposed to 40-45% in the original breeding lines.

Incorporation of non-shattering gene into our breeding lines of common vetch resulted in a range of non-shattering lines which are now grown in some countries. IFLVS 715 was released as a variety in Jordan. It is a variety of high L/S ratio, erect and relatively drought tolerant. The reduction of pod-shattering was sufficient to allow normal header harvesting at maturity with minimal loss of seeds. Reduced pod-shattering at maturity in common vetch is the major agronomic advance achieved in common vetch.

4.1.5.2. Studies on the hybrids between *V. sativa* ssp. *sativa* and *V. sativa* ssp. *amphicarpa*

To increase the productivity of underground vetch (*V. sativa* ssp. *amphicarpa*) and to improve drought and cold tolerance of common vetch (*V. sativa* ssp. *sativa*) work was initiated in 1989/90 to hybridize the two subspecies, to transfer and combine the desirable traits and to increase variations for selection. In 1992, F_3 families descending from F_2 single plant selections of four crosses were selected. The selected plants had 4-9 underground pods, cold and drought tolerance like *V. sativa* ssp. *amphicarpa*, and more vigorous above ground growth than the original amphicarpous types. Selection for F_4 families was obtained by bulking an equal number of seeds of 20 F_3 plants from the selected F_3 families. Because yield always gives low heritability values, we uses recurrentrestricted phenotypic selection (RRPS), which was more effective in increasing above ground biomass yield and maintain reasonable numbers of underground pods.

4.1.5.3. Improving nutritional quality of *Lathyrus sativus* by breeding

One of our main objectives of *L. sativus* breeding is developing promising lines with low BOAA content and high yield. So far, little work has been done to determine the genetic basis of variation in the neurotoxin content. Having identified low BOAA content (18 - 316 μg/g seeds) lines, a program was started to study the genetic control of this neurotoxin.

In 1990/91 four low neurotoxin lines (testers) were crossed with 21 lines, making 84 crosses. Gene markers such as seed, flower and stem colours were used to eliminate pods which might have developed from selfing and to identify F_1 hybrids. F_1 plants were obtained in 1991/92. In 1992, 192 families descending from F_2 single-plant selections of the 84 crosses were selected for early maturity, small seed size and light cream seed colour. These characters are considered major selection criteria for breeding low neurotoxin (BOAA) *Lathyrus sativus*. The material generated will be further analysed to study the inheritance of low BOAA content.

4.1.5.4. Genetic studies of cyst nematode (*Heterodera ciceri*) resistance in common vetch

Seven lines of common vetch (*Vicia sativa* L.), namely IFLVS 713, 1429, 2003, 2025, 2023, 2040 and 2052, were diallel mated to produce both direct and reciprocal crosses. IFLVS 713 and 1429 were found to be resistant, IFLVS 2003 was susceptible, whereas IFLVS 1429, 2052 and 2040 were found to be highly susceptible. The 42 F_1 seeds were obtained in 1992/93. In 1993/94, the 42 F_1's with the seven parents will be tested for their resistance under artificial conditions in the plastic house.

4.2. Crop Physiology

4.2.1. Relationship of Cold Tolerance with Some Physiological and Biochemical Traits

In this study, the objective was to identify a screening technique for cold tolerance that is quantitative, rapid, reproducible, sensitive, cost effective, environmentally independent and most importantly non-destructive.

Biochemical characters such as content of various sugars in roots have been found by several workers to be implicated in cold tolerance. Also proportion of dry matter distribution to roots, which could indirectly reveal the amount of sugars in the roots, was suggested as a trait to determine the ability of a plant to withstand cold. More recently, chlorophyll fluorescence kinetics has been used to quantify the reaction of genotypes to cold stress.

Preliminary studies conducted during 1991/92 indicated that chlorophyll fluorescence kinetics measured on leaflets of stressed plants belonging to *Lathyrus ochrus, Vicia sativa* and *V. ervilia* could be a useful technique to measure the degree of cold tolerance/susceptibility on a species basis. However, this technique is comparatively new and doubt has been raised as to its reliability inspite of its ability to satisfy the requirements mentioned above, and the advantage of being highly computerized. This study therefore tested additional techniques such as field scoring, sugar content in roots and proportion of dry matter distributed to roots to evaluate the validity of chlorophyll fluorescence technique. As the ultimate objective in this study was to identify cold tolerant genotypes specially in *L. ochrus*, which has been normally classified as a cold susceptible species. This technique was mainly used to screen cold tolerant genotypes in *L. ochrus* during 1992/93. In 1992/93, we had two accessions (numbers 82 and 109) of *L. ochrus*, which were found to be tolerant to cold during the 1991/92 winter, to be used as controls.

The results indicated that there was a close relationship ($Y=-8.607X+64.82$; $r=-0.841^{**}$) between the chlorophyll fluorescence kinetics (Y) measured as the rate of rise in induced chlorophyll fluorescence (Fr) and cold damage rating (X) (Figure 4.1.3). The total sugar content in roots, measured on contrasting genotypes showing various degrees of damage due to cold, indicated that this technique could be useful in screening plants on a species basis ($Y=-6.541X+59.74$; $r=-0.66^{*}$) but its expression is dependent on the growth environment, involves a destructive method, and it has failed to detect the difference in cold damage on a genotype level within a species such as *L. ochrus*. The proportion of dry matter distribution to roots, however, not only quantified the reaction at species level but also at genotype level within a species, such as *L. ochrus*. It was independent of growth environment, measurements obtained under plastic house condition could be related to cold effect under field condition; the disadvantage being that it too is a destructive method and can only be used to screen on a pure line basis where individual plants can be sampled and analyzed. **M. Ratinam, A.A. El Moneim and M.C. Saxena.**

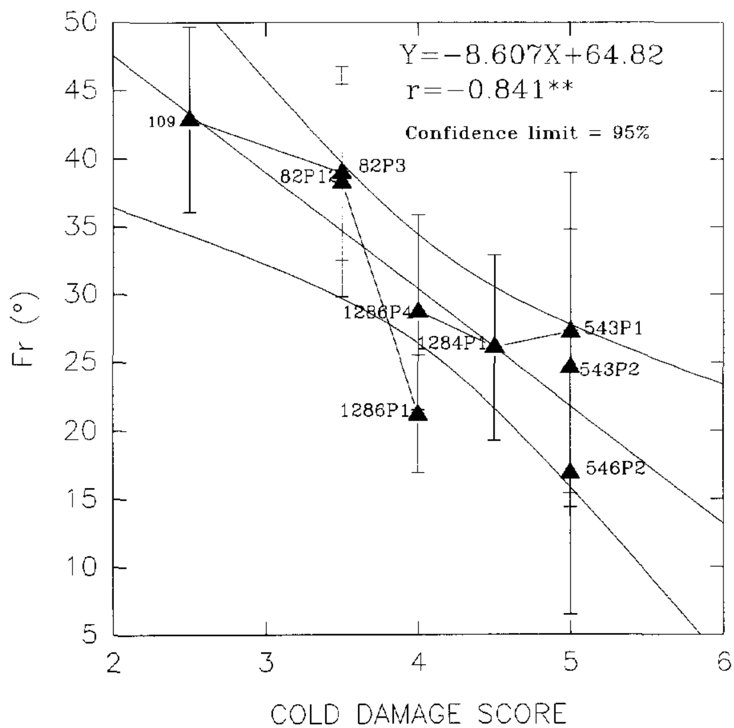


Figure 4.1.3. Relationship between cold damage score and the rate of rise in induced chlorophyll fluorescence in stressed plants established under controlled condition.

4.2.2. Preliminary Study on the Effect of Boron on Seed Setting in Wooly-pod Vetch

Several soils in WANA normally show deficiency of boron. Field experiments conducted in various parts of the world on different crops indicated that boron application appreciably increased the seed yield although no visible boron deficiency symptom was observed on any of them. At the biochemical level, a direct relation between boron concentration and enhancement of pollen tube length was noticed.

The seed yield in wooly-pod vetch (*Vicia villosa* ssp. *dasycarpa*) is generally low. The variability for this character amongst the accessions evaluated so far at ICARDA was found to be very narrow. Various reasons have been postulated for the low yielding ability of this species inspite of the fact that it produces large number of flowers. This species flowers very late (128-151 days) in comparison with other forage legume species (93-120 days). Consequently, the flowering, fertilization and seed formation coincides with unfavourable conditions such as drought and hot weather which in turn may lead to reduced grain yield. In the present study, a preliminary investigation was carried out to find out whether application of boron on to the flower had any influence on seed setting and hence the seed yield.

A split-plot design with time of spraying as the main plot and concentration of boron as the sub-plots was used. The treatments were replicated three times. Borax ($NaB_4O_7.10H_2O$, 11%boron) was used as the source of boron. Four concentrations of boron (0.0, 0.3, 0.6, and 0.9% by weight) were sprayed at 100% flowering at two different times (morning and evening). There was a gradual increase in seed yield with increase in boron concentration and spraying in the morning gave better results (seed yield 1131 kg/ha) than spraying in the evening (seed yield 1033 kg/ha) and 0.9% concentration of boron gave higher grain yield (1145 kg/ha) as against no boron control (1054 kg/ha) (Figure 4.1.4). **M. Ratinam and A.A. El Moneim.**

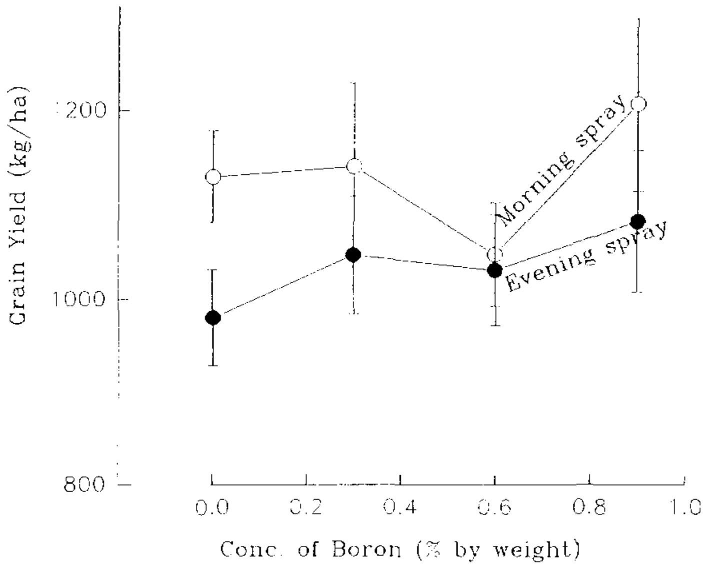


Figure 4.1.4. Effect of Boron on seed setting in *Vicia villosa* ssp. *dasycarpa*.

4.2.3. Response of and Genotypic Differences in Food and Feed Legumes to Drought

Experiments on response of food and feed legume crops to drought and genotypic differences in drought tolerance were repeated for validation of results of 1992 season at the three sites in Syria - Tel Hadya, Breda and Jinderess. The objectives were:

1. to quantify yield losses due to drought,
2. evaluate relative differences in drought resistance and water-use efficiency (WUE), and
3. test a simple method of field screening for evaluating response of a large number of genotypes.

Site characteristics

Soils at Breda are high in silt and $CaCO_3$, low in native fertility and nutrient holding capacity (low CEC), compared to soils of Tel Hadya or Jinderess (Table 4.2.1). Effects of low rainfall on crop growth were accentuated at Breda because of the low available water in these soils.

Climatic conditions during the 1993 (1992/93 crop season) at the three sites are shown in Figure 4.2.1. For the third consecutive year rainfall at Tel Hadya was low (277 mm) compared to the long term average (352 mm) (Table 4.2.1). In 1993 rainfall at Tel Hadya was even lower than the rainfall at Breda (285 mm), the dry site. Thermal regimes (occurrence of frost and absolute minimum temperatures), in general, were similar to 1992 season at Tel Hadya and Jinderess but at Breda frost events were few (73 in 1992 compared to 38 in 1993) and the absolute minimum higher (-6.5°C) than in 1992 (-8.2°C).

Experimental details

Varying drought intensity treatments were created by partial alleviation of drought of the rainfed conditions. Responses to two kinds of drought patterns were studied. One was a drought continuum created by applying a gradient of irrigation using a line-source sprinkler irrigation method both at Breda and Tel Hadya. The quantity of water (irrigation + rainfall) received at the most wet end of the line-source was 453 mm at Breda and 439 mm at Tel Hadya.

In an another experiment at Tel Hadya three discrete drought intensities, rainfed, least drought treatment (with irrigation applied at frequent intervals), and a moderate drought (staggered irrigation frequency of the least drought treatment) were created by an overhead boom of sprinklers suspended over the crop and drawn by a mobile hose-drawn irrigation machine (M3000/125-410, 56766 Ulmen, Germany). Quantity of water (irrigation + rainfall) was 448 mm and 364 mm in the least drought and moderate drought intensity treatments. At Jinderess, where irrigation facilities are not available at the experimental site, we studied genotypic differences in rainfed crops.

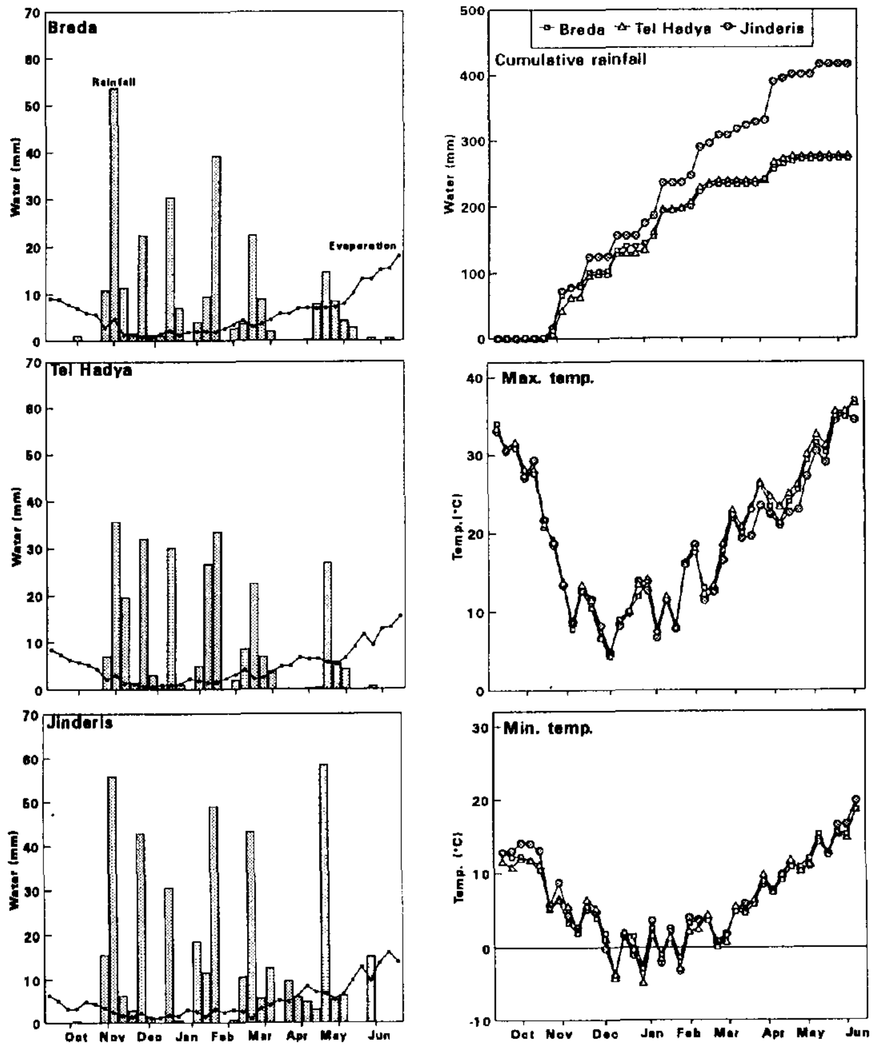


Figure 4.2.1. Climatic conditions at Breda, Tel Hadya, and Jinderess, Syira, 1992/93.

Table 4.2.1. Some selected weather parameters at the three experimental sites.

Characteristics	Breda	Tel Hadya	Jinderess
<u>Location</u>			
Latitude (N)	35° 55'	35° 55'	36° 22'
Longitude (E)	37° 10'	36° 55'	36° 41'
Altitude	350	362	231
<u>Soil</u>			
Soil type*	Typic calciorthid	Chromoxerertic calcic rhodoxeralf	Palexerollic chromoxerertic
Clay (%)	40-44	60-63	60-61
Silt (%)	41-45	31-33	33-34
Sand (%)	15-25	4-8	4
CEC (meq/100 g)	28.0	51.4	64.8
pH	8.3-8.5	8.1	7.8-7.9
EC (1:1) ds m^{-1}	0.3-5.0	0.2-0.3	0.1-0.2
Kjeldahl N (ppm)	100-650	210-460	280-670
Organic matter (%)	0.3-1.2	0.5-1.1	0.5-0.8
$CaCO_3$ (%)	30-50	28-29	20-24
Active lime (%)	9-22	9-11	11-12
Available water	12.3	14.6	14.7
Field capacity	31.9	39.3	45.3
Permanent wilting	19.6	24.7	30.6
<u>Weather</u>			
Rainfall (mm)	285	277	417
Long term (1979-1992)	264	328	441
Number of frost days	38	50	53
Temperature (abs. min.)	-6.5	-8.7	-8.0
<u>Nutrients applied</u>			
P (kg/ha) as triple superphosphate	23	23	23

* Based on USDA soil taxonomy, 1975.

Four genotypes in each of the four food (lentil, chickpea, faba bean and peas) and feed legumes (*Vicia sativa, Lathyrus sativus, Vicia narbonensis*, and *Vicia villosa* ssp. *dasycarpa*) were studied. Only one genotype (Acc. # 2650/2571) of *Vicia sativa* ssp. *amphicarpa*, a crop which bears both aerial and subterranean pods characteristic of the subspecies, was included in the line-source study at Breda and Tel Hadya.

Plantings were done on 5 Dec at Breda, on 10 Dec in the line-source trial at Tel Hadya (Tel Hadya-1) and on 28 Dec 1992 in the irrigation trial with three discrete irrigation treatments at Tel Hadya (Tel Hadya-2), and on 21 Dec 1992 at Jinderess.

Soil moisture:
Total (averaged over all crops) soil moisture in the top 120 cm soil profile during the crop season (Figure 4.2.2) showed that the soil moisture recharge continued for a longer period of time at Jinderess (a wet site), followed by Tel Hadya and Breda. At Tel Hadya there was a greater build up of soil moisture in trial 'Tel Hadya-1' which was planted 18 days earlier. Soil moisture discharge proceeded in the reverse order, with earliest being at Breda (Figure 4.2.2a). Supplemental irrigation enhanced the soil moisture status and delayed commencement of discharge (Figure 4.2.2b and 4.2.2c).

Soil moisture extraction patterns (averaged over the food and feed legume crops) in the 120 cm soil depth for the rainfed (Figure 4.2.3), moderate drought (Figure 4.2.4) and least drought (Figure 4.2.5) treatments are shown for Tel Hadya, Breda and Jinderess. Crops extracted moisture from the top 75 cm at Breda, around 90 cm at Tel Hadya and 105 cm at Jinderess, irrespective of the irrigation treatments. However, bulk of the soil moisture was extracted from the top 60-75 cm at Breda and Tel Hadya and around 90 cm at Jinderess.

The zone from where intense soil moisture extraction (depletion below the initial soil moisture status at planting) occurred was the top 30-45 cm at Breda and Tel Hadya and top 70 cm at Jinderess. Differences in soil depth from where intense soil moisture extraction took place perhaps reflects the zones of extensive root proliferation. Soil moisture recharge occurred below these depths as indicated by the build up of soil moisture above the initial status at the time of plantings (Figure 4.2.6 and Figure 4.2.7). This recharge at Breda and Tel Hadya was in the top 90 cm but occurred up to 120 cm at Jinderess. In the trial Tel Hadya-1, the zone of intense soil moisture extraction was restricted to top 30 cm only. Crop differences in soil moisture extraction were narrow at Tel Hadya, both for food and feed legumes. Lentil and faba bean were more effective in extracting greater amounts of soil moisture at Breda and chickpea closely followed by lentil at Jinderess (Figure 4.2.6). Among the feed legumes, *Vicia villosa* ssp *dasycarpa* and *Lathyrus sativus* (Figure 4.2.7) were effective exploiters of soil moisture.

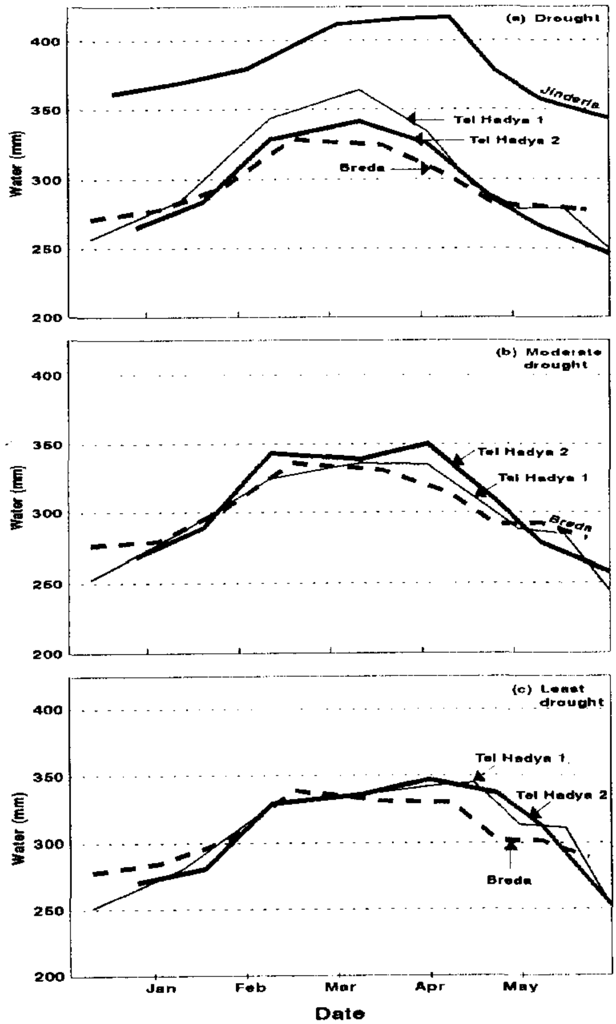


Figure 4.2.2. Changes in total soil moisture (mm water in the top 120 cm soil depth) averaged over food and feed legumes with time in (a) drought (rainfed), (b) moderate drought (partially irrigated), and (c) least drought treatments at Breda, Tel Hadya-1, Tel Hadya-2, and Jinderess, Syria, 1992/93.

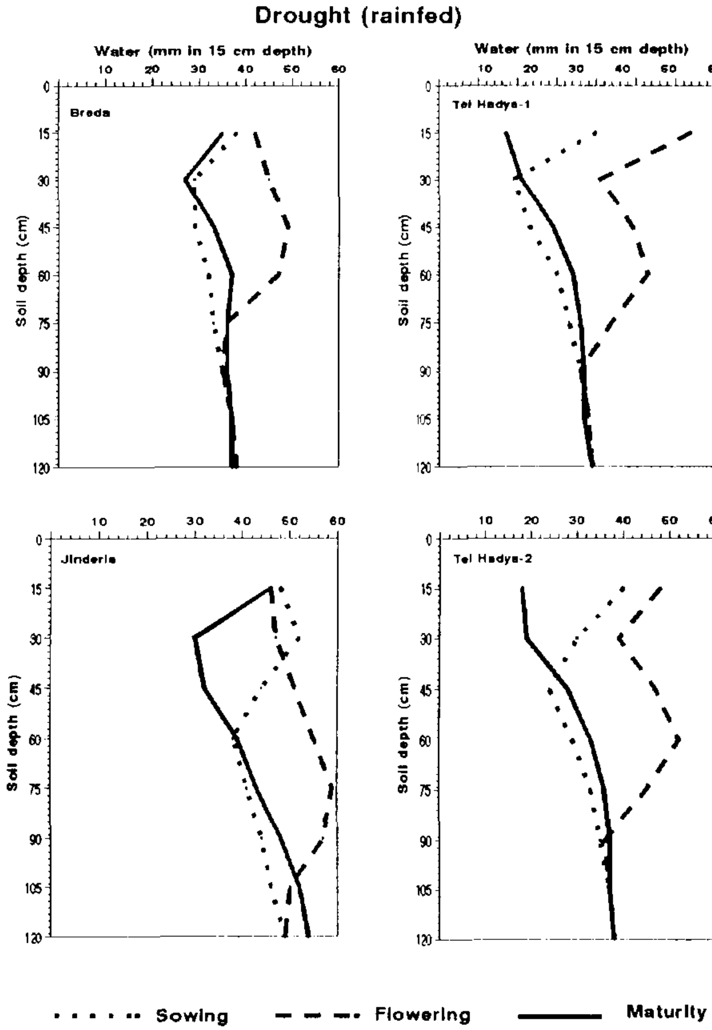


Figure 4.2.3. Average (over four food and four feed legumes) soil moisture profiles in the drought (rainfed) treatments at Breda, Tel Hadya-1, Tel Hadya 2, and Jinderess, Syria, 1992/93.

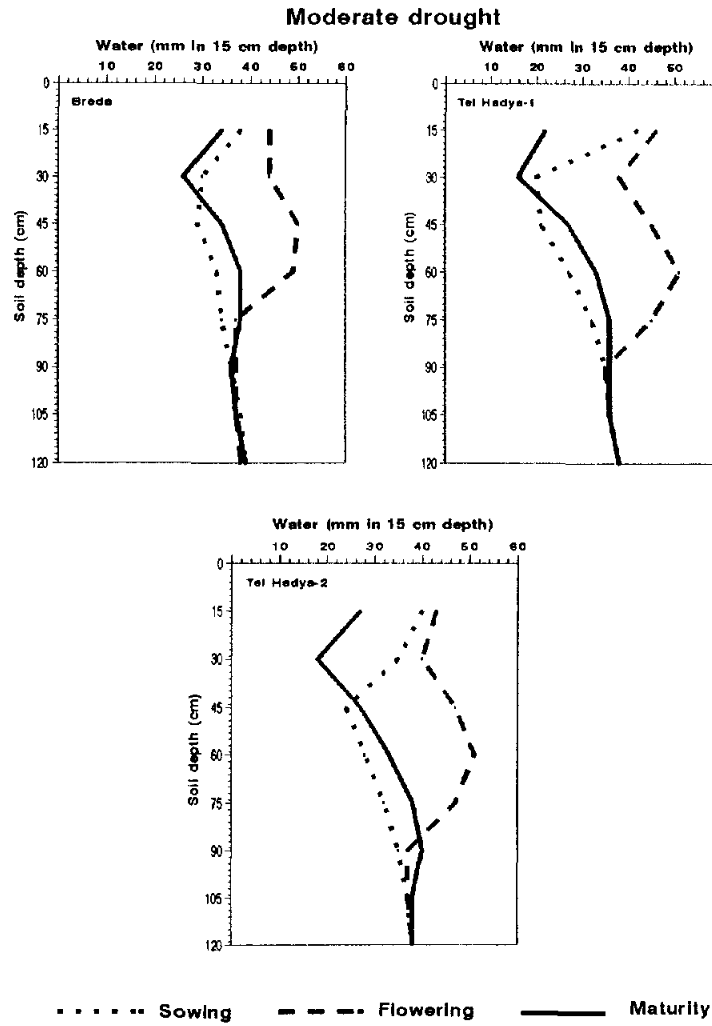


Figure 4.2.4. Average (over four food and four feed legumes) soil moisture profiles in the moderate drought (partially irrigated) treatments at Breda, Tel Hadya-1 and Tel Hadya 2, Syria, 1992/93.

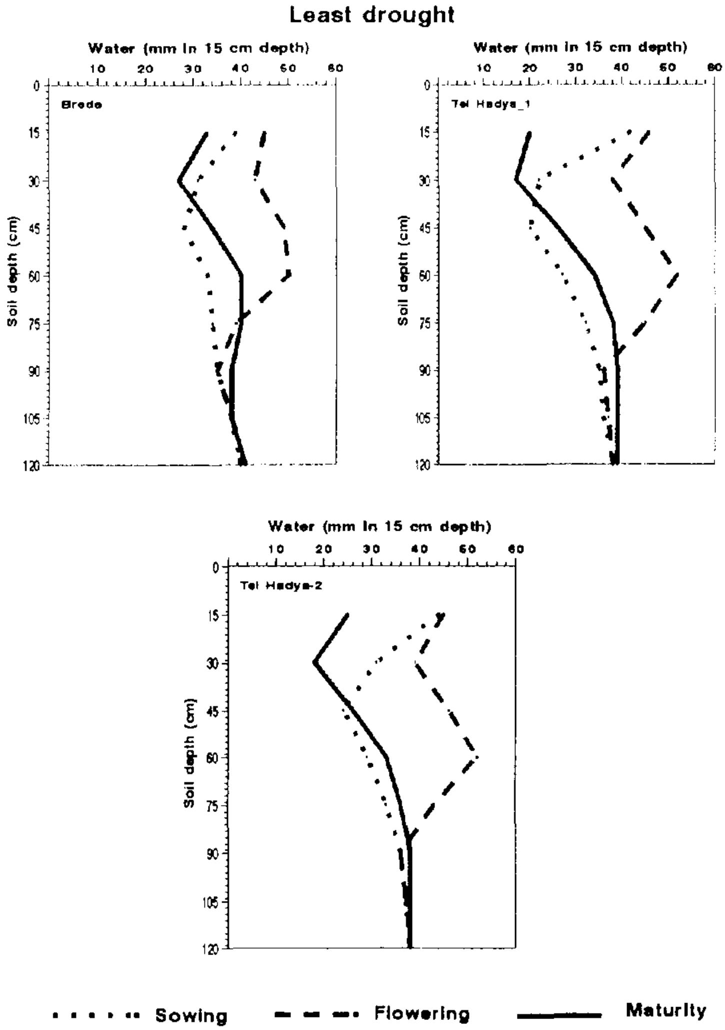


Figure 4.2.5. Average (over four food and four feed legumes) soil moisture profiles in the least drought treatments at Breda, Tel Hadya-1 and Tel Hadya 2. Syria, 1992/93.

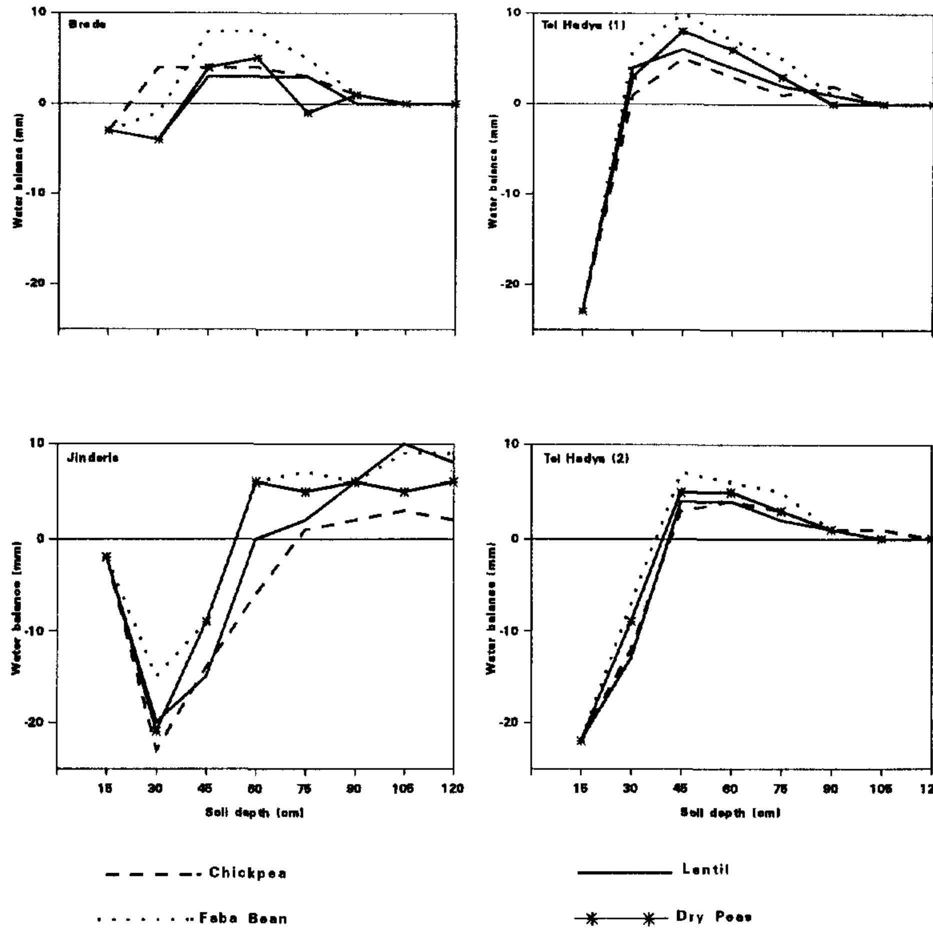


Figure 4.2.6. Soil moisture balance (difference between sowing and harvest time) in the drought treatments in four food legumes at Breda, Tel Hadya (1= line-source and 2= discrete irrigation treatments), and Jinderess. Syria, 1992/93.

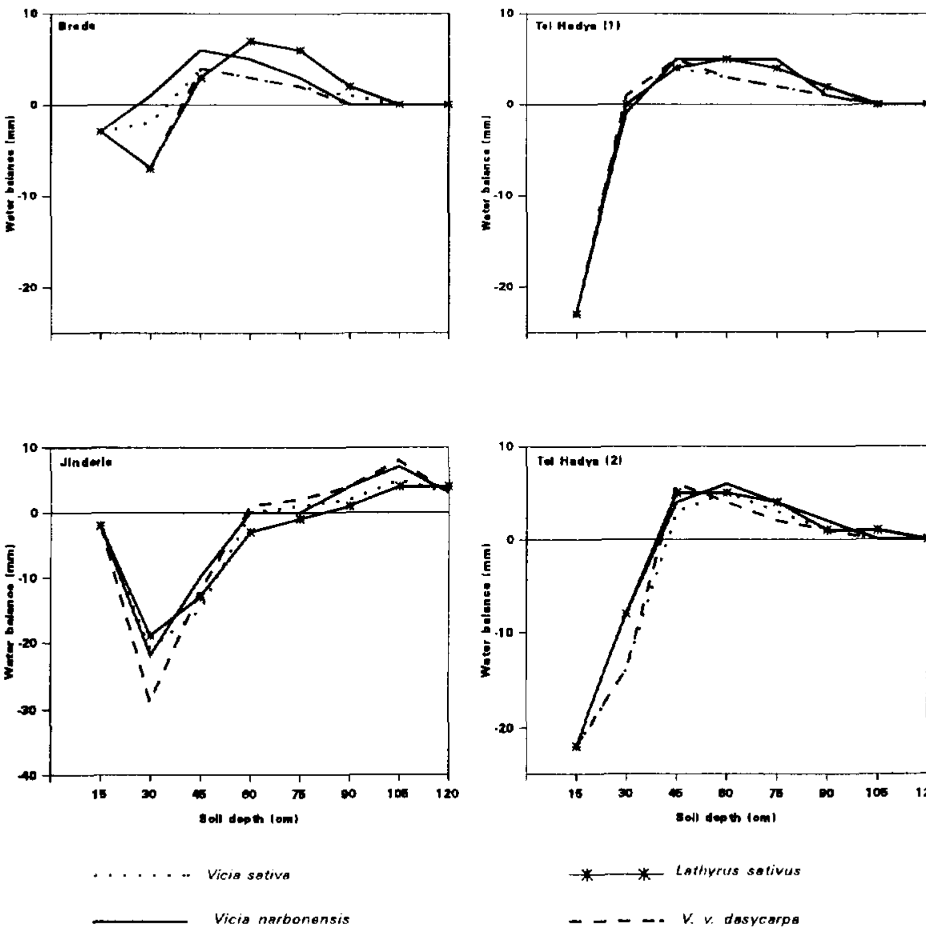


Figure 4.2.7. Soil moisture balance (difference between sowing and harvest time) in the drought treatments in four feed legumes at Breda, Tel Hadya (1= line-source and 2= discrete irrigation treatments), and Jinderess. Syria, 1992/93.

The differences in soil moisture depletion patterns primarily reflect water extraction by the crop roots and this process seems to be strongly influenced by environmental factors, primarily soil physical properties which are not easily amenable to modification. Studies on roots in filed grown plants will be useful in improving understanding of the dynamics of water use by these food and feed legume crops.

Phenology and yield

Faba bean was the first and chickpea the last to flower, the difference being more than 20 days (Table 4.2.2). Crop differences in maturity, however, were narrow. Mean rainfed seed yield was lower at Breda than Tel Hadya, but irrigated yields were similar (Table 4.2.3). Response to irrigation in shoot mass was larger than in seed yield and, therefore, the harvest indices in the irrigated treatments were lower (Table 4.2.3).

Table 4.2.2. Crop and cultivaral differences in days from sowing to flowering and flowering to maturity in food and feed legumes at Breda, Tel Hadya and Jinderess.

	Days to flower				Days to maturity			
		Tel Hadya				Tel Hadya		
Crop*	Br	1	2	Jin	Br	1	2	Jin
CP	130	112	125	117	166	151	166	157
Lens	122	104	117	109	150	139	151	145
FB	109	94	104	92	155	143	158	164
Peas	126	105	119	109	156	136	152	145
VS	123	109	119	112	152	141	155	153
LS	127	108	121	109	161	147	161	161
VN	120	103	117	107	150	138	153	148
VVD	123	109	121	112	157	142	156	157
SEm	0.1	0.4	0.5	0.2	0.9	1.3		
LSD(0.05)	0.4	1.1	1.6	0.5	2.5	3.8		

CP = Chickpea, Lens = Lentil, FB = Faba bean, VS = *Vicia sativa*, LS = *Lathyrus sativus*, VN = *Vicia narbonensis*, VVD = *Vicia villosa* ssp. *dasycarpa*.

Table 4.2.3. Effects of irrigation on seed yield (t/ha).

Location	Rainfed	irrigated	SE	LSD	CV%
		Seed yield (t/ha)			
Breda	0.8	2.4	0.03	0.09	22
Tel Hadya 1	1.2	2.1	0.09	0.36	52
Tel Hadya 2	1.4	2.5	0.04	0.10	20
Jinderess	1.8	-			
		Shoot mass (t/ha)			
Breda	2.4	6.7	0.07	0.20	20
Tel Hadya 1	2.7	5.5	0.28	1.1	66
Tel Hadya 2	3.1	6.8	0.07	0.21	17
Jinderess	3.7	-			
		Harvest index (%)			
Breda	36	36	0.5	1.3	14
Tel Hadya 1	47	39	1.3	5.1	29
Tel Hadya 2	46	40	0.4	1.0	9
Jinderess	46	-			

Crop differences in rainfed yield were small, both at Breda and Tel Hadya and response to irrigation was large in *Vicia narbonensis* (Table 4.2.4).

Non-irrigated seed yield was positively correlated with days to flowering across crops, genotypes, and locations (Table 4.2.5) which showed that the time when dry matter partitioning commenced into the seeds (escape from drought), in the narrow range of flowering duration of various crops and their genotypes studied, may not be an important constraint of seed yield in winter planted legume crops in mediterranean environments if selection for adapted phenelogy is practiced. Negative relationships between time of flowering and seed yield are observed commonly in crops grown in severe terminal drought environments, such as spring-planted chickpea in WANA or the postrainy season crops in the warm winter environments of semi-arid tropics (SAT), particularly when genotypes very diverse in time of flowering outside the range of adapted group are included in a study.

A closer relation between shoot mass and flowering time (higher 'r' values, Table 4.2.5) showed that late flowering favors higher shoot mass production and may be an important consideration if feed (shoot mass) production is the primary objective.

Table 4.2.4. Crop differences in rainfed and irrigated seed yield, shoot mass and harvest index at Breda, Tel Hadya, and Jinderess (each values is a mean of four genotypes).

	Rainfed				Irrigated		
		Tel Hadya				Tel Hadya	
Crop*	Br	1	2	Jin	Br	1	2
				Seed yield (t/ha)			
CP	1.0	1.4	1.5	1.4	1.9	2.0	2.2
Lens	1.1	1.4	1.5	2.0	2.8	3.1	3.3
FB	0.6	1.1	1.2	1.7	3.0	2.8	2.7
Peas	0.9	1.0	1.2	0.9	2.8	2.2	2.3
VS	0.9	1.2	1.2	2.2	2.7	2.2	2.5
LS	0.8	1.2	1.6	1.7	1.1	1.0	2.1
VN	1.0	1.4	1.7	1.8	3.8	2.6	3.4
VVD	0.6	1.0	1.2	1.4	1.4	1.0	1.8
SEm	0.12	0.15	0.16	0.12	0.12	0.15	0.16
LSD(0.0.5)	0.34	0.41	0.45	0.35	0.34	0.41	0.45
				Shoot mass (t/ha)			
CP	2.4	2.9	3.2	3.5	4.8	4.6	5.9
Lens	2.9	3.4	3.6	4.5	8.7	8.1	7.8
FB	1.8	2.0	2.1	2.8	6.0	5.0	4.9
Peas	2.2	1.9	2.4	2.0	5.7	4.0	4.3
VS	2.5	2.6	2.6	4.5	7.3	5.9	6.3
LS	2.3	3.0	3.9	4.4	5.4	4.8	9.1
VN	2.4	2.9	3.5	3.7	8.4	5.9	8.0
VVD	2.4	2.7	3.6	3.7	7.4	5.7	8.2
SEm	0.30	0.28	0.32	0.24	0.30	0.28	0.32
LSD(0.05)	0.87	0.81	0.92	0.67	0.87	0.81	0.92
				Harvest index (%)			
CP	42	47	48	41	39	46	38
Lens	36	42	40	45	32	38	43
FB	33	58	58	60	49	55	55
Peas	44	51	54	47	49	51	57
VS	36	48	45	48	38	39	40
LS	34	40	42	38	23	21	22
VN	40	49	49	48	46	45	41
VVD	23	37	35	38	19	20	22
SEm	1.5	2.2	1.6	1.5	1.5	2.2	1.6
LSD(0.05)	4.3	3.0	4.5	4.2	4.3	3.0	4.5

CP = Chickpea, Lens = Lentil, FB = Faba bean, VS = *Vicia sativa*, LS = *Lathyrus sativus*, VN = *Vicia narbonensis*, VVD = *Vicia villosa* ssp. *dasycarpa*.

Table 4.2.5. Simple correlation coefficients (r) of nonirrigated seed yield and shoot mass with other characters.

Character	Seed yield			Shoot mass		
		Tel Hadya			Tel Hadya	
	Breda	1	2	Breda	1	2
Days to flowering	0.33	0.30	0.18	0.44	0.53	0.43
Days to maturity	-0.20	0.18	0.19	-0.18	0.12	0.29
Irrigated seed yield	0.33	0.46	0.54	-	-	-
Rainfed shoot mass	0.53	0.76	0.78	-	-	-
Irrigated shoot mass	-	-	-	0.48	0.86	0.71

At Breda, only a small proportion of total variation (45 to 50 %) in nonirrigated seed yield was accounted by phenology, shoot mass production, and potential seed yield (Table 4.2.6). Among various parameters, negative effects of crop duration (days to maturity) were larger at Breda, a dry site, which explained 20-25% variation in seed yield (Table 4.2.6). Selection for optimum crop duration for maximum productivity would be important at Breda. On the other hand, potential productivity was more important than the phenological traits at Tel Hadya. Studies on the mechanism of yield formation are likely to be more rewarding in identifying crop traits useful in genetic and agronomic management options for enhancing yield.

Table 4.2.6. Percent variation accounted by each trait.

Character	Seed yield			Shoot mass		
		Tel Hadya			Tel Hadya	
	Breda	1	2	Breda	1	2
Variation accounted by						
Days to flowering	11.2	9	3.1	9.0	28.1	18.1
Days to maturity	20.6	0.7	1.7	24.5	0.4	1.3
Irrigated yield	11.7	36.6	?	-	-	-
Nonirrgated shoot mass	8.3	27.1	56.8	-	-	-
Irrigated shoot mass	-	-	-	10.3	54.4	59.9
Total	45	69.5	79.9	49.0	81.1	77.1
Mean yield (kg/ha)						
Nonirrigated	1193	1918	1557	3257	4112	3535
Irrigated	4832	4302	3380	9802	9985	8249

Yield losses

Yield loss (%) was computed as $\frac{\text{(Nonstress yield - stress yield)}}{\text{(Nonstress yield)}} \times 100$

Effects of drought in seed yield loss were smaller than in shoot mass (Table 4.2.7), perhaps because seed yield is a fraction of total biomass. As expected, drought at Breda caused 20% greater reduction in seed yield than at Tel Hadya in crops planted around the recommended dates of planting and in spite of the fact that the total and cumulative build up of the rainfall over the crop season was similar. This seems to be because of differences in rainfall distribution (Figure 4.2.1) and the soil physical properties which render less water available for crop growth at Breda (Figure 4.2.2). Effects of low soil fertility at Breda are unlikely to be large because most of the legumes meet their N demand through symbiosis, and nodulation is generally adequate. A uniform basal application of 23 kg P2O5/ha was applied to meet the P demand.

Table 4.2.7. Average seed yield and shoot mass yield loss at Breda and Tel Hadya.

Experiment	Seed yield loss (%)	Shoot mass loss (%)
Breda	56	61
Tel Hadya 1	36	50
Tel Hadya 2	46*	48

* Excludes *Lathyrus sativus* and *Vicia villosa* ssp. *dasycarpa* which showed negative response to irrigation.

Crop (Table 4.2.8) and genotypic differences (Table 4.2.9) in the loss of seed yield and shoot mass were large, ranging from 10-80%. Among the food legumes, chickpea was the least sensitive to drought followed by peas, lentil, and faba bean on the criteria of seed loss. A negative seed yield response to irrigation in Lathyrus and VVD observed at Tel Hadya (Table 4.2.8 and 4.2.9) is confounded with the effects of lodging in the irrigated treatments. Less loss in seed yield in chickpea at Breda showed that it was best adapted to dry conditions and among the chickpea genotypes, ICC 4958 showed minimum seed yield loss. Yield losses, across genotypes of different crops, were correlated positively between Breda and Tel Hadya-1 and Tel Hadya-2 (Table 4.2.10) and this correlation was more close for seed than in shoot mass explaining nearly 50% variation in seed yield, the rest being due to genotype x environment interaction.

Table 4.2.8. Percent losses in crop seed yield and total biological yield due to drought in feed and food legumes, Tel Hadya.

	Seed yield			Total biological yield		
		Tel Hadya			Tel Hadya	
Crop	Br	1	2	Br	1	2
Chickpea	43.6	28.7	30.4	47.9	43.0	32.6
Lentil	60.2	54.6	52.2	65.0	51.6	56.8
Faba bean	79.7	52.5	57.8	69.8	54.9	59.0
Peas	59.3	35.5	49.6	59.3	31.2	50.5
Vicia sativa	65.3	49.6	42.7	63.7	55.6	54.1
Lathyrus sativus	21.5	9.5	156.8*	53.8	56.6	33.8
Vicia narobonensis	73.0	43.4	44.5	69.6	53.5	50.0
Vicia villosa dasycarpa	48.5	14.4	105.3*	63.9	54.8	49.1
LSD (P<.05)	21.02	21.06	24.59	12.73	15.74	17.60
Significance	***	***	***	*	NS	*

* Indicates that the nonirrigated seed yield was higher than the irrigated seed yield.

Thus both genotypic and environmental factors are equally important in yield expression. On the other hand the low correlation between genotypic performance in shoot mass between the locations showed that the environmental factors are more dominant in its expression. These finding are useful in the overall management of food and feed legumes, depending upon whether the objective is seed yield or feed yield.

Seasonal Et and WU

Seasonal Et at Breda was smaller than at Tel Hadya or Jinderess (Figure 4.2.8 and Table 4.2.11a and 4.2.11b). Differences in seasonal Et between Tel Hadya and Breda persisted in the moderate and least drought treatments because of the characteristic soil physical properties at Breda reducing total profile available water and also perhaps crop interactions with frost.

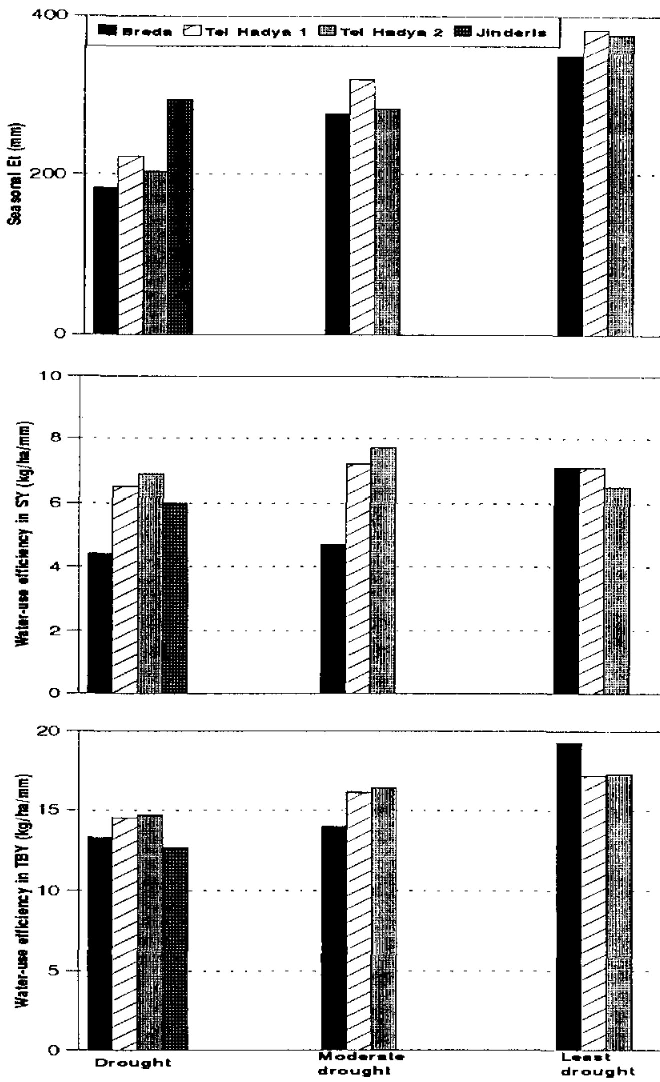


Figure 4.2.8. Effect of irrigation on seasonal evapotranspiration (Et, mm) and water-use efficiency (kg/ha/mm) in seed yield (SY) and shoot mass at Breda, Tel Hadya (1=line-souce and 2= discrete irrigation treatments), and Jinderess. Syria, 1992/93.

Table 4.2.9. Genotypic differences in percent losses in seed yield and total biological yield due to drought in feed and food legumes, Tel Hadya.

		Seed yield			Shoot mass		
			Tel Hadya			Tel Hadya	
Crop		Br	1	2	Br	1	2
Chickpea	ILC 482	50.8	26.6	20.8	55.7	41.2	39.7
	ILC 3279	49.7	34.9	28.7	44.7	47.6	30.3
	ICC 4958	25.9	24.2	39.4	43.7	45.9	20.5
	F83-47C	48.0	28.9	32.7	47.3	37.3	39.9
Lentil	ILL 4400	70.1	52.6	57.8	71.7	50.5	56.9
	ILL 4401	52.0	57.3	50.2	62.0	55.4	57.8
	ILL 2069	63.3	50.2	49.2	65.8	48.5	54.3
	ILL 5604	55.5	58.3	51.7	60.7	52.1	58.2
Faba bean	ILB 1814	80.5	45.7	58.6	66.8	48.3	56.6
	ILB 1811	72.4	50.5	62.0	67.5	54.0	62.7
	ILB 1270	80.9	54.7	54.8	72.5	55.9	55.7
	ILB 1266	85.0	59.3	55.6	72.3	61.2	60.9
Peas	Acc#21	67.9	57.1	40.5	67.9	55.9	42.4
	Acc#30	62.5	37.9	43.2	62.5	36.1	49.0
	Acc#3	60.9	35.3	57.9	60.9	29.9	55.6
	Acc#11	46.0	11.9	57.0	46.0	2.8	55.0
Vicia sativa	Acc#2541	64.3	51.1	47.7	59.4	57.4	57.7
	Acc#715	57.0	42.7	37.5	55.0	49.8	56.9
	Acc#1403	68.7	53.2	50.2	69.3	55.5	52.0
	Acc#709	71.2	51.3	35.6	70.9	59.5	49.8
Lathyrus sativus	Acc#347	45.5	47.4	32.2	51.3	63.3	45.5
	Acc#205	6.2	1.3	-133.8	59.2	55.4	31.2
	Acc#208	22.3	-9.3	-14.8	55.4	56.3	30.5
	Acc#206	12.1	-1.5	-110.7	49.2	51.5	28.1
Vicia narbonensis	Acc#67	68.9	51.7	47.8	67.3	57.1	55.8
	Acc#586	71.9	47.9	44.7	67.4	60.5	49.2
	Acc#588	69.5	49.2	43.1	66.1	52.6	47.2
	Acc#121	81.6	24.6	42.3	77.5	44.0	47.8
Vica villosa dasycarpa	Acc#683	60.4	24.6	4.0	66.4	47.5	54.6
	Acc#535	53.3	1.8	7.1	67.9	53.5	53.7
	Acc#1088	33.0	52.0	-7.0	54.5	54.9	54.7
	Acc#596	47.1	28.2	-25.1	66.9	63.5	33.5
LSD (P<.05)		22.71	32.07	40.45	15.47	20.97	20.07
Significance		NS	**	***	NS	*	NS

Table 4.2.10. Correlation of seed yield and shoot mass yield losses at Breda with losses in trials 'Tel Hadya-1' and 'Tel Hadya-2'.

	Seed yield	Shoot mass
Tel Hadya-1	0.691	0.398
Tel Hadya-2	0.784	0.535

Effects of sowing date on seasonal Et were large (Table 4.2.11a) and a delay of 18 days in planting in the trial Tel Hadya-2, resulted in 19 mm and 37 mm decrease in Et in the rainfed and moderate drought treatments. Crop differences in seasonal Et were narrow but significant at Breda and Tel Hadya-2 (Table 4.2.11a). Within a crop, seed yield was positively correlated with seasonal Et and shoot mass, the correlation being closer in feed than in food legumes (Table 4.2.12). Relationship of Et with shoot mass (Figure 4.2.10) was similar to seed yield (Figure 4.2.9). Seasonal Et was linearly correlated both with seed yield (Figure 4.2.9) and shoot mass (Figure 4.2.10) in all the crops, except chickpea which showed a curvilinear response.

WUE

WUE in seed yield and shoot mass, in general, were higher in the irrigated than in the rainfed treatments (Figure 4.2.8, Table 4.2.11a and 4.2.11b). This is contrary to the known responses observed in warm winter environments in the SAT, where WUE is always higher in the rainfed or drought treatments. Coefficients of determination of seed yield and shoot mass with Et and WUE (Table 4.2.12) were of similar magnitude.

Drought resistance

Two criteria were used for comparison of genotypic difference in drought resistance. Criteria one (DT1) was the estimates of slopes and intercepts predicted as rainfed seed or shoot mass yield from the linear regression of yield on mm water (irrigation + rainfall) in the line-source irrigation trials conducted at Breda and Tel Hadya (Tel Hadya-1), where a drought continuum was used. Genotypes with high intercepts and low slopes were considered drought resistant.

Criteria two (DT2) was the standardized residuals calculated from a multiple regression of rainfed yield on days to flowering and near potential yield (least drought, frequently irrigated treatment) in the trial Tel Hadya-2. Genotypes with standardized residuals exceeding the value of 1.3 were recognized as significant since these would represent the top or bottom 10% of the standardized residuals in the normal distribution curve of these residuals; those with the negative value were considered susceptible and those with a positive value as resistant.

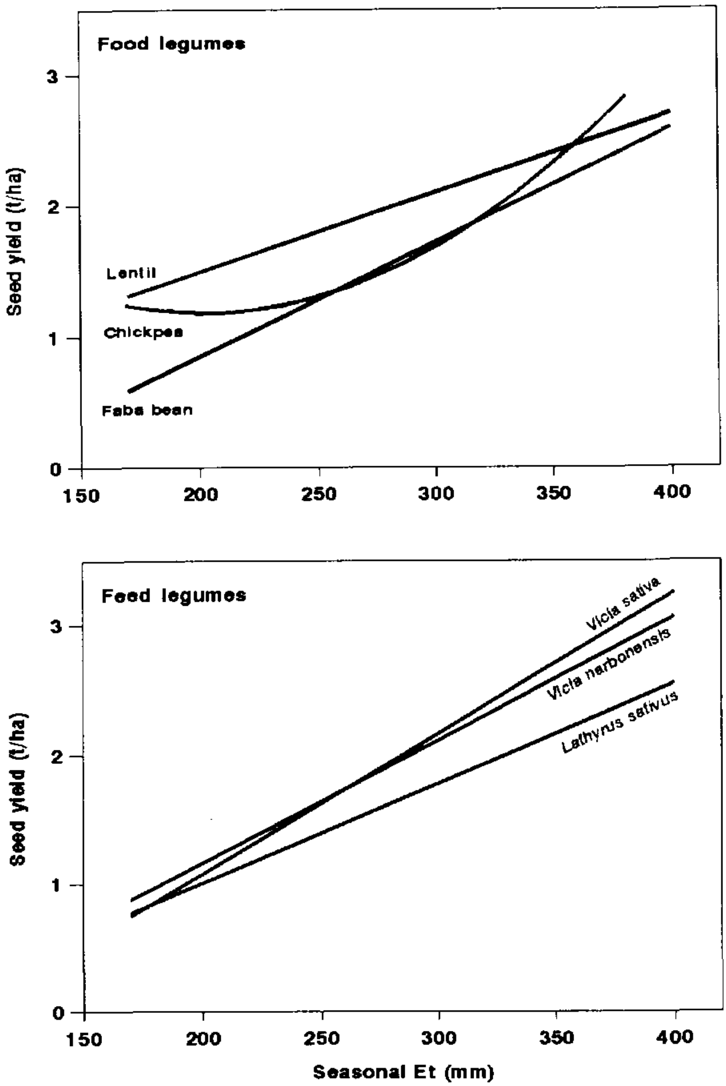


Figure 4.2.9. Relationship between seasonal evapotranspiration (Et mm) and seed yield (t/ha) of some cool season food and feed legumes. Syria, 1992/93.

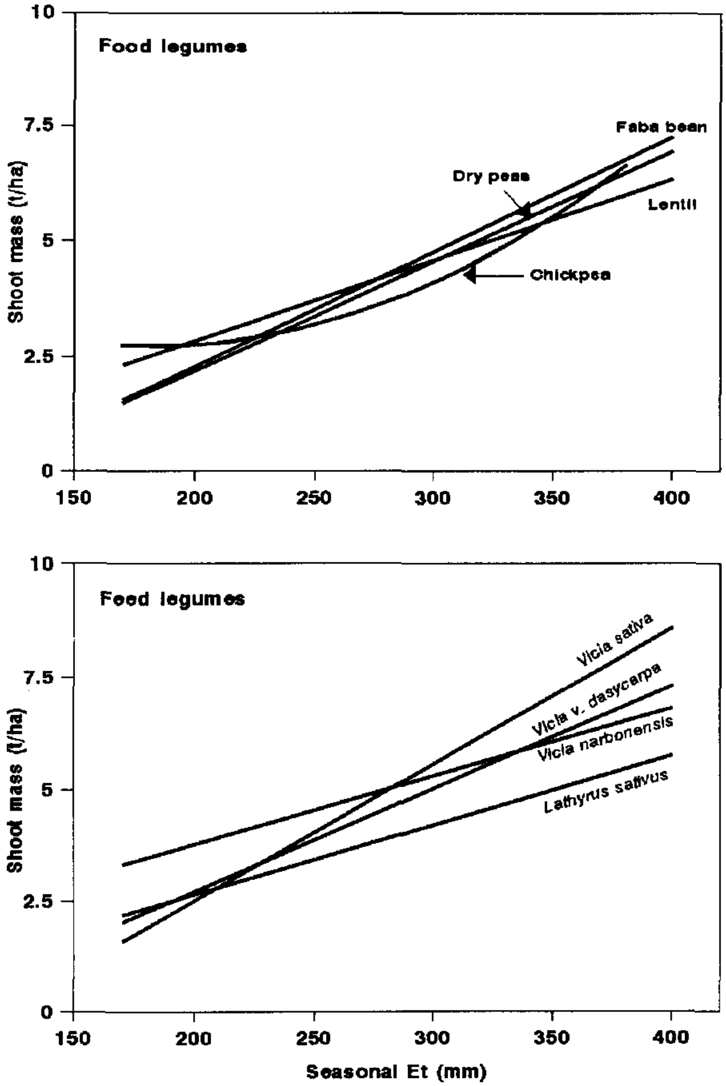


Figure 4.2.10. Relationship between seasonal evapotranspiration (Et mm) and shoot mass (t/ha) of some cool season food and feed legumes. Syria, 1992/93.

Table 4.2.11a. Cumulative evapotranspiration (mm water), (ET) and WUE (kg/mm water/ha) for SY and TBY in four feed and feed legume crops at Breda and Tel Hadya.

	ET				WUE seed yield				WUE shoot mass			
Crop	Irr	MI	NI	Mean	Irr	MI	NI	Mean	Irr	MI	NI	Mean
					Breda							
CP	347	26	169	261	5.3	3.1	4.5	4.3	12.8	14.2	13.1	134
FB	347	28	174	268	5.3	5.8	5.6	5.6	12.5	11.8	12.1	121
Lens	347	277	189	271	5.3	2.3	2.3	3.3	21.6	13.5	12.4	159
Peas	347	287	184	273	8.5	5.4	5.2	6.4	19.2	13.7	13.7	155
VS	332	277	194	268	7.6	5.4	4.0	5.6	30.1	16.6	12.6	198
LS	357	272	174	268	6.9	5.1	2.9	5.0	15.5	13.1	12.5	137
VN	367	267	184	273	7.9	4.8	5.5	6.1	18.2	15.0	15.3	162
VVD	362	287	189	279	9.8	5.4	5.5	6.9	24.7	14.2	14.5	178
SE		4.3***		2.5***		0.98		0.56***		2.83		1.65
Mean	350	277	182		7.1	4.7	4.4		19.3	14.0	13.3	
SE		5.1***				0.43				0.83		
					Tel Hadya-1							
	381	320	221	307	8.9	7.5	6.6	7.7	22.5	18.1	15.3	186
	384	321	223	309	5.4	5.8	6.8	6.0	11.9	12.4	12.7	123
	383	319	222	308	5.2	5.8	5.4	5.5	21.5	16.3	15.5	178
	382	319	222	307	7.2	9.2	7.6	8.0	15.3	19.0	16.1	168
	386	321	222	310	8.4	7.1	6.1	7.2	19.3	15.6	15.9	170
	383	320	222	308	6.5	6.2	5.9	6.2	11.6	11.6	10.6	113
	384	320	222	309	9.0	7.5	5.9	7.4	17.9	15.0	12.8	152
	381	320	223	308	6.0	8.5	7.6	7.4	17.3	20.5	17.2	183
SE		1.1		0.6		1.42		0.82		2.67		1.54
Mean	383	320	222		7.1	7.2	6.5		17.2	16.1	14.5	
SE		1.7***				0.09*				0.26*		
					Tel Hadya-2							
	371	264	194	276	6.1	6.6	8.8	7.2	12.4	15.8	15.8	138
	377	286	207	290	9.0	8.5	6.8	8.1	22.7	17.0	17.0	201
	392	290	209	297	7.9	8.2	6.4	7.5	15.0	12.4	12.4	139
	372	282	203	285	8.0	9.3	8.2	8.5	17.5	16.4	16.4	174
	369	280	208	286	7.4	8.2	6.8	7.5	20.7	12.8	12.8	166
	366	284	200	283	5.1	5.4	6.2	5.6	17.9	16.3	16.3	160
	391	289	199	293	6.5	8.3	7.3	7.3	16.8	15.1	15.1	169
	376	294	208	292	2.3	5.9	4.4	4.2	15.7	11.9	11.9	146
SE	6.3			3.6**		0.64*		0.37		1.37*		0.79***
Mean	377	283	203		6.5	7.6	6.9		14.7	16.4	17.3	
SE		8.6*				0.50				0.45		

Irr= full irrigation, MI= medium irrigation, NI= no irrigation.
*,**,***, significant at 5%, 1% and 0.1% level of probability respectively.

Table 4.2.11b. Cumulative water use (CWU, mm) and WUE (kg/mm/ha) for seed yield (WUESY) and shoot mass (WUETBY) in cool season food and feed legumes at Jinderess.

Crop	CWU	WUESY	WUETBY
Chickpea	303	4.7	10.1
Lentil	269	7.7	16.9
Faba bean	303	6.0	10.0
Peas	273	5.3	11.1
Vicia sativa	273	7.7	14.7
Lathyrus sativus	277	6.5	15.3
Vicia narbon	308	5.7	12.3
Vicia villosa subsp. *dasycarpa*	326	4.4	10.9
	NS	NS	*
SE	16.6	1.07	1.74
CV%	5.6	17.8	13.7

Table 4.2.12. Simple correlation of seed yield and shoot mass with seasonal ET and WUE for seed yield and shoot mass. (n-2= 8; r (5%)=0.632; (1%)=0.765).

	Crops							
	CP	LEN	FB	PEA	VS	LS	VN	VVD
				(a) <u>Seed yield</u>				
Shoot mass	0.90	0.99	0.54	0.14	0.78	0.72	0.94	0.84
Seasonal Et	0.74	0.74	0.77	0.50	0.95	0.92	0.88	0.49
WUE seed yield	0.76	0.71	0.88	0.01	0.88	0.80	0.83	0.88
				(b) <u>Shoot mass</u>				
Seasonal Et	0.76	0.69	0.86	0.79	0.84	0.84	0.93	0.79
WUE shoot mass	0.81	0.82	0.92	0.75	0.94	0.67	0.77	0.88

Genotypic differences in drought resistance, both for seed yield and shoot mass, were similar at Breda and Tel Hadya on the criteria of DT1 (Table 4.2.13 and 4.2.14). Among food legumes, winter chickpea and among feed legumes, Lathyrus was the most drought tolerant as these crops

Table 4.2.13. Regression estimates of slopes (intercept and slope) for seed yield on mm water applied + rainfall at Breda and Tel Hadya.

		Breda		Tel Hadya	
Crop	Geno	Intc	Slope	Intc	Slope
Chickpea	ILC 482	1115.1	4.858	1569	4.232
	ILC3279	876.3	3.653	1253	3.680
	ICC 4958	1275.6	3.731	1505	3.571
	F83-47C	1081.2	4.491	1440	4.151
Lentil	ILL4400	722.7	10.019	1245	11.720
	ILL4401	931.3	8.703	1380	10.663
	ILL2069	720.6	10.756	1403	9.827
	ILL 5604	842.8	9.300	1357	13.791
Faba bean	ILB 1814	167.6	13.513	1508	8.139
	ILB 1811	220.1	10.883	939	6.483
	ILB 1270	195.4	13.566	1163	11.571
	ILB 1266	20.3	14.744	1266	10.247
Peas	ACC.#21	637.3	12.904	1686	11.279
	ACC.#30	672.0	12.001	1161	5.885
	ACC.#3	557.8	9.528	1096	4.471
	ACC.#11	521.1	9.135	1100	4.645
Vicia sativa	ACC.#2541	747.3	10.275	1306	11.474
	ACC.# 715	665.4	8.613	1551	7.766
	ACC.#1403	548.2	10.672	729	5.533
	ACC.# 709	460.2	10.325	897	9.038
Lathyrus sativus	ACC.# 347	672.6	6.531	1559	8.094
	ACC.# 205	748.7	0.551	1503	-1.982
	ACC.# 208	884.0	1.659	1612	-0.399
	ACC.# 206	804.9	1.650	1700	-1.863
Vicia narbonensis	ACC.# 76	648.7	11.749	1615	9.364
	ACC.# 586	569.9	13.136	1623	9.239
	ACC.# 588	676.5	11.456	1386	10.985
	ACC.# 121	357.8	16.509	2060	5.408
Vicia villosa subsp. dasycarpa	ACC.# 683	541.0	5.242	1367	1.341
	ACC.# 535	462.8	4.892	1388	1.922
	ACC.#1088	756.0	3.049	1204	5.507
	AAC.# 596	432.7	5.229	1399	2.218
SE(±)		181	1.5	141	1.25

combined lower response slopes to irrigation with high rainfed seed yield. The ranking of the crops in the decreasing order of drought resistance was chickpea>lentil>peas>faba bean both at Tel Hadya and Breda (Figure 4.2.11). Among the feed legumes (Figure 4.2.12) the ranking was *Lathyrus sativus*>*Vicia sativa* = *V. narbonensis*>*V. villosa* ssp. *dasycarpa* at Breda. At Tel Hadya, *V. narbonensis* showed a greater drought resistance combined with responsiveness to irrigation, which was also observed in the 1992 season.

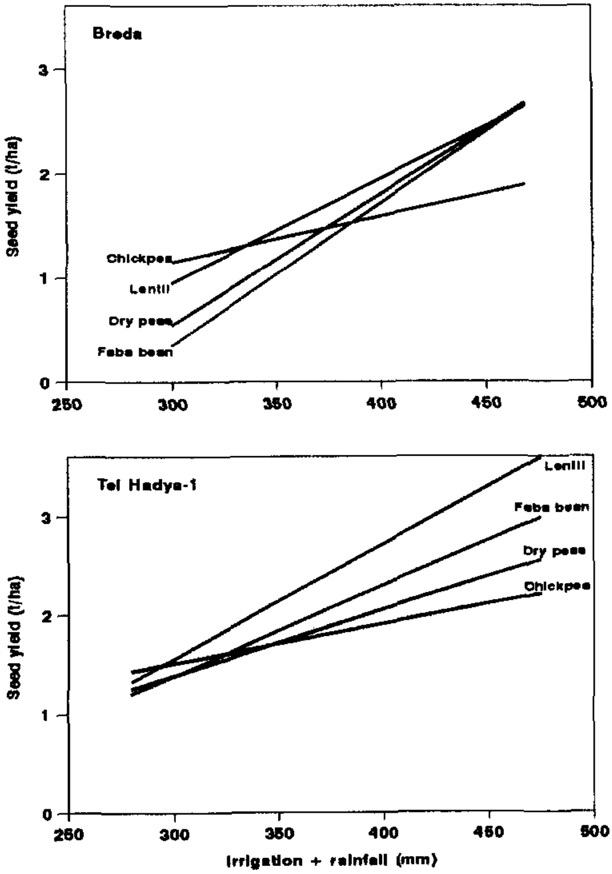


Figure 4.2.11. Response of some cool season food legumes to line-source irrigation in seed yield at Breda and Tel Hadya. Syria, 1992/93.

Crop and genotypic differences in the slopes for total biological yield were similar, except that the differences were small and peas showed the smallest slopes compared to any other crop at Tel Hadya (Table 4.2.14).

On the criteria of DT2 one chickpea genotype (ILC 482), two genotypes of Lathyrus (Acc #208, and #206) and one genotype of *Vicia narbonensis* (Acc #588)showed a significant drought resistant response (Table 4.2.15).

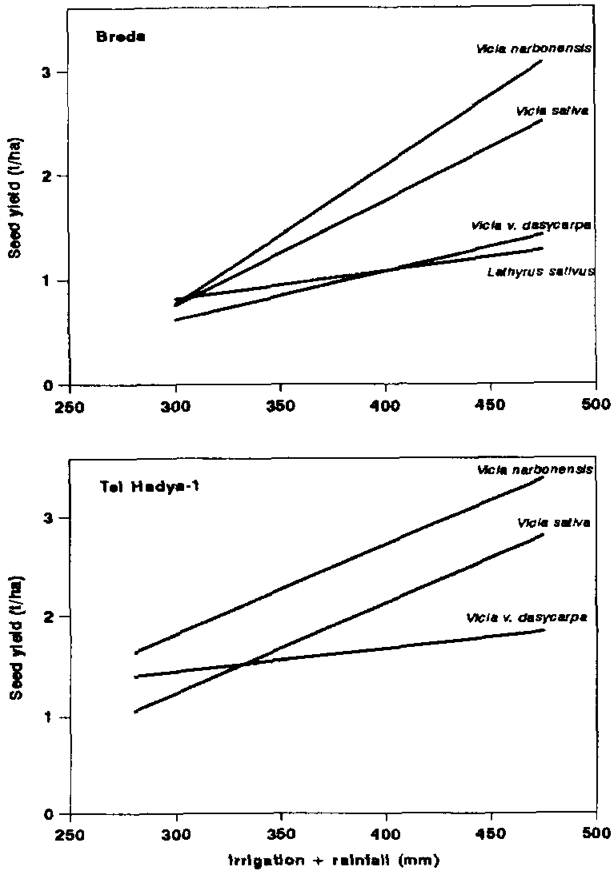


Figure 4.2.12. Response of some cool season feed legumes to line-source irrigation in seed yield at Breda and Tel Hadya. Syria, 1992/93.

Table 4.2.14. Regression estimates of slopes for total biological yield on mm water applied + rainfall at Breda and Tel Hadya.

Crop	Geno	Breda Intc	Breda Slope	Tel Hadya Intc	Tel Hadya Slope
Chickpea	ILC482	2110	12.89	2877	14.35
	ILC 3279	2750	11.34	2866	18.72
	ICC 4958	2134	11.53	2582	15.72
	F83-47C	2298	14.20	3144	13.88
Lentil	ILL 4400	1725	34.27	2787	26.52
	ILL 4401	2046	27.27	3109	25.12
	ILL 2069	1677	32.14	3435	22.40
	ILL 5604	1987	30.17	3534	25.13
Faba bean	ILB 1814	1354	24.65	2510	15.75
	ILB 1811	804	21.21	1633	12.55
	ILB 1270	959	23.09	1878	20.85
	ILB 1266	900	24.25	2136	18.55
Peas	ACC.#21	2122	25.61	3355	22.30
	ACC.#30	1594	21.04	2158	8.77
	ACC.#3	1268	18.09	1992	6.78
	ACC.#11	1290	16.65	1978	7.50
Vicia sativa	ACC.#2541	2196	21.45	2343	29.27
	ACC.# 715	1841	20.80	2985	22.26
	ACC.#1403	1235	27.71	1552	12.91
	ACC.# 709	1420	27.20	1922	25.83
Lathyrus sativus	ACC.# 347	2101	15.45	3000	32.07
	ACC.# 205	1539	19.19	3361	25.37
	ACC.# 208	1977	17.91	3276	21.75
	ACC.# 206	1981	15.90	3764	18.81
Vicia narbonensis	ACC.# 76	1559	31.02	3289	26.39
	ACC.# 586	1631	26.55	3031	24.69
	ACC.# 588	1608	24.17	2859	21.79
	ACC.# 121	1151	34.96	3705	21.63
Vicia villosa subsp. dasycarpa	ACC.# 683	1848	25.82	3246	25.87
	ACC.# 535	1476	27.37	3337	27.51
	ACC.#1088	2263	17.40	3342	21.31
	ACC.# 596	1161	30.17	3049	29.26
SE(±)		141	1.25	329	2.92

Table 4.2.15. Drought tolerance index (DTI) for seed yield (SY) and total biological yield (TBY) at Tel Hadya.

		SY (kg/ha)		DTI	TBY (kg/ha)		DTI
		NI	Irrig		NI	Irrig	
Chickpea	ILC482	1557	1993	1.72	2816	4768	0.44
	ILC 3279	1227	1744	-0.84	3222	4633	0.51
	ICC 4958	1252	2064	-0.50	2615	3832	0.71
	F83-47C	1491	2212	0.43	3101	5161	-0.09
Lentil	ILL 4400	1424	3380	0.06	3535	8249	-0.29
	ILL 4401	1506	3048	0.24	3411	8206	-0.19
	ILL 2069	1463	2897	0.35	3431	7674	0.74
	ILL 5604	1368	2947	-0.47	3356	8124	-0.28
Faba bean	ILB 1814	1220	2931	0.21	2352	5395	-1.42
	ILB 1811	895	2395	-0.61	1585	4357	-2.10
	ILB 1270	1214	2822	0.25	2090	5105	-1.87
	ILB 1266	1259	2917	0.44	1980	5342	-2.09
Peas	ACC.#21	1553	2651	0.50	3152	5670	1.58
	ACC.#30	936	1894	-1.56	1772	3961	-0.34
	ACC.#3	747	1797	-2.17	1439	3312	0.01
	ACC.#11	668	1639	-2.21	1261	2917	-0.50
Vicia sativa	ACC.#2541	1412	2709	-0.19	2738	6781	-0.45
	ACC.# 715	1406	2262	-0.09	2958	7087	-0.81
	ACC.#1403	1052	2151	-1.73	2100	4541	-0.49
	ACC.# 709	1126	1792	-0.61	2610	5357	-0.33
Lathyrus sativus	ACC.# 347	1145	1694	1.00	3007	5672	1.45
	ACC.# 205	1142	527	1.05	2895	4277	0.33
	ACC.# 208	1240	1070	1.33	2908	4463	0.71
	ACC.# 206	1291	673	1.91	3138	4662	1.49
Vicia narbonensis	ACC.# 76	1398	2786	0.69	2959	6735	0.90
	ACC.# 586	1438	2676	0.40	2904	5749	0.87
	ACC.# 588	1351	2408	1.33	2656	5032	1.30
	ACC.# 121	1542	2677	0.53	3234	6186	1.04
Vicia villosa subsp. *dasycarpa*	ACC.# 683	974	1062	-0.38	2678	5902	-0.18
	ACC.# 535	1054	1133	-0.27	2810	6181	-0.46
	ACC.#1088	987	983	-0.37	2651	5942	-0.81
	ACC.# 596	941	909	-0.30	2562	4668	0.68

Conclusions
Judging on the criteria of yield loss as well as on the DT1 criteria, *Lathyrus sativus* was the most drought resistant crop among feed legumes and chickpea among the food legumes. Among the crops studied the least response to irrigation in the above two crops suggest that these will benefit relatively less in the years when there is a good rainfall. **N.P. Saxena and M.C. Saxena.**

4.2.4. Response of *Vicia sativa* subsp. *amphicarpa* to Drought

Amphicarpy, having pods both above and below ground, is known to occur in several legumes including *Vicia sativa*. Amphicarpous crops thus leave a seed bank in the soil which results in establishment of a self-seeded crop next season. This trait is of importance in developing a ley-farming system. Effect of a drought continuum, created by a line- source sprinkler irrigation system, was studied on the distribution of above-ground (AG) and below-ground (BG) seed yield, shoot mass and harvest index in an accession (Acc. No. 2650/2571) of *Vicia sativa* subsp. *amphicarpa* at Breda and Tel Hadya sites. Total seasonal precipitation at Breda and Tel Hadya was similar, as already indicated earlier.

Rainfed crop took 137 days to flower and 174 days to mature at Breda and 122 and 161 days, respectively, at Tel Hadya. The effects of various levels of moisture supply on flowering and maturity were studied at Tel Hadya. Days to flowering and maturity increased as the moisture supply increased (Table 4.2.17).

The tested accession showed rather low yield potential. Under nearly non-limiting mositure supply, about 3.0 t/ha of total shoot mass and 0.8 t/ha of seed yield was produced. Crop growth and productivity was drastically reduced because of drought with rainfed yields of shoot biomass and grain being less than 1.0 t/ha and 0.2 t/ha, respectively (Table 4.2.17).

The total and the above ground (AG) biomass yields of the crop increased linearly as the mositure supply was increased (Figure 4.2.13, Table 4.2.17). The below ground (BG) seed yield response was, however, quadratic with yield maximization occurring at around 400 mm of total mositure supply (rainfall + irrigation). Thus, the BG seed yield was less sensitive to drought than the AG seed yield.

Crop performed better at Breda than at Tel Hadya, particualrly in terms of BG seed yield. This reflects the adaptation of the crop to courser soil texture common in Breda in contrast to Tel Hadya. **N.P. Saxena, M.C. Saxena and A.A. El Moneim.**

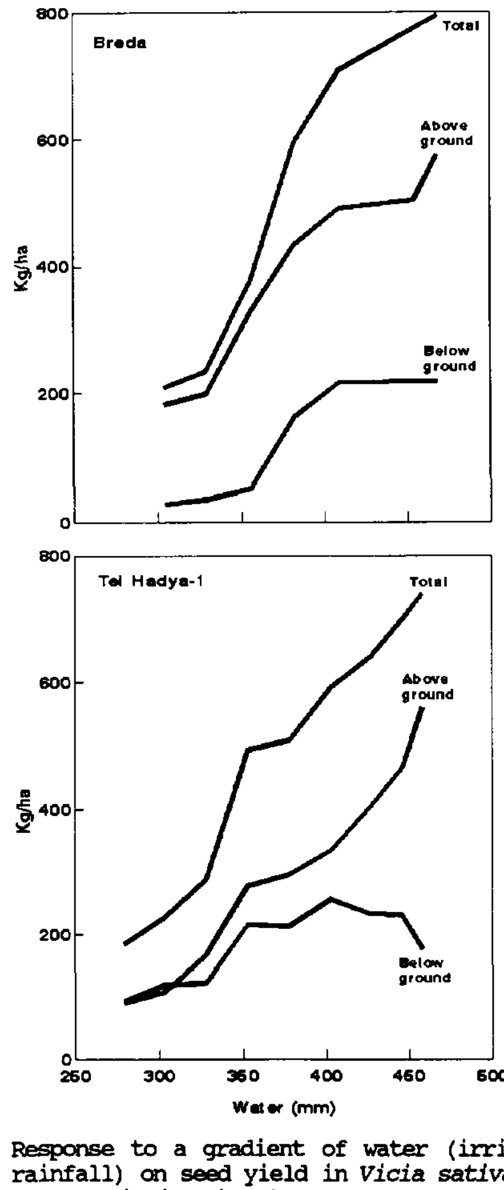


Figure 4.2.13. Response to a gradient of water (irrigation applied + rainfall) on seed yield in *Vicia sativa* ssp. *amphicarpa* and partioning in above ground and below ground seed yield. Syria, 1992/93.

Table 4.2.17. Effect of different levels of moisture supply above the seasonal precipitation on the performance of *Vicia sativa* subsp. amphicarpa at Breda and Tel Hadya, 1992/93.

Additional moisture supply (mm)	Days to flower	Days to flower	Above ground			Under ground			Total	
			Shoot mass (t/ha)	Seed yield (t/ha)	HI (%)	Shoot mass (t/ha)	Seed yield (t/ha)	HI (%)	Shoot mass (t/ha)	Seed yield (t/ha)
Breda										
168	-	-	1.66	0.22	11.7	1.93	0.58	29.8	3.59	0.80
158	-	-	1.58	0.12	5.8	1.46	0.50	35.0	3.04	0.62
140	-	-	0.57	0.05	8.6	1.13	0.35	32.1	1.70	0.40
119	-	-	1.55	0.22	11.9	1.44	0.49	33.3	2.99	0.71
94	-	-	1.29	0.16	12.7	1.27	0.43	35.5	2.56	0.59
61	-	-	0.81	0.05	6.2	1.07	0.33	32.6	1.88	0.38
25	-	-	0.61	0.03	5.7	0.54	0.20	37.2	1.15	0.23
0	137.0	174.0	0.46	0.03	5.6	0.51	0.18	36.7	0.97	0.21
SEM±	-	-	0.225	0.053	2.14	0.170	0.067	2.49		
LSD (0.05)	-	-	0.662	0.155	6.30	0.501	0.197	7.32		
CV(%)	-	-	42.18	95.12	50.34	29.14	35.00	14.6		
Tel Hadya										
162	128.5	170.5	2.06	0.56	26.4	0.47	0.18	39.4	2.53	0.74
156	128.5	170.5	1.94	0.47	24.2	0.83	0.23	31.5	2.77	0.70
144	127.0	170.5	1.81	0.41	23.3	0.60	0.23	53.5	2.41	0.64
126	124.3	169.0	1.40	0.34	24.3	0.63	0.26	44.3	2.03	0.60
104	124.0	169.0	1.34	0.30	22.8	0.51	0.21	45.7	1.85	0.51
67	123.5	166.7	1.09	0.28	25.1	0.43	0.22	53.6	1.52	0.50
22	122.5	165.7	0.56	0.17	30.4	0.26	0.12	47.3	0.82	0.29
0	121.7	161.0	0.30	0.11	38.1	0.28	0.12	42.0	0.58	0.23
SEM±	0.39	0.32	0.209	0.066	2.03	0.138	0.036	5.97		
LSD(0.05)	1.15	0.94	0.610	0.192	5.94	0.404	0.105	17.42		
CV(%)	0.63	0.39	35.84	43.78	17.05	59.26	38.97	26.71		

4.2.5. Effects of Drought on BOAA Content of Seeds of Chickling

Chicklings are known to contain BOAA in seed which results in reduced nutritional value of this otherwise valuable food and feed legume. In our 1991/92 season study we observed that drought increased the BOAA content in the seeds. This aspect was further studied in the 1992/93 season by analysing seeds of four different genotypes of *Lathyrus sativus* under different mositure regime treatments in the drought studies described earlier. The protein content of seed was also examined.

In the experiment where 3 levels of moisture supply were created at Tel Hadya to simulate different degrees of drought (Table 4.2.18) results on BOAA content confirmed the observations of 1991/92; the BOAA content increased as the level of drought increased (moisture supply decreased). There was no significant genotypes x moisture supply interaction.

In the experiment with the line source sprinkler system where a gradient of drought was created both at Tel Hadya and Breda, the effect was similar to that obtained in the above mentioned experiment. There was a negative correlation between total seasonal moisture supply and the BOAA content in seed of all the genotypes (Table 4.2.19), although there were genotypic differences in the rate of response. The correlation was stronger in Acc No. 206 at Breda and in Acc No. 205 at Tel Hadya.

Response to increased moisture supply (decreased drought) was positive (Table 4.2.19). This response is rather surprising and is in contrast to the response observed in other grain legumes such as chickpea, where the protein content tends to increase in droughty conditions because of greater sensitivity of carbohydrate accumulation in the seeds to drought. This contrasting response of chickling needs to be further investigated.

Table 4.2.18. Effects of drought on % BOAA content in the seeds of 4 chickling genotypes, Tel Hadya, 1992/93.

Genotype Acc #	Severe	Level of drought Moderate	None	Mean
347	0.6200	0.5950	0.6683	0.6278
205	0.6110	0.6420	0.6073	0.6201
208	0.6047	0.5760	0.6047	0.5951
709	0.5870	0.5927	0.6483	0.6093
SE(±)	---------- 0.10996	-------------		0.01470
Mean	0.6057	0.6014	0.6322	
SE(±)		0.00827		

Table 4.2.19. Correlation coefficients between seasonal moisturs supply varied through a line-source sprinkler system, and the levels of protein and BOAA content in four genotypes of *Lathyrus* at Breda and Tel Hadya.

Genotypes Acc #	Protein %		% BOAA conent	
	Breda	Tel Hadya	Breda	Tel Hadya
347	0.605	0.932	-0.370	-0.544
205	0.785	0.653	-0.419	-0.936
208	0.934	0.849	-0.146	-0.539
206	0.769	0.617	-0.759	-0.400

4.3. Rotation Effects on Seed Bank of Underground Vetch

In the 1989/90 season an underground vetch (*V. sativa* ssp. *amphicarpa*) - barley (AS46/Atlas) trial was commenced. In the year of establishment, four grazing treatments were imposed. They were: grazed in February or March or April or not at all. In the following year, plots were sown to barley and vetch was allowed to come up as volunteer. During the 1991/92 to 1992/93 seasons, the vetch was allowed to self regenerate. At the beginning of the 1992/93 season, seedling emergence was measured. Each plot was divided in two parts. At 100% flowering one half was cut for estimations of herbage yield, while the second half was harvested at maturity. Above ground biomass and seedbank size were measured. Germinability of the underground seedbank was also determined at bimonthly intervals after seed maturity.

The pattern of seedling emergence is described in Table 4.3.1. The majority of seedlings emerged at the beginning of March with at least 85% emerging at the end of the month. An average of 37 seedlings/m^2 had emerged by the end of April. There was no significant difference between treatments indicating that during successive regenerations any difference in seedbank sizes had evened out.

Table 4.3.2 shows the aboveground biomass figures at 100% flowering and at maturity for the 1992/93 season. There was no difference between the 1989/90 treatments. This is not surprising since there was no difference in the seedling emergence figures. Likewise there was no difference between the 1992/93 treatments. This perhaps reflects the very poor aboveground seed production during the season.

Seedbank status at maturity (1992/93 season) is described in Table 4.3.3. Although mean seed numbers ranged from 1429 to 2502 seed/m^{2}for the 1989/90 treatments, there was no statistical difference. This is reflected in the lack of treatment difference for the seedling emergence and aboveground biomass data. Likewise for the 1992/93 treatments there was no difference between cutting at 100% flowering and harvesting at maturity (except for the no-grazing treatment). This could be due to underground seed formation taking place before the cutting treatment.

Table 4.3.1. Seedlings emergence in the 1992/93 season for underground vetch plots which in the year of establishment (1989/90) had been grazed in February or March or April or not at all.

Grazing treatment (1989/90)	Seedling emergence (Plants/m2)*					
	3/3/93	17/3/93	31/3/93	14/4/93	28/4/93	Total
February	17	8	4	2	1	32
March	26	8	1	1	1	37
April	28	10	2	1	1	42
No grazing	19	9	2	1	1	32
Mean	22.9	9	2.3	1.1	1	36.6
SEM±	2.9	4	1.4	1.3	0.61	6.8
LSD (P=0.05)	7.2	n.s.	n.s.	n.s	n.s.	n.s

* Each figure is a mean value derived from 3 reps per treatment and 4 quadrants per replicate.

Table 4.3.2. Aboveground biomass for self regenerating plots of underground vetch for the 1992/93 season. In the year of establishment (1989/90) plots were grazed in February or March or April or not at all.

Grazing treatment (1989/90)	Aboveground biomass (kg/ha)				
	100% flowering	Maturity	Mean	SEM±.	Sig.
February	657	873	765	460	n.s.
March	903	830	866	380	n.s.
April	1351	1026	1189	271	n.s.
No grazing	856	1576	1216	554	n.s.
Mean	941	1076	1008		
SEM±	289	434			
Sig	n.s.	n.s.			

Table 4.3.3. Seedbank status for self regenerating plots of underground vetch after the 1992/93 seed-set. In the year of establishment (1989/90) plots were grazed in February or March or April or not at all. In the 1992/93 season each plot was subdivided and cut at 100% flowering and harvested at maturity. Each value is a mean derived from 3 reps per treatment and 3 core-samples per subplot.

Grazing treatment (1989/90)	Cutting treatment (1992/93)	Seed/m^2	Mean	SEM±	LSD
February	100% flowering	1398			
	Maturity	1461	1429	169	n.s
March	100% flowering	2176			
	Maturity	2628	2402	241	n.s.
April	100% flowering	2786			
	Maturity	2218	2502	783	n.s.
No grazing	100% flowering	1335			
	Maturity	2912	2123	316	831
Mean	2114				
SEM±	645				
LSD (P=0.05)	n.s.				

Table 4.3.4 shows the seed softening process after seed maturity. On average there was 80% hardseededness at the beginning of summer. This declined to 58% during autumn with the sharpest decline occurring during September. There was some difference between treatments over the first 3 determinations with February maturity treatments being around 10% lower. **Ken Street and A.A. El Moneim.**

Table 4.3.4. Hardseed breakdown for the underground seed component of the underground vetch rotation trial beginning June 1993. In the establishment year, plots were grazed in February or March or April or not at all. In the 1992/93 season, each plot was divided into two, one plot was 'grazed' at 100% flowering, the other at maturity. The numbers in the body of the table are percentages of seeds which did not germinate or imbibe.

Grazing treatment (1989/90)	Cutting treatment (1992/93)	Sampling dates								
		23/6	6/7	22/7	8/8	7/9	21/9	11/10	SE (±)	LSD (P=0.05)
February	Flowering	82	87	87	65	69	60	64	7.5	16.1
	Maturity	64	72	72	67	64	70	55	7.1	15.3
March	Flowering	80	82	82	83	70	65	54	8.3	18.9
	Maturity	78	82	82	69	71	64	55	9	19.4
April	Flowering	81	86	85	78	77	70	60	51	11
	Maturity	80	80	80	76	79	81	56	6.8	14.6
No grazing	Flowering	85	80	80	72	72	71	63	6.7	14.4
	Maturity	85	69	69	8.3	67	70	56	6.2	13.2
Mean		79	82	79	74	71	68	58		
SEM±		6.6	6.2	5.5	6.8	5	8.6	7.2		
LSD (P=0.05)		14.2	n.s.	11.9	n.s.		n.s.	n.s.	n.s.	

4.4. Forage Legume Pathology

The program of feed legume improvement of *Vicia* spp. and chicklings (*Lathyrus* spp.) has identified promising genotypes of these species in term of yields and adaptation. The objectives of the pathology section is to evaluate the selected genotypes for resistance to the major diseases and make available information on sources of resistance to individual and multiple diseases. Since the feed legume genotypes are not yet widely grown in the WANA region, the relative importance of the diseases on the genotypes should be monitored annualy through disease surveys. This would identify the major diseases and their potential economic significance in different agroecological areas where the crops are grown.

4.4.1. Screening for Disease Resistance

4.4.1.1. Evaluation of germplasm accessions in the field

Germplasm accessions of five *Vicia* species and two *Lathyrus* species were evaluated for resistance to ascochyta blight and botrytis stem blight in the field, and to powdery mildew in the greenhouse. The results are presented in Table 4.4.1 and 4.4.3. *Vicia* species had some accessions that were resistant to each of the three diseases except *V. palaestina* which had no resistance to powdery mildew. *V. narbonensis* had one accession (566/2381) which was rated resistant (R) to powdery mildew, but all other *Vicia* species showed moderate resistance to Ascochyta blight, botrytis stem blight and powdery mildew (Table 4.4.1). Some lines had resistance to multiple diseases and they are presented in Table 4.4.3. *Lathyrus sativus* and *L. cicera* were susceptible to the three diseases and only one selection of *L. sativus* (349/564) was moderately resistant to Ascochyta blight and two selections (410/510 and 410/524) were moderately resistant to powdery mildew (Table 4.4.2). None of the *L. sativus* and *L. cicera* accessions showed multiple disease resistance (Table 4.4.3).

Table 4.4.1. Disease reactions of some promising selections of *Vicia* species at Tel Hadya in 1992/93.

Vicia spp. (no of acc.)	Disease	No of accessions showing disease rating of reaction				
		1	2	3	4	5
V. sativa	Asc. blight	0	8	27	15	0
(50)	Bot. blight	0	14	25	11	0
	P. mildew	0	8	26	16	0
V. narbonensis	Asc. blight	0	2	14	9	0
(25)	Bot. blight	0	8	13	4	0
	P. mildew	1	15	8	1	0
V. ervilia	Asc. blight	0	12	7	6	0
(25)	Bot. blight	0	6	8	11	0
	P. mildew	0	23	2	0	0
V. palaestina	Asc. blight	0	5	11	0	0
(16)	Bot. blight	0	5	6	5	0
	P. mildew	0	0	0	9	7
V. hybrida	Asc. blight	0	16	0	0	0
(16)	Bot. blight	0	13	3	0	0
	P. mildew	0	7	6	3	0

+ Disease reaction for ascochyta (Asc.) blight and Botrytis (Bot.) stem blight from field and powdery mildew (P. Mildew) from greenhouse; 1=resistant (R), 2=moderately resistant (MR), 3=Intermediate (I), 4=susceptible (S) and 5=highly susceptible (HS).

Table 4.4.2. Disease reactions of promising *Lathyrus* species at Tel Hadya, 1992/93

Lathyrus spp. (No. of acc)	Disease	No of accessions showing disease rating of 1	2	3	4	5
L. sativa	Asc. blight	0	1	13	2	0
	Bot. blight	0	0	4	9	3
	Pow. mildew	0	2	7	14	15
L. cicera	Asc. blight	0	0	4	5	0
	Bot. blight	0	0	5	4	0
	Pow. mildew	0	0	0	9	0

4.4.1.2. Evaluation of *Lathyrus sativus* to Ascochyta blight at Breda

Lathyrus species grown in advanced yield trials and adaptation trials at Breda station developed widespread disease symptoms in March 1993. The disease was identified as ascochyta blight and the field diagnosis was confirmed by isolation and identification of *Ascochyta pisi* in cultures. The reaction of different selections are presented in Figure 4.4.1. The area was planted with several *Lathyrus* and *Vicia* species, but only *L. sativus* was infected. *Lathyrus cicera, L. ochrus* and *Vicia narbonensis* were free from infection. The other *Lathyrus* species in the trials are also hosts of the same fungus, but did not get infected. This may be because they were resistant or that inoculum was not available in all plots.

4.4.1.3. Reconfirmation of resistance

Lines of *Vicia* and *Lathyrus* species that were resistant and moderately resistant in the 1991/92 disease screening were re-evaluated in the greenhouse to confirm the resistance. A total of 29 selections (6 of *V. sativa*, 12 of *V. narbonensis*, 7 of *V. ervilia*, and 8 of *L. sativa*) were evaluated. Results are presented in Figure 4.4.2. None of the selections was resistant and only one selection of *V. narbonensis* (S 2397), two of *V. sativa* (S 2495 & 2497) and three of *V. ervilia* (S 2509, 2510, & 2517) were moderately resistant. **M.T. Mmbaga, A.A. El Moneim and M. Bellar.**

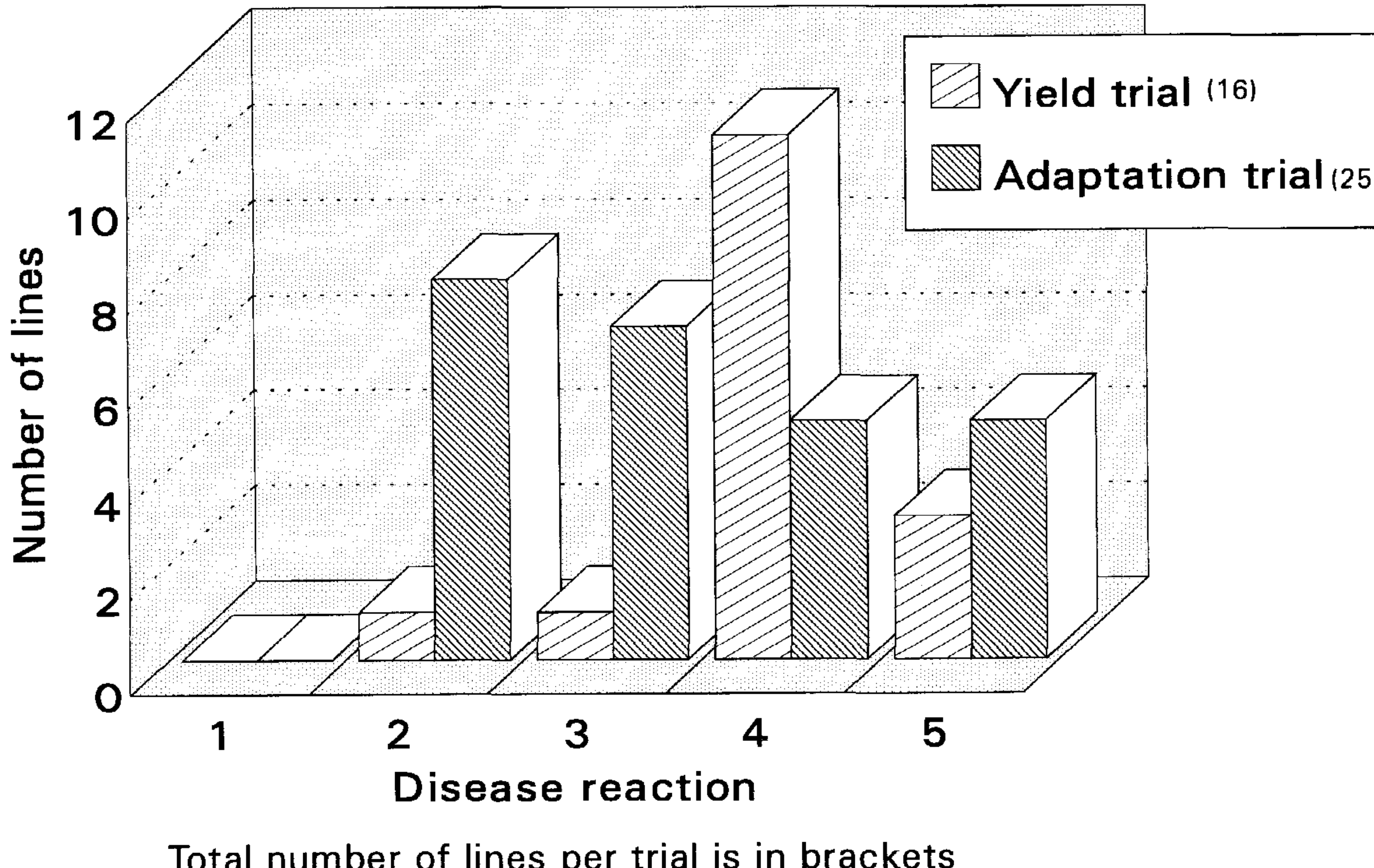


Figure 4.4.1. Ascochyta blight infestation in *Lathyrus sativus* trials at Breda station 1992-93.

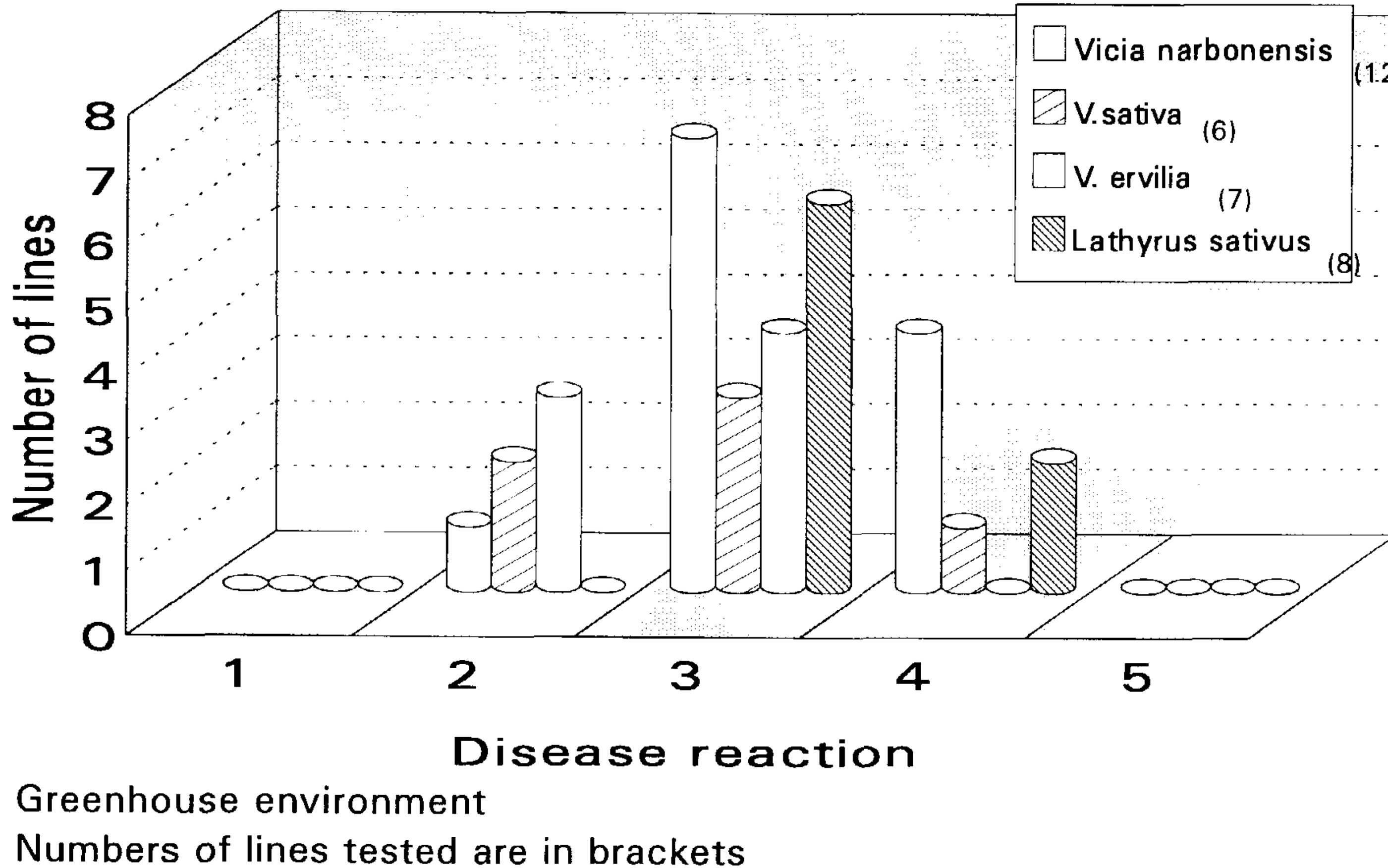


Figure 4.4.2. Reconfirmation of ascochyta blight resistance in *Vicia* and *Lathyrus* species in green house. No. of lines listed is in paranthesis.

Table 4.4.3. The best sources of multiple disease resistance in the *Vicia* and *Lathyrus* species, 1992/93.

Species	Accession/selection number showing R to MR* reaction to			
	Asc. & Bot.	Asc. & P. mildew	Bot. & P. mildew	Asc. Botrytis & P. mildew
V. sativa	3637/2609 3840/2614 3841/2615 4169/2626	None	None	None
V. narbonensis	67/2561	67/2561	67/2561 556/2376 564/2379 1145/2394 1146/2395 2521/2398	67/2561
V. ervilia	2943/2519 4657/2647 4658/2648 4659/2649 2660/2650	2943/2519 4657/2647 4658/2648 4659/2649 2660/2650 2793/2509 2799/2510 2804/2513 3479/2521 2661/2651	2943/2519 4657/2647 4658/2648 4659/2649 2660/2650	2943/2519 4657/2647 4658/2648 4659/2649 2660/2650
V. palaestina	3251/2531 3270/2534	None	None	None
V. hybrida	2908/2540 2938/2542 2988/2543 3035/2544 3044/2545 3108/2548 2914/2141 3105/2547 3285/2549 3333/2551 3353/2552 3565/2553 3524/2554	2908/2540 2938/2542 2988/2543 3035/2544 344/2545 3108/2548	2908/2540 2938/2542 2988/2543 3035/2544 3044/2545 3108/2548	2908/2540 2938/2542 2988/2543 3035/2544 3044/2545 3108/2548
Lathyrus sativus	none	none	none	none
L. cicera	none	none	none	none

4.4.2. Screening *Vicia* and *Lathyrus* Species to Cyst Nematode (*Heterodera ciceri*)

Promising genotypes of narbon-vetch (*Vicia narbonensis*), common vetch (*V. sativa*), bitter vetch (*V. ervilia*), *V. palaestina*, *V. hybrida*, and common chickling (*L. sativus*), and dwarf chickling (*L. cicera*) were planted in nematode infested soil in the greenhouse. Inoculum density was about 20 eggs of *Heterodera ciceri* per cm_3 soil and the greenhouse was maintained at 16/25°C night/day temperature. Disease reading was done 50 days after seedling emergence and lines were rated for *H. ciceri* infestation by using a 1-5 scale, based on number of female nematodes and cysts per gram fresh weight of roots. The reaction of the different species is presented in Table 4.4.4. Most of the *Vicia sativa* and *V. hybrida* accessions were R to MR according to symptom expression and number of nematodes/g of root. None of the other species had resistance to cyst nematode and most of the accessions were susceptible. **M. Bellar, A.A. El Moneim and M.T. Mmbaga.**

Table 4.4.4. Reaction of promising lines of *Vicia* and *Lathyrus* species to cyst nematode (*Heterodera ciceri*) in the greenhouse.

Species (no. of acc. tested)	No. of lines showing a rating* of					Range of no. of nematodes/ g root
	1	2	3	4	5	
Vicia sativa (50)	20	25	5	0	0	1-65
V. narbonensis (25)	0	0	5	15	5	38-289
V. ervilia (25)	0	0	4	15	6	92-294
V. palaestina (16)	0	0	5	11	0	50-184
V. hybrida (16)	1	14	1	0	0	3-30
Lathyrus sativus (16)	0	0	3	11	2	65-370
L. cicera (9)	0	0	2	4	3	73-265

* Reaction rating of 1=resistant, 2=moderately resistant, 3=Intermediate, and 4-5=susceptible and highly susceptible.

4.4.3. Disease Survey for Forage Legumes

Disease incidence and severity in *Vicia* and *Lathyrus* species was evaluated in farmer's fields and on-farm trials in south, central and northern Syria. The target sites for the survey were the on-farm and on-station trials of promising lines that were planted at Dara'a, Dael, Izra'a, Hama, Idleb, Afes, Ghazael, Hemo and Kamishly locations. In addition, farmers fields enroute and around these locations were also included in the survey. The objective was to assess the disease situation in vetches and chicklings and evaluate selected promising lines for disease reaction.

Disease incidence and severity was recorded and samples were collected for identification and for inoculum development for future use. Results are presented in Table 4.4.5. Wilt, caused by *Fusarium oxysporum*, was most prevalent at all locations. Other root rot pathgoens that were associated with the wilt were *Rhizoctonia bataticola*, and had a lower frequency of occurrence than the wilt/root rot. The rainfall data for the locations is presented in Table 4.4.6.

Table 4.4.5. Distribution of different diseases and average frequency of isolation (Av. freq.) promising forage legume crops grown in on-farm and on-station trials in Syria in 1992/93.

Trial	Diseases	Isolated pathogen	No. of farms	Av. frq. (%)	Locations
		Crop			
		Vicia ervilia			
on-st. On-farm	Wilt/root rot	*F. exysporum*	1	49	Dara'a, Izra'a Hama, Afes
		Phoma?	2	28	Ghasael
		R. bataticola	1	46	
		Vicia sativa			
On-st. On-farm	Wilt/root rot	*F. oxysporum*	3	59	Ghasael, Izra'a
		R. solani	1	25	
	Stem blight	*S. sclerotiorum*	2	72	Hemo
		Ascochyta sp.	2	70	Kamishly
	Downy mildew	-	1	-	Kamishly
	Ascochyta blight	*A. pisi*	2	57	Kamishly/Latakia
		Vicia narbonensis			
On-st.	Stem blight	*S. sclerotiorum*	1	42	Izra'a
		F. oxysporum	1	42	
	Ascochyta blight	*Ascochyta* sp.	1	33	
		Vicia amphicarpa			
On-st.	Wilt/root rot	*F. oxysporum*	1	70	Hama
		R. solani	1	53	
		R. bataticola	1	17	
		Lathyrus sativa			
On-st.	Wilt/root rot	*F. oxysporum*	1	64	Dara'a
		R. bataticola	1	30	
	Root rot/stem	*R. oxysporum*	1	30	Hama
	Blight	Phoma	1	40	
		Ascochyta sp.	1	20	
	Ascochyta blight	*Ascochyta* sp.		100	Breda
		Lathyrus ochrus			
On-st.	Root rot/wilt	*F. oxysporum*	1	85	Hama

Table 4.4.6. Total monthly rainfall (mm) during the 1992/93 season at different locations where on-farm/on-station trials on forage legumes were conducted.

Location	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	Long-term Average
Jelline	0.0	0.0	55.0	140.4	39.3	54.0	40.0	1.9	25.0	0.0	356.0	450
Izra'a	0.0	0.0	43.9	122.0	37.0	22.4	22.4	9.6	0.0	0.0	266.0	284
Homs	0.0	0.0	69.2	99.4	48.0	46.9	56.1	14.0	71.8	1.0	406.0	413
Hama	5.3	0.0	90.9	35.1	72.6	50.9	45.2	8.2	67.1	0.3	375.6	327
Ghab	4.5	0.0	170.0	75.6	88.2	158.2	99.0	13.4	86.2	5.0	698.9	673
Idleb	16.4	0.0	56.4	48.8	70.4	32.6	41.8	2.8	24.4	9.0	304.0	520
Azaz	0.0	0.0	63.7	53.3	73.1	71.0	51.5	37.3	56.3	7.0	413.0	-
Aleppo												
Tel Hadya	0.0	0.0	49.0	49.7	57.9	39.0	41.4	1.6	51.2	0.0	288.8	352
Hassake	0.0	0.0	57.5	14.5	48.2	40.3	16.3	69.7	161.4	3.2	421.0	285
Hemo	0.0	0.0	112.2	30.5	42.1	101.2	43.8	94.0	150.6	2.5	576.0	403
Der Ezur	0.0	0.0	8.9	15.8	24.8	8.8	7.0	19.1	36.5	0.0	120.7	155
Tartus	0.0	1.0	79.5	216.0	104.5	190.0	108.0	16.0	61.5	0.0	777.0	855
Jableh	-	-	-	-	-	-	-	-	-	-	-	891

4.5. Forage Entomology

4.5.1. Effect of *Sitona crinitus* on *Vicia* Yield

The experiment on *Sitona* control in *Vicia dasycarpa* was conducted at Jinderess and Alkamiye, using the same Promet treatment as in lentil (Section 3.4.1). The nodule damage started slightly later and was lower at Alkamiye than at Jinderess. The mean nodule damage was 69 % at Alkamiye and 79 % at Jinderess and was significantly reduced by Promet treatment (Figure 4.5.1). At Alkamiye and Jinderess both seed and biological yields were significantly increased by Promet treatment.

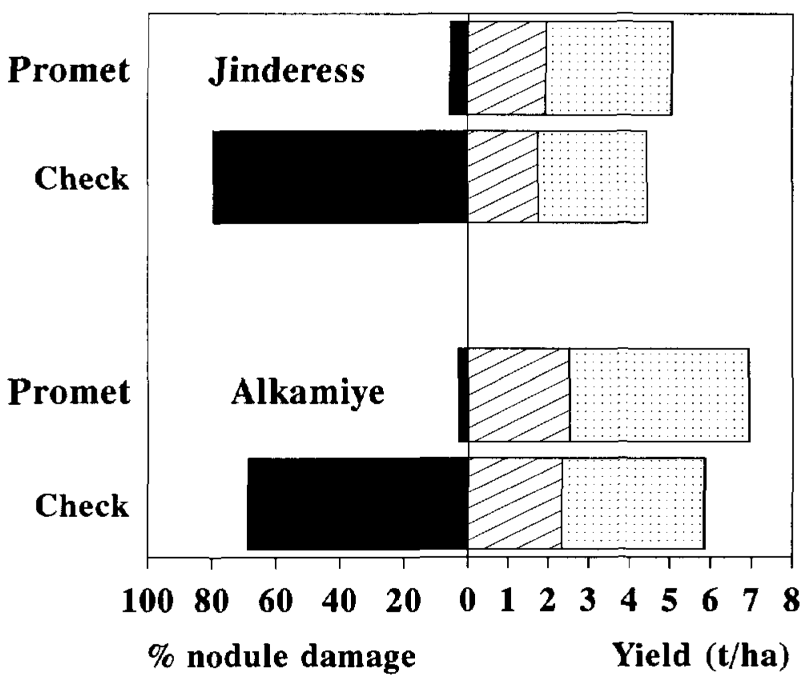


Figure 4.5.1. Effect of Promet seed treatment on *Vicia dasycarpa* seed and biological yield and nodule damage by *Sitona crinitus* at 2 locations, Syria, 1992/93.

Plant samples were taken once in early May and at harvest and analysed for nitrogen content. No significant differences due to treatments were found in spite of the nodule damage (Table 4.5.1). The nitrogen yields were higher with Promet treatment, but not significantly and only due to crop yield increases.

The experiment confirmed that *Sitona* does infest *Vicia* and control results in significant yield increases. However, Promet treatment may not be economical in subsistence farming. In commercial seed production fields it might be economical.

Table 4.5.1. Effect of Promet (12 ml/kg seed, P 12) treatment on percent shoot nitrogen content, seed, total and nitrogen yield and nodule damage by *Sitona* in *Vicia dasycarpa* at 2 locations in Syria, 1992/93.

Location	Treatment	% N		*Vicia* yield (kg/ha)		N yield (kg/ha)	%nodule damage 26 April
		4 May	22 May	Seed	Total		
Jinderess	Check	2.83	2.26	1750	4440	99.8	79.6
	P 12	2.65	2.33	1931	5049	117.8	5.5
	S.E.M.	0.06	0.12	29.7	101.0	4.8	0.8
	LSD 5%	NS	NS	133.8	454.4	NS	3.4
Alkamiye	Check	3.14	2.06	2334	5851	120.3	68.9
	P 12	3.01	2.01	2517	6941	139.4	3.0
	S.E.M.	0.08	0.12	38.3	196.4	7.5	4.2
	LSD 5%	NS	NS	172.5	883.9	NS	19.5

4.5.2. Aphid Control in *Vicia*

This experiment was designed to compare the effectiveness of Gaucho seed treatment (Gaucho 35, 2.85 ml/kg seed) and Pirimor spray (50%, 0.5 g/l) for aphid control, but due to low infestation no data could be collected. Samples were taken to also record the nodule damage. Gaucho seed treatment did not have any effect as the nodule damage was 77% and 79%, respectively with and without treatment.

4.5.3. Effect of Neurotoxin Content in *Lathyrus* on Insect Infestation

Three lines of *Lathyrus sativus* with low (IFLV 347/587), medium (IFLV 522/535) and high (IFLV 482/530) neurotoxin content and several lines of *Vicia sativa, Vicia narbonensis, Vicia benghalensis* and species of *Vicia* *dasycarpa* were evaluated for insect infestation by counting number of insects per white board (25x50 cm). In general insect infestation was low in all the species, aphids and thrips were the most common insects. Only thrips were recorded in higher numbers, especially in the *Lathyrus* lines. The neurotoxin content had no significant effect on the thrips infestation, as on average 179 thrips per board were recorded in the low, 125 in the medium and 138 in the high neurotoxin lines. In *Vicia* species number of thrips was lower, between 10 and 40 per board, than in *Lathyrus*. **S. Weigand and A.A. El. Moneim**

4.5.4. Insect Control in Sainfoin (*Onobrychis viciafolia*)

In a collaborative project with the University of Ankara potential ways to control damage caused by *Bembicia scopigera* to sainfoin are being examined. Sainfoin is a native, widely grown, semi-perennial forage legume well adapted to highland farming systems in central and eastern Anatolia. Over the past years the area under seed production by the Turkish State Farm Organization as well as on farmers fields has decreased rapidly due to the increasing attack by *B. scopigera*. The larvae tunnel into the root crown killing the plants frequently in the first years.

In 1992/1993, work was initiated to screen existing cultivated and wild germplasm for potential resistance. From previous selections 1324 seedlings were transplanted from greenhouse to field plots and evaluated for several growth characteristics. At different locations plants were selected from 3,4,5, and 6 year old plots and seed will be planted next year. At one location different sowing densities, 40 and 80 kg/ha, and treatment with Thiodan are studied. A further national collection of germplasm was made, which will be continued next year with emphasis on wild species. **S. Elci (University of Ankara) and S. Weigand.**

4.6. Biotechnology

4.6.1. DNA Fingerprinting in *Vicia sativa*

The DNA from 5 *Vicia sativa* ssp. *sativa* accessions and 1 *Vicia sativa* ssp. *amphicarpa* accession was analyzed with the probe/enzyme combination $(GATA)_4$/DraI. The obtained patterns (Figure 4.6.1) demonstrate the presence of *V. sativa* ssp. *amphicarpa* specific bands. Many polymorphisms could be detected between the different accessions of *V. sativa* ssp. *sativa* but no polymorphism was revealed between the 2 plants from the same accessions. **W. Choumane and F. Weigand.**

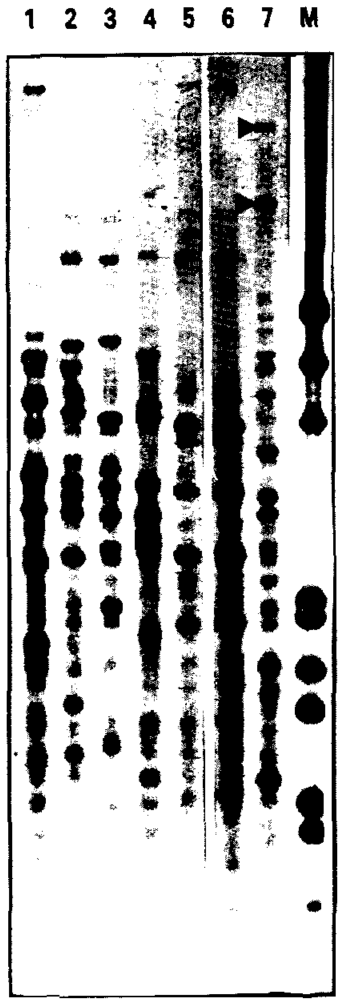


Figure 4.6.1. DNA fingerprinting of *Vicia sativa* ssp. *sativa* and *Vicia sativa* ssp. *amphicarpa*. The lanes 1-6 show different *V. sativa* ssp. *sativa* accessions, namely S 2670, S 3011, S 3029, S 3091, S 3325.1 and S 2\3325.2; 7 shows the *V. sativa* ssp. *amphicarpa* accession A 2660; M shows the molecular weight marker, lambda EcoRI/HindIII digest. The black triangles show *V. sativa* ssp. *amphicarpa* specific bands.

5. DRY PEA IMPROVEMENT

The dry pea research at ICARDA was initiated in 1986/87. As extensive varietal improvement work is being done on dry pea crop at a number of institutions in the developing and developed countries we capitalise on this research, instead of running our own breeding program, to identify dry pea cultivars adapted to the farming systems of WANA. Our work is concentrated in the following areas:

i. Collecting enhanced germplasm/cultivars from the institutes working on dry pea in developed and developing countries and testing them at ICARDA sites to identify superior lines for evaluation by the national programs in WANA.
ii. Developing suitable production technology and its transfer to the national programs for testing and adaptation.

5.1. Germplasm Collection and Evaluation

The new accessions obtained from various institutions were evaluated at Tel Hadya in two trials, Pea Genetic Evaluation Trial-1 with 24 entries in a randomized complete block design and Pea Genetic Evaluation Trial-2 with 49 entries in a 7x7 lattice design. The data were recorded on various phenological and morphological characters.

5.1.1. Pea Genetic Evaluation Trial 1

Time taken to flower ranged from 113 days for Acc. No. 494 to 129 days for Acc No. 507; time taken to mature ranged from 153 days for Acc Nos. -323, -326, -328 to 168 days for Acc No. 507; and the harvest index ranged from 33% for Acc No. 507 to 61% for Acc No. 223 (Table 5.1.1). Seed yield varied from 400 to 3408 kg/ha and the five highest seed yielding entries included Acc Nos. -501, -503, -225, -495 and -497 with seed yields of 3562, 3408, 3122, 3037 and 2922 kg/ha, respectively.

5.1.2. Pea Genetic Evaluation Trial 2

Time to flowering ranged from 92 days for Acc No. 541 to 116 days for Acc No. 550. The Acc Nos. 507 and -550 were the latest to mature taking 150 days. The harvest index in these introductions ranged from 30% to 60%. The Acc No. 225 was the highest yielder and was followed by Acc Nos. -551, -534, -514, and -549 with seed yields of 3180, 3100, 3025, 3013, and 2954 kg/ha respectively. The entries with semi-leafless character were ranked 20, 28, 33, 43 and 48; two entries were with prostrate growth habit and were ranked 48, and 49; and the entry with semi-prostrate habit ranked 47. All the lines with high biomass (>5000 kg/ha) were the top seed yielders and had semi-erect growth habit. Some of the high yielding entries along with their seed yield, time to flower, time to mature, and harvest index are given in Table 5.1.2.

Table 5.1.1. Adjusted seed yield (YLD=kg/ha) and rank (R), biological yield (BYLD=kg/ha), time to flower (DFLR), time to mature (DMAT) and harvest index (HI) of some of high yielding entries in Pea Genetic Evaluation Trial 1, at Tel Hadya during 1992/93.

Acc. No.	Origin	YLD	R	BYLD	DFLR	DMAT	HI
321	France	2072	13	3716	119	158	56
323	Denmark	565	23	1104	116	153	51
324	Denmark	862	21	1791	116	158	48
326	Denmark	828	22	1727	115	153	48
327	Denmark	400	24	832	115	155	48
328	Denmark	1296	20	2511	114	153	52
492	Australia	2591	9	5139	118	157	50
493	Australia	2506	11	5090	120	158	49
494	Australia	2683	8	5215	113	159	51
495	Australia	3037	4	5630	116	158	54
496	Australia	1821	17	3726	121	158	49
497	Australia	2922	5	5276	115	158	55
498	Australia	2061	15	3993	115	158	52
499	Australia	2300	12	4427	117	158	52
500	Australia	1857	16	4491	118	157	41
501	Australia	3562	1	6680	114	158	53
502	Australia	2797	7	4813	114	157	58
503	Australia	3408	2	6570	119	157	52
504	Ethiopia	2842	6	5476	122	159	52
505	Sudan	2546	10	4580	112	156	56
506	Sweeden	1507	19	2831	116	154	53
507	Sweeden	1610	18	4929	129	168	33
223	Syria	2072	14	3419	115	157	61
225 (Check)	Syria	3122	3	6292	120	157	50
Location Mean		2136		4177	117	157	
S.E. of Mean		343.48		619.38	0.65	1.06	
L.S.D. at 5%		977.72		1763.09	1.85	3.03	
C.V. %		27.85		25.68	0.96	1.17	
Significance		*		*	*	*	

Table 5.1.2. Adjusted seed yield (Yield=kg/ha) and rank (R), biological yield (BYLD=kg/ha), time taken to flower (DFLR), time taken to mature (DMAT), and harvest index (HI) of some of the high yielding entries in Pea Genetic Evaluation Trial 2 at Tel Hadya during 1992/93.

Acc. No.	Origin	YLD	R	BYLD	DFLR	DMAT	HI
508	Australia	2542	16	4674	94	140	54
514	Australia	3013	4	5579	94	138	54
516	Australia	2447	20	4507	93	135	54
518	Australia	2865	10	4992	92	137	57
519	Australia	2944	7	5284	96	140	56
520	Australia	2951	6	4908	96	140	60
526	Australia	2862	11	5118	95	138	56
527	Australia	2883	9	5447	95	141	53
529	Australia	2479	18	4138	90	135	60
533	Australia	2839	12	4824	92	140	59
534	Australia	3025	3	5465	94	140	55
538	Australia	2513	17	4511	99	140	58
539	Australia	2787	13	4974	99	141	56
542	Australia	2674	15	4573	93	137	58
545	Australia	2468	19	4484	94	140	55
546	Australia	2918	8	5253	94	138	56
548	Australia	2715	14	4694	93	140	58
549	Australia	2954	5	5072	94	140	58
551	Croatia	3100	2	5536	93	140	56
223	Syria	1514	46	3845	95	138	39
224	U.K.	1383	47	3028	95	138	46
225	Syria	3180	1	5823	99	141	55
Location Mean		2302		4207	95	139	
S.E. of Mean		336.78		595.95	1.50	1.35	
LSD at 5%		965.84		1709.10	4.27	3.83	
C.V. %		20.69		20.04	2.23	1.37	
Significance		*		*	*	*	

5.1.3. Evaluation for Cold Tolerance

Thirty six accessions of pea for reconfirmation and 90 new accessions were evaluated for cold tolerance. The material was sown in the autumn on Oct 1, 1992 with a post-sowing irrigation to ensure adequate moisture supply for germination. Visual cold tolerance ratings on a 1-9 scale, where 1 = free from damage, 9 = killed, were assigned after the susceptible check was killed. During the growing season, below zero temperatures were observed for 48 days and minimum temperature during the season was -8.7°C on 17 Jan 1993. The higher rating of the two replications was considered as the actual cold tolerance rating of the lines. The susceptible check got a rating of 9 all through. All the thirty six lines (Acc. Nos. 77, -80, -85, -86, -87, -92, -111, -158, -184, -186, -188, -190, -195, -197, -198, -199, -200, -203, -205, -206, -207, -210, -211, -214, -243, -244, -338, -342, -343, -344, -346, -348, -351, -352, -354 and -355) rated as cold tolerant during previous seasons maintained their tolerance reaction during 1992/93. Among the 90 new lines 3,8,3,7,22,11,28 and 8 accessions took the rating of 2,3,4,5,6,7,8 and 9 respectively. The fourteen new lines with a rating ≤ 4 included Acc. Nos. -12, -17, -201, -202, -337, -339, -340, -341, -353, -465, -473, -462, -467 and -470.

5.2. Yield Trials

5.2.1. Preliminary Yield Trial

Sixty four entries selected from the genetic evaluation trials and from the preliminary yield trial (PYT) of 1991/92 were evaluated for their performance in a 8x8 lattice design during the 1992/93 season at three locations, Tel Hadya, Jinderess and Terbol. Adjusted seed yield for the entries varied from 950 to 2937 kg/ha at Tel Hadya; 492 to 2700 kg/ha at Jinderess; and 1364 to 3965 kg/ha at Terbol. Location means at Tel Hadya, Jinderess, and Terbol were 1889, 1424, and 2882 kg/ha, respectively. Based on the mean yield over locations the five best lines included Acc Nos. 452, -225, -447, -448, and -164, with seed yields of 2974, 2892, 2865, 2676, and 2537 kg/ha respectively (Table 5.2.1). None of the top yielding lines was semi-leafless.

5.2.2. Pea International Adaptation Trial (PIAT)

Twenty three entries selected from PYT and PIAT conducted during the previous season were tested in this trial at Tel Hadya and Terbol during 1992/93. All the test entries yielded better than the local check. The five highest yielding entries at Tel Hadya included Acc. Nos. 8 (Syrian Local Aleppo), -21 (Local Selection 1690), -149 (MG 102029), -173 (MG 102703), and -172 (MG 102702); and at Terbol included Acc Nos. 21 (Local Selection 1690), -216 (Collegian), -77 (K-129), -182 (G 22763-2C), and -108 (MG 100446). On the basis of mean seed yield over locations, Local Selection 1990 ranked first and was followed by Syrian Local Aleppo, MG102029, Collegian, and MG 102703 with seed yields of 3179, 2938, 2737, 2688, and 2653 kg/ha respectively (Table 5.2.2). The entry PS 510571 was the earliest to flower and mature. **R.S. Malhotra and M.C. Saxena.**

Table 5.2.1. Adjusted seed yield (YLD=kg/ha) and rank (R), and days to flower (DFLR) of some entries in Preliminary Yield Trial at Tel Hadya, and Terbol during 1992/93.

Acc. No.	Origin	Tel Hadya YLD	Tel Hadya R	Jinderess YLD	Jinderess R	Terbol YLD	Terbol R	Mean over locations YLD	Mean over locations R	Mean over locations DFLR
164	U.K.	2270	9	1941	7	3400	10	2537	5	133
223	Syria	1531	53	1614	22	1364	64	1503	58	127
224	U.K.	1236	62	1168	49	1794	63	1400	62	126
225	Syria	2937	1	2028	4	3711	5	2892	2	132
284	U.S.A.	2061	25	1186	47	3746	4	2331	11	113
296	China	2170	16	1299	42	3377	12	2282	15	133
372	India	2230	10	1818	10	3243	15	2430	7	125
375	India	2127	18	1737	15	2958	29	2274	16	123
380	India	1829	36	1876	9	3285	13	2330	12	122
388	New Zealand	2212	12	1654	19	3256	14	2374	10	132
390	New Zealand	1902	34	1356	36	3526	8	2261	17	130
402	New Zealand	1959	33	1744	14	3213	17	2305	14	125
445	Ethiopia	1982	31	1343	39	3389	11	2238	19	117
446	Ethiopia	2372	5	1710	16	2892	32	2325	13	129
447	Ethiopia	2453	4	2177	2	3965	1	2865	3	130
448	Ethiopia	2371	6	1900	8	3758	3	2676	4	132
452	China	2535	3	2700	1	3688	6	2974	1	133
479	USSR	2028	29	1628	21	3560	7	2405	9	123
483	USSR	2292	8	1748	13	3236	16	2426	8	122
485	USSR	2207	13	2011	6	2474	49	2231	20	131
486	USSR	2055	26	1471	27	3204	18	2243	18	124
487	USSR	2034	28	1647	20	3914	2	2532	6	127
490	USSR	1691	46	1661	18	2758	39	2037	34	138
Location Mean		1889		1424		2832				
S.E. of Mean		201.03		195.30		235.92				
L.S.D. at 5%		571.12		554.86		670.24				
C.V.%		15.05		19.39		11.78				

Table 5.2.2. Mean seed yield (YLD=kg/ha) and rank (R), days to flowering (DFLR), and days to maturity (DMAT), plant height (PLHT), and harvest index (HI) of entries at Terbol, Jinderess and Tel Hadya in PIAT-93.

Entry Name	Acc. No.	Origin	Tel Hadya YLD	Tel Hadya R	Terbol YLD	Terbol R	Mean over locations YLD	Mean over locations R	Mean over locations DFLR	Mean over locations DMAT
Syrian Local Aleppo	8	Syria	2924	1	2952	6	2938	2	139	177
Local Sel 1690	21	Syria	2850	2	3508	1	3179	1	139	177
K - 129	77	Greece	2147	10	3143	3	2645	7	138	178
MG 100446	108	Greece	1921	18	2952	5	2437	11	129	176
MG 100729	119	Greece	1776	21	2468	15	2122	19	128	175
MG 101197	125	Egypt	2143	11	2421	17	2282	14	135	180
MG 101831	141	Ethiopia	2172	8	2444	16	2308	13	136	178
MG 102029	149	Netherlands	2585	3	2889	8	2737	3	132	175
MG 102256	152	Germany	1861	20	2675	14	2268	15	130	175
MG 102369	154	Poland	2214	7	2294	19	2254	16	128	176
MG 102469	160	U.K.	2027	16	2810	11	2418	12	134	179
MG 102702	172	India	2426	5	2841	9	2636	8	131	176
MG 102703	173	India	2472	4	2833	10	2653	5	134	178
MG 104325	178	Afghanistan	2380	6	2921	7	2650	6	130	173
G 22763-2C	182	Ethiopia	2090	15	3111	4	2601	9	136	177
Collegian	216	Australia	2129	13	3246	2	2688	4	129	175
Derrimut	217	Australia	1946	17	2413	18	2179	17	127	173
Early Dun	222	Australia	2112	14	2810	12	2461	10	134	175
LE 25	252	India	1345	23	2730	13	2038	20	129	173
PS 210713	267	U.S.A.	2165	9	1754	23	1959	22	129	171
PS 210688	278	U.S.A.	2133	12	2214	20	2174	18	124	172
Umatilla	281	U.S.A.	1889	19	2087	22	1988	21	126	173
PS 510571	291	U.S.A.	1720	22	2111	21	1915	23	120	169
Local Check	223	-	1141	24	1238	24	1189	24	136	179
Location Mean			2107		2619					
S.E. of Mean			294.75		263.10					
L.S.D. at .05			839.02		748.92					
C.V. %			24.23		17.40					

6. OROBANCHE CONTROL

Integrated control of *Orobanche crenata* Forsk. was studied during the 1992/93 season. The rainfall in this season amounted to 286.1 mm and therefore was less than the average of the last 13 years (325 mm). In addition the rainfall pattern was irregular. First substantial rain occurred at the end of November and thus, the sowing date scheduled for mid-November had to be postponed for two weeks. There was a dry period with 1.7 mm rain only, lasting over 40 days from mid-March until the end of April. Under these climatic conditions the plant growth and thus *Orobanche* infestation would have been reduced. Since normal development of both the host plants and parasite are basic precondition for proper comparison of the treatments to be tested in these trials, on April 15 the faba bean field was irrigated (45 mm). Temperatures during this period, however, were normal. No severe frost spells occurred during winter.

Field trials for faba bean and lentil were conducted to investigate the effect of a combination of sowing date, genotypes and herbicide on the *Orobanche* infestation. Trials were designed as split-split-plot with sowing date as mainplot, genotype as subplot, and herbicide as sub-subplot (Table 6.1.1).

Table 6.1.1. Summary of experimental factors studied in the integrated control trial during 1992/93 at Tel Hadya.

Crop	Factor	Level	Description
Faba bean	Sowing date	Nov. 30	
		Dec. 30	
	Genotype	Giza 402	*Orobanche* tolerant
		ILB 1814	*Orobanche* susceptible
	Herbicide	Imazethapyr	220g a.i/ha post-emergence
		Imazaquin	220g a.i/ha post-emergence
		Glyphosate	264g a.i/ha post-emergence
		Control	
Lentil	Sowing date	Nov. 23	
		Jan. 5	
	Genotype	ILL 5883	*Orobanche* tolerant
		ILL 8	Adapted to delayed sowing
		ILL 4400	*Orobanche* susceptible
	Herbicide	Imazethapyr	140g a.i/ha pre-emergence
		Imazaquin	17.5g a.i/ha post-emergence
		Imazaquin	25.5g a.i/ha post-emergence

Pre-emergence = application of herbicide 2-3 days after planting.
Post-emergence = application of herbicide at tubercle and bud stage of *Orobanche* development.

Plots were 3m wide and 5m long. The row spacing for faba bean was 45cm, resulting in 20 plants per m^2, and for lentil 25cm, that is 250 plants/m^2.

6.1. Faba Bean

Since the three-factor interaction (sowing date x genotype x herbicide) was not significant only the significant two-factor interactions (sowing date x herbicide and genotype x herbicide) are presented.

6.1.1. Sowing Date and Herbicide Interaction

With the delayed sowing date, both crop seed yield and straw yield were significantly higher in the untreated check plots. Compared with the check plots the Imazethapyr and Imazaquin application at the first sowing date (Nov. 30) increased the faba bean seed yield by 22% and 37%, respectively. The highest crop seed yield was achieved by Imazaquin applied at first sowing date. However, as far as the second sowing date (Dec. 30) is concerned the above-mentioned herbicides did not have any significant positive effect on faba bean seed yield. The effect of Glyphosate application on seed yield at first sowing date was the same as with Imazethapyr, but with delayed sowing a significant reduction of both seed and straw yield was observed (Figure 6.1.1).

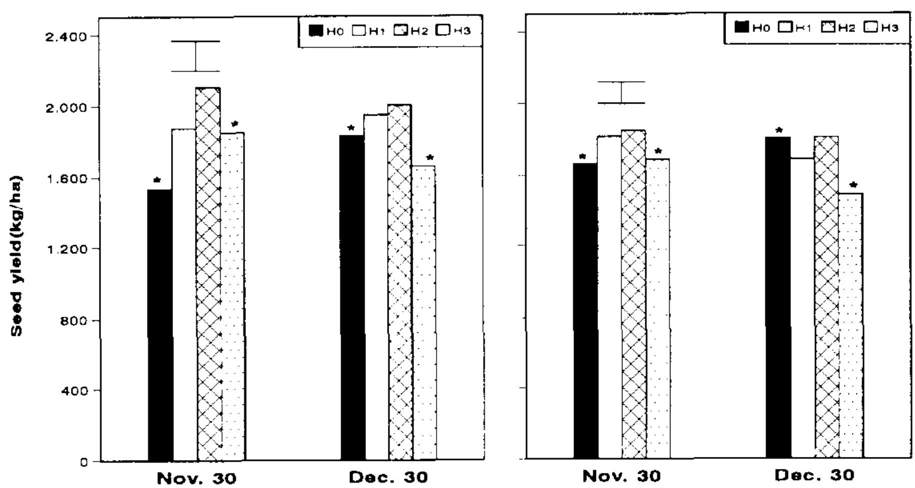


Figure 6.1.1. Integrated *Orobanche* control in faba bean by combination of sowing date (Nov. 30, Dec. 30) and herbicide (H1=Imazethapyr; H2=Imazaquin; H3=Glyphosate; H0-Control). Means are average of 4 replications and 2 genotypes; *=significant at 5% level; I=LSD at 5% level when comparing means of the same sowing date.

This reduction was presumably due to high phytotoxicity of Glyphosate on faba bean (Table 6.1.2).

Table 6.1.2. Phytotoxicity of herbicides on faba bean plants.

Herbicide	Phytotoxicity (1-9)[a]
Imazethapyr (220g a.i/ha)	1.0
Imazaquin (220g a.i/ha)	1.5
Glyphosate (264g a.i/ha)	3.5

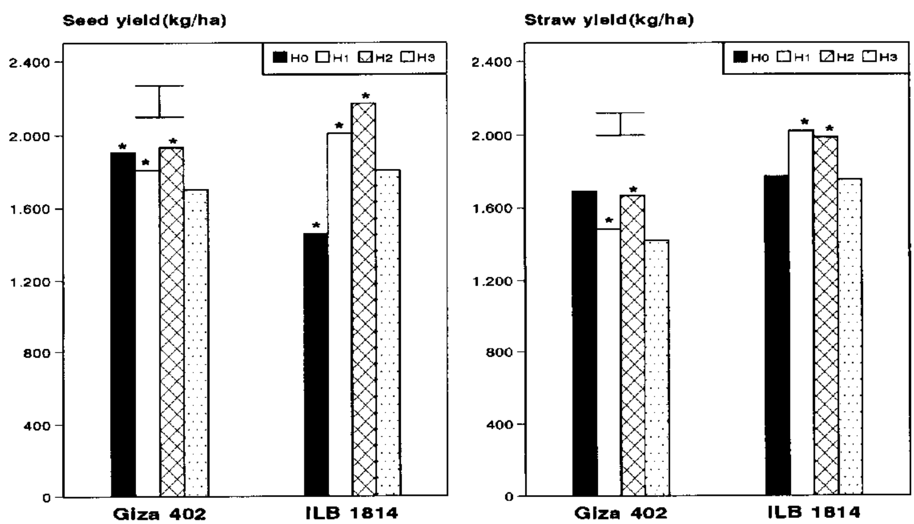


Figure 6.1.2. Integrated *Orobanche* control in faba bean by combination of herbicide (H1=Imazethapyr; H2=Imazaquin; H3=Glyphosate; H0-Control) and genotype (Giza 402=*Orobanche* tolerant; ILB 1814 *Orobanche* susceptible). Means are average of 4 replications and 2 sowing dates *=significant at 5% level; I=LSD at 5% level when comparing means of the same genotype.

6.1.2. Genotype and Herbicide Interaction

In the check plots, the seed yield of Giza 402 (1906 kg/ha) was significantly higher than the ILB 1814 one (1457 kg/ha). It is therefore confirmed that Giza 402 is a *Orobanche* tolerant genotype. Compared with the check plots the herbicide treatments on Giza 402 did neither increase the seed nor the straw yield, on the contrary, Imazethapyr and Glyphosate resulted in a reduction of both seed and straw yield. The results show that the faba bean genotype Giza 402 is highly susceptible to herbicide applications. But using herbicides could lead to an increase in seed and straw yield of the *Orobanche* susceptible genotype ILB 1814. The highest seed yield (2171 kg/ha) was achieved with a combination of ILB 1814 and Imazaquin (Figure 6.1.2).

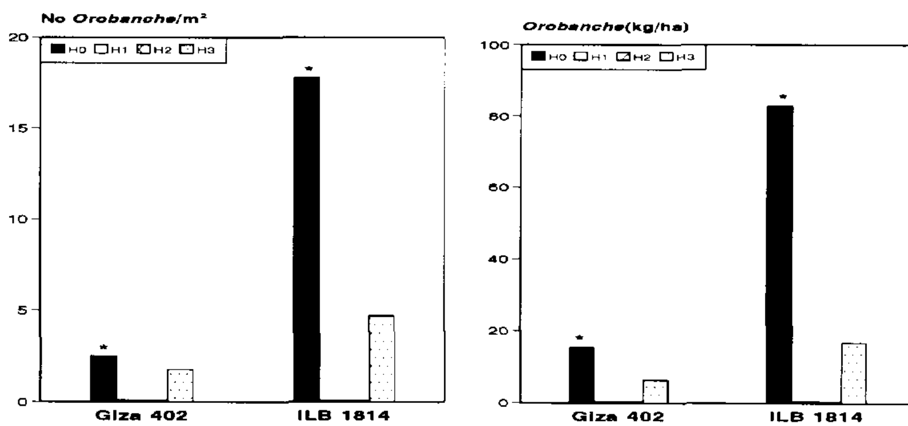


Figure 6.1.3. Effect of herbicides (H1=Imazethapyr; H2=Imazaquin; H3=Glyphosate; H0-Control) on number and dry weight of *Orobanche* on two faba bean genotypes (G402= *Orobanche* tolerant; ILB 1814= *Orobanche* susceptible). Means are average of 4 replications and 2 sowing dates; *=significant at 5% level.

The effect of herbicides on *number and dry weight of Orobanche on* Giza 402 and ILB 1814 is shown in Figure 6.1.3. In the check plots both the number and dry weight of emerged *Orobanche* shoots on ILB 1814 were significantly higher than those on Giza 402. In the treatments with Imazethapyr and Imazaquin no emerged *Orobanche* shoots were observed. Glyphosate application reduced significantly the number as well as the dry weight of *Orobanche* only on ILB 1814 genotype.

6.2. Lentil

Due to a long dry period in the 1992/93 growing season from mid-March until the end of April the lentil seed yield was in general low. The plants suffered from lack of water, especially at flowering stage and no *Orobanche* shoots were observed. In the check plots ILL 5883 and ILL 8 reached significantly higher seed yields than the *Orobanche* susceptible genotype ILL 4400, and the highest seed yield was achieved by ILL 8 (adapted to delayed sowing) planted at the second sowing date (Jan. 5). Delayed sowing did not increase the seed yield of the other two genotypes, significantly.

Table 6.1.3. Effect of combination of sowing date, genotype, and herbicide, on the seed yield (kg/ha) of lentil, Tel Hadya, 1992/93.

Herbicide treatments	Sowing date					
	Nov. 23			Jan. 5		
	ILL 5883	ILL 8	ILL 4400	ILL 5883	ILL 8	ILL 4400
Imazethapyr (40g a.i/ha)	892	905	761	938	601	438
Imazaquin (17.5g a.i/ha)	1018	937	644	867	1013	678
Imazaquin (27.5g a/i/ha)	961	736	533	921	961	591
Control	861	724	522	800	930	636
LSD (P=0.05)				170		

Combination of ILL 5883 and Imazaquin (17.5g a.i/ha) resulted in the highest seed yield (1018 kg/ha) at the first sowing date (Nov. 23). The same seed yield was achieved by an application of this herbicide to ILL 8 planted at the second sowing date. However, the difference between the yield obtained with this treatment and the yield of ILL 8 genotype without herbicide application was not significant. Under this season's climatic conditions no gain was achieved by herbicide application (Table 6.1.3). **A.M. Manschadi and M.C. Saxena.**

7. INTERNATIONAL TESTING PROGRAM

The International Testing Program on lentil, kabuli chickpea, dry pea, lathyrus, and vetches is a vehicle for the dissemination of genetic materials and improved production practices, *in the form of international* nurseries and trials, to 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. 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 agroecological conditions.

In the current year the two international trials on forage legumes, Lathyrus Adaptation Trial and Vetch Adaptation Trial, were further diversified and new trials on various vetch species (*V. sativa, V. ervilia, V. narbonensis, V. villosa* ssp. *dasycarpa*) and lathyrus species (*L. sativus, L. ochrus*, and *L. cicera*) were developed for the 1993/94 season. We supplied 1176 sets of 37 different types of trials and nurseries (Table 7.1.1) to cooperating scientists in 53 countries for the 1993/1994 season. Several cooperators requested large quantities of seed of elite lines, identified by them from the earlier international nurseries/trials for multilocation yield testing and on-farm verification.

The salient features of the 1991/92 international nursery results, received from cooperators until 15 October 1993, are presented here. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

7.1. Lentil

For *Lentil International Yield Trial-Large Seed* (LIYT-L) data from 23 locations were analyzed for seed yield. At Al Ghassim in Saudi Arabia; Sonora in Mexico, Toshevo in Bulgaria; El Kef and Beja in Tunisia; Tiaret in Algeria; Ghazvin in Iran; Izra'a, Gelline, and Breda in Syria; and Christchurch in New Zealand, 10, 7, 3, 1, 11, 1, 5, 1, 5, 13 and 1 of the test entries exceeded the respective local check in seed yield by a significant margin (P=0.05). On the basis of mean across locations the five heaviest yielding lines were FLIP 87-16L, FLIP 87-17L, FLIP 88-6L, FLIP 88-7L, and 78S 26002.

Stability analysis for seed yield of LIYT-L entries based over 19 locations revealed that linear and non-linear portion of entry x environment (GxE) interaction were significant (Table 7.1.2). The

Table 7.1.1. Legume international nurseries supplied for the 1993/94 season.

International Trial/Nursery	No. of sets
Lentil	
Yield Trial, Early (LIYT-E-94)	40
Screening Nursery, Large-Seed (LISN-L-94)	69
Screening Nursery, Small-Seed (LISN-S-94)	47
Screening Nursery, Early (LISN-E-94)	38
F_5 Nursery, Large Seed (LIF$_5$N-L-94)	25
F_5 Nursery, Small Seed (LIF$_5$N-S-94)	11
F_5 Nursery, Early (LIF$_5$N-E-94)	5
F_5 Nursery, Cold Tolerance (LIF$_5$N-CT-94)	16
Cold Tolerance Nursery (LICTN-94)	25
Ascochyta Blight Nursery (LIABN-94)	15
Fusarium Wilt Nursery (LIFWN-94)	35
Rust Nursery (LIRN-94)	15
Chickpea	
Yield Trial Spring (CIYT-Sp-94)	47
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-94)	61
Yield Trial Southerly Latitudes-1 (CIYT-SL1-94)	20
Yield Trial Southerly Latitudes-2 (CIYT-SL2-94)	20
Yield Trial Latin American (CIYT-LA-94)	21
Screening Nursery Winter (CISN-W-94)	50
Screening Nursery Spring (CISN-Sp-94)	33
Screening Nursery, Southerly Latitudes-1 (CISN-SL1-94)	15
Screening Nursery, Southerly Latitudes-2 (CISN-SL2-94)	15
Screening Nursery, Latin American (CISN-LA-94)	15
F_4 Nursery, Mediterranean Region (CIF$_4$N-MR-94)	23
F_4 Nursery, Southerly Latitudes (LIF$_4$N-SL-94)	13
Ascochyta Blight Nursery: Kabuli (CIABN-A-94)	26
Ascochyta Blight Nursery: Kabuli & Desi (CIABN-B-94)	24
Fusarium Wilt Nursery (CIFWN-94)	36
Leaf-Miner Nursery (CILMN-94)	12
Cold Tolerance Nursery (CICTN-94)	31
Forage Legumes	
Lathyrus Adaptation Trial (ILAT)	
- *Lathyrus sativus* (ILAT-LS-94)	55
- *Lathyrus cicera* (ILAT-LC-94)	38
- *Lathyrus ochrus* (ILAT-LO-94)	33
Vetches Adaptation Trial (IVAT)	
- *Vicia sativa* (IVAT-VS-94)	50
- *Vicia narbonensis* (IVAT-VN-94)	41
- *Vicia ervilia* (IVAT-VE-94)	43
- *Vicia villosa* ssp dasycarpa (IVAT-VD-94)	40
Peas	
Adaptation Trial (PIAT-94)	73
TOTAL	1176

perusal of stability parameters revealed that out of 23 entries only one namely FLIP 87-16L with above average mean yield, regression coefficient (b) greater than 1, and non-significant deviations from regression, exhibited specific adaptation to the high yielding environments.

Table 7.1.2. ANOVA for stability for seed yield for the entries in LIYT-L, LIYT-S, and LIYT-E conducted during 1991/92.

Source of variation	LIYT-L		LIYT-S		LIYT-E	
	df	MS(x10)^3	df	MS(x10)^3	df	MS(x10)^3
Entry	22	334.528**	22	250.781**	22	217.737ns
Entry x Location (Linear)	22	100.951**	22	259.582**	22	162.837ns
Pooled deviation	391	43.272**	276	73.015**	69	133.686**
Pooled error	836	15.817	616	35.033	220	36.134

* Significance at $P \leq 0.05$, ** Significance at $P \leq 0.01$.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) from 19 locations revealed that at 9 locations namely, El Kef in Tunisia; Jema'a Shain in Morocco; Beni-Slimane and Tiaret in Algeria; Gelline, Heimo, Breda and Tel Hadya in Syria; and Christchurch in New Zealand, 4, 15, 1, 6, 3, 8, 1, 8, and 1 of the test entries exceeded the local check in seed yield by a significant margin. The five heaviest yielders across locations included FLIP 90-43L, FLIP 87-55L, FLIP 89-25L, FLIP 90-40L, and FLIP 90-36L. Stability analysis for seed yield for the entries in LIYT-S (Table 7.1.2) based over 14 locations revealed that both linear and non-linear components of GxE interaction were important. Five entries, FLIP 90-36L, FLIP 90-41L, FLIP 89-16L, FLIP 90-43L, and FLIP 90-22L having above-average yield performance, regression coefficient (b) equal to 1, and nonsignificant deviations from regression, had general adaptation. A line FLIP 89-15L having above average mean yield, nonsignificant deviations from regression and b>1.0 was adapted to high yielding environments.

The results of Lentil International Yield Trial-Early (LIYT-E) received from 8 locations revealed that at 2 locations, Shendi in Sudan and Jema'a Shain in Morocco, 6 and 4 of the test entries exceeded the respective local check in seed yield by a significant ($P \leq 0.05$) margin. The five heaviest yielders in this trial included FLIP 86-39L, FLIP 89-61L, FLIP 89-53L, L1282 and FLIP 88-34L. Stability analysis for seed yield based over five locations revealed that only deviations from regression (nonlinear) were significant (Table 7.1.2). Seven entries namely, LL, FLIP 89-61L, FLIP 89-60L, FLIP 89-53L, FLIP 85-35L, Pant L406 and FLIP 89-52L having above-average yield, nonsignificant deviations from regression, and regression coefficient equal to 1, exhibited general adaptation.

For Lentil International Screening Nursery - Large (LISN-L), Small (LISN-S), Tall (LISN-T) and Early (LISN-E), the data for seed yield were reported from 19, 12, 26 and 14 locations, respectively. The analyses of data revealed that at 3 locations in LISN-L (El Kef and Beja in Tunisia; and Erzurum-2 in Turkey), 6 locations in LISN-S (Sonora in Mexico, El Kef in Tunisia, Karmanshah in Iran; Gelline, Tel Hadya and Heimo in Syria), 10 locations in LISN-T (Toshevo in Bulgaria; Beja and El Kef in Tunisia; Erzurum-2 in Turkey; Tiaret in Algeria; Karmanshah and Nishabour in Iran; Gelline, Idleb and Izra'a in Syria), and 4 locations in LISN-E (Al Ghassim in Saudi Arabia; Ghazvin in Iran; Gelline in Syria; and Faisalabad in Pakistan) some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). The five heaviest yielding lines across locations in these nurseries are given in Table 7.1.3.

Table 7.1.3. The five heaviest yielding lines across locations in different lentil screening nurseries, 1991/92.

Rank	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 92-11L	FLIP 89-32L	FLIP 87-45L	FLIP 92-42L
2	FLIP 92-12L	FLIP 91-14L	FLIP 89-31L	FLIP 92-41L
3	FLIP 92-14L	FLIP 90-27L	FLIP 86-35L	FLIP 92-52L
4	FLIP 92- 7L	FLIP 89-29L	FLIP 89-30L	FLIP 92-45L
5	FLIP 90-13L	FLIP 91-18L	FLIP 84-59L	74TA441 X PantL 639

The results of Lentil International F_3-Nursery Large (LIF_3N-L), F_3-Nursery Small (LIF_3N-S), F_3-Nursery Early (LIF_3N-E), and F_3-Nursery Cold Tolerance (LIF_3N-CT), were received from 4, 3, 1, and 2 locations, respectively. At all the locations some individual plant selections were made by the cooperators.

The results of Lentil International Cold Tolerance Nursery were received from 5 locations. None of the lines at Haymana in Turkey showed tolerant reaction (rating ≤ 4), five lines namely ILL 52, ILL 323, ILL 759, ILL 780 and L21 were tolerant at Toshevo in Bulgaria (rating $\leq$ 3). Three of these entries namely ILL 52, ILL 759 and L 21 also exhibited comparatively less killing ($\leq$ 15%) at Zanjan and Gazvin in Iran and the two entries ILL 52 and ILL 759 at Marageh in Iran.

The results of Lentil International Ascochyta Blight Nursery were received from Guelma in Algeria and Islamabad in Pakistan. There was no disease infestation at Guelma in Algeria whereas at Islamabad 9 entries namely ILL 358, ILL 2439, Lenka, 78S 26013, 78S 26038, FLIP 84-11L, FLIP 84-43L, FLIP 84-55L, and FLIP 85-33L showed resistant reaction (rating ≤ 3).

The results of Lentil International Fusarium Wilt Nursery were reported from 4 locations but disease infestation was reported only at Sonora in Mexico. Four entries namely ILL 813, ILL 1712, ILL 6461 and local check were rated as tolerant (with rating ≤ 3).

7.2. Chickpea

The Chickpea International Yield Trial-Spring (CIYT-SP) was reported from 25 locations in 10 countries. A number of test entries exceeded the respective local check by a significant margin (P=0.05) at six locations, namely Cordoba in Spain, Al Ghassim in Saudi Arabia, Tel Hadya in Syria, Quinghai in China, Khroub in Algeria and Marageh in Iran. The five best entries across the locations were ILC 482, FLIP 89-127C, FLIP 88-68C, FLIP 88-70C, and FLIP 88-8C. The stability analysis (Table 7.2.1) revealed that only entry x location (non-linear) component was significant. The entries ILC 482, FLIP 89-127C, FLIP 88-68C, FLIP 89-24C and FLIP 89-118C with above average seed yield, regression equal to 1.0, and deviations approaching to zero had average stability.

For Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) data were reported from 35 locations in 13 countries. At 12 locations namely Tomejil and Badajoz in Spain; El-Safsaf in Libya; Jinderess, Heimo, Hama, Gelline and Tel Hadya in Syria; Marchouch in Tunisia; Altinova and Amasya in Turkey; and Terbol in Lebanon some of the entries exceeded the respective local check by a significant margin (P=0.05). The five best entries across locations included FLIP 88-85C, FLIP 89-63C, FLIP 89-29C, FLIP 84-15C and FLIP 85-42C. The ANOVA for stability for seed yield indicated that mean squares due to pooled deviations were significant and those for entry x location (linear) were not significant (Table 7.2.1). The entries FLIP 89-29C, FLIP 89-38C, FLIP 85-93C, FLIP 89-44C, FLIP 88-82C and ILC 482 had regression coefficient equal to 1, deviations approaching to zero and seed yield more than the general mean, and were thus widely adaptable.

The results of Chickpea International Yield Trial Southerly Latitudes-1 (CIYT-SL1) was reported from 10 locations in 8 countries. The location means for seed yield at Rumais in Oman (39 kg/ha) and Hudeiba in Sudan (256 kg/ha) were very low. At three locations namely, Al Kharaj in Saudi Arabia, Tel Hadya in Syria, and Jimah in Oman some of the test entries exceeded the local check by a significant margin. The five best entries across locations included, FLIP 87-60C, FLIP 88-79C,

Table 7.2.1. ANOVA for stability parameters for seed yield for the entries in CIYT-SP, and CIYT-MR conducted during 1991/92.

Source of variation	CIYT-SP		CIYT-MR		CIYT-SL1		CIYT-SL2	
	df	MS(x10)^3	df	MS(x10)^3	df	MS(x10)^3	df	MS(x10)^3
Entry	22	108.699ns	22	299.347**	22	295.331**	22	225.563*
Entry x Location (Linear)	22	60.024ns	22	111.296ns	22	64.710ns	22	105.006ns
Pooled deviation	322	79.215**	275	88.499**	69	88.639**	69	112.254**
Pooled error	704	38.982	1188	50.558	220	33.976	220	25.442

* Significant at P = 0.05, ns = non-significant.

FLIP 89-110C, FLIP 89-86C and FLIP 87-42C. The ANOVA for stability for seed yield revealed the significance of non-linear portion and non-significance of linear portion (Table 7.2.1). A few entries namely, ILC 482, FLIP 89-130C, FLIP 87-45C, FLIP 88-84C and FLIP 87-89C with regression coefficient equal to unity, deviations approaching zero, and seed yield above the overall location mean, were stable across environments.

The results for Chickpea International Yield Trial Southerly Latitudes-2 (CIYT-SL2) were reported from 7 locations in six countries. At five locations, Shendi in Sudan, Rhue Ruer in Thailand , Breda and Tel Hadya in Syria and Bandarawela in Sri Lanka some of the test entries were significantly superior to the local check in seed yield. The five heaviest yielding entries across locations included FLIP 88-56C, FLIP 88-39C, FLIP 88-66C, FLIP 89-82C and FLIP 88-30C. The ANOVA for stability revealed the significance of non-linear portion of variance (Table 7.2.1). The adaptable lines across environments included FLIP 88-56C, FLIP 88-39C, FLIP 89-120C, FLIP 88-48C, FLIP 89-117C, FLIP 88-46C and FLIP 88-61C.

The results for Chickpea International Yield Trial Latin American (CIYT-LA) were reported from 4 locations in 3 countries. The ANOVA for seed yield revealed that at Badajoz and Cordoba in Spain, Sonora in Mexico, and Tel Hadya in Syria, 2, 23, 6, and 17 test entries, respectively, exceeded the local check in seed yield by a significant margin (P=0.05). The five heaviest yielders across locations included ILC 4184, FLIP 88-6C, FLIP 89-131C, ILC 3356, and ILC 99.

The results of Chickpea International Screening Nurseries -Winter (CISN-W), -Spring (CISN-SP), -Southerly Latitudes-1 (CISN-SL1), -Southerly Latitudes-2 (CISN-SL2) and -Latin American (CISN-LA) were reported from 30, 22, 5, 4, and 3 locations, respectively. Some of the test entries exceeded the local check by significant margins at 11, 8, 1, 2, and 0 locations, respectively. The five best entries across locations are given in Table 7.2.2.

Table 7.2.2. The five heaviest yielding lines across locations in different chickpea screening nurseries, 1990/91.

Rank	CISN-W	CISN-SP	CISN-SL1	CISN-SL2	CISN-LA
1	FLIP 90- 71C	FLIP 90-170C	FLIP 90- 64C	FLIP 90-113C	ILC 3367
2	FLIP 90- 97C	FLIP 90- 36C	FLIP 90- 65C	FLIP 90- 81C	ILC 3377
3	FLIP 90- 60C	FLIP 90-173C	FLIP 89- 67C	FLIP 90- 13C	ILC 3808
4	FLIP 90-102C	FLIP 90- 43C	FLIP 90-144C	ILC 2566	ILC 3847
5	FLIP 90- 12C	FLIP 90- 90C	FLIP 90- 63C	FLIP 90-148C	ILC 3930

Chickpea International F_4 Nurseries for Mediterranean (CIF_4N-MR) and for Southerly Latitudes (CIF_4N-SL) were supplied to cooperators at 25 and 12 locations respectively for making plant selections under their own environmental conditions and for developing their own breeding materials. Several national programs made good use of these nurseries by selecting several individual plants and lines.

The Chickpea International Ascochyta Blight Nursery (CIABN) results for kabuli type were reported from 14 locations and for desi+kabuli type from 6 locations. None of the entries (kabuli or desi) was tolerant to ascochyta blight infestation across all locations. Considering the frequency of occurrence of an entry among the tolerant group in kabuli types (with rating $\leq$ 4 on 1-9 scale), two entries, ILC 3279 and FLIP 89-47C, showed tolerance at 10 out of 14 locations and appeared best, and were followed by FLIP 83-48C, FLIP 83-71C, FLIP 84-79C, FLIP 84-81C, FLIP 84-83C, FLIP 84-92C, FLIP 84-93C, FLIP 84-102C, FLIP 84-112C, FLIP 84-182C, FLIP 85-86C, FLIP 85-99C FLIP 85-114C, FLIP 85-118C, FLIP 88-1C, FLIP 88-86C, FLIP 88-48C, FLIP 89-49C, FLIP 89-50C, FLIP 89-6C and FLIP 90-112C which each occurred 6 times. Similarly, among desi lines FLIP 90-112C, FLIP 87-505C, FLIP 87-506C, FLIP 87-507C, ICC 13269, ICC 13416, ICC 13497, ICC 13508, ICC 13555 and ICC 13728 were resistant at 3 out of 4 locations. These entries thus exhibited broad-based resistance to ascochyta blight. The differential reaction of lines at various places further revealed the presence of variability in the pathogen.

The results of Chickpea International Fusarium Wilt Nursery (CIFWN) were received from 8 locations in 8 countries. Out of 30 test entries, 13 entries at Oued Smar in Algeria, 15 entries at New Delhi in India, 26 entries at Sonora in Mexico, 4 entries at Oroumieh in Iran, 3 at Al Ghassim in Saudi Arabia, 30 at Tapioszele in Hungary, 9 at Izmir in Turkey, and 5 at Hudeiba in Sudan took rating of 5 or less and were tolerant. Four lines namely FLIP 85-35C, FLIP 85-30C, FLIP 85-29C and ILC 837 were tolerant at 5 out of 8 locations, and 9 other lines namely ILC 240, ILC 336, ILC 860, ILC 871, FLIP 82-78C, FLIP 84-97C, FLIP 85-20C, Be Sel 81-103, and PTA (82)29 were tolerant at 4 out of 8 locations.

The results of Chickpea International Leaf miner Nursery (CILMN) were reported from three locations, (Menemen in Izmir, Turkey, Terbol in Lebanon and Tel Hadya in Syria). The susceptible check took a score between 5 and 9 (on 1-9 scale, 1=free, 9=highly susceptible). Out of 30 test entries, nine entries, ILC 316, ILC 394, ILC 655, ILC 822, ILC 1048, ILC 1216, ILC 3800, ILC 5351 and ILC 5901, were rated at $\leq$ 5 at all the locations and were better in tolerance to leaf miner than the others.

For Chickpea International Cold Tolerance Nursery (CICTN) the cold tolerance score was reported from six locations. All the test entries at Setif in Algeria, Hymana in Turkey, and Terbol in Lebanon showed moderate to highly susceptible reaction. On the basis of other three locations, Toshevo in Bulgaria, Breda and Tel Hadya in Syria, five entries ILC 3468, ILC 5948, ILC 8262, ILC 482-205, and ILC 482 Mutant were cold tolerant at all the sites.

7.3. Forage Legumes

The lathyrus and vetch adaptation trials were supplied to cooperators for the second time in 1991/92. The International Lathyrus Adaptation Trial included 13 entries from *L. sativus* and 10 entries from *L. cicera*. The results for International Lathyrus Adaptation Trial (ILAT) were received from 12 locations. At six locations (Breda in Syria; Al Ghassim in Saudi Arabia; Dhamar in Yemen; and Beni-Slimane, Setif and Khroub in Algeria) some of the test entries exceeded the local check in seed yield by a significant margin. Five best entries across locations included *L. sativus* accessions (Acc no. 347 LS Local, Acc. No. 3 sel 311, Acc No. 170 sel 439, Acc No. 206 sel 463, and Acc No. 277 sel 476) with seed yields of 1445, 1352, 1338, 1330 and 1328 kg/ha, respectively.

The International Vetch Adaptation Trial (IVAT) included 17 entries from *Vicia sativa* and 6 entries from *Vicia narbonensis*. The results for IVAT were reported from 13 locations. The seed yields of *Vicia narbonensis* accessions were more as compared to *Vicia sativa* accessions. The five highest yielding entries across the locations belonged to *V. narbonensis* and included Acc Nos. 565 sel VN 2380, Acc no. 574 sel -2388, Acc no. 577 sel -2391, Acc no. 568 sel -2383, and Acc no. 573 sel -2387 with seed yields of 1933, 1796, 1753, 1738, and 1643 kg/ha respectively. Among *V. sativa*, the highest yielding entries included Acc Nos. 705 sel 2556, Acc no. 384 sel -2062, and Acc no. 716 with seed yields of 1185, 1010, and 957 kg/ha, respectively.

7.4. Dry Pea

The results of Pea International Adaptation Trial (PIAT) were reported from 12 locations. At eleven locations, namely, Tiaret in Algeria; Toshevo in Bulgaria; Terbol in Lebanon; Oeiras in Portugal; Jinderess and Tel Hadya in Syria; Beja and El Kef in Tunisia; Cambridge in U.K., Hudeiba in Sudan; and Diyarbakir in Turkey, some of the test entries exceeded the local check in seed yield by a significant ($P=0.05$) margin. The five heaviest yielding entries over all locations included, Local selection 1690, Collegian, PS 210713, LE 25, and Derrimut. The ANOVA for seed yield for stability parameters based over nine environments showing CV $\leq$ 30 revealed that six entries namely Collegian, MG 102702, ILP 56, MG 102583, Wirrega, Derrimut, and MG 102623, with above average yield, and deviation approaching zero, were relatively stable across environments.

7.5. Identification of Superior Genotypes by the NARS

The national program scientists participating in the Legume International Testing Program identified and reported the release of 8 varieties of chickpea, 9 of lentil, 3 of faba bean and 3 of forage legumes during 1993. The characteristic features of these lines are given in Table 7.5.1. In addition, several lines were identified for multi-location testing, on-farm trials or pre-release multiplication. Also a large number of lines resistant to various stresses were identified and they are being used for direct or indirect eploitation. **National Program Scientists, R.S. Malhotra, A.A. El Moneim, W. Erskine, M.C. Saxena and K.B. Singh.**

7.6. Precision in Chickpea and Lentil International Nursery Trials

The coefficient of variation as percent of mean (CV %) and standard errors of mean expressed as percentage of trial means (SE) were examined for 22 experiments in Chickpea International Yield Trial - Winter - Mediterranean - 1992 (CIFT-W-MR-92) and for 17 experiments in Lentil International Yield Trial -Small Seed - 1992 (LIYT-S-92). The CV represents the variability in the experimental material while SE indicates the precision of the estimates of genotypic means.

The CV % values in trial CIYT-W-MR-92 were below 15% in 36.35% trials and > 30% (an often quoted value in literature) in 18.19% (Table 7.6.1). Estimates of mean had an error between 5-10% for 45.45% of the trials, while 77.26% of the trials were with an error less than 15% of the mean. This indicates that either replications may be increased in 55% of the trials to achieve SE <10% or devise the means of experimentation and analysis to obtain reduced CV%.

Similarly in LIYT-S-92 CV% was < 15% for 52.94% of the trials and > 30% in 23.53% of the trials. SE was less than 10% in 58.82% of trials and it was <15% in 76.47% trials. In order to achieve precision on estimates with SE <10% there is a need to look into 53% of the trials for controlling experimental error variability further. **R.S. Malhotra and M. Singh.**

Table 7.5.1. Food and forage legume cultivars reported in 1993 as released by the national programs.

Country	Cultivars released	Year of release	Specific features
Chickpea			
China	FLIP 81-71C	1993	High yield
	FLIP 81-40C	1993	High yield
Egypt	ILC 195	1993	Blight resistance, high yield
Lebanon	FLIP 85-5C	1993	Green seed consumption
Libya	ILC 484	1993	Blight resistance, high yield
Sudan	Jebel Mara 1 (ILC 915)	1993	High yield, heat and wilt resistance, for jebel Mara and Northern Sudan
USA	Sanford (Surutato x FLIP 85-58C)	1993	Large seed, blight resistance
	Dwelley (Surutato x FLIP 85-58C)	1993	Large seed, blight resistance
Lentil			
Australia	Digger (FLIP 84-51L)	1993	High yield, red codyledon
	Cobber (FLIP 84-58L)	1993	High yield, red cotyledon
	Matilda (FLIP 84-154L)	1993	High yield, yellow cotyledon
Bangladesh	Sel. from ILL4353xILL35		
	Bari Masur-2 (Falguni)	1993	High yield, rust resistance
Ethiopia	NEL 2705	1993	High yield, rust resistance
	FLIP 84-7L	1993	High yield, rust resistance
Libya	El Safsaf 3 (78S26002)	1993	High yield, standing ability in E. Libya
Sudan	Rubatab (ILL 813)	1993	High yield, for Northern Sudan
Forage Legumes			
Jordan	*V. villosa* ssp *dasycarpa*		
	IFLVD 683	1993	Tolerance to Orobanche, suitable for grazing
	V. sativa IFLVS715	1993	Erect, non-shattering, high L/S Ratio
	L. ochrus IFLL0101/185	1993	Resistant to *Orobanche*, High yield
Faba bean			
Sudan	Shambat 616 (00616)	1993	High yield, tolerance to biotic and abiotic stresses, for Khartoum state and non-traditional production areas
	Basabeer (BB7)	1993	High yield, tolerance to biotic and abiotic stresses, for Northern Sudan and traditional production areas
	Hudeiba 93 (Bulk1/3)	1993	High yield, tolerance to biotic and abiotic stresses, for Northern Sudan and traditional production areas

Table 7.6.1. Precision of experimental CV and SE in Chickpea International Yield Trial - Winter - Mediterranean (CIYT-W-MR-92) and Lentil International Yield Trial - Small Seed (LIYT-S-92).

	CIYT-MR-92				LIYT-S-92			
	SE(%)		CV(%)		SE(%)		CV(%)	
Class	% of trials	No. of trials	% of trials	No. of trials	% of trials	No. of trials	% of trials	No. of trials
0-5	0	0	0.00	0	11.76	2	0.00	0
5-10	45.45	10	4.54	1	47.06	8	11.76	2
10-15	31.81	7	31.82	7	17.65	3	41.18	7
15-20	9.09	2	13.64	3	5.88	1	17.65	3
20-25	9.09	2	22.73	5	5.88	1	5.88	1
25-30	0	0	9.09	2	0	0	0	0
30-35	0	0	4.55	1	0	0	5.88	1
35 >	4.55	1	13.64	3	11.76	2	17.65	3

8. INTERNATIONAL COOPERATION

8.1. Nile Valley Regional Program

The Nile Valley regional Program (NVRP), started in 1988/89, covers research, transfer of technology and human resources development to improve the production of cool season food legumes (faba bean, lentil and chickpea) in Egypt, Sudan and Ethiopia. The program in Ethiopia includes field pea as an additional cool-season food legume. The strategy followed in the NVRP involved a multidisciplinary, multi-institutional, and problem-oriented network making full use of the expertise, human resource and the infra-structure available in the participating countries. Emphasis is on back-up research to develop and transfer sustainable improved technology suitable to farmers in various agro-climatic regions. As a partner, ICARDA collaborates with the three countries in developing the annual workplans, providing germplasm, technical and management backstopping, training, and coordinating activities at the national and regional levels. Funding continued from the United Europe (UE) for Egypt, the Netherlands Government for the Sudan, and the Swedish Agency for Research Cooperation for Developing Countries (SAREC) for Ethiopia.

8.1.1. Faba Bean

In Egypt, improved production packages, demonstrated on large fields in Minia, Beni Suif and Assuit, increased yield by 22 to 36%, with a marginal rate of return (MRR) of 68 to 258%. The advantages of using the rotavator in sowing were demonstrated to farmers in Minia and Fayoum with yield increases of 33 and 18%, respectively. Yield gains of 6.6 to 26.6% were achieved through integrated control of chocolate spot and rust diseases between 1990/91 and 1992/93 (Table 8.1.1). In Upper Egypt and Beheira, control of *Orobanche* by an integrated package of sowing date, resistant/tolerant cultivars, low rate of Glyphosate and foliar fertilizer increased yield by 54 to 88%. The new faba bean cultivars Giza 461 and Giza Blanca were officially released to farmers in the Delta and Nubaria, respectively. Two systematic surveys of legume viruses revealed faba bean necrotic yellows virus (FBNYV) as the most prevalent (49.3%) particularly in Middle Egypt followed by BYMV (24.3%) in Fayoum. It was apparent that FBYNV was the main reason behind the drastic drop (40%) in national faba bean production in 1991/92.

Table 8.1.1. Percentage increase in faba bean yield as a result of integrated control of foliar diseases (chocolate spot and rust) using resistant cultivars and a fungicide* in the North Delta in Egypt between 1990/91-1992/93.

Cultivar	Seed Yield Increase over untreated fields (%)			Mean
	1990/91**	1991/92	1992/93	
Highly resistant				
Giza 461[1]	11.7	6.6	7.5	8.6
Moderately resistant				
Giza Blanca[1]	26.6	7.4	8.7	14.2
Giza 3	22.0	11.7	11.7	15.1

[1] Newly released cultivars with resistance/tolerance to diseases.
* Dethane M 45 sprayed once in February.
** Environmental conditions favourable for diseases.

In Sudan, faba bean yield increases ranging between 27 to 115% were obtained by farmers adopting improved production package with average MRR of 588%. Three new faba bean cultivars were officially released in 1993: Shambat 616, Basabeer and Hudeiba 93 (Table 8.1.2). Screening for resistance to aphids is underway using the introduced line "Pakistani" as a source of resistance.

In Ethiopia, yield increases of 85 to 115% were realized due to the adoption of improved package with an average MRR of 292%. Five improved faba bean selections were submitted in 1993 for Varietal release Committee for high and mid altitude areas. Three lines with *Botrytis* resistance and one with wilt/root rot resistance are in the last stages of release. Yield responses to N and P fertilization in Adet region indicated the need for inoculation with effective *Rhizobium*, starter N and P fertilization.

8.1.2. Chickpea

In Ethiopia, average yield increases of 117% were realized due to the adoption of improved production packages with MRR of 526%. The desi line ICCL-84227 gave 10% more yield than the improved check; kabuli line ICC-12339 produced 8 and 49% more yield than the improved desi and kabuli checks, respectively. At Adet, 3 lines outyielded the local check and improved desi check (Mariye) by 37 to 42% and 16 to 19%, respectively. Advancing planting date at Alem Tena from August to July increased yield by more than 200%. The advantages of using broad-bed furrows (BBF) for growing chickpea in heavy vertisols were confirmed by 18-22% more seed yield compared to the ridge and furrow seedbed.

Table 8.1.2. Food legume cultivars officially released to farmers in Sudan in 1993.

Released cultivars	Characteristics/Recommended region
Faba bean	
Shambat 616 (00616)	- High and stable yield, plant height 92 - 108cm and resistant to lodging. For Khartoum State and non-traditional production areas.
Basabeer (BB7)	- High and stable yield, large seed, seed protein content 24.7%. For Northern Sudan, traditional production areas.
Hudeiba 93 (Bulk 1/3)	- high and stable yield, large seed, seed protein content 25.5%. For Northern Sudan, traditional production areas.
Lentil	
Rubatab-1 (ILL 813)	- High and stable yield, erect growth habit, dark seed coat color, red cotyledon, maturity in 108 days, seed protein content 28.5%. For Northern Sudan.
Chickpea	
Jebel Mara 1 (ILC 915)	- High and stable yield. For Jebel Mara and Northern Sudan.

In Egypt, on-farm demonstrations gave yield increases between 24 to 42% in traditional and 26 to 53% in non-traditional production areas as a result of improved production package. The promising lines Giza 531 and Giza 195 outyielded farmers cultivars by 55 and 32%, respectively. Seeds of these two lines were released to farmers in Upper egypt. Nubaria and the North West Coast. Disease surveys confirmed wilt/root rot diseases as the major disease problem in Egypt. The need of *Rhizobium* inoculation of chickpea was shown in 4 out of 6 locations and yield increase across locations was 40% for *Rhizobium* inoculation with starter-N (36 kg N/ha) (Table 8.1.3).

In Sudan, farmers adopting improved chickpea production package got an increase in their yields by 35%, on average, with 120 to 213% MRR. The ICARDA introduction ILC915 was officially released to farmers in Sudan under the name Jebel Mara-1 (Table 8.1.2). Twenty four chickpea lines were resistant to wilt/root rot diseases, and five of these lines confirmed their resistance after two cycles of screening in two seasons. The seed dresser Tecto-TM increased seed yield by 23 to 33% under farmers conditions because of improving seed emergence by 17 to 64% and 156%, respectively, in naturally and artificially flooded areas.

Table 8.1.3. Seed yield for promising chickpea line 531 with and without *Rhizobium* inoculation versus high nitrogen dose at six locations in Egypt during 1993.

Treatments	Seed Yield (kg/ha)*						
	Fayoum	Assuit	Bostan	Alex.	N.West Coast	Ismailia	Mean
Control	1544d	1858b	1977	660b	1394d	1667	1516d
Inoc. with *Rhizobium*	1867c	1977b	1847	750b	1798c	1929	1695c
120kg N/ha split twice	2072b	2290a	2068	1254a	2081b	1857	1937b
36 kg N/ha+ *Rhizobium*	2371a	2340a	2008	1411a	2285a	2321	2126a
Mean	1964	2121	1975	1019	1889	1843	1819
DMRT at 5%	93	196	N.S.	163	127	N.S.	161
C.V. (%)	3.0	5.8	9.6	10.0	4.2	15.0	8.1

* Values followed by the same letter are not significantly different from each other according to Duncan Multiple Range Test at 5% probability level.

8.1.3. Lentil

In lentil, the most prominent achievement was the self-sufficiency attained in Sudan in the 1992/93 season through increasing acreage and adopting improved production package. Government incentives contributed greatly to this achievement through credit support, guaranteed lentil prices, availability of threshing machines and decorticator. Yield increases ranged between 20 to 246% in demonstration plots as a result of package adoption with MRR of 588 to 1447%. Lines ILL 813 (introduction from ICARDA) was officially released to farmers (Table 8.1.2). In Rubatab, seed and straw yields were increased by 15 and 19%, respectively, on increasing seed rate to 107 kg/ha, and by 22 and 11% in the same order as a result of ridge planting over broadcasting on flat seed bed.

In Ethiopia, farmers adopting improved production packages got an increase in their yields by 63% with average MRR of 312%. The selections NEL 2704 and FLIP 84-78L (from ICARDA) are being released for the low lands and the high lands, respectively. Ten exotic lines, mostly from ICARDA, were selected for adaptation to high altitude areas because of their tolerance to frost. Five early and high yielding lines were selected for drought tolerance at Alem Tena.

In Egypt, 65 lentil demonstrations with improved package gave average yield advantages of 19 to 29% in traditional areas and 33% in non-traditional areas in Nubaria (Table 8.1.4). Precoz is being released to farmers in the Northern areas while Giza 370 is being released all over the country. Surveys indicated that downy mildew, rusts, grey mold, wilt/root rots and *Sclerotinia* rot were the important diseases on lentil in that order. NPK fertilization in the newly reclaimed areas showed a yield increase of 133% indicating the need for effective *Rhizobium* inoculation, P and K fertilization.

8.1.4. Field Pea

In Ethiopia, demonstration of aphid control by Primiphos-methyl 50EC resulted in 18 to 63% increase in yield in two locations with 2807% average MRR. Verification trials on three cultivars and improved management practices resulted in 12 to 60% increase in yield with average 95% MRR. Yield levels as high as 6.87 t/ha were obtained in Sinana. **National Program Scientists and M. Solh.**

Table 8.1.4. Average seed and straw yields obtained by participating (PF) and non-participating (NPF) farmers in lentil demonstrations in various governorates in Egypt, 1992/93.

Governorate	No. of sites	Seed yield (t/ha)			Straw yield (t/ha)		
		PF	NPF	% Over NPF	PF	NPF	% Over NPF
Sharkia*	24	2.95	2.37	25	7.12	6.12	16
Kafr El-Sheikh	10	2.16	1.69	28	5.42	4.34	25
Dakahlia	20	2.05	1.72	19	6.24	4.63	35
Assuit	5	2.61	2.02	29	4.99	4.93	1
Nubaria	6	1.11	0.91	33	—	—	—
Total/Mean	65	2.17	1.74	27	5.94	5.01	19

* Increase over traditional practices in:
- Net Returns: 47%
- Benefit/Cost Ratio: 41%

8.2. North African Regional Program

ICARDA continued its collaborative research on food legumes with the national programs of Algeria, Libya, Morocco and Tunisia during the 1992/93 crop season. Collaborative research activities on feed legumes received greater attention this season. The Regional Legume Scientist of ICARDA, based at Douyet Research Station of INRA-Morocco, Douyet (Near Fes), continued providing technical input into these collaborative activities. The emphasis continued on germplasm enhancement for the major stress factors, agronomic aspects, and transfer of technology.

Enhancing the national research capabilities and strengthening regional networking activities were also emphasized. Some highlights of research results for each country and the regional network activities are presented here. Details are available in the individual country reports prepared by each national program.

8.2.1. Algeria

8.2.1.1. Trial sites and crop season

In general, weather conditions during the 1992/93 crop season were less favorable compared with the last crop season. The rainfall was lower especially in the western part of the country. The crop season was characterized by a rainy autumn (October), a dry and cold winter, a relatively dry spring with considerable number of frost days, and an early *sirocco* (hot winds) in May - June adversely affecting grain filling. As in the past, legume trials were conducted at all the nine research stations of ITGC in Algeria, viz., Saida, Tiaret, Sidi Bel Abbes (SBA), Khemis Meliana (in western region), Oued Smar, Beni Slimane (in central region), Setif, El-Khroub and Guelma (in eastern region). However, major research stations for legume work were: Sidi Bel Abbes, Tiaret, El-Khroub and Guelma.

8.2.1.2. Germplasm enhancement

Major emphasis on germplasm enhancement was on chickpea followed by lentil, dry pea, vetch and grasspea (chickling). Number of nurseries and yield trials conducted in different food legumes during the 1992/93 crop season are presented in Table 8.2.1.

Table 8.2.1. Number of nurseries and yield trials conducted in different food legumes in Algeria, 1992/93 crop season.

Crop	Crossing program	International nurseries/trials	National trials	Total	Percent
Chickpea	1	19	21	41	46
Lentil	-	18	20	38	43
Faba bean	-	3	3	6	7
Dry pea	-	1	3	4	4
Total	1	41	47	89	100

Chickpea: Chickpea selection work was carried out at all the nine research stations of ITGC. The selection criteria were ascochyta blight and wilt resistance and high grain yield. As a result of a crossing program carried out at El-Khroub, 44 F2 progenies were evaluated during the 1992/93 crop season. From International Nurseries (CIF4N-W-93 and CISN-SP-93 of ICARDA), 42 lines were selected at different research stations. Similarly, 47 lines were selected from CIYT-W-MR-93 and CIYT-SP-93. These will be evaluated for yield performance through PYT-94 at different stations during the 1993/94 crop season. Through PYTs conducted at different stations, a total of 105 chickpea lines were evaluated from ICARDA-supplied nurseries/yield trials. Of these, 22 lines were selected at different locations for further yield testing during the 1993/94 season.

In chickpea multilocation trials-I and -II year conducted at different locations, a total of 59 lines were evaluated during the 1992/93 crop season. Of these, five lines were selected for the national yield trial-I year (NYT-I) for the 1993/94 season. Sixteen lines were yield-tested through NYT-I at all the nine stations. Most of them yielded better than the check. Outstanding lines in different zones are presented in Table 8.2.2. These selected lines will be yield-evaluated again through NYT-II during the 1993/94 crop season. Information on chickpea varieties recommended in different areas by the nine research stations is presented in Table 8.2.3.

Table 8.2.2. Chickpea lines selected from the national yield trial-I year grown at different stations in Algeria, 1992/93 crop season.

Region	Lines selected	Yield range (kg/ha)
All the zones over 9 stations	79TH 101-2, FLIP 85-17C, FLIP 84-109C	1630-1660
Coastal zone	FLIP 85-17C, FLIP 84-109C	2184-2298
Interior plains	79TH 101-2, 80TH 177, FLIP 85-94	1550-1590
High plateaux	FLIP 85-94	983-1108

Lentil: Lentil selection work was carried out mainly at Sidi Bel Abbes, Tiaret, Saida, Setif, El-Khroub and Guelma stations. The selection criteria were tallness, erect plant type, rust resistance and high grain yield. The national program very heavily depended upon the lentil material supplied by ICARDA's legume program.

Across stations, 13 lines were selected from International lentil nurseries, and 31 lines from international yield trials. In the PYT-L-93, 97 lines were tested across stations from which 20 lines were selected for further evaluation. In lentil multilocation trials-I and -II year conducted at different stations, a total of 59 lines were evaluated. Of these, seven lentil lines were selected for further evaluation in the lentil national yield trial-I year during the 1993/94 crop season. In the lentil national yield trial-I year, 10 lines were yield-tested. Of these, 2 lines (FLIP 87-48L and -85-7L) in the coastal zone, one line (FLIP 84-145L) in the interior plains, and two lines (FLIP 87-30L and ILL 5671) in the high plateaux outyielded the check. In LNYT-II year, the local varieties performed better than the introduced ones (Table 8.2.4).

Dry pea: Selection for dry pea is done mainly at Sidi Bel Abbes station from PIAT supplied by ICARDA. During the 1992/93 crop season, only the multilocation-II year trial was conducted at Tessala. Six lines, viz. Le 25, SVS 1741, Century, Frisson, Frijaune and Local Sel 1690 significantly outyielded the check (SBA 184). Based on two-year results,

Table 8.2.3. Status of varieties of chickpea, lentil, dry pea and faba bean in different zones of Algeria, 1992/93 crop season.

Station	Chickpea	Lentil	Faba bean	Dry pea
Sidi Bel Abbes	Chetoui 1 (ILC 3279) Chetoui 2 F 84-92C	Syrie 229 ILL 4400 Balkan 755 NEL 468	Sidi Aich	LE 25 SV 51741
Saida	Chetoui 1	NEL 468 Balkan 755	-	-
Tiaret	Chetoui 1 F 84-92C F 84-79C	L.B. Redjas NEL 468 Balkan 755 Metropole	-	-
K. Meliana	Chetoui 1 F 84-92C	Syrie 229 NEL 468	Talo Tanagra	-
Oued Smar	Chetoui 1 F 84-92C F 84-79C F 84-15C	-	8-9/128 88Sel 18009 18035 18054	-
Beni Slimane	Chetoui 1	Syrie 229 Balkan 775	-	-
Setif	F 84-92C Chetoui 1 ILC 72	Setif 618 NEL 45R L.B. Redjas F 87-48L F 88-8L	-	-
Guelma	F 84-79C F 85-17C F 85-54C	NEL 45R Anicia P.B.Dahra	Seville Aquadulce New Mammoth	-
El-Khroub	Chetoui 1			

Table 8.2.4. Performance of lentil lines in the national yield trial-II year in different zones in Algeria, 1992/93 crop season.

Zone	Best lines	Yield range (kg/ha)
All the zones	NEL 45R, L.B. Redjas, Kreta	1050-1150
Coastal	NEL 45R, Kreta, L.B. Redjas	1160-1420
Interior plains	L.B. Redjas, NEL 45R	1000-1220
High plateaux	NEL 45R, Kreta, L.B. Redjas	910-1050

six lines, viz., Century, SVS 1741, Local Sel 1690, Syrian Local Sel, AMAC, and AFH 332 will be included in the dry pea national yield trial-I year for the 1993/94 crop season.

Feed legumes: The activity on feed legumes (vetch and grasspea) is very limited and almost restricted to evaluation of IVAT and ILAT from ICARDA. In IVAT-93, two species of *Vicia, V. sativa* and *V. narbonensis*, were evaluated. Similarly, two species of grasspea (*Lathyrus*), *L. sativus* and *L. cicera*, were evaluated through ILAT-93. The evaluation was done at Guelma, El-Khroub, Khemis Meliana, SBA, Beni Slimane, Tiaret and Saida. However, trials at the last four stations were lost due to drought. Both grain yield and biological yield were considered as selection criteria.

In *V. sativa*, 11 accessions at Guelma, four at El-Khroub, and three at SBA were selected. The dry matter yields ranged from 1.9 -3.3 t/ha at Guelma, 0.47-0.7 t/ha at El-Khroub and 0.78-1.0 t/ha at SBA, whereas the grain yields ranged from 2900-5500 kg/ha at Guelma, 1900-3500 kg/ha at El-Khroub, and 100-300 kg at SBA (low due to drought).

In *V. narbonensis*, six accessions in IVAT-93 showed similar performance for dry matter and grain yield. In grasspea, two accessions of *L. sativus* and three of *L. cicera* were selected at Guelma; 10 accessions of *L. sativus* and three of *L. cicera* at El-Khroub; whereas three accessions of *L. sativus* at SBA. Based on their performance in subhumid zone at Guelma, *V. narbonensis* performed best followed by *L. sativus, L. cicera*, and *V. sativa*. In the dry and cold zone of El-Khroub, *L. sativus* was the best performing species followed by *L. cicera, V. narbonensis*, and *V. sativa*.

8.2.1.3. Pathology

The major emphasis in pathology was on chickpea ascochyta blight and wilt. For ascochyta work, SBA station was used as the site for field screening whereas laboratory screening was done at INA-El Harrach by Prof. Dr. Bouznad and his group. Effective field screening for wilt was done at Guelma combined with laboratory screening at INA-El Harrach. Lines identified for good resistance to Ascochyta blight were FLIP 82-83C, -84-93C, -84-102C, -84-109C, -88-82C, -88-87C, and 79TH 101-2. Lines with good resistance to wilt included Amdoun 1, UC 15, UC 27, FLIP 85-17L, and -85-54C. Also, lines with combined resistance to ascochyta blight and wilt were identified which were FLIP 84-79C, -84-92C, and -85-17C.

8.2.1.4. Agronomy

The 1992/93 crop season experienced an improvement in the agronomy work in food legumes in Algeria. The trials conducted were: date, density and row spacing in chickpea and lentil, and integrated weed management in chickpea and lentil. In SBA, December sowing was found best for chickpea FLIP 85-94C and 80TH 177 with plant density of 90 plants/m2 and 70 plants/m2, respectively. In Saida, 15 January was observed as the best sowing date for lentil NEL 468 with optimum density of 210 plants/m2. However, a plant density of 240 plants/m2 was found best at Guelma with 30 cm row spacing.

8.2.1.5. Technology transfer

Efforts on transfer of the improved technology on winter chickpea and lentil were intensified by all the nine stations of ITGC. However, special efforts on technology transfer were made by SBA, El-Khroub and Guelma stations. In SBA, El-Khroub and Guelma areas, on-farm demonstrations of ILC 3279 (Chetoui 1) were carried out which successfully conveyed the message to farmers on the usefulness of winter planting of chickpea over the traditional spring planting. In Guelma area, FLIP 84-79C was also successfully demonstrated on farmers' fields. Similarly, lentil demonstrations in Pilot Farms served equally useful purpose in Guelma and Beni Slimane areas.

8.2.1.6. Seed production

During the 1992/93 crop season, seed production activity was also intensified. As a result, fairly large quantities of seed of the recommended varieties of chickpea were produced, especially of Chetoui 1. Some other chickpea varieties multiplied included FLIP 84-79C, -84-92C, and -85-17C. In lentil, seed of L.B. Redjas, NEL 45R, NEL 468, and Balkan 755 was multiplied. However, seed production activity needs further intensification to benefit farmers by using these improved varieties. **Algerian National Program Scientists and S.P.S. Beniwal.**

8.2.2. Libya

8.2.2.1. Trial sites and crop season

Different nurseries/trials in chickpea, lentil and dry pea were conducted at four different locations in Libya. These included Tajoura and Zahra in the Western region, Misurata and Khoums in the Central region, El-Safsaf and El-Marj in the Eastern region, and Sebha in the Southern region. The Western region received low rainfall (140 mm) during the 1992/93 crop season which adversely affected crop growth and productivity. Also, this encouraged wilt/root rot diseases in dry pea. In the Eastern region, a total of 482 mm at El-Safsaf and 380 mm at El-Marj was received which was above the average annual rainfall of 350 mm for the region.

8.2.2.2. Germplasm enhancement

Chickpea: Four trials were conducted: chickpea international yield trial-winter-Mediterranean region-1993 (CIYT-W-MR-93), chickpea North Africa regional yield trial-93 (CNARYT-93), chickpea national yield trial-B-1993 (CNYT-B-93), and chickpea adaptation trial-1993 (CAT-93).

In CIYT-W-MR-93 at Sebha, grain yields ranged from 1800 to 3680 kg/ha. The highest yielder was FLIP 82-150C (3680 kg/ha) followed by FLIP 89-78C (3470 kg/ha), FLIP 89-44C (3400 kg/ha) and FLIP 90-4C (3300 kg/ha) compared with 1940 kg/ha of the local check. At El-Safsaf, highly significant yield differences were obtained and all the test entries outyielded the check (ILC 484) which yielded only 480 kg/ha. Line FLIP 88-82C was the highest yielder (1660 kg/ha). Six lines (FLIP 88-82C, -88-85C, -89-78C, -82-150C, -90-96C and -86-6C) were selected for further testing during the next cropping season.

The CNYT-B-93 with 17 entries (10 from CIYT-W-MR-92 and seven from CNARYT-92) was conducted at El-Safsaf and El-Marj. No significant yield differences were obtained at El-Safsaf, and the check (ILC 484) yielded higher than all the test entries. At El-Marj, although three lines (FLIP 89-38C, -88-82C and -85-5C) yielded higher than the check (ILC 484) grain yield levels were lower than that of El-Safsaf, mainly due to poor soils and lack of *Rhizobium* nodulation. In CAT-93 with four varieties conducted at Sebha, no significant yield differences were obtained among different varieties (yield range of 2500 to 3000 kg/ha). However, FLIP 84-93C was the highest yielder (3000 kg/ha) followed by FLIP 84-79C (2840 kg/ha), ILC 484 (2740 kg/ha), and local variety (2500 kg/ha). In CNARYT-93 at El-Marj, yield levels were low and no significant yield differences were observed among different varieties. However, lines FLIP 85-94C, -84-182C, 80TH 177, FLIP 84-92C, -84-164C and -84-79 yielded better than the check.

Lentil: Five trials/nurseries were conducted at El-Marj and El-Safsaf. These were lentil international yield trial-small seed-1993 (LIYT-S-93) and -large seed-1993 (LIYT-L-93), lentil North Africa regional yield trial-1993 (LNARYT-93), lentil national yield trial-B-1993 (LNYT-B-93) and -C-1993 (LNYT-C-93). In LIYT-S-93 at El-Marj, no significant yield differences were observed. However, six lines (FLIP 90-36L, -89-37L,-90-43L, -90-30L, 81S15 and FLIP 90-40L) the grain yield of the check variety (El-Safsaf 3). Of these, FLIP 90-36L was the highest yielder (1960 kg/ha) compared with 1720 kg/ha of El-Safsaf 3. The trial at El-Safsaf was completely damaged by birds and thus no yield data could be recorded. In the LIYT-L-93 at El-Safsaf, significant yield differences among the test lines were obtained. Eleven lines outyielded the check (El-Safsaf 3) that yielded 1620 kg/ha. The best yielder was FLIP 90-13L (2930 kg/ha). The other 10 lines yielding better than the check were FLIP 84-27L, -86-6L, -87-17L, -88-7L, -88-12L, -88-14L, -89-5L, -90-1L, -90-10L, and -91-8L.

In the LNYT-B-93 with 10 varieties conducted at El-Safsaf and El-Marj, no significant yield differences were observed among varieties. However, the best yielder was FLIP 87-48L (2090 kg/ha) followed by the check, El-Safsaf 3 (1980 kg/ha). At El-Marj, significant yield differences among varieties were observed. FLIP 89-37L was the best yielder (1750 kg/ha) whereas the check (El-Safsaf) ranked fourth (1500 kg/ha). Five varieties (FLIP 87-48L, -87-55L, -89-26L, -87-26L and -89-37L) were selected for further testing in the 1993/94 crop season. In LNYT-C-93, which was conducted with five varieties at El-Marj and El-Safsaf, no significant yield differences were observed at either location. However, three of them (78S26013, 78S26052 and FLIP 87-49) outyielded the check (El-Safsaf 3) at both El-Safsaf and El-Marj, and will be further tested in LNYT-D-94 during the 1993/94 crop season.

Dry pea: Three trials were conducted: pea international adaptation trial-1993 (PIAT-93), pea national yield trial -C-1993 (PNYT-C-93), and pea adaptation trial-1993 (PAT-93). PIAT-93 from ICARDA was raised at Zahra and Sebha stations. At Zahra, results showed highly significant yield differences (range of 210 to 2550 kg/ha), and several entries significantly outyielded the local check (570 kg/ha). These were MG 102029 (2550 kg/ha), -101830 (2470 kg/ha), Syrian Local, Aleppo (2420 kg/ha), Collegian (2310 kg/ha), MG 101197 (2300 kg/ha), Local Sel 1690 (1990 kg/ha), G 22763-C(1900 kg/ha), MG 102703 (1850 kg/ha), Early Dun (1770 kg/ha) and MG 102702 (1710 kg/ha). At Sebha, no significant yield differences were observed among entries (yield range of 3610 to 6310 kg/ha). However, the highest yielder was MG 102029 (6310 kg/ha) followed by local check Hirst 40 (6040 kg/ha), and Local Sel. 1690 (5970 kg/ha).

In PAT-93 with five entries conducted at Sebha, local check (Hirst 40) significantly outyielded all the four test varieties viz., Solara, Chantal, Calypso, and Blanda. The PNYT-C-93 at Tajoura was badly affected with wilt/root rots, and so no useful yield data could be obtained.

Vetch: The IVAT-93 from ICARDA was raised at Zahra and Khoums stations. At Zahra, significant yield differences were observed among entries for both seed and biological yield. For seed yield, entry 20 (*V. narbonensis*) was the top yielder (913 kg/ha) followed by entry 23 (855 kg/ha), entry 22 (762 kg/ha) and entry 19 (683 kg/ha) compared with 315 kg/ha of the local check. For biological yield, entry 22 was the top yielder (4093 kg/ha) followed by entry 20, 18, 19, 6, 23, and 17. At Khoums also, significant differences in both seed and biological yield were obtained. For seed yield entry 23 was the top yielder (781 kg/ha) followed by entry 20 (726 kg/ha) and entry 19 (596 kg/ha) compared with 229 kg/ha of the local check. For biological yield, entry 8 (*V. sativa*) was the top yielder (5741 kg/ha). Other better entries were number 1, 12, 9, 3, 7 and 23.

Chickling (Grasspea): The ILAT-93 from ICARDA was raised at Zahra and Khoums stations. No significant differences in seed and biological yields were observed at either location. However, yields were better at Khoums than that of Zahra. At Zahra, entry 18 (*Lathyrus cicera*) was the best seed yielder whereas entry 7 (*L. sativus*) was best at Khoums. For biological yield, entry 18 (*L. cicera*) was the best yielder at Zahra whereas entry 16 (*L. cicera*) at Khoums. Results showed a good possibility of growing chickling in Khoums area.

8.2.2.3. Pathology

Disease surveys in food legumes were conducted in southern, eastern and western regions of Libya. The most prevalent disease of dry pea was Alternaria spot followed by wilt, downy mildew, and rust. Bean leaf roll virus (BLRV) was observed in severe form at Sebha station only. Wilt was observed in dry pea at Meknousa farm in the Southern region. In chickpea, Ascochyta blight was the most important disease in the Eastern region. Stemphyllium spot was observed at Meknousa. In lentil, lentil yellows (BLRV) was observed in a severe farm at Meknousa farm where Botrytis gray mold was also observed in certain entries. BLRV was also observed in lentils at El-Safsaf.

For Ascochyta blight screening, CIABN-A-93 was grown under natural disease conditions at El-Safsaf. Two lines (FLIP 88-83C and -96-56C) were rated 1 (out of a maximum of 9), two (FLIP 85-84C and -84-124C) were rated 2. Most of the remaining lines were rated 3 except line ILC 3279, FLIP 82-132C, -91-14-C, and -91-45 that were rated susceptible (7 and/or above) along with the susceptible check, ILC 263. In the chickpea national ascochyta blight nursery (CNABN-93) with 11 entries tested at El-Safsaf, three lines, viz., FLIP 88-82C, -89-110C and -90-112C were rated 3 (out of a maximum of 9), whereas two (FLIP 84-144C and ILC 195) were rated susceptible (7-9 rating) along with the susceptible check.

8.2.2.4. Agronomy

Two agronomic trails were conducted. These were chickpea weed control verification trial-1993 at El-Marj, and dry pea date of planting x row spacing trial-1993 at Tajoura and Sebha stations. In the chickpea weed control verification trial with three treatments, no significant yield differences were observed among treatments. However, pre-emergence treatment of Igran + Kerb provided the best weed control and highest grain yield over pre-emergence Maloran + Kerb and weedy check.

In the pea trial with four sowing dates (15 Sept, 1 Oct, 15 Oct and 1 Nov) and four row spacings (30, 45, 60 and 75 cm) at Sebha, significant differences between sowing dates were observed with the last date (15 Oct) providing the highest grain yield of (7900 kg/ha) and the first date (1 Sept) providing the lowest grain yield (4400 kg/ha). Also, significant differences were observed among row spacings. An inter-row spacing of 30 cm provided the highest grain yield (7910 kg/ha), whereas the 75 cm row spacing provided the lowest grain yield (5700 kg/ha. **Libyan National Program Scientists and S.P.S. Beniwal.**

8.2.3. Morocco

8.2.3.1. Trial sites and crop season

Different nurseries/trials in chickpea and lentil were raised at Marchouch, Douyet, and Jemaa Shaim stations of INRA-Morocco. However, Morocco, like the last crop season, again faced a severe drought situation that adversely affected crop growth and development. No useful data for yield could be obtained in any of the trials in chickpea and lentil.

8.2.3.2. Germplasm enhancement

Germplasm enhancement with resistance to major stress factors continued to be the major objective of the national food legume program of Morocco. As in the past, the national program very heavily depended on chickpea and lentil material from ICARDA in the form of international nurseries and yield trials.

Chickpea: Chickpea trials/nurseries were raised at Marchouch, Jemaa Shaim, and Douyet, and included CIYT-W-MR-93, CPYT-W-I-93, CPYT-W-II-93, CAYT-W-93, CNARYT-W-93, CNYT-W-93, CIF4N-MR-93, CISN-W-93, CNYT-SP-93, CAYT-SP-93, and seed increases. These yielded no useful data because of erratic plant stands and the drought. However, some selections were made based on visual observations.

Lentil: Lentil trials/nurseries were raised at Marchouch and Jemaa Shaim, and included LIYT-E-93, LIYT-L-93, LIYT-S-93, LPYT-93, LAYT-93, LNYT-93, LNARYT-93, and seed increases. Here again, no useful yield data could be obtained due to the drought situation that prevailed during the crop season. However, some selection based on visual observations was exercised. Lentil lines ILL 6002, -6209, FLIP 86-19L, -86-21L and ILL 5883, which have done well in the past seasons, were also observed to be early to medium in maturity and good yielding. Other early and good lines identified at Jemaa Shaim in LIYT-E-93 were ILL 4605, -6262, -6465, -6467 and -6818. In LIYT-L-93, line ILL 6436 was early and better than others.

8.2.3.3. Pathology

Major emphasis in chickpea pathology continued on Ascochyta blight and wilt. Screening for Ascochyta blight was done by raising CIABN-A-93 under artificial inoculation conditions at Marchouch, and in a greenhouse at Settat. In spite of the drier conditions at Marchouch, a reasonable amount of disease developed in the nursery with the susceptible check showing 7-9 rating (out a maximum of 9). Three entries were identified as resistant (FLIP 88-83C, -90-85C, and -91-45C).

Interesting and useful information on the role of infected crop debris was obtained through a small field experiment at Douyet. Infected debris spread on the soil surface caused 34% seedling infection, whereas infected debris burried at 15-20 cm depth resulted only in 2% seedling infection. No seedling infection was observed in plots where the infected debris was burried at 30 cm depth and also in plots where only healthy debris was used.

All the six ICARDA-reported races of *A. rabiei* were found in Morocco with Race 5 being predominant. Races 3 and 6 were least frequent.

Chickpea wilt was observed to be important in certain areas of northern and central Morocco, and thus deserves attention from researchers. Two races of the wilt pathogeny (*Fusarium oxysporum* f. sp. *ciceri*) were identified, namely, Race 1 and 0. The former was found predominant in Morocco.

Lentil rust screening was continued under field conditions at Jemaa Shaim. However, no disease developed due to extremely dry conditions that prevailed during the crop season.

8.2.3.4. Entomology

Field screening of CILMN-93 at Jemaa Shaim provided useful information. Leaf miner development was good due to drier weather conditions. Line ILC 3800 showed 5 rating (out of a maximum of 9) compared with 9 of the susceptible check, ILC 3397.

8.2.3.5. Agronomy

Good progress was made in chickpea agronomy work at ENA-Meknes. Pre-emergence application of Igran + Kerb combined with one intercultivation in twin-row planting arrangement provided good management of weeds in chickpea. Results of a weed competition study indicated that weeds in chickpea in the Meknes area are critical up to 60 days after emergence.

In faba bean, dodder (*Cuscuta* sp.) was considered an important problem at Douyet especially because of the prevailing drier weather conditions during 1991/92 and 1992/93 crop seasons. Highly effective control of dodder in faba bean was obtained by a pre-emergence soil application (75 g a.i./ha) or a foliar spray (25 a.i./ha) of imazethapyr. **Morocco National Program Scientists and S.P.S. Beniwal.**

8.2.4. Tunisia

8.2.4.1. Trial sites and crop season

Chickpea and lentil trials were conducted at Beja, Kef and Oued Meliz research stations of INRAT. Rainfall was close to the long-term average at Beja and Kef. Fall (Oct-Dec) was wet. Winter (Jan-Feb) had less than normal rainfall with above-than-normal temperatures. Snowfall occurred at Kef in Dec, Jan and March. Good rainfall was experienced in March (50 mm at Beja and 45 mm at Kef), however, April was dry with higher than normal temperatures which adversely affected flowering and pod setting and thus grain yield. Good rainfall occurred in May. Generally, less Ascochyta blight in chickpea was observed in the crop season.

8.2.4.2. Germplasm enhancement

Chickpea: Grain yields at Oued Meliz were better (average of 3550 kg/ha) than at Beja (2864 kg/ha). On an average, FLIP 84-92 (INRAT 88) was the highest yielder (3744 kg/ha) in all the yield trials followed by FLIP 84-79C (3363 kg/ha), Kessab (3150 kg/ha), ILC 3279 (2938 kg/ha), and Amdoun 1 (1742 kg/ha).

Lentil: Average yields at Beja were much higher (2675 kg/ha) than those of Kef (621 kg/ha) where poor and unfavorable weather conditions prevailed during the crop season. In the yield trials, on an average, 78S26002 was the highest yielder (1726 kg/ha at Kef and 2950 kg/ha at Beja) followed by Nsir (1683 kg/ha at Kef and 2712 kg/ha at Beja), Nefza (1440 kg/ha at Kef and 2250 kg/ha at Beja), and local variety (1201 kg/ha at Kef and 1975 kg/ha at Beja).

8.2.4.3. Pathology

Major emphasis in pathology continued on chickpea Ascochyta blight and wilt. In 1992/93 crop season, average Ascochyta ratings at Oued Meliz were lower than those of Beja. Importantly, resistance in chickpea material to Ascochyta blight has improved over the years. The present situation is: R(3.0-3.5 rating), 2.1%; MR (4.0-5.5 rating), 31.5%; MS (6.0-6.5 rating), 25.3%; and S (7.0 rating or more), 41.0%.

For chickpea wilt, a total of 952 lines/accessions were screened in a wilt-sick plot at Beja. Over years, resistance in chickpea material in the program has improved; 7% of the total material screened showed 0-10% wilt, 5% showed 11-50% wilt, whereas 88% showed more than 50% wilt. Of the 500 ICARDA accessions screened during the 1992/93 crop season, only three (ILC 5345, -5363 and -5364) showed less than 10% wilt, and 35 accessions were classified as late-wilters.

8.2.4.4. Soil microbiology

Soil microbiology work on chickpea and lentil was done at INRST (Institut National de Recherche Scientific et Technique) by Dr. Mohd. Elarbi Aouani. In chickpea, three *Rhizobium* strains (CP 39, CP 42 and CP 51 from ICARDA) were tested in soil-cores on soils from three different sites (one in Mateur and two in Cap Bon area) using two varieties (Amdoun 1 and ILC 3279= Chetoui). Nodulation improved in soils from Cap Bon soils indicating the possibility of improving yields in this area with *Rhizobium* inoculation.

In lentil, three *Rhizobium* strains (Le 735, Le 857 and L 933 from ICARDA) were tested in soil-cores on soils from three sites (Alia, S. Ncir and Tebourga) on two varieties (Nefza = ILL 4406 and Ncir = ILL 4400). Nodulation was improved in soils from S. Ncir on both the varieties by strains Le 933 and Le 735, whereas in soils from Tebourga on variety Nefze by only strain Le 735.

8.2.4.5. Technology transfer

On-farm verification trials: In a chickpea on-farm varietal trial, winter sowing provided yield advantages ranging from 295% in Amdoun 1 to 450% in FLIP 84-92C, and 395% in Flip 84-79c. In a chickpea maximization trial, highest yield of 2336 kg/ha was obtained in a winter chickpea variety (FLIP 84-92C), planted in January and at a higher density in Beja area compared with farmers' practice of spring planting of a local variety that yielded only 874 kg/ha, thus providing a 167% increase in chickpea grain yield.

In lentil, an early sowing (mid-Nov) provided a 25% grain yield advantage over the delayed sowing (farmers' practice of end-Dec sowing). In the early sowing, variation in plant density from 100 to 200 plants/m2 was not important, whereas in the delayed sowing grain yields were doubled in the higher density (200 plants/m2).

On-farm demonstrations: Chickpea on-farm demonstrations were conducted in the Cap Bon area in 0.25 ha plots. Results clearly showed that chickpea yields could be doubled by planting winter chickpea varieties FLIP 84-79C and FLIP 84-92C. Also, results of a demonstration on two dates of winter sowing in the same area indicated that winter chickpea could be planted from end-December to end-January without much adverse influence on grain yield by the latter planting. **H. Halila, other National Program Scientists and S.P.S. Beniwal.**

8.2.5. Regional Trials

Five regional trails were conducted during the 1992/93 crop season. These included Chickpea North Africa Regional Yield Trial-1993 (CNARYT-93), Lentil North Africa Regional Yield Trial-1993 (LNARYT-93), Regional Trial on Integrated Management of Chickpea Weeds-1993 (RTIMCW-93), Regional Trial on Integrated Management of Lentil Weeds-1993 (RTIMLW-93), and Regional Trial on Integrated Control of Ascochyta Blight of Chickpea-1993 (RTICAB-93).

8.2.5.1. Chickpea North Africa regional yield trial - 1993

The trial was conducted at Marchouch and Jemaa Shaim in Morocco, Beja and Oued Meliz in Tunisia, El-Marj in Libya, and Tessala in Algeria (Table 8.2.5). The 1992/93 crop season faced a severe drought in Morocco, and a moderate one in Tessala area of Algeria. This makes comparisons across locations and countries difficult.

In Tunisia, variety FLIP 82-150C was the highest yielder at both Beja (3457 kg/ha) and Oued Meliz (4525 kg/ha). Other better varieties were FLIP 84-182C (3809 kg/ha), -85-94C (3639 kg/ha), -84-79C (3605 kg/ha), -84-109C (3502 kg/ha),and -84-92C (3461 kg/ha). In Algeria, FLIP 85-94 was the highest yielder (2621 kg/ha) and was the only variety that outyielded the check. Other better varieties were ILC 195 (2420 kg/ha), FLIP 82-150C (2376 kg/ha), 80TH 177 (2156 kg/ha), and FLIP 84-182C (2135 kg/ha). In Libya, the yields were low. The highest yielder was FLIP 85-94C (970 kg/ha).

Over locations (considering all six locations), the first six entries in descending order were FLIP 85-94C (1932 kg/ha), -82-150C (1927 kg/ha), -84-182C (1901 kg/ha), -84-79C (1766 kg/ha), 80TH 177 (1738 kg/ha), and FLIP 84-92C (1711 kg/ha). The varieties that were top yielders at more than one location were FLIP 85-94C at El-Marj and Tessala, and FLIP 82-150C at Beja and Oued Meliz.

Table 8.2.5. Chickpea North Africa regional yield trial, 1992/93 crop season.

Line	Grain yield (Kg/ha)						Mean	Rank
	Morocco		Tunisia		Libya	Algeria		
	MCH	JSH	BJ	OM	ELM	TSL		
FLIP 84-109C (A)[1]	296	270	3439	3600	680	1878	1694	7
FLIP 85-17C (A)	386	160	2991	3100	700	1488	1471	14
FLIP 81-293C (A)	406	213	2728	3725	790	1911	1629	12
80TH177 (A)	740[3]	193	3213	3275	850	2156	1738	5
FLIP 85-94C (A)	493	230	3153	4125	970	2621	1932	1
FLIP 84-93C (L)	440	130	3156	3782	640	1985	1698	8
FLIP 83-46C (T)[2]	403	193	3156	3440	740	2080	1669	10
FLIP 84-79C (T)	370	170	3135	4075	790	2058	1766	4
FLIP 84-92C (T/M)	386	106	3333	3590	830	2022	1711	6
ILC 3279 (T/A)[2]	283	110	2676	3225	530	1873	1450	15
FLIP 83-48C (M)	443	140	2943	3432	750	1535	1541	13
FLIP 84-182C (M)	580	193	3228	4390	880	2135	1901	3
FLIP 82-150C (M)	250	253	3457	4525	700	2376	1927	2
FLIP 84-145C (M)	370	146	3005	3732	740	2067	1677	9
FLIP 84-164C (M)	366	196	3313	3525	800	1963	1694	7
ILC 195 (M)[2]	311	233	2953	3350	590	2420	1643	11
Mean	408	180	2900	3680	749	2035		
SE±	-	-	817	55	NS	NS		
CV%	38	42	28	15	25			

1. A=Algeria; L=Libya; M=Morocco; and T=Tunisia national programs that contributed variety.
2. These are three check varieties of the countries.
3. The variety that yielded highest at the location.

8.2.5.2. Lentil North Africa regional yield trial - 1993

The trial was conducted at Marchouch and Jemaa Shaim in Morocco, Tiaret in Algeria, Beja and Kef in Tunisia, and El-Marj in Libya (Table 8.2.6). As mentioned earlier, a severe drought occurred in Morocco, and a moderate one in western Algeria. The trial failed at Tiaret because of drought. In Morocco, in spite of the drought it is interesting to note that the lines that have shown good performance in the past also did well this season. These included FLIP 86-19L, Precoz, FLIP 86-21L and -86-19L at Marchouch. In Tunisia, yield levels were very good at Beja and fair at Kef. First four varieties at Beja were FLIP 84-106L, Precoz, FLIP 86-21L and 78S26002 whereas these were ILL 5700, -6809, Precoz, and ILL 6212 at Kef. In Libya, yield levels at El-Marj (Eastern region of Libya) were fair. The first four varieties were ILL 6209, Nylon, 78S26002, and ILL 5700.

Across five locations in the three countries, the best five lines in descending order were Precoz (1120 kg/ha), ILL 6209 (1117 kg/ha), FLIP 84-106L (1077 kg/ha), ILL 5700 (1066 kg/ha), and ILL 6002 (1018 kg/ha).

8.2.5.3. Regional trial on integrated management of chickpea weeds-1993

The trial was conducted at Douyet and ENA-Meknes in Morocco, Setif and Saida in Algeria, and Beja in Tunisia. Good results were obtained only from Beja and Setif locations whereas no yield data could be obtained from Douyet, ENA-Meknes, and Saida.

At Setif station in Algeria, the trail was slightly modified. The two planting plans were in simple rows (30cm apart) and paired-rows (30cm between each row and 70 cm between two paired-rows). The pre-emergence treatment of Igran + Kerb (2.5 l + 0.5 kg/ha) with two hand-weedings at 40 and 70 days after emergence was most effective in weed control, and resulted in highest grain yield of 710 kg/ha. This was followed by the treatment Igran + Kerb with one hand-weeding that yielded 520 kg/ha in twin-row planting (17.5 cm between rows) spaced 70 cm apart. The treatment Igran+Kerb alone yielded 400 kg/ha compared to only 70 kg/ha of the non-weeded control.

In Tunisia in spring-sown chickpea, the treatment with two hand-weedings or herbicides + one hand weeding improved grain yield by 30% in the paired-row planting situation. In close simple planting (20cm row to row), the treatment with two hand-weedings provided 55% yield increase, whereas the herbicide treatment alone provided 35% yield increase.

8.2.5.4. Regional trial on integrated management of lentil weeds-1993

Although the trial was planned to be conducted at one location each in Morocco, Tunisia, Libya, and two locations in Algeria, it was conducted only at Tessala and Tiaret in Algeria. However, no yield data could be obtained even from these locations because of the drought situation that prevailed at these locations.

8.2.5.5. Regional trial on integrated control of Ascochyta blight of chickpea-1993

The Trial was conducted at Douyet and ENA-Meknes in Morocco, and Beja in Tunisia. Because of the drought no results could be obtained from Douyet, and the trial, although proposed, was not conducted in Algeria and Libya.

The trial was modified at ENA-Meknes to include control of leaf miner also. Here, the disease development was low and delayed. However, much more disease developed in the susceptible cv. PCH 46 than on ILC 195 or FLIP 84-92C(moderately resistant). Even two fungicide sprays did not affect much disease development in FLIP 84-92 and ILC 195, whereas they reduced some disease development in PCH 46.

In Tunisia, without any fungicide sprays, grain yields were 1800 kg/ha in moderately resistant (MR) versus 720 kg/ha in moderately susceptible (MS) or 13 kg in susceptible (S) chickpea varieties. One spray, made no impact on yield increase in S and MR but doubled yield in MS. Although three sprays made no improvement over two sprays in MS, they resulted in phenomenal grain yield increase in S (499 kg/ha) and significant yield increase in MR (2329 kg/ha). **National Program Scientists in the Region and S.P.S. Beniwal.**

Table 8.2.6. Lentil North Africa regional yield trial, 1992/93 crop season.

Line	Country	Grain yield (kg/ha) Morocco		Tunisia		Libya	Mean	Rank
		MCH	JHC	BJ	KF	ELM		
BALKAN 755	Algeria	423	15	2683	804	1000	985	9
SETIF 618	Algeria	73	15	2525	634	880	825	16
L.B.REDJAS	Algeria	123	3	2758	540	850	855	15
76S26002[1]	Tunisia	244	120	2783	720	1170	1007	7
NYLON	Morocco	216	130	2508	740	1200	959	10
ILL 4400[1]	Tunisia	250	26	2691	700	1090	951	13
ILL 4606	Tunisia	230	173	2458	636	1090	917	14
ILL 6002	Morocco	460	353	2616	830	830	1018	6
ILL 6209	Morocco	467[2]	313	2691	866	1250	1117	2
ILL 6212	Morocco	350	303	2291	832	1030	961	11
ILL 5700	Morocco	333	200	2708	980	1110	1066	4
ILL 4605[1]	Morocco	363	433	2908	844	1050	1120	1
FLIP 84-106L	Morocco	234	206	3166	730	1050	1077	3
ILL 5883	Morocco	326	193	2658	730	930	967	10
FLIP 86-21L	Morocco	410	413	2833	648	1020	1065	5
FLIP 86-19L	Morocco	400	440	2516	778	830	933	8
Mean		306	209	2674	754	1024		
SE±		-	-	467	153	NS		
CV%		46	35	17	36			

1. These are three check varieties in the trial.
2. The variety that yielded highest at the location.

8.2.6. Training Activities

Scientists/technicians from Algeria, Libya, Morocco and Tunisia participated in the Group Training Courses at ICARDA. They included one each from Algeria, Libya, and Tunisia and two from Morocco for the Legume Breeding Methodology Course; and one from Algeria for the Mechanical Harvest of Legumes Course. Two scientists from Algeria underwent the individual training in chickpea breeding at ICARDA, and one senior technician from Morocco received individual training in lentil and chickpea pathology. One scientist from Tunisia participated in the Third International Symposium on *Orobanche* held at Amsterdam, 8-12 November 1993.

A regional legume travelling workshop was organized in Algeria in May 1993. It provided an excellent opportunity for scientific interaction and training to participating legume scientists of Algeria, Libya, Morocco, and Tunisia. **ICARDA Home-base Program Scientists, TCU and S.P.S. Beniwal.**

8.3. West Asia Regional Program

In the Mashreq Project (RAB/89/026) on '<u>Increased Productivity of Barley, Pasture and Sheep in Syria, Jordan and Iraq</u>', the role of annual forage legume is being investigated in the rainfed farming systems in the low rainfall areas of these countries. During the 1992/93 season the seasonal precipation in the test areas in Syria was around 300 mm; in Jordan the rainfall was less than 300 mm and crop suffered from early cold and late drought; while in Iraq the rainfall was more than 300 mm with severe rain storms in March.

8.3.1. Performance of Annual Forage Legumes

Several forage legume species and accessions were found to have a good potential for dry matter production and for grain and straw production. In Syria, *Vicia sativa* 715 and 800, *Vicia ervilia* 219, and *Vicia narbonensis* 717 and 683 were found to be promising. In Jordan, *Vicia sativa* 715, *Vicia villosa* subsp. *desycarpa* 683 and *Lathyrus sativus* 101 were promising and the national programs are intending to release these lines.

8.3.2. Effect of Vetch on Subsequent Barley

Work on the demonstration of vetches was extended in the project to cover large areas in the three countries during the 1992/93 season. The vetch was directly grazed by sheep. The results in Syria indicated that barley after *Vicia ervilia* yielded 35% more than that after barley and the yield was at a par with that of barley following clean fallow.

In Iraq, barley yield after vetch was 10% higher than barley after barley and 12% higher than barley after fallow. In Jordan, barley following *Vicia ervilia* gave 32% more grain yield as compared to barley after barley but 32% lesser than that of barley after clean fallow.

More details of the work are given in the Project Annual Report Mash/Doc/017, Jan, 1994. **National Program Scientists and Nasri Haddad.**

8.3.3. Field Verification Trials in Lebanon

In collaboration with the Lebanese Agricultural Research Institute (LARI), Tel Amara, Beqa'a, verification trials were conducted on chickpea and lentil genotypes at various research stations of LARI and ICARDA during the 1992/93 season. The weather conditions in Beqa'a were not very favourable for growing these crops. Very severe cold during winter and dry spring resulted in stressed crop.

Three varieties of lentil and 3 varieties of chickpea were evaluated at 3 coastal sites (Abdeh, Lebaa and Kfarshakhna) and 3 sites in Beqa'a valley (Tel Amara, Terbol and Kfardan) in replicated trial (3 replications) with large plots. Area harvested ranged from 78-84m^2 in case of chickpea and was 45 m^2 for lentil for each genotype. The morpho-physiological characters of varieties used in the trials are given in Table 8.3.1.

Table 8.3.1. Some morpho-physiological characters of the chickpea and lentil varieties used in the field verification trials in Lebanon.

	Range in attributes				
Crop and genotype	Days to flower	Plant type	Plant height(cm)	1000-seed wt(g)	Cooking time(mt)
Chickpea					
FLIP 85-5C	78-92	Semi spreading	32-85	468-507	
Janta 2	75-93	Semi erect	25-61	248-330	
FLIP 84-15C	78-100	Erect	28-70	405-513	
Lentil					
FLIP 86-2L	69-85	Non lodging	33-55	35.5-51.5	35-42
Talia 2	68-82	Non lodging	30-45	26.5-36.5	29-41
FLIP 87-56L	74-89	Non lodging	30-48	34.5-44.5	35-41

The yield performance of the tested genotypes is shown in Table 8.3.2. The performance was better in the Beqa'a sites than in the coastal sites particularly for lentil. The new genotypes did not show any major superiority over the improved check varieties (Janta 2 and Talia 2) which were released in 1988.

Table 8.3.2. Grain yield (kg/ha) of different chickpea and lentil genotypes in field verification trials in Lebanon in 1992/93.

Crop and genotypes	Stations					
	Kfarshakhna	Lebaa	Abdeh	Tel Amara	Kfardan	Terbol
Chickpea						
FLIP 85-5C	-	857	2682	-	1791	2563
Janta 2	-	734	4096	-	2077	2941
FLIP 84-15C	-	559	2710	-	1964	2764
Lentil						
FLIP 86-2L	316	774	1046	1806	2304	1826
Talia 2	463	791	1255	1460	2702	1337
FLIP 87-56L	340	496	1073	1378	2833	1575

Of the chickpea varieties, FLIP 84-15 showed lower number of filled pods and high number of empty pods. This was observed in 1988/89 and 1989/90 season as well. Hence it does not appear suitable for cultivation in Lebanon. On the other hand FLIP 85-5C has larger seed size and better taste of green seeds than Janta 2. Since most of the chickpea in the coastal areas is grown for green seeds this varieties seems superior to Janta 2 for introduction there. There is a need for introduction of more promising varieties in the field verification trials in the 1993/94 season, as several such varieties have been identified in the yield trials at Terbol and Kfardan . **Lebanese National Scientists and Pierre Kiwan.**

9. TRAINING AND NETWORKING

The purpose of training is to develop or enhance the technical capabilities of NARS scientists and their support staff. It also aims at strengthening networking and to assist in transfer of technologies. Table 9.1.1 summarizes the activities undertaken by LP during 1992 to meet the above objectives. This was done in some cases in collaboration with NARSs and other ICARDA programs. A total of 207 participants received training in the improvement of lentil, kabuli chickpea and annual forage legumes (Table 9.1.1).

Table 9.1.1. Summary of training activities in 1992.

Type of training	Participants	Represented countries
I. Training at Aleppo		
1. Group courses		
1.1. Legume Disease Control	9	8
1.2. Insect Control in Food Legumes and Cereal Crops	12	10
1.3. Breeding Methodologies in Food Legumes	16	10
1.4. Mechanical Harvesting of Legumes	12	5
1.5. DNA Molecular Marker Techniques	12	12
2. Individual Non-degree	35	5
3. Graduate Research	7	4
II. In-country/Sub-regional Training Courses		
1. Winter Chickpea technology Transfer, Algeria	23	4
2. Legume Seed Production, Egypt	21	3
3. Use of Computer in Breeding Experiments, Turkey	9	1
4. Computer Application for Multilocation Testing and Stability Analysis, Egypt	14	3
5. Lentil and Chickpea Production Technology, Turkey	18	1
6. Food Legume Improvement, Lebanon	18	1

9.1. Group Training at ICARDA

Table 9.1.2. Participation in group training by countries.

Type of training	Countries
Short Courses at Aleppo	
1. Legume Disease Control	Algeria, Bulgaria, Egypt, Iran, Lebanon, Libya, Syria, Turkey
2. Insect Control in Food Legumes and Cereal Crops	Algeria, Iran, Lebanon, Libya, Morocco, Pakistan, Sudan, Syria Tunisia, Turkey
3. Screening Methodologies in Food Legumes	Algeria, China, Ethiopia, Iran, Lebanon, Libya, Mexico, Pakistan, Syria, Yemen
4. Mechanical Harvesting of Legumes	Cyprus, Iran, Iraq, Pakistan, Syria
Short Courses In-country/Sub-regional	
1. Winter Chickpea Technology Transfer	Algeria, Morocco, Libya, Tunisia
2. Legume Seed Production	Egypt, Ethiopia, Sudan
3. Use of Computer in Breeding Experiments	Turkey
4. Computer Application for Multilocation Testing and Stability Analysis	Egypt, Ethiopia, Sudan
5. Lentil and Chickpea Production Technology	Turkey
6. Food Legume Improvement	Lebanon

9.1.1. Legume Disease Control

Integrated control methods of legume diseases are developed to increase farm incomes and to maintain a clean environment. In order to strengthen the research capacity of national programs in this area, a short course was conducted at Tel Hadya from 9 to 19 March, 1992. The course was attended by 9 participants. The program included theoretical, laboratory and field training. Lectures were on major legume diseases, methodologies for handling pathogens, strategies for the identification of resistant sources and integrated management of legume diseases. Laboratory training covered general management and basic procedures used in plant pathology laboratories, pathogenicity tests, new approaches in identifying different populations of a given fungus, inoculum preparation, inoculation and seed pathology. Field training covered mainly disease rating, management of disease screening nurseries and integrated disease control. A field trip was organized to visit farmers fields in Lattakia and Idleb. Participants rated the organization and the level of the course as very good.

9.1.2. Insect Control

Food legume crops are attacked by many pests resulting in sizable yield reduction and post-harvest losses. The same applies for cereal crops as well. Realising the need of NARSs for strengthening the research skills in this field, the Cereal and Food legume Improvement Programs conducted a joint training course on 20 to 30 April, 1992 in Aleppo. The course was attended by 12 participants (41.67% female) and covered topics such as sampling and identification of insects and monitoring of insect populations, collection of insects, screening for host-plant resistance, use of pesticides and application of biological control. The course will continue to be offered in the future with increased time allocated for practical skills such as planning of experiments.

9.1.3. Breeding Methodologies in Food Legumes

To promote sound strategies and strengthen the network of collaborators in the improvement of legumes germplasm, a training course on "Breeding Methodologies in Food Legumes" was conducted from 3 to 14 May, 1992 at Aleppo. The course was attended by 16 participants and covered topics such as quantitative genetics as applied to plant breeding; plant genetic resources; breeding methods; mutation breeding; methods in cytogenetics; breeding for resistance to environmental stresses, diseases and insects; variety maintenance and experimental designs. One participant presented the strategies and achievements in his breeding program as a seminar. The participants evaluated the course as highly successful and useful.

9.1.4. Harvest Mechanization

A legume harvest mechanization short course was organized at Tel Hadya from 10 to 22 May, 1992 jointly by the Legume Program and the Pasture Forage and Livestock Program, including lecturers from Farm Resources Management Program and Station Operations. The course was attended by 12 participants. The purpose of the training was to demonstrate systems of legume production and mechanization to decrease the cost of producing legumes. The program included both lectures and practicals related to harvest machinery, such as mowers (self-propelled and tractor-drawn), combines and the lentil puller. Lectures were on the problems of mechanization, the breeding and agronomy of mechanization for different legumes, seed-bed preparation, economic and techniques for farmer interviews and on-farm trials. In addition, trainees presented the situation of legume production and mechanization in their own countries.

9.1.5. DNA Molecular Marker Techniques for Germplasm Evaluation and Crop Improvement

Plant biotechnology tools offer innovative approaches in plant improvement research. To increase the awareness of national scientists about the potential of biotechnological tools in facilitating the crop improvement research, ICARDA conducted a course from 20 Sept to 1 Oct, 1992 at Aleppo, attended by 12 participants. The course introduced participants to theoretical and practical aspects of DNA marker techniques, covered current and future uses of DNA technology in plant breeding and provided practical experience in some aspects of DNA technology. The lecture series included gene structure, regulation and inheritance, gene identification and marking, genome mapping, application of genetic engineering as well as the use of wide crossing and somaclonal variation. During the practical sessions, each participant successfully extracted, purified and digested DNA by a restriction endonuclease Taq I, electrophoresed the fragments and probed them with a non-radioactive probe. The practicals also focused on RFLP methods and DNA amplification using Polymerase Chain Reaction. The trainees evaluated the course as useful and hoped that this interaction will lead to the start of a core network in this upstream research area.

9.2. In-Country/Sub-Regional Courses

9.2.1. Winter Chickpea Technology Transfer

A course on transferring winter-chickpea technology was conducted at Sidi Bel Abbas, Algeria from 17 to 20 May, 1992 jointly with FRMP and ITGC, Algeria. It was attended by 23 participants, a mixture of extension, research, and production workers. The emphasis was mainly on transferring winter-chickpea technologies to farmers including discussion on adoption aspects. The lectures were augmented by visits to research stations and farmers' fields where winter sowing was adopted. In addition, participants gave presentations on breeding, agronomy, seed production and socio-economic aspects of chickpea for winter sowing. Participants evaluated the course as very interesting.

9.2.2. Legume Seed production

The course was conducted jointly, with ICARDA Seed Unit, in Cairo from 18 to 29 April, 1992 and was attended by 21 participants from Egypt, Sudan and Ethiopia. It was sponsored by the Agricultural Research Center and the Central Administration for Seed in Egypt and by the German Agency for Technical Cooperation. The course covered all major aspects of legume seed production including variety maintenance, description and release, seed production, processing, storage and quality control. Emphasis was given to crop management, field inspection techniques and detection methods of seed-borne diseases.

9.2.3. Use of Computers in Breeding Experiments

LP and CBSU jointly conducted this in-country course in Diyarbakir, Turkey from 27 April to 3 May, 1992. It was attended by 9 participants (55.0% female) from Turkey. The course was jointly sponsored by ICARDA and South Eastern Anatolian Agricultural Research Institute, Diyarbakir. 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 MSTAT-C, basic knowledge about dBASE IV and its use for breeding-data management, and the use of Harvard Graphics. The course generated much enthusiasm and the participants continued additional exercises in late evenings using computers. The level of skill achievement was very high.

9.2.4. Computer Application for Multilocation Testing and Stability Analysis

LP and CBSU jointly conducted this sub-regional training course in Cairo, Egypt. Sponsored by ICARDA and Agricultural Research Institute, Egypt, the course was held from 10 to 21 May, 1992 and was attended by 14 participants from Egypt, Ethiopia and Sudan. The course provided an overview of the basic principles of designing experiments for varietal trails, the designing and analysis of trials conducted over several locations and years to examine stability and adaptability of varieties, and assessment of genotype x environment interactions. The course covered basic statistical principles of trials on RCBD with common checks and in RCBD conducted over locations/years, analysis of trials in lattices, stability analysis, zoning of environments, AMMI model and stochastic dominance.

9.2.5. Lentil and Chickpea Production Technology

LP and FRMP jointly conducted this in-country training course in Ankara, Turkey from 29 June to 1 July, 1992. The course, jointly sponsored by ICARDA and Central Research Institute for Field Crops, Ankara, Turkey, was attended by 18 participants from different organizations in the Central Anatolian Plateau (dealing with research, extension, and seed multiplication). The lectures covered legume production in Turkey; breeding; cold tolerance; weed, nematode, disease and insect pest control; mechanization; biological nitrogen fixation; seed multiplication and economics of production and adoption. In addition, trainees visited farmer's fields and Haymana Research Station where they saw several experiments on breeding, disease control, cold tolerance, seed multiplication and rotations. The trainees evaluated the course as quite useful.

9.2.6. Food Legume Improvement in Lebanon

This in-country course was conducted at Terbol, Lebanon from 14 to 18 Sept, 1992. The course was attended by 18 Lebanese participants from the American University of Beirut, the Lebanese University, the University of Saint-Joseph, the Kaslik University and the Agricultural Research Institute. The course covered food legume production in Lebanon, their agronomy and cropping system, biological nitrogen fixation, varietal improvement and diseases, pest and weed management of lentil, chickpea, pea and faba bean. The practical session dealt with hybridization techniques. Group presentations on winter sowing of chickpea, mechanization of legumes, control of *Orobanche* in food legumes and biological nitrogen fixation were done by the participants with the aid of audio-visuals and posters. These presentations included the introduction to the problem, its present status, the up-to-date results of improvement and the future trends. The course allowed a good interaction between the trainees and the instructors and was evaluated as highly successful.

9.3. Individual Non-degree Training

As per the request of NARSs, training on an individual basis was offered for 35 participants from 5 countries. Skills covered and countries represented are given in Table 9.3.1. The syllabi were tailored to meet the specific needs of NARSs and the academic background and performance objectives of the participants.

Table 9.3.1. Participation in the individual non-degree training, 1992.

Topic	No. of participants	Countries
1. Agronomy and Crop Physiology	5	Ethiopia, Morocco, Syria
2. Biological Nitrogen Fixation	3	Algeria, Ethiopia, Syria
3. Lentil Breeding	4	Algeria, Syria
4. Virology	2	S. Oman, Syria
5. Legume Cold Tolerance	2	Syria
6. Quality	3	Ethiopia, Syria
7. Computer Application	3	Syria
8. Rating of Diseases and Insects	5	Syria
9. Screening Chickpea for Drought Resistance	3	Syria
10. Entomology	3	Ethiopia, Syria
11. Chickpea Breeding	2	Syria

9.4. Graduate Research Training

As a part of the degree-oriented training 8 students started their thesis research in the program during 1992. The names are given in Table 9.4.1. Six students received their M.Sc./Ph.D. degree and some are writing their thesis.

Table 9.4.1. Participants in graduate research training in 1992.

Name	Degree	University	Country
Registered in 1992			
1. Widad Shehadeh	M.Sc.	Damascus	Syria
2. Abbas Abbas	Ph.D.	Aleppo	Syria
3. Ahmad M. Manschadi	Ph.D.	Hohenheim	Iran
4. Hassan Tambal	M.Sc.	A.U.B.	Sudan
5. Hassan Khalid	M.Sc.	A.U.B.	Sudan
6. Mohamed A. Adlan	M.Sc.	A.U.B.	Sudan
7. Ismail Kusmenoglu	Ph.D.	Selcuk	Turkey
8. Suhaila Arslan	M.Sc.	Aleppo	Syria
Registration continuing from previous years			
1. Aziza Dibo Ajouri	Ph.D.	Aleppo	Syria
2. Sara Nour	Ph.D.	INRA	Sudan
3. Hossam El Din M. El Sayed Ibrahim	Ph.D.	Alexandria	Egypt
4. Mohamed Labdi	Ph.D.	INRA	Algeria
5. Marja van Hezewijk	Ph.D.	Amsterdam	The Netherlands
Completed and degree awarded			
1. Imad Mahmoud	M.Sc.	Gezira	Sudan
2. Jihad Yasin	M.Sc.	Amman	Jordan
3. Ahmad Al Seoud	Ph.D.	Damascus	Syria
4. Huda Kawas	Ph.D.	Damascus	Syria
5. Edwin Weber	Ph.D.	Hohenheim	Germany
6. Stefan Schlingloff*	Ph.D.	Giessen	Germany
7. Elias Zerfu	M.Sc.	Haryana	Ethiopia
8. Heiko Schnell	Ph.D.	Hohenheim	Germany
9. Christiane Weigner	Ph.D.	Hohenheim	Germany
10. Eckhard George	Ph.D.	Hohenheim	Germany

* Completed in 1991.

9.5. Training Material

In an effort to increase information comprehension and retention by the trainees during the course, LP is developing a series of Lecture Notes. Lecture Notes are a print-on-paper medium distributed to training participants before or after a lecture, depending on the type of lecture and the audience. They summarize the lecture, reproduce the tables, charts and graphics presented in the lecture, give glossary of terms used and list additional reading material. Therefore, the trainee can use the notes to reinforce the spoken words of the lecturer. Lecture Notes are developed as modules that are usually designed as self-instructional units for independent study containing some type of prompt response/reinforcement pattern. They are one component of multi-media training kits that contain a variety of courseware such as audio-visuals, posters, skill manuals, handouts, trainer's manuals and computer-based instructional units.

A multi-media training kit for the course "Legume harvest mechanization" and Lecture Notes for the course "Insect control in food legumes and cereals" were developed this year. The feedback from training participants was quite positive. Work will continue to develop Lecture Notes for a wide variety of courses.

9.6. Chickpea Adaptation Workshop

A workshop on the Adaptation of Chickpea in WANA was jointly hosted by ICARDA's LP and FRMP and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at ICARDA, Syria, from 9 to 12 Nov, 1992. Fifty-two participants from 11 NARS, ICRISAT and ICARDA, representing multidisciplinary team of scientists, across biological and social sciences, participated in this workshop. Case studies on 11 countries (Algeria, Egypt, Ethiopia, Iran, Iraq, Jordan, Morocco, Sudan, Syria, Tunisia, and Turkey) were presented, providing an up-to-date understanding of the problems and prospects of chickpea adaptation at the national (micro) scale. In the following sessions, paper on critique and synthesis integrated the current knowledge at regional (agro-ecological) and global scales.

After the presentation, papers were reviewed and revised, to the extent possible, by the authors and resource personnel from ICARDA and ICRISAT, during two hands-on- workshop sessions. Maps prepared at ICRISAT using Geographic Information Systems (GIS) computer software, were also reviewed.

The editorial committee had the task of summarizing the global scenario, identifying new potential areas for chickpea cultivation, gaps in the current knowledge and listing priority areas for future research on biotic and abiotic constraints. Proceedings of the workshop will appear at the end of 1993 in the form of a book jointly published by ICRISAT and ICARDA. **Habib Ibrahim, S. Weigand and other Scientists from Legume Program**

10. PUBLICATIONS

10.1. Journal Articles

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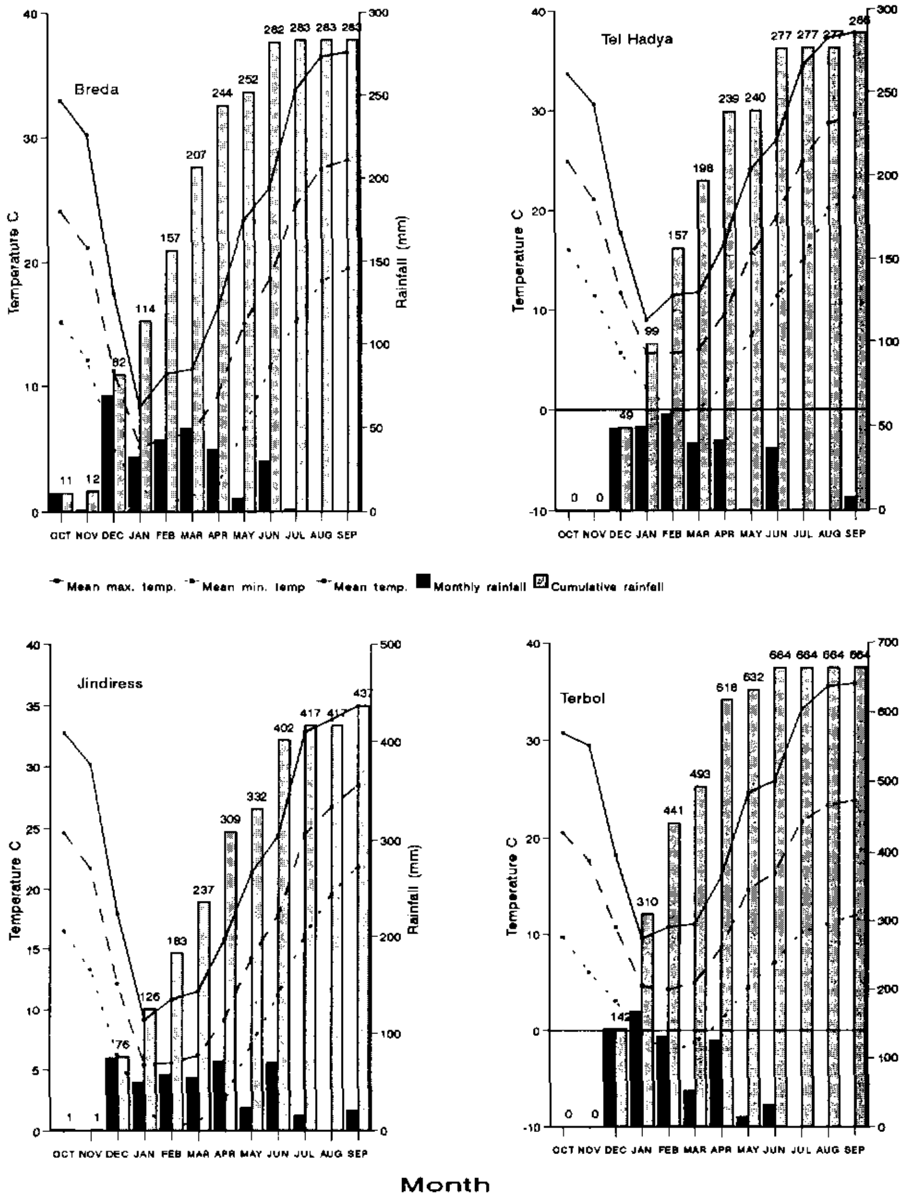
11. WEATHER DATA 1992/93



12. STAFF LIST

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S. Weigand	Entomologist
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Bassam Bayaa	Consultant Pathologist (University of Aleppo)
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Ghazi Khatib	Research Technician (Terbol)
Aida Naimeh	Research Technician (Terbol)
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Hasna Boustani	Secretary
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Namman Ajanji	Driver
Assad Omar El-Darwish*	Fieldman
Hussain El-Humeidi*	Fieldman
Abdulla El-Khaled*	Store Attendant

* Left during the year