LEGUME PROGRAM

Annual Report for 1992

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1992 ANNUAL REPORT

Page

1. INTRODUCTION

1.1. General

The aim of Legume Program is to encourage and support national efforts, in West Asia and North Africa (WANA) and other developing countries with similar ecologies, in improving the productivity and yield stability of cool-season food legumes (lentil, chickpea, faba bean and dry pea) and annual feed legumes (vetches and chicklings) and enhance their role in increasing the sustainable productivity of cereal-based, rainfed farming systems. Research was continued with this aim during the 1991/92 season.

The process of devolution of ICARDA's faba bean improvement research to INRA, Morocco was completed by handing over all the breeding material, research supply, laboratory facilities and field equipment to the faba bean improvement team of INRA at Douyet Research Station near Fes. The Federal Ministry of Economic Cooperation (BMZ), Germany approved a financial grant for the 'North African Faba Bean Improvement Research Network' to ensure continuity of faba bean improvement teams in North Africa. The German Agency of Technical Cooperation (GTZ) was designated as the executing agency for this project with INRA, Morocco playing the lead role in the coordination of network activities. At the request of and the fund support from GTZ, a workshop was organized by ICARDA at Tunis 15-17 July, 1992 to formally launch this regional network and develop detailed workplan for the first phase of the project. Senior research managers and faba bean scientist from all the four North African countries participated in this workshop along with representations from GTZ and ICARDA. A second meeting to plan details of the first season's activities was held in August 1992 in Morocco. GTZ has appointed a network coordinator to work closely with INRA, Morocco faba bean team in ensuring implementation of agreed workplan.

Consistent with the center-wide strategy of focusing on the dry areas, research efforts on legumes adapted to dry environments were increased. LP researchers worked with scientists from other programs as well as the national program scientists in multidisciplinary teams. Research on kabuli chickpea was conducted jointly with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), which has posted a Principal Chickpea Breeder at ICARDA. Collaboration with institutions in the industrialized countries on basic research continued.

During the season there were several staff movements. The Senior Training Scientist left the Program in April 1992 to join the International Center for Research in Agroforestry (ICRAF). The Principal Chickpea Breeder proceeded on sabbatic leave at the University of Western Australia, Perth in September 1992. A Molecular Biologist joined the program in March 1992. The Forage Legume Breeder returned from sabbatic leave in July 1992.

Research on lentil, kabuli chickpea, dry pea, chicklings and vetches was mainly centered at the 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). Summer nurseries were raised at Terbol for lentil and chickpea for additional generation advancement. Research sites of several national programs were used, jointly with national scientists, for strategic 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 the ICARDA sites in Breda, Tel Hadya, Jinderess and Terbol are depicted in Section 11. The long-term average seasonal total rainfall at these sites is 280, 350, 470 and 600 mm. During the 1991/92 season the total seasonal precipitation received was around the long-term average in Syria but above-average at Terbol with 263, 353, 428 and 860 mm received at the end of June at Breda, Tel Hadya, Jinderess and Terbol, respectively. The rainfall at Jinderess was on the lower side. Also the distribution of rainfall at Tel Hadya was not ideal: nearly 310 mm was received till end of February and the remaining 43 mm during the later period; this adversely affected the productivity of the spring chickpea. The winter in 1991/92 was colder than average with 63, 53, 50 and 84 frost nights recorded at Breda, Tel Hadya, Jinderess and Terbol, respectively. The minimum temperature dropped to -8.8°C at Tel Hadya, which permitted good screening of legume material for cold tolerance this season. The rise of temperature was rather sharp from end of March at all Syrian sites accentuating open-pan evaporation and drought stress.

1.3. Achievements

A summary of the major achievements of the program in research, training and networking activities during the 199/92 season in given below:

1.3.1. Kabuli Chickpea

Yields of chickpea are low and unstable in WANA, but improvement is possible through the adoption of winter sowing in low altitude regions. Trials at three ICARDA sites (Tel Hadya, Jinderess and Terbol) for nine years (1983/84 to 1991/92) with more than 100 newly bred lines per year have shown that winter-sown chickpea produces 61% or 616 kg/ha higher yield than spring-sown chickpea. The yield increase from winter sowing rises to 123% with the top 10% yielding genotypes. Winter sowing is expanding in WANA with the area estimated at 65,000 ha for 1991/92.

National programs have made good use of ICARDA enhanced germplasm. Seven cultivars including one in France (Roye Rene), Two in Morocco (Douyet and Rizki), one in Pakistan (Noor 91) and three in Turkey (Aydin 92, Izmir 92 and Menemen 92) were reported released in 1992. Fourteen NARSs have selected 42 lines for pre-release multiplication and/or on-farm trials. Evaluation of 357 Ascochyta blight-resistant breeding lines, 19 germplasm lines and 4 high yielding lines under diseased and disease-free conditions revealed that breeding lines produced 33% higher yield than germplasm lines, that high yielding susceptible lines produced zero yield in diseased field, that some breeding lines yielded >4 t/ha and that with a unit increase in the disease severity rating the yield reduced by 437 kg/ha.

Ascochyta blight-resistant lines combining high yield and early maturity (FLIP 90-98C, FLIP 91-22C, and FLIP 91-46C) and high yield and large-seed size (FLIP 91-2C, FLIP 91-24C, FLIP 91-50C, and FLIP 91-54C) have been bred. In the project for the transfer of genes for resistance to cyst nematode from _Cicer_ _reticulatum_ and to cold from _Cicer_ _echinospermum_ and _C_. _reticulatum_, to cultivated _Cicer_ species, progress made until 1992 suggests that in three years time, gene transfer is expected. A simple, reliable field screening technique for evaluating germplasm lines to drought tolerance has been developed. Evaluation of 1000 germplasm lines using this technique revealed that FLIP 87-51C and FLIP 87-58C were drought resistant.

Progress has been made in the application of non-radioactive DNA-marker techniques for variety identification, in following the resistance to Ascochyta blight, and for studying variability in *Ascochyta rabiei*. Studies on the components of host resistance to Ascochyta blight have shown presence of different mechanisms of resistance in different genotypes. Variations in latent period, sporulation, lesion expansion rate and resistance to stem breakage can all affect field performance of a chickpea cultivar when disease epidemics develop.

Chickpea entomology studies showed that winter-sown chickpea had low leafminer, but high podborer damage, whereas in spring-sown chickpea the reverse was true. Neem extract effectively reduced damage from pod borer and leaf mining. Parasitoides of leafminer were present in high numbers when leafminer populations peaked. Studies on mechanism of resistance showed that amount of malic acid in leaf exudates and leaf area were related to resistance.

The proportion of plant nitrogen coming from symbiotic nitrogen fixation increased when the chickpea plants were inoculated with superior rhizobia in the presence of native rhizobia, although there were no increases in yield. The implications of these findings in the systems perspective are far-reaching in view of the preservation of soil nitrogen.

1.3.2. Lentil

Average lentil yields are low because of poor crop management and the low yield potential of the land races. In some areas diseases are also a major constraint to production. Accordingly an integrated approach to lentil improvement is being pursued covering development of improved technology and genetic stocks. Approximately 250 crosses are made annually and handled in a bulk pedigree system using off-season generation advancement at Terbol. Segregating populations targeted for the different regions are distributed to national programs for selection and cultivar development in situ. A total of 27 cultivars have been registered by national programs in 20 countries so far, of which two were registered during 1992. A large number of lines have been selected for pre-release multiplication or on-farm trials: 15 in the Mediterranean region, four in the high elevation region, 12 in the southern latitude region, four in Argentina, five in Australia and two in China.

A screening method has been developed in the field using a wilt-sick plots and genotypes identified with resistance to the Fusarium wilt disease. Sources of resistance identified are being disseminated to NARSs in the International Legume Testing Network. Some of the sources of resistance have a high yield potential in lowland Mediterranean environments and are in joint tests with the national program on farmers' fields in wilt-infested areas in Syria. Screening of lentil genotypes for resistance to Ascochyta blight has revealed that lines ILL 358 and ILL 5684 are resistant at most of the locations and could be used in the breeding program. Studies have been initiated for developing screening techniques for cold-hardiness in collaboration with the Turkish national programs.

Evaluation of 121 wild lentil accessions for different agronomic traits led to the identification of two accessions of L. culinaris subsp. orientalis that were faster to flower and mature than the earliest cultivated check ILL 4605. This precocity will be of value in the crop improvement work.

In a collaborative project with the Washington State University, RAPD (random amplified polymorphic DNA) - markers are being used to establish linkage to agronomic traits. DNA-fingerprinting is being used for detecting somaclonal variations in the plantlets derived from motherplant by tissue culture.

Studies on symbiotic nitrogen fixation revealed that at lower moisture supply, lentil had a large proportion of its total nitrogen coming from fixation than chickpea. As the moisture supply was raised to attain high yield levels the percentage of plant nitrogen coming from fixation levelled off at 66%, whereas in chickpea it continued to increase. These observations reinforce the regional practice of growing lentil under the drier environments, and switching to chickpea when rainfall increases to around 400 mm. Results from multi-location tests confirmed the effectiveness of Promet seed treatment for Sitona control. The results will be verified in the on-farm trials in the coming season.

1.3.3. Forage Legumes

Development of forage legume cultivars as an economic alternative to fallow for use in rotation with barley in drier areas received the major emphasis in this project. Narbon vetch and common chickling, proved more drought tolerant than other species giving a yield of 1.50 t and 1.26 t/ha, respectively, at Breda where total seasonal precipitation was only 263 mm. Progress was made in incorporating shattering resistance in common vetch and five superior families with 95-97% non-shattering pods were selected as against 60% pod shattering in the original lines. Studies on breeding for reduced neurotoxin (BOAA) content in common chicklings continued.

Studies on the use of underground vetch as a self-reseeding pasture plant showed the promise of this species for use in ley-farming. The yield of dry herbage of self-regenerated vetch from 1988/90 seeding was nearly 3.5 t/ha at 50% flowering in the 1991/92 season. The Moroccan national program identified one line of narbon vetch (577/2391) and one of common vetch (709/2603) for the catalogue trial and the Jordan national program a common vetch (715) as promising for pre-release multiplication.

A simple field method of screening crops and genotypes for drought resistance with two drought intensities created by supplemental irrigation was found effective in discriminating drought tolerance amongst forage legume species and cultivars. Amongst the feed and food legumes tested, narbon vetch was most drought tolerant. The BOAA content in chickling increased as the intensity of drought increased.

Screening of promising forage legume accessions against foliar diseases helped in the identification of 4 lines of narbon vetch showing resistance to powdery mildew and Botrytis blight. Also resistant sources for cyst nematode were identified in Vicia sativa and V. hybrida. Sitona crinitus caused 75% nodule damage in Vicia villosa ssp. dasycarpa at two locations in northwest Syria. Seed treatment with Promet increased seed and biomass yield.

1.3.4. Dry Pea

Sixty-one new accessions were evaluated in the preliminary yield trial at Tel Hadya and Terbol and the best entries were advanced to the Pea International Adaptation Trial. Evaluation of cold tolerance of 438 lines at Tel Hadya, where the prevailing weather conditions were ideal for cold tolerance screening, revealed that 31 lines were tolerant and presence of anthocyanin pigmentation was generally associated with cold.

1.3.5. International Nurseries

A total of 1050 sets of 34 different nurseries of chickpea, lentil, pea, chicklings and vetches were distributed to 160 cooperators in 55 countries for the 1992/93 season. Several cooperators requested a large quantity of seed of elite lines, identified by them from the international nurseries/trials, for on-farm verification trials.

1.3.6. Training and Networking

Group training was conducted at ICARDA in the form of short specialized training courses, besides the in-country and sub-regional training courses. Specialized courses at ICARDA included: 'Disease Control', 'Insect Control', 'Advanced Breeding Methodologies', 'Mechanical Harvesting' and 'DNA Molecular Marker Techniques'. In-country and subregional courses covered 'Winter Chickpea Technology Transfer' in Algeria, 'Legume Seed Production' in Egypt, 'Use of Computer in Breeding' in Turkey, 'Computer Application in Multilocation Testing', in Egypt, 'Lentil and Chickpea Production Technology' in Turkey and 'Food Legume Improvement' in Lebanon. A total of 206 participants received training in the improvement of lentil, chickpea, faba bean, pea, vetches and chicklings through these courses. As a part of the degree-oriented training 8 students (4 for M.Sc. and 4 for Ph.D.) started their thesis research in the Program.

Travelling workshops were organized in Egypt, Ethiopia, Sudan, Syria and Turkey. Joint training, travelling workshops and regional coordination meetings enhanced interaction and encouraged networking.

A workshop on the 'Adaptation of Chickpea in WANA' was organized at ICARDA, 9-12 November 1992, in which scientists from eleven national programs in WANA participated. The proceedings will be published. The LP was also heavily involved in organizing the 2nd International Food Legume Research Conference, 14-16 May in Cairo, Egypt.

2. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea improvement is a joint program with ICRISAT Center, India. The main objective of the program is to increase and stabilize kabuli chickpea production in the developing world. Of the four 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 two main production regions (Indian subcontinent and East Africa) is also devoted to production of the kabuli type. In West Asia-North Africa (WANA) region kabuli chickpea is also grown in high elevation areas (>1000 m above sea level) especially in Turkey, Iraq, Iran, Afghanistan and the Atlas mountains. Ascochyta blight and Fusarium wilt are the two major diseases of chickpea. Leaf miner in the Mediterranean region and pod borer in other regions are major insect pests. 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 WANA. 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. There are indications that increasing plant density and reducing row width also increase yield significantly, especially during winter sowing. Winter sowing allows the chickpea 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), other parasites (cyst nematode and Orobanche crenata Forsk.), and physical stresses (cold and drought). Efforts are also underway to collect basic information for generating input-responsive cultivars, especially those which respond to application of phosphate fertilizer and supplemental irrigation. Exploitation of wild Cicer species for transfer of genes for resistance to different stresses is also receiving high priority. DNA fingerprinting for studying variability in Ascochyta rabiei is another piece of research being pursued with great promise.

During 1992, 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 done in association with the Departamento de Patologia Vegetal, Cordoba, Spain and INRAT, Tunisia. Screening for tolerance to cold was done in cooperation with agricultural research institutes in Turkey. Genetics of phosphate uptake was investigated in association with the University of Hohenheim, Germany. 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 on genetic diversity in kabuli chickpea. Studies on mechanism of drought and cold resistance and some aspects of biological nitrogen fixation are being conducted in collaboration with INRA, Montpellier, France. Studies on leaf miner resistance and application of restriction fragment length polymorphism (RFLP) in characterizing chickpea genotypes and Ascochyta rabiei isolates are carried out, respectively,in collaboration with the Max Planck Institute and University of Frankfurt, Germany. Survey on chickpea usage in Syria is being done with the University of Aleppo, Syria.

2.1. Chickpea Breeding

The objectives of the breeding are to (1) produce cultivars and genetic stocks with high and stable yield, (2) develop segregating populations and materials for crossing programs to support National Agricultural Research Systems (NARSs) and (3) 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) for winter sowing: resistance to Ascochyta blight, tolerance of cold, suitability for machine harvesting, medium to large seed size (30% of resources); (b) for 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: for 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 and breeding lines

During 1992, based on specific requests, 20578 chickpea entries were furnished to 46 countries. Eighty-three percent of the matrial was furnished to the developing countries and the remaining 17% to the industrialized countries (Table 2.1.1). The demand came from all continents, from Chile to China and from Canada to Australia-New Zealand. The demand for international nurseries increased by 11%, indicating the usefulness of the chickpea material to NARSs. Overall, 14% more entries were supplied over 1991. Despite our encouragement to national programs to accept more of segregating and crossing block materials, the demand for the finished material is on increase, suggesting that breeders have found ICRISAT-ICARDA chickpea lines 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 entries furnished in the form of international yield trials and nurseries and breeding lines during 1992.

Country	Trial and nursery		Breeding line (no.)	Total entries (no.)
	No. of sets of trial/nursery	No. of entries		
Afghanistan	5	223	-	223
Algeria	41	1487	8	1495
Argentina	2	96	-	96
Australia	8	260	100	360
Bahrain	1	31	-	31
Bhutan	10	316	-	316
Bolivia	4	167	-	167
Bulgaria	3	87	-	87
Canada	8	262	136	398
Chile	6	530	-	530
China	1	31	-	31
Colombia	4	125	-	125
Cyprus	2	86	-	86
Egypt	7	187	-	187
Ethiopia	9	318	-	318
France	-	-	7	7
Greece	4	150	-	150
India	62	2340	95	2435
Iran	23	971	-	971
Iraq	6	199	-	199
Italy	23	896	139	1035
Japan	-	-	11	11
Jordan	12	560	2	562
Kenya	5	115	-	115
Kuwait	1	23	-	23
Lebanon	6	246	-	246
Libya	3	87	-	87
Mexico	10	364	1	365
Morocco	11	402	-	402
Nepal	2	79	-	79
New Zealand	4	92	-	92
Oman	2	46	-	46
Pakistan	22	945	179	1124
Peru	4	142	-	142
Portugal	8	328	-	328
Russia	1	51	-	51
Saudi Arabia	6	171	-	171
South Africa	7	186	10	196
Spain	17	684	1075	1759
Srilanka	2	46	-	46
Sudan	8	245	-	245
Syria	40	1682	-	1682
Thailand	2	71	-	71
Tunisia	20	972	-	972
Turkey	57	2317	14	2331
U.S.A.	5	168	17	185
Total	484	18,784	1794	20,587

2.1.1.2. On-farm trials

Two chickpea lines were selected by the Directorate of Agriculture and Scientific Research (DASR), Ministry of Agriculture and Agrarian Reform from the ICARDA/ICRISAT international trials. Together with ICARDA they conducted researcher-managed on-farm trials throughout Syria during 1991-92. The number of locations were 13 (Table 2.1.2). The 1991/92 season had cold winter and wet spring. Weather conditions provided opportunity to evaluate entries for cold tolerance as well as resistance to Ascochyta blight. The two new entries were resistant/tolerant to both stresses. Both FLIP 86-5C and FLIP 86-6C produced marginally higher yields than the two checks, Ghab 1 and Ghab 2. But FLIP 86-5C and FLIP 86-6C have 50% larger seed size, the attribute in great demand in the WANA region, and have tall growth habit facilitating combine harvest, an important attribute for a large scale introduction of winter chickpea.

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 Scientific Research, Syria and ICARDA during the 1991/92 season. Disease and cold tolerance scores are based on evaluation at Tel Hadya.

Entry	Seed yield (kg/ha)	100-seed weight	Plant height (g)	Days to flower (cm)	Protein content (no.)	Ascochyta blight (%)	Cold score score
FLIP 86-5C	20	84	46	54	142	20.0	RT
FLIP 86-6C	19	77	41	51	132	19.8	RT
Ghab 1	19	25	27	38	128	20.3	FRT
Ghab 3	19	31	29	43	131	20.2	RT
Location	13	10	13	10	8		

The ICRISAT-ICARDA Kabuli Chickpea Project was involved in the conduct of on-farm trials in many countries including Algeria, Iraq, Jordan, Lebanon, Morocco, Tunisia, and Turkey. Our involvement varied from full involvement in the conduct of trials (e.g. Lebanon) to only providing advice (e.g. Turkey). Results have been encouraging as is clear from a large number of release of cultivars and their adoption.

NARSs scientists and K.B. Singh

2.1.1.3. Pre-release multiplication of cultivars

Fifty-two lines have been chosen by 14 NARSs from the ICRISAT/ICARDA international trials for the pre-release multiplication and on-farm tests (Table 2.1.3). Barring three selections from germplasm

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
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82-169C
Jordan	ILC 496, FLIP 84-15C, FLIP 85-5C
Lebanon	FLIP 85-5C, FLIP 84-15C
Libya	ILC 484, FLIP 84-79C, FLIP 84-93C, FLIP 84-144C
Mexico	ILC 482, FLIP 81-293C
Morocco	FLIP 84-145C, FLIP 84-182C
Syria	FLIP 83-98C, FLIP 84-15C, FLIP 86-5C, FLIP 86-6C
Tunisia	FLIP 83-47C
Turkey	FLIP 81-70C, FLIP 82-74C, FLIP 82-161C, FLIP 82 -269C, FLIP 84-15C, FLIP 83-31C, FLIP 83-41C, FLIP 83-47C, FLIP 83-77C, FLIP 84-79C, FLIP 84-144C, FLIP 84-150C, FLIP 85-13C, FLIP 85-14C, FLIP 85-15C, FLIP 85-60C, 87AK 71112

collection, all the remaining are developed through hybridization. All the new lines have resistance to Ascochyta blight, tolerance of cold and large seed size. If grown in winter, they attain a height of minimum of 40 cm and can 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, K.B. Singh, R.S. Malhotra and M.C. Saxena

2.1.1.4. Release of cultivars

During 1992, seven cultivars were released by four countries, namely France (1), Morocco (2), Pakistan (1) and Turkey (3) Table (2.1.4). NARSs in 17 countries have released 48 lines as cultivars from material furnished from ICARDA (Table 2.1.4). Thirty-eight of them have been released for winter sowing in the Mediterranean region, seven for spring sowing including two in China, two for winter sowing in more southerly latitudes to be sown with irrigation, and one in Pakistan. Noor 91, the cultivar released in Pakistan during 1992, replaces Pb 1 which was released in 1933.

NARSs Scientists

Table 2.1.4. Kabuli chickpea cultivars released by different national programs.

Country	Cultivars released	Year of release	Specific features
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
	FLIP 84-79C	1991	Cold tolerant
	FLIP 84-92C	1991	Large-seeded
China	ILC 202	1988	High yield, for Ginghai pr.
	ILC 411	1988	High yield, for Ginghai pr.
Cyprus	Yialousa (ILC 3279)	1984	Tall, cold tolerant
	Kyrenia (ILC 464)	1987	Large-seeded
France	TS1009 (ILC 482)	1988	High yield, cold tolerant
	TS1502 (FLIP 81-293C)	1988	High yield
	Roye Rene (FLIP84-188C)	1992	Cold, High blight resistance
Iraq	ILC 482	1991	High yield, wide adaptation
	ILC 3279	1991	Tall, cold tolerant
Italy	Califfo (ILC 72)	1987	Tall, high yield
	Sultano (ILC 3279)	1987	Tall, high yield
Jordan	Jubeiha-2 (ILC 482)	1989	High yield, wide adaptation
	Jubeiha-3 (ILC 3279)	1989	High yield, tall
Lebanon	Janta 2 (ILC 482)	1989	High yield, wide adaptation
Morocco	ILC 195	1987	Tall, cold tolerant
	ILC 482	1987	High yield, wide adaptation
	Douyet (FLIP 84-92C)	1992	Large seed, blight resistance
	Rizki (FLIP 83-48C)	1992	Large seed, blight resistance
Oman	ILC 237	1988	Irrigation responsive
Pakistan	Noor 91 (FLIP 81-293C)	1992	High yield, blight resistance
Portugal	Elmo (ILC 5566)	1989	High yield
	Elvar (FLIP 85-17C)	1989	High yield
Spain	Fardan (ILC 72)	1985	Tall, high yield
	Zegri (ILC 200)	1985	Mid-tall, high yield
	Almena (ILC 2548)	1985	Tall, high yield
	Alcazaba (ILC 2555)	1985	Tall, high yield
	Atalaya (ILC 200)	1985	Mid-tall, high yield
Sudan	Shendi (ILC 1335)	1987	Irrigation responsive
Syria	Ghab 1 (ILC 482)	1986	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold tolerant
	Ghab 3 (FLIP 82-150C)	1991	High yield, wide adaptation
Tunisia	Chetoui (ILC 3279)	1986	Tall, high yield
	Kassab (FLIP 83-46C)	1986	Large-seeded, high yield
	Amdoun1 (Be-sel-81-48)	1986	Large-seeded
	FLIP 84-79C	1991	High yield
	FLIP 84-92c	1991	Large-seeded, high yield
Turkey	ILC 195	1986	Tall, cold tolerant
	Gunei Sarisi (ILC 482)	1986	High yield, wide adaptation
	Damla 89 (FLIP 85-7C)	1990	High yield, large-seeded
	Tasova 89(FLIP 85-135C)	1990	High yield, large-seeded
	Akcin (87AK71115)	1991	High yield
	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 Ascochyta blight (Ascochyta rabiei [Pass.] Lab.), in 1979 for cold, in 1981 for leaf miner (Liriomyza cicerina Rond), in 1982 for seed beetle (Callosobruchus chinensis L.), in 1986 for 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 for drought. Field screening techniques have been developed for Ascochyta blight, leaf miner, cold and drought. Wilt-sick plots developed near Cordoba, Spain and at Beja Station of INRAT, Tunisia are used for screening resistance against Fusarium wilt. 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 1992 for different stresses are shown in Table 2.1.5. The 1991/92 evaluations included 27 lines for resistance to Ascochyta blight, 2024 lines to cyst nematode, 1000 lines to Fusarium wilt, and 1000 lines to drought. Tolerant lines identified to cold during 1990/91 were grown in cold nursery for confirmation. 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.

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Table 2.1.5. Reaction of chickpea germplasm accessions to some biotic and abiotic stresses at Tel Hadya between 1978 and 1992.

Scale	Ascochyta blight	Fusarium wilt	Leaf miner until 1990	Leaf miner 1991[1]	Seed beetle	Cyst nematode	Cold	Drought[1]
1	0	0	0	0	0	0	0	0
2	0	2	0	19	0	0	0	0
3	10	0	0	93	0	0	3	1
4	22	26	8	148	0	0	10	10
5	9	57	201	162	0	20	1191	106
6	1444	155	509	68	164	0	1023	526
7	1833	251	1167	97	185	494	1014	290
8	1185	584	8	5	1551	1104	2284	66
9	14867	1547	3538	2	3253	7639	3570	1
Total	19370	2622	5431	594	5153	9257	9095	1000

Scale: 1 = free; 5 = tolerant; 9 = killed.
[1] Preliminary evaluation, needs confirmation.

2.1.2.2. Wild *Cicer* species

Evaluation of eight annual wild *Cicer* species continued for the fourth year to identify sources of resistance to different stresses. The highest susceptibility rating from the four-year evaluation of a line has been taken as the actual rating for that line. The results are summarized in Table 2.1.6. The evaluation during 1991/92 included 49 new accessions for resistance to cyst nematode and 31 lines to leaf miner. Sources of resistance were found for Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold. Wild species were the only source of resistance so far found for seed beetle and cyst nematode and 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. There is a need to evaluate the accessions for resistance to other important stresses such

Table 2.1.6. Reaction of germplasm accessions of *Cicer* spp. to some biotic and abiotic stresses at Tel Hadya, Syria from 1987/88-1991/92.

Scale[a]	Blight		F. wilt		Leaf miner		Seed beetle		Cyst nematatode		Cold	
	No.	species[b]	No.	species	No.	species	No.	species	No.	species	No.	species
1	0	0	72	1,4,5,6,7	2	2,6	20	1,3,4,5,7	3	6	0	0
2	1	2	0	0	36	1,2,3,5,6,8	12	1,5,6,7	1	0	25	1,7
3	4	1	7	1,5,7	36	1,4,5,6,7	4	1,7	17	1,6,7	38	1,4,5,6,7
4	2	5,6	15	1,5,6,7	33	1,4,5,6,7	3	1,6,7	0	1	34	1,4,5,6,7
5	22	5,6	6	5,6,7	61	1,5,6,7,8	3	3,5	28	1,7	13	6,7
6	29	1,5,6	4	5,6	26	1,4,5,6,7	8	1,5,7	0	1,8	7	5,6,8
7	24	1,4,5,6	4	6	23	1,4,5,6,7,8	18	2,4,5,7	49	1,2,3,4,5,7,8	8	2,5,6,8
8	30	4,5,6,7	0	0	1	8	52	2,5,6,7,8	0	1,5,6,7,8	8	5,6,8
9	81	2,3,4,5,6,7,8	5	6	3	1,8	10	5,6,8	144	2,3,4,5,6,7,8	62	2,3,5,6,7,8
Total	193		113		231		130		241		195	

[a] Scale: 1 = free; 5 = intermediate; 9 = killed/complete damage.
[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.

as drought and to collect additional accessions for evaluation.

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2.1.2.3. Listing 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. These have been used in breeding programs at ICARDA and NARSs. Differential disease race-patterns caused some lines to be resistant at ICARDA but susceptible elsewhere.

Table 2.1.7. Sources of resistance in cultigen to biotic and abiotic stresses identified between 1978 and 1992.

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.
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 482CT (Mut), ILC 482 (Mut) (M 17033).
Drought	FLIP 87-58C, FLIP 87-59C.

N.B. No source of resistance was found for seed beetle and cyst nematode.

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 30-2, ILWC 30/S-1, ILWC 31/S-1; C. pinnatifidum: ILWC 30-1.
Fusarium wilt	C. bijugum: 20; C. echinospermum: 4; C. judaicum: 31; C. pinnatifidum: 6; C. reticulatum: 11. Out of these: C. bijugum: ILWC 7-1, ILWC 8-3, ILWC 32 -2; C. echinospermum: ILWC 35/S-1, ILWC 39; C. judaicum: ILWC 4/3, ILWC 20/S-1, ILWC 46; C. pinnatifidum: ILWC 22-2, ILWC 29/S-2; C. reticulatum: ILWC 21-14, ILWC 36/3.
Leaf miner	C. chorassanicum: ILWC 23/3; C. cuneatum: ILWC 37/7; C. judaicum: ILWC 4/1, ILWC 4/3, ILWC 4/4, ILWC 20/3, ILWC 20/S-2, ILWC 31-2, ILWC 33/S-9, ILWC 33/S-10, ILWC 37/S-2, ILWC 41/1, ILWC 43/1, ILWC 46; Cicer yamashitae: ILWC 3-2.
Callosobruchus chinensis	C. bijugum: ILWC 7-1, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-14, ILWC 7/S-17, ILWC 7/S -18, ILWC 8-3, ILWC 34/S-1; C. cuneatum: ILWC 37/7; C. echinospermum: ILWC 35/S-1, ILWC 35/S-3, ILWC 39; C. judaicum: ILWC 3-1/2, ILWC 33/S-6, ILWC 33/S-8, ILWC 33/S-10, ILWC 38/S-2, ILWC 46; C. reticulatum: ILWC 21-1/1.
Cyst nematode	C. bijugum: ILWC 7-1, ILWC 7-2, ILWC 7-4, ILWC 7/S-1, ILWC 7/S-3, ILWC 7/S-4, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-14, ILWC 7/S-15, ILWC 7/S-17; C. reticulatum: ILWC 21-1-3/2; C. pinnatifidum: ILWC 212, ILWC 213, ILWC 226, ILWC 236.
Cold tolerance	C. bijugum: ILWC 7-1, ILWC 7-2, ILWC 7-4, ILWC 7/S-1, ILWC 7/S-3, ILWC 7/S-4, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-13, ILWC 7/S-14, ILWC 7/S-15, ILWC 7/S-17, ILWC 7/S-18, ILWC 8-4, ILWC 8/S-1, ILWC 8/S-3, ILWC 32-2, ILWC 42/1, ILWC 42/2.

Sources of resistance in wild Cicer species for Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold are given in Table 2.1.8. Whereas no line of cultigen was found resistant to two or more than two stresses, there were several accessions in wild Cicer species which were resistant to three or more stresses. A few of them are shown in Table 2.1.9. These accessions may be very useful in hybridization program for the transfer of genes for resistance.

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

Acc. no.	Cicer species	Blight	Wilt[a]	Leaf miner	Bruchid	Cyst nem.	Cold
32	bijugum	S	R	S	R	R	R
39	echinospermum	S	R	R	R	S	R
46	judaicum	S	R	R	R	S	S
62	bijugum	R	R	S	R	R	R
73	bijugum	R	R	S	R	R	R
79	bijugum	S	R	R	R	R	R
81	reticulatum	S	R	R	S	S	R
112	reticulatum	S	R	S	R	S	R
181	echinospermum	S	R	S	R	S	R
236	pinnatifidum	S	NE	R	NE	R	R

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

K.B. Singh et al.

2.1.3. Germplasm Enhancement

The main objective of this project is to develop superior germplasm for use in the breeding programs of NARS and ICARDA. The emphasis is on cold tolerance, Ascochyta blight resistance, combined resistance to cold and Ascochyta blight, and increased biomass.

2.1.3.1. Cold tolerance

F_4, F_5 and F_6 generations of crosses between cold-tolerant lines of diverse origins were grown during 1991/92. The winter was very severe, thus it provided an opportunity to select cold-resistant plants. Eleven, 14 and 39 plants were selected in F_4, F_5, F_6 generations, respectively. All these plants have cold rating of 3 which was as good as the two best germplasm from cultigen, ILC 8262 and ILC 482M. But these plants are agronomically superior having early maturity and large seed size.

R.S. Malhotra and K.B. Singh

2.1.3.2. Ascochyta blight resistance

Mutation studies: An attempt was made to induce Ascochyta blight-resistance in two chickpea cultivars (ILC 1929 and ILC 3279) to improve the level of resistance for use in the breeding program. Both genotypes have good agronomic qualities, but ILC 3279 is moderately resistant and ILC 1929 is highly susceptible to Ascochyta blight disease, taking a 3-4 and 9 ratings, respectively. One thousand seeds of ILC 1929 and ILC 3279 were treated with 40, 50, and 60 kR of gamma rays and with concentration of 0.1% or 0.2% of ethylmethane sulfate (EMS) at the Nuclear Institute of Agriculture and Biology, Faisalabad, Pakistan. The first three generations (M1 to M3) were advanced in the disease-free conditions. The M_4 generation was planted at the ICARDA farm in Tel Hadya in 1990/91. The chickpea field was inoculated first by spreading chickpea diseased-debris early in March which was supplemented with inoculations using spore suspensions of a mixture of pathogen isolates. Mist irrigation was applied to induce high humidity for epidemic development. Susceptible check was used as a reference of a good disease development.

Disease severity ratings were taken twice in the season on an individual plant basis. The first reading was taken at the vegetative stage for stem infection and the second reading at the podding stage for both stem and pod infection. Plants were considered resistance when they received a disease severity rating of 3 or less on a 1-9 scale.

Seeds of the plants showing resistance to both stem and pod infections were harvested individually (M_5). In the 1991/92 season, half seeds from each resistant plant were sown in the greenhouse and the other half in the field in order to re-evaluate their resistance to Ascochyta blight. The M_5 generation in the field was exposed to the blight epidemic as in 1991. In the greenhouse, seeds were planted in pots in sterilized soil and young seedlings were inoculated with a spore suspension of mixed isolates of the fungus. The pots were kept under a clear polyethylene cover for one week after inoculation to ensure proper conditions for infection. Disease ratings were taken on indivdual plants in the greenhouse twice, first at the vegetative stage and then at the flowering stage. In the field, readings were also taken at vegetative, late flowering and podding stages. The last two readings were taken on both stem and pod infections. Results represent the final and highest disease rating scored in all experiments.

No resistant plants were found among the 3274 plants of ILC 1929 studied in 1991. All of the 100 untreated ILC 1929 plants used as a check also showed complete susceptibility from the first reading. Of the total 10,084 single mutated ILC 3279 plants tested, only 45 were resistant (Table 2.1.10). But at the final stem rating only 26 also had a pod infection rating of ≤3. Of the 115 ILC 3279 plants screened as nonmutant checks, only one plant was resistant (Table 2.1.10).

Table 2.1.10. Frequency distribution of the disease severity ratings (DSR) on stems of the M_4 generation of ILC 3279 plants exposed to mutations; field results of 1990/91.

Treatment	DSR									Total
	1	2	3	4	5	6	7	8	9	
40 kR	0	0	10	239	875	712	190	36	17	2079
50 kR	0	0	10	154	715	1086	435	36	14	2450
60 kR	0	0	11	91	563	947	508	17	15	2152
0.1% EMS	0	1	8	80	488	760	380	16	5	1738
0.2% EMS	0	0	6	63	334	708	504	39	11	1665
Total	0	1	45	627	2975	4213	2017	144	62	10084
Control	0	0	1	1	36	52	23	2	0	115

Out of the total 236 ILC 3279 mutant plants tested in the greenhouse in 1992, 150 plants were found resistant (DSR ≤3) after the last reading. However, only 5 plants of the selected M_4 resistant plants of 1991 had all plants (M_5) resistant in the greenhouse test (Table 2.1.11).

Table 2.1.11. Disease severity of some ILC 3279 mutated <u>Ascochyta</u> resistant plants (M_4) whose progenies (M_5) still show acceptable resistance levels in the field and greenhouse in 1992 (disease in the M_5 expressed as the highest severity observed).

Treatment	Plant code	Field 1991 (M_4)		Field 1992 (M_5)		Greenhouse 1992 (M_5)
		Stem	Pod	Stem	Pod	Stem
40 kR	3-11	3	2	>4	1	4
	26-04	3	2	>4	1	3
	82-14	3	2	>4	1	3
	118-01	3	2	>4	1	4
	121-06	3	3	>4	1	4
50 kR	46-04	3	3	>4	1	4
	97-21	3	3	>4	1	3
	101-21	3	2	>4	1	3
60 kR	58-15	3	3	>4	1	4
	58-23	3	2	>4	1	3
ILC 3279	Control	3	2	>4	1	3

In the field, only 31 plants out of 270 plants tested were resistant on plant-row basis. All plants were resistant to pod infection. In the progeny rows of the resistant M_4 parents selected in 1991 there were always some plants susceptible as well as resistant (Table 2.1.11) and the variation in the resistance level within the progenies of resistant M_4 plants was quite high.

Comparing the different mutation treatments, the 40 kR treatment seemed to have the most positive effect on the resistance level of the plants at the seedling stage although this effect was no longer obvious at the later developmental stages of the plants.

The resistance screening conducted in 1990/91 and 1991/92 was on the M4 and M_5 generation, respectively. Accordingly, more homogeneity in the disease reaction was expected to be seen within the individuals coming from the same resistant parent. The large heterogeneity in the disease reaction in the more advanced generation of the plants suggests that the observed and selected resistance in the field in 1990/91 was actually a disease escape rather than true resistance.

W. Khoury and K.B. Singh

Pyramiding of genes for resistance to Ascochyta blight: Five crosses between different parents resistant to Ascochyta blight have been made in an attempt to pyramid genes for resistance. Six F_2 and 2 F_3 populations of crosses between resistant x resistant parents of diverse origin were grown in the Ascochyta blight nursery. Plants in each of these populations were bulk harvested and F_3 and F_4 bulks were advanced in the 1992 off-season nursery. The seed of F_4 and F_5 generation has been produced. The F_2, F_4 and F_5 generations will be grown in the disease nursery next season.

2.1.3.3. Combined resistance to cold and Ascochyta blight

In 1986, a project was begun to combine high level of resistance to cold and Ascochyta blight for use in breeding program. In the 1991-92 season, the material sown in cold and Ascochyta blight nursery is shown in Table 2.1.12. The winter was very severe and it destroyed much of

Table 2.1.12. Reaction of chickpea material to combined resistance to cold and Ascochyta blight at Tel Hadya, 1991/92.

Generation	Sown	Selected
F_6	130 progenies	8 plants
F_5	23 progenies	5 plants
F_4	17 progenies	18 plants
F_3	12 progenies	1 plant
F_2	6 bulks	5 bulks

material. Of the remaining, many progenies/plants succumbed to Ascochyta blight. As a result, none of the progenies was resistant. Only a few plants were resistant and 32 out of about 7300 plants were selected from F_3 to F_6 progenies. These will be reevaluated next season. The F_2 generation was sown in December, hence plants were only exposed to Ascochyta blight epidemic. But blight killed a lot of plants.

K.B. Singh and R.S. Malhotra

2.1.3.4. Increased biomass

In chickpea, one way to increase seed yield is through the increase in biomass yield. A project was initiated three years ago for this purpose. Under Tel Hadya conditions biomass yield is seldom higher than 7 t ha^{-1}, therefore target was kept at 10 t ha^{-1}. Crosses are being made to increase the plant height because plant height is positively associated with the biomass. During 1991-92, eight crosses were made in the main season and F_2 seeds were produced in the off-season. In the main season, five F_2 bulks were grown and tall plants were bulk harvested from two crosses. Three F_4 bulks between tall x tall crosses were grown in the main season and selection for tall plants were made from all crosses. The F_3 and F_5 bulks were grown in the 1992 off-season and seeds of F_4 and F_6 generation have been produced.

M. Omar and K.B. Singh

2.1.4. Improved Germplasm for Wheat-based System

A bulk-pedigree method for breeding cold and Ascochyta blight resistant chickpeas was described in the program annual report of 1989 and the second for breeding combined resistance to blight, cold and drought in the annual report of 1990. Both methods take full advantage 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 and have been released as cultivars.

K.B. Singh

2.1.4.1. Segregating generations

During the 1991/92 season, 456 crosses were made, of which 267 were grown in the off-season during 1992. F_2 and F_4 bulks were grown in the main season and F_3 bulks in the off-season (Table 2.1.13). About 10,000

Table 2.1.13. Chickpea breeding material grown at Tel Hadya during winter and spring and at Terbol during off-season, 1991/92.

Generation	No. of bulk/ progeny grown	No. of plants selected	No. of bulked progenies
F_0	456	-	-
F_1	267	-	-
F_2 Bulk	241	-	-
F_3 Bulk	169	-	-
F_3 Progeny	746	686	-
F_4 Bulk	386	14,865	-
F_5 Progeny (Large)	200	8	10
F_5 Progeny (Early)	255	8	23
F_5 Progeny (Desi)	52	12	-
F_5 Progeny (Others)	5811	752	288
F_6 Progeny (Large)	239	-	18
F_6 Progeny (Tall)	366	-	36
F_6 Progeny (Early)	607	-	29
F_6 Progeny (Desi)	234	100	-
F_6 Progeny (Others)	1808	-	60
Total:			
$F_2/F_3/F_4$ Bulks	796	14,865	-
$F_3/F_4/F_5/F_6$ Progeny	10,318	1566	464

progeny rows were grown. A total of 464 promising and uniform F_5 and F_6 progenies were bulked, grown in the off-season and purified for multi-season evaluation. Due to infestation by wilt root-rot complex, late maturity, and poor growth habit, 167 lines had to be rejected, leaving only 297 for evaluation in the yield trials next season.

The weather conditions of the 1991/92 season permitted effective selection for cold tolerance and Ascochyta blight resistance.

K.B. Singh

2.1.4.2. Yield performance of newly bred lines

Three hundred and twelve newly-bred lines were evaluated in preliminary yield trials (PYTs) and 216 lines in advanced yield trials (AYTs) for yield at three locations (Tel Hadya, Jinderess and Terbol) by sowing in winter and spring. Due to severe infestation of root-knot nematode in PYTs at Jindiress, all trials were discarded. Several lines were superior in yield over the check, although only a few were significantly better (Table 2.1.14). The 1991/92 season favored spring chickpea because of very severe winter and wet spring. Consequently, winter chickpea produced a mere 23.4% more yield than spring chickpea against the average of 71% increase in yield over the past eight years.

K.B. Singh

2.1.4.3. Performance of FLIP 88-85C in multilocation tests in Syria

Chickpea line FLIP 88-85C had an impressive yield performance in Syria during the 1991/92 winter season. It ranked first at six out of nine locations and ranked first in overall performance. The mean yield of this line was 3113 kg ha^{-1} with a range of 2088 to 4204 kg ha^{-1} (Table 2.1.15). 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. These nine locations are spread all over Syria and had a very divergent agroclimatic conditions. FLIP 88-85C has a 100-seed weight of 35 g, excelling the check by 20%. FLIP 88-85C is highly resistant to both Ascochyta blight and cold. It has been developed from a cross ILC 629 x FLIP 82-144C.

Syrian National Scientists and K.B. Singh

2.1.4.4. Performance of blight-resistant lines under diseased and disease-free conditions

During the 1990/91 season, 1344 blight-resistant breeding lines developed between 1980 and 1989 were re-evaluated for resistance to Ascochyta blight by inoculating material with diseased debris supplemented by spore suspension prepared from six races. Results revealed that only 117 lines remained resistant (see details from Legume Program Annual Report for 1991, pp 30-31). These 117 lines along with 240 lines, which were developed during 1990 and 1991, were re-evaluated for yield under diseased and disease-free conditions during the 1991/92 season along with 19 blight-resistant germplasm lines and 4 high yielding land races. Alpha design with 2 replications was adopted. The plot size was 2.5 m x 2 rows, 45 cm apart under disease-free condition and 1.75 m x 2 rows, 45cm apart in diseased conditions. The experiment was conducted in two separate fields. The disease-free condition trial was protected from Ascochyta blight by repeated spray of Bravo 500 and no disease developed here.

Table 2.1.14. Performance of newly developed lines during winter and spring sowing at Tel Hadya, Jindiress and Terbol, 1991/92.

Location and season	No. of trials	Entries: Tested	Entries: Exceeding check	Entries: Signif. exceeding check	Yield (kg/ha): Mean of location	Yield (kg/ha): Mean of highest yield	Range for: C.V. (%)	Range for: LSD ($P \leq 0.05$) (kg ha)
Tel Hadya								
-Winter	22	528	226	28	1782	2302	8-27	289-889
-Spring	22	528	41	1	1316	1826	9-19	243-778
Jindiress								
-Winter	9	216	116	3	1837	2284	8-17	342-644
-Spring	22	528	35	0	1644	1978	8-13	265-531
Terbol								
-Winter	22	528	231	28	2369	3150	9-33	425-1788
-Spring	22	528	76	1	1893	2519	10-25	443-1112
Overall								
-Winter	-	-	-	-	1996	-	-	-
-Spring	22	528	-	-	1618	-	-	-

Table 2.1.15. Performance of FLIP 88-85C chickpea at nine locations in Syria, 1991/92.

Location	Yield (kg/ha) and rank				Mean yield (kg/ha) of 24 entries	CV (%)	SE ±
	FLIP 88-85C		Ghab 3 (check)				
	Yield	Rank	Yield	Rank			
Tel Hadya	2088	3	1580	18	1732	11.9	119.0
Jindiress	2633	3	1456	24	2038	22.7	267.1
Izraa	3306	2	2204	23	2767	27.1	433.6
Jellin	2674	1	2061	18	2193	13.6	171.7
Homs	3921	1	3509	5	3223	13.8	256.3
Hama	3825	1	2894	17	2988	11.2	192.5
Ghab	4204	1	3538	15	3622	12.6	263.7
Idleb	3241	1	2612	7	2441	21.1	297.3
Heimo	2122	1	1889	2	1690	13.0	126.4
Mean	3113	1	2416	19	2552	-	-

Whereas the disease condition trial was inoculated with disease debris supplemented by spore suspension spray prepared from a mixture of six races, here the disease developed in epidemic form. Observations were recorded on days to flower and maturity, plant height, biological yield, seed yield, and 100-seed weight under both conditions. In diseased plots, Ascochyta blight score on a 1-9 scale was recorded. Due to poor stand, data were not collected on three lines.

Results under diseased- and disease-free conditions could be compared with some reservation because the crop had to be mist irrigated repeatedly in diseased-field to create the epiphytotic condition. Also variations in soil fertility in two fields cannot be ruled out.

Table 2.1.16. Summary of the performance of blight-resistant breeding lines, blight-resistant germplasm lines and high yielding land races under diseased condition.

Character	No. of lines	Mean	Range	C.V (%)	S.Em. (±)
Resistant breeding lines					
AB	357	3.2	2.5-5.5	12.46	0.021
DFLR	357	139	133-147	2.05	0.151
DMAT	357	192	189-196	0.70	0.072
PLHT	357	49	30-70	14.67	0.380
BYLD	357	4536	349-7982	26.76	64.240
SYLD	357	1812	193-3080	26.44	25.369
100SW	357	33	15-47	16.13	0.284
Resistant germplasm lines					
AB	19	3.3	3.0-8.0	34.83	0.263
DFLR	19	140	138-146	1.88	0.604
DMAT	19	191	189-194	0.68	0.299
PLHT	19	47	35-58	15.41	1.648
BYLD	19	3131	11-5201	52.94	380.312
SYLD	19	1363	34-2197	50.94	159.296
100SW	19	24	18-30	18.89	1.036
High yielding landraces					
AB	4	7.4	4.0-9.0	31.06	1.145
DFLR	4	136	127-142	4.72	3.210
DMAT	3	192	191-193	0.56	0.617
PLHT	3	41	39-43	4.56	1.068
BYLD	3	1146	0-3229	159.87	1057.57
SYLD	3	386	0-1275	200.18	446.271
100SW	3	31	26-36	16.80	2.968

AB = Ascochyta blight score, DFLR = Days to 50% flowering, DMAT = Days to maturity, PLHT = Plant height (cm), BYLD = Biological yield (kg/ha), SYLD = Seed yield (kg/ha), 100SW = 100-seed weight (g).

The mean seed yield under diseased condition was 1813, 1363 and 386 kg ha^{-1} for resistant breeding lines, resistant germplasm lines and high yielding land races, respectively (Table 2.1.16). In the disease-free condition, the mean seed yield was 2698, 2141 and 2956 kg ha^{-1} for resistant breeding lines, resistant germplasm lines and high yielding land races respectively (Table 2.1.17). These results clearly indicated that on average 33% improvement in yield has been achieved over resistant germplasm lines through breeding and that high yielding land races are not good under diseased conditions.

Ten highest yielding breeding lines, one each highest yielding germplasm line and land races under diseased and disease-free conditions are shown in Table 2.1.18. There is a clear improvement in yield through breeding over resistant parental lines and land races. Under disease-free condition some breeding lines produced over 4000 kg ha^{-1} yield, whereas the highest yield of the germplasm line and land race was 2865 and 3410 kg ha^{-1}, respectively. Under diseased conditions the gain over the highest yielding land race was substantial (141.6%).

Table 2.1.17. Summary of the performance of blight-resistant breeding lines, blight resistant germplasm lines and high yielding land races under disease-free condition.

Character	No. of lines	Mean	Range	C.V (%)	S.Em. (±)
Resistant breeding lines					
DFLR	355	134	129-152	1.62	0.116
DMAT	355	183	180-186	0.67	0.065
PLHT	355	51	35-70	13.39	0.363
BYLD	355	6126	770-9123	15.98	51.976
SYLD	355	2698	414-4059	17.57	25.163
100SW	355	32	18-44	14.69	0.248
Resistant germplasm lines					
DFLR	18	136	132-139	1.48	0.474
DMAT	18	183	181-186	0.76	0.328
PLHT	18	50	37-60	12.45	1.459
BYLD	18	5013	2061-8099	26.75	316.059
SYLD	18	2141	635-2865	25.80	130.193
100SW	18	23	18-28	14.20	0.783
High yielding landraces					
DFLR	4	129	117-135	6.20	4.002
DMAT	4	182	181-184	0.59	0.537
PLHT	4	39	36-41	5.88	1.141
BYLD	4	5995	4627-7290	20.98	628.951
SYLD	4	2956	2377-3410	15.04	222.313
100SW	4	40	28-58	31.43	6.291

Correlations of seed yield under diseased condition with othercharacters were estimated and shown in Table 2.1.19. Seed yield was significantly ($P \leq 0.05$) correlated with Ascochyta blight resistance, the higher the resistance the better the yield. Seed yield had the highest correlation of $r = 0.829$ ($P \leq 0.01$) with biological yield. Whereas Ascochyta blight was significantly correlated with late maturity and plant height in resistant germplasm lines, it had no association with maturity and height in resistant breeding lines. This is an important achievement of breeding because seed yield in chickpea is strongly negatively correlated with lateness.

The mean seed yield of lines in different Ascochyta blight susceptibility classes on 1-9 scale is shown in Table 2.1.20. The seed yield was the highest in category 2 and there was a continuous decline in yield as the disease severity increased from 2 to 9. In fact, there was zero yield in lines rated 8 or 9. The regression equation for yield was: $[(SYLD = 2874.5 \pm 127.0) - (340.7 \pm 38.8)(AB)]$ where AB is Ascochyta blight score. The results are shown in Figure 2.1.1.

The major conclusions of this experiment are as follows. First, 33% improvement in yield has been achieved over the resistant parent through breeding. Second, the highest yielding breeding lines yield significant better than the best land race both under disease-free and diseased conditions. The susceptible land races cannot be recommended to be grown in disease-prone areas. Third, through breeding linkage of Ascochyta blight resistance with late maturity has been broken. Now there are early maturing lines with blight resistance and high yield.

Fifth, there is a decline 472 kg ha^{-1} with the increase of severity of one class reaching zero yield with eight and nine classes.

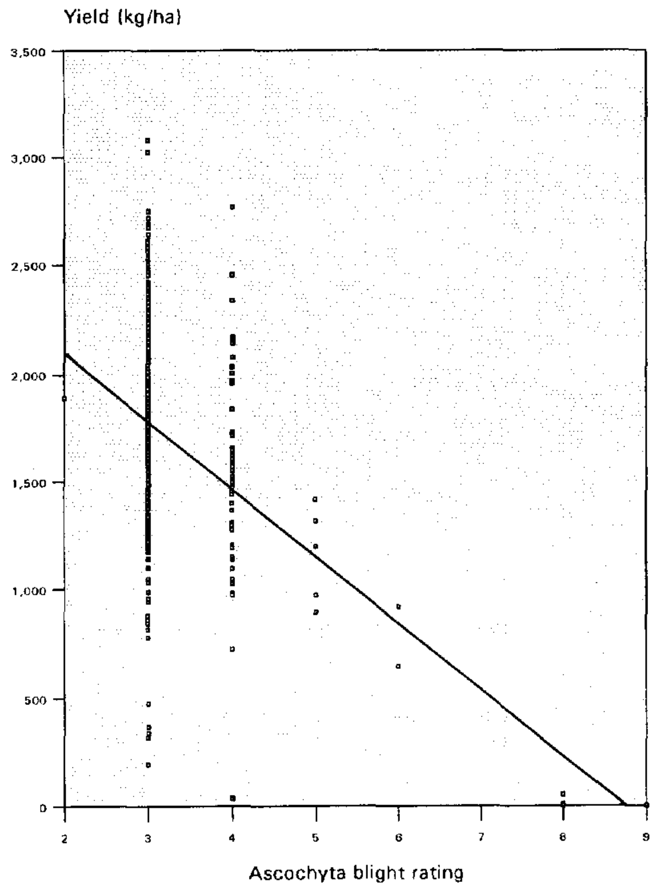

Fig. 2.1.1. Relationship between Ascochyta blight disease score and yield of chickpea.

Table 2.1.18. Yield performance of 10 highest yielding breeding lines compared with the best resistant germplasm line and land race under diseased and disease-free conditions in a replicated yield trial.

Entry name	Seed yield (kg ha^{-1})
Disease-free conditions	
FLIP 91-50C	4059
FLIP 81-270C	4004
FLIP 91-205C	3955
FLIP 91-46C	3752
FLIP 84-79C	3670
FLIP 82-97C	3621
S 91342	3606
FLIP 81-299C	3572
FLIP 90-98C	3546
S 91331	3528
ILC 5894 (germplasm line)	2865
ILC 263 (land race)	3410
Diseased conditions	
FLIP 91-204C	3080
FLIP 91-180C	3025
FLIP 81-7C	2770
FLIP 82-144C	2754
FLIP 88-83C	2750
FLIP 90-98C	2719
FLIP 91-201C	2691
S 91242	2675
FLIP 90-64C	2644
FLIP 91-28C	2617
ILC 5586 (germplasm line)	2197
ILC 482 (land race)	1275

Table 2.1.19. Correlation of seed yield with other characters in diseased conditions.

	ABR	DFLR	DMAT	PLHT	BYLD	SYLD	100SW
ABR	1.000	-0.377	0.147	-0.163	-0.393	-0.428	-0.080
DFLR	-0.038	1.000	0.410	0.238	-0.060	-0.231	0.154
DMAT	0.147	0.410	1.000	0.241	0.138	-0.130	0.435
PLHT	-0.163	0.238	0.241	1.000	0.592	0.306	0.492
BYLD	-0.393	-0.060	0.138	0.592	1.000	0.857	0.499
SYLD	-0.428	-0.231	-0.130	0.306	0.857	1.000	0.309
100SW	-0.080	0.154	0.435	0.492	0.499	0.309	1.000

Table 2.1.20. The mean and range of seed yield (kg/ha) of different classes of Ascochyta blight.

Class	No. of entries	Mean ± S.Em.	Range
2	1	1895	-
3	316	1847±27.0	193-3080
4	52	1564±64.2	34-2770
5	5	1158±100.0	890-1417
6	2	779±136.7	643-916
8	3	0	0
9	1	0	0

2.1.4.5. Performance of newly bred lines at ICARDA sites in winter sowing

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

Winter-sown trials on average produced 1621 kg/ha against 1005 kg of spring-sown trials, giving 61.3% or 616 kg/ha more yield (Fig. 2.1.2). The

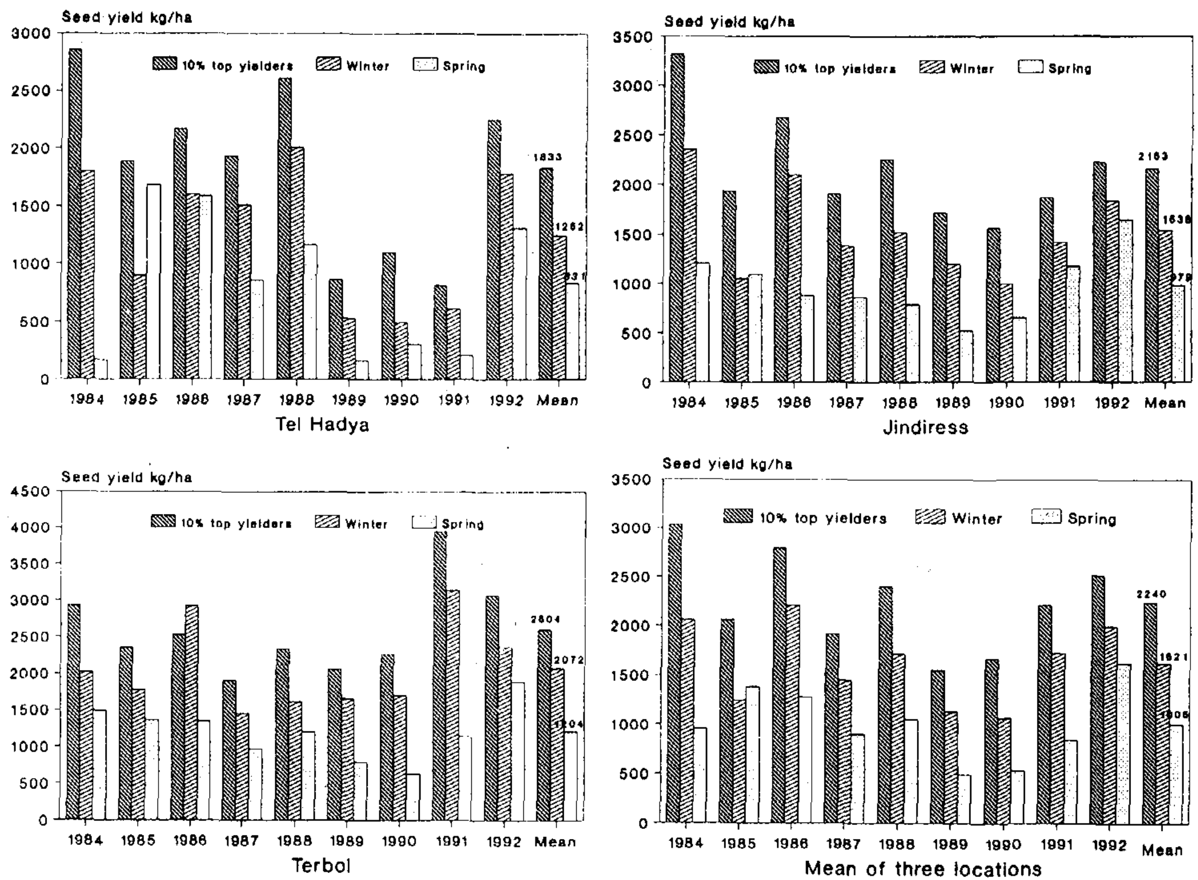

Figure 2.1.2. Mean seed yield (kg ha^{-1}) of chickpea grown in winter and spring at three locations and eight years.

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 1988/89, 1989/90 and 1991/92 seasons which were also very cold, because of deliberate selection for cold tolerance since 1984/85. Breeders usually select the top 10% for further evaluation and possible release; these 10% top yielders in winter sowing produced 122.9% or 1235 kg/ha more than the mean yield produced in spring over eight years.

K.B. Singh

2.1.4.6. Spread of winter chickpea in the Mediterranean environment

Adoption 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 and by 1991/92 an estimated 20,500 ha was winter sown. 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. Winter sowing of chickpea has been adopted in other continents as well where the Mediterranean environments exist. California (U.S.A.), which grew chickpea during spring, has now introduced winter sowing in Central Valley. Nearly all chickpea area in Western Australia is sown in winter. Likewise Chile has introduced winter sowing of chickpea. A guesstimate of area under winter-sown chickpea in different countries is shown in Table 2.1.21 and the evolution of total winter-sown area is shown in Fig. 2.1.3.

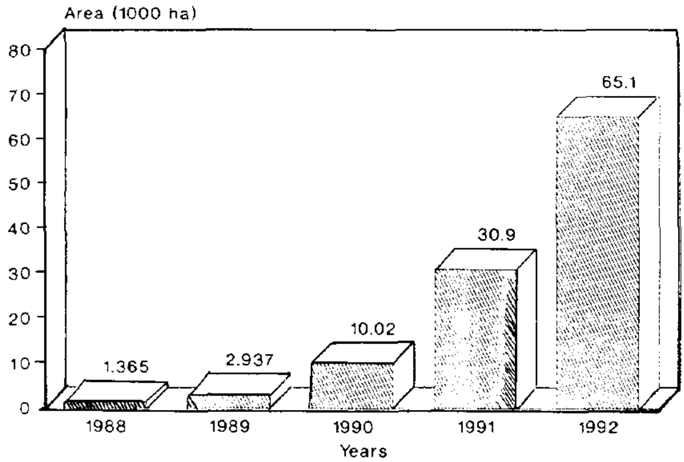

Figure 2.1.3. Guesstimated adoption of winter-sown chickpea in the Mediterranean areas in the world, 1991/92.

Table 2.1.21. A guesstimate of adoption of winter-sown chickpea in the Mediterranean environments in the world, 1991/92.

Country	Area (ha)
Cyprus	1500
Iraq	1000
Jordan	2000
Lebanon	1000
Syria	20500
Turkey	10000
Algeria	2500
Egypt	5000
Morocco	3000
Tunisia	3000
France	1000
Italy	3000
Portugal	4000
Spain	5000
Western Australia	1000
U.S.A. (California)	1500
Chile	100

2.1.5. Strategic Research

2.1.5.1. Studies on drought tolerance

Little research has been conducted on drought tolerance of kabuli chickpea in a Mediterranean environment. A line-source sprinkler system is being used to evaluate genotypic differences, but a screening technique is necessary that permits evaluation of a large number of germplasm and breeding materials for tolerance to drought. Since the crop experiences terminal drought, it was thought worthwhile to test the effect of delayed spring sowing to accentuate the stress effects to permit identification of genotypic differences in drought tolerance. An experiment with four sowing dates, 28 Feb (normal sowing date), 10 Mar, 20 Mar, and 30 Mar and 25 genotypes varying in maturity, plant height, seed size, and seed yield, was conducted at Tel Hadya during 1990. This study indicated that sowing on 20 or 30 Mar can be effective in distinguishing drought-susceptible lines from tolerant ones.

Following this lead, this experiment was repeated in 1991 by sowing on 28 Feb and 20 Mar 1991 with and without irrigation. The irrigation treatment was included to obtain potential yield to enable comparison with the yield obtained under moisture stress conditions.There was a gradual reduction in the performance for all characters with delay in sowing from first to second date. However, seed size, seed yield, biological yield and harvest index were higher with irrigation over rainfed. Some genotypes produced good yield on both dates of sowing under rainfed conditions, but their performance under irrigated conditions was just average. On the contrary, other genotypes produced little yield on the first date of sowing, but virtually no yield was produced by them on the second date of sowing under rainfed conditions. Their performance under irrigated conditions was equally bad. The former group of genotypes was early in maturity while the latter group was late in maturity. The best performing lines under rainfed conditions (i.e., drought-tolerant ones) produced 50-60% of the potential yield on the first date of sowing and 35-45% of the potential yield on the second date of sowing, whereas the drought-susceptible lines produced less than 10% of the potential yield. There was no association between the performance of genotypes under rainfed and irrigated conditions.

In order to confirm the findings of the first two years, the experiment was repeated in the third year by sowing on 28 Feb and 20 Mar 1992 without and with irrigation to ensure that the available soil moisture does not fall below 50% in the active root zone. The plot size was 4 rows, 4 m long with 30-cm row spacing. Split-plot design was used with three replications for each date. Observations were collected on 15 morphological, phenological and seed characters. In addition, the amount of soil moisture was determined at sowing, and plant count at emergence and maturity, percent of emergence, and canopy temperatures at late vegetative, flowering and pod filling stages were recorded.

Mean performance of genotypes for 12 characters at each date and for rainfed and irrigated conditions is shown in Table 2.1.22. In general, there was a reduction in performance for most characters with delay in sowing. However, the reduction was not as sharp as in other two years because spring was wet and even rains occurred in early June which favored delayed sowing more than normal sowing. Nevertheless, the mean performance of genotypes under irrigation was better than rainfed for yield and yield contributing characters such as biological yield, pod number and secondary branches.

Table 2.1.22. Genotypic means for different characters on two dates of sowing and two levels of moisture regimes (rainfed and irrigated) during the 1992 spring.

Characters	Dates of sowing						Genotype
	28 Feb		20 Mar		Mean		
	Rain.	Irrig.	Rain.	Irrig.	Rain.	Irrig.	mean
Days to flowering	63	66	52	54	58	60	59
Days to maturity	106	120	92	99	99	110	105
Plant height (cm)	29	41	30	39	30	40	35
Primary branches	10.1	9.1	10.6	10.0	10.3	9.6	99
Secondary branches	20.8	24.5	24.8	24.9	22.8	24.7	238
No. of pods	20	27	20	27	20	27	235
No. of filled pods	17	22	19	24	18	23	205
% of filled pod	85	81	95	89	90	85	875
100-seed weight (g)	32	31	30	30	31	31	308
Seed yield (kg/ha)	1802	3085	1629	2576	1716	2831	1416
Biol. yield (kg/ha)	3862	6856	3689	5917	3776	6387	3194
Harvest index (%)	46	45	44	43	45	44	445
Score*	5.4	4.4	6.1	4.4	5.8	4.4	51

* Visual rating at maturity for overall assessment of drought susceptibility on a 1-9 scale, where 1 = no damage, 5 = intermediate level of damage, 9 = killed.

Overall, yield only reduced 10.8% and 17.8% under rainfed and irrigated conditions respectively from the first date to second date (Table 2.1.23). Four genotypes (FLIP 87-51C, FLIP 87-58C, FLIP 87-59C, and ICC 4958) performed well in both dates of sowing yielding nearly

Table 2.1.23. Yield (Y) performance (kg/ha) and rank (R) of different chickpea genotypes in the drought study, as affected by two dates of sowing and at two levels of moisture (rainfed and irrigated) during the 1992 spring.

Genotype	Dates of sowing						Mean		
	28 Feb			20 Mar					
	Rainfed Y(R)	Rain. Y % of irrig.	Irrig. Y(R)	Rainfed Y(R)	Rain. Y % of irrig.	Irrig. Y(R)	Rainfed Y(R)	Rain. Y % of irrig.	Irrig. Y(R)
ILC 72	947(25)	41.0	2311(26)	885(25)	49.4	1790(26)	916(25)	44.7	2051(26)
ILC 3279	1431(23)	57.8	2476(24)	1030(23)	50.6	2035(24)	1231(23)	54.6	2256(24)
FLIP 85-142C	913(26)	37.6	2431(25)	817(26)	43.2	1890(25)	865(26)	40.0	2161(25)
FLIP 86-12C	1235(24)	45.6	2708(21)	952(24)	43.3	2199(22)	1094(24)	44.6	2454(20)
ICCV 88504	1639(21)	63.7	2575(22)	1450(21)	66.8	2172(23)	1545(21)	65.1	2374(22)
ICCV 88512	1629(22)	63.7	2557(23)	1332(22)	59.5	2239(21)	1481(22)	61.8	2398(21)
ILC 1929	1959(9)	57.4	3414(6)	1944(5)	62.5	3112(1)	1952(6)	86.3	2263(23)
ILC 482	1966(8)	63.5	3094(14)	1716(15)	64.2	2671(13)	1841(10)	63.9	2883(15)
ILC 1919	1899(12)	61.2	3105(13)	1750(12)	65.7	2664(14)	1825(12)	63.3	2885(13)
FLIP 87-5C	1869(14)	64.1	2916(18)	1576(18)	56.5	2790(10)	1723(18)	60.4	2853(16)
FLIP 87-7C	2122(5)	61.4	3454(5)	1686(16)	55.0	3068(3)	1904(7)	58.4	3261(3)
FLIP 87-8C	2033(7)	59.8	3401(7)	1724(14)	57.4	3006(4)	1879(8)	58.6	3204(5)
FLIP 87-51C	2197(2)	61.1	3598(4)	2131(2)	77.3	2758(11)	2164(1)	68.1	3178(6)
FLIP 87-58C	2141(1)	58.3	3672(2)	1979(4)	63.9	3099(2)	2060(4)	60.8	3386(1)
FLIP 87-59C	2123(4)	57.4	3697(1)	2152(1)	72.1	2986(5)	2138(3)	64.0	3342(2)
FLIP 87-80C	1835(16)	64.5	2844(20)	1512(20)	64.8	2333(20)	1674(19)	64.7	2589(19)
FLIP 87-85C	1893(13)	55.9	3388(8)	1858(6)	64.2	2893(7)	1876(9)	59.7	3141(7)
ILC 710	1769(19)	59.9	2952(17)	1801(8)	61.8	2916(6)	1785(15)	60.8	2934(10)
ILC 830	1910(11)	66.7	2862(19)	1596(17)	60.6	2634(16)	1753(17)	63.8	2748(17)
ILC 1130	1924(10)	62.8	3063(15)	1727(13)	63.8	2705(12)	1826(11)	63.3	2884(14)
ILC 1141	2087(6)	66.3	3150(12)	1829(7)	65.3	2803(9)	1958(5)	65.8	2977(8)
ILC 1687	1779(18)	56.3	3156(11)	1788(9)	67.3	2657(15)	1784(16)	61.4	2907(12)
ILC 1748	1797(17)	55.3	3249(10)	1775(10)	68.6	2588(17)	1786(14)	61.9	2919(11)
ILC 6104	1850(15)	55.8	3316(9)	1759(11)	68.3	2576(18)	1805(13)	61.3	2946(9)
ILC 6118	1745(20)	57.3	3048(16)	1541(19)	63.6	2422(7)	1643(20)	60.1	2735(18)
ICC 4958	2230(1)	61.9	3602(3)	2055(3)	71.0	2893(7)	2143(2)	66.0	3248(4)
Mean	1805	58.6	3078	1629	62.4	2612	1717	60.4	2845
C.V. (%)								2.70	
SE of difference between two date means								102.5	
SE of difference between two genotype means								112.0	
SE of difference between two genotype means at the same level of the date									202.7
SE of difference between two date means for the same genotype mean or for different levels of the entry									

2t/ha, and very little reduction in yield was noticed with delayed sowing. Under rainfed conditions, these four drought-tolerant lines produced nearly 70% yield of that obtained under irrigated conditions on the second date of sowing, as against only 48% produced by the drought-prone genotypes.

Correlations of seed yield with other characters on two dates of sowing and two irrigated conditions are given in Table 2.1.24. Like

Table 2.1.24. Correlation of seed yield with other variables as affected by two dates of sowing and two levels of moisture regimes at Tel Hadya in the 1992 spring.

Variable	Date of sowing			
	(28 Feb)		(20 Mar)	
	Rainfed	Irrigated	Rainfed	Irrigated
Days to flowering	-0.6126	-0.6545	-0.6595	-0.5678
Days to maturity	-0.6618	0.0190	-0.7879	-0.4097
Plant height (cm)	-0.5898	-0.4394	-0.6957	-0.4118
Primary branches	-0.1024	-0.3178	-0.1522	-0.0512
Secondary branches	0.1072	0.0673	-0.2883	-0.0729
Pod number	0.2045	0.1191	0.2045	-0.0793
Filled pod	0.1051	-0.0007	0.1782	-0.1403
% filled pod	-0.3465	-0.3237	-0.0975	-0.2733
Shoot biomass (kg/ha)	0.6444	0.6378	0.7184	0.6829
Harvest index (%)	0.8519	0.5507	0.8446	0.4536
100 seed weight (g)	0.0546	0.2666	0.0320	0.2028
Rating score	-0.7644	-0.7190	-0.8671	-0.7570

the previous two seasons, yield was positively associated with early maturity and total biological yield and negatively correlated with height ($P \leq 0.01$). Other characters had no association.

Three general conclusions can be drawn from these studies: First, drought-tolerant lines, in general, are early maturing. Second, lines will be preferred which perform well under dry conditions but are able to take full advantage of any additional moisture available. (For example, FLIP 87-58C and FLIP 87-59C performed equally well under the dry spring of 1990 and 1991 and wet spring of 1992. Whereas, ILC 6104 and ILC 6118 performed well under the dry spring of 1990 and 1991, but did not do well under wet spring). Third, sowing on 20 Mar seems appropriate for screening drought-resistant chickpeas.

The seed yield data from three years (1990, 1991 and 1992) were used for stability analysis. The analysis of variance of seed yield per plot is presented in Table 2.1.25. The genotype X year component was highly significant indicating that genotypes differed markedly in response to environmental changes. The average mean seed yield per plot (X) for 25 genotypes along with their regression coefficient (b) and coefficient of determination (R^2) are given in Table 2.1.26. Seed yield per plot averaged from 274 to 1125 kg/ha. The genotype FLIP 87-59C gave seed yield/plot greater than other genotypes. The low variance estimate of this genotype reflected the low variability of its performance over the three years. The genotypes FLIP 87-51C and ILC 1929 performed in the same manner. These genotypes are thus the most stable and high yielding genotypes with great potential for spring sowing.

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Table 2.1.25. Pooled analysis of variance for seed yield/plot of 25 chickpea genotypes grown in three years at Tel Hadya, Syria 1990, 1991 and 1992.

Source of variation	D.F.	Mean square	F value
Genotype	24	169592	7.68**
Genotype x date x moisture	74	479639	21.73**
Genotype x Year + Year	50	628461	28.47**
Year	1	29798300	1349**
Entry x Year (linear)	24	44701	2.02*
Pooled deviations	25	22077	3.31**
Pooled error	144	6663	

Table 2.1.26. The average performance of 25 genotypes of chickpea grown in three years 1990, 1991 and 1992 at Tel Hadya, Syria.

Genotype	Mean yield (kg/ha)	Regression coefficient	coefficient of determination
ILC 72	299	0.626	0.9064
ILC 3279	371	0.715	0.9330
FLIP 85-142C	274	0.577	0.9000
FLIP 86-12C	352	0.659	0.9476
ICCV 88504	653	0.961	0.9966
ICCV 88512	591	0.870	0.9995
ILC 1929	1004	1.170	0.9778
ILC 482	825	1.063	0.9992
ILC 1919	774	1.137	0.9978
FLIP 87-5C	861	0.872	0.9913
FLIP 87-7C	849	1.033	0.9843
FLIP 87-8C	875	1.012	0.9995
FLIP 87-51C	1093	1.286	0.9807
FLIP 87-58C	966	1.150	0.9849
FLIP 87-59C	1125	1.225	0.9993
FLIP 87-80C	586	1.062	0.9913
FLIP 87-85C	943	1.116	0.9915
ILC 710	879	1.130	0.9888
ILC 830	729	1.024	1.0000
ILC 1130	810	1.114	0.9935
ILC 1141	741	1.230	0.9804
ILC 1687	792	1.098	0.9543
ILC 1748	951	1.051	0.9536
ILC 6104	959	0.988	0.9837
ILC 6118	862	0.831	0.9893
Mean 766.6 kg/ha			

2.1.5.2. Effect of plant density on cold tolerance in chickpea

Five genotypes with varying level of cold tolerance were used to study the effect of three plant densities, (33.33, 44.44, and 66.66 plants per m^2) on their cold tolerance at Tel Hadya and Breda for two years. The analysis of variance for cold tolerance at different locations and years revealed that mean square due to plant density was non-significant at Tel Hadya in both seasons, whereas it was significant only at Breda in 1991/92 (Table 2.1.27). This indicated that increased

Table 2.1.27. Analysis of variance for cold tolerance at various plant densities at Tel Hadya and Breda during 1990/91 and 1991/92 seasons.

Source of variation	d.f.	Mean square 1990/91 Breda	Mean square 1990/91 Tel Hadya	Mean square 1991/92 Breda	Mean square 1991/92 Tel Hadya
Replication	2	0.269 ns	0.478 ns	0.133 ns	0.211 ns
Date (D)	1	9.025 **	46.944 *	9.344 *	41.344 **
Error A	2	0.058	0.144	0.178	0.211
Population (P)	2	0.136 ns	0.211 ns	0.433 *	0.144 ns
D x P	2	0.525 ns	0.211 ns	0.478 *	0.144 ns
Error	8	0.281	0.528	0.089	0.111
Entry (E)	4	30.997 **	50.739 **	93.961 **	99.378 **
D x E	4	5.136 **	5.639 **	0.706 **	5.678 **
E x P	8	0.226 ns	0.322 *	0.128 ns	0.061 ns
D x P x E	8	0.532 *	0.239 ns	0.256 ns	0.061 ns
Error B	48	0.200	0.150	0.181	0.033

* $P \leq 0.05$, ** $P \leq 0.01$

plant density, in general, had little effect on the cold tolerance of chickpea.

R.S. Malhotra, K.B. Singh and M.C. Saxena

2.1.5.3. Inheritance of resistance to race 4 of Ascochyta rabiei

Inheritance of resistance to race 4 of Ascochyta rabiei was studied in 15 germplasm accessions in greenhouse during 1991/92. Resistance in ILC 200, ILC 5921, ILC 6043 and ILC 6090 was governed by a single recessive gene. Whereas, resistance in ILC 202 and ILC 2956, was governed by two recessive complementary genes and in ILC 5586 by two dominant complementary genes. Resistance in ILC 2506 was controlled by two recessive genes with epistasis. Resistance in ILC 3279, ILC 3856 and ILC 4421 was controlled by 3 recessive genes. Resistance in ILC 72, ILC 182, ILC 187 and ILC 5902 was more complex.

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2.1.5.4. Transferability of selection indices from drought-free to drought-prone environments in chickpea

An experiment was conducted at two drought-free and one drought-prone locations in Syria and Lebanon during the spring for three years (1989-1991) to determine the transferability of selection indices from one set of environment to another with a view to assess the possibility of selecting an environment appropriate for the development of cultivars adapted to both sets of environments. Each year, 192 to 240 newly-bred lines were evaluated in replicated trials for seed yield, days to flowering and maturity, plant height, and 100-seed weight. Correlation study showed that increased seed size, early maturity and reduced plant height at drought-prone location and early maturity at drought-free locations were of prime importance in increasing seed yield. Regression equations developed to predict seed yield showed that days to flower and maturity accounted for 67 to 80% variation in seed yield at dry location, whereas at drought-free locations contribution of days to maturity was little except in 1991 at Terbol. The percent of success in the transferability of selection indices from drought-free environments to drought-prone environment was higher. These results suggest that the chickpea material developed under favorable environments could be useful under both favorable and non-favorable (drought) environments and that early maturing lines selected under favorable environment would also adapt better in droughty conditions.

K.B. Singh, G. Bejiga, M.C. Saxena, and M. Singh

2.1.5.5. Genetics of seed size

Seed size is an important quality character in chickpea receiving the highest priority in breeding, after yield and disease resistance. Yet genetics of seed size is not fully understood. Therefore, a study was conducted to determine the genetics of seed size in chickpea. Six lines with a range of seed size from 11 g to 60 g per 100 seeds were used in a complete diallel cross. The 6 parents, 15 F_1s, 15 reciprocal F_1s, 15 F_2s, 15 BC_1 to parent 1 (B1), and 15 BC_1 to parent 2 (B2) were grown in a randomized complete block design with two replications and data on seed size were recorded after the harvest. Analysis of variance showed that general combining ability was significant, suggesting that additive gene action is important for seed size. The estimated genetic parameters showed that additive gene action was more important in all crosses except one. Dominant gene action was observed in seven crosses, but it was more important than additive gene action in only one cross. Additive and dominant gene actions due to maternal effects were realized in 7 crosses and 6 crosses, respectively. The crosses that involved the small-seeded parents as females had small seeds because of maternal effects suggesting that where large and small-seeded parents are involved in crosses, large seeded parents should be used as female. Conventional pedigree and bulk methods of breeding can be used to develop large-seeded cultivars.

Geletu Bejiga and K.B. Singh

2.1.5.6. Selection criteria for yield in winter-sown chickpea

A total of 6224 kabuli chickpea germplasm accessions were grown at Tel Hadya, Syria during the 1987-88 winter season with an objective of developing selection criteria for yield. Observations were recorded on seed yield and 10 other characters. Correlation, stepwise regression and path analyses were done to determine the relationships between yield and other characters. Results showed that seed yield had significant and positive associations with all the characters studied. Correlations of seed yield with biological yield (0.856**), harvest index (0.590**), number of seeds/m^2 (0.566**) and canopy width (0.521**) were high and significant ($P \leq 0.01$). The high correlation between days to 50% flowering and maturity suggests that days to 50% flowering can be used to identify early and late lines even where crop maturity is affected by terminal drought. Path coefficient and stepwise regression analyses indicated that biological yield, harvest index and days to maturity can be used simultaneously to select for high seed yield in chickpea.

Geletu Bejiga and K.B. Singh

2.1.5.7. Evaluation of kabuli chickpea germplasm for tolerance to herbicide

One thousand four hundred and three kabuli chickpea accessions were grown during autumn winter and spring 1988-89 and 1989-90 season to evaluate their reaction to commonly used herbicide -Igran + Kerb. The trials were grown at Tel Hadya. The results showed that there were significant differences between winter and spring seasons, indicating that herbicide damage is influenced by the season of planting, damage being more in spring than winter sowing. Study also showed that genotypes responded differently to herbicide.

Geleu Bejiga, K.B. Singh and M.C. Saxena

2.1.5.8. Evaluation of world collection of kabuli chickpea for resistance to iron deficiency chlorosis

Iron-deficiency chlorosis is often seen in some chickpea fields in the Mediterranean region. This is particularly severe in the winter-sown fields when iron-inefficient lines are planted. Therefore, to facilitate supply of iron-efficient lines to national programs and ICARDA's chickpea breeding program, 6224 kabuli chickpea germplasm accessions were field evaluated for iron-deficiency chlorosis on a Calcic Rhodoxeralf soil (pH 8.5, 20-25% calcium carbonate) at Tel Hadya during both winter and spring of 1987-88. The lines identified as susceptible during 1987-88 were grown again during autumn, winter and spring of 1988-89 for confirmation of their susceptibility and to examine the effect of sowing time on the appearance of the deficiency symptoms.

About 99% accessions were resistant to iron- deficiency chlorosis. Evaluation of susceptible lines during autumn, winter, and spring sowing revealed that iron-deficiency chlorosis was more pronounced during winter sowing. There were also significant genotypes x time of sowing interactions. Since the iron-deficiency chlorosis character is controlled by recessive genes, a negative selection, as used in chickpea improvement program at ICARDA, is recommended as an effective breeding strategy.

Geletu Bejiga, K.B. Singh and M.C. Saxena

2.1.5.9. Genetics of time to flower

Four kabuli chickpea lines (ILC 6104, ILC 6118, ILC 72 and ILC 3279) which flowered in 130, 130, 154 and 152 days were grown in a complete diallel cross to determine the genetics of time to flower in chickpea. The parents, F_1s and reciprocal F_1s, F_2, backcross to parent 1 (B_1) and backcross to parent 2 (B_2) were grown in a randomized complete block design. Observations on time to flower were recorded except on reciprocal F_1s since there were many missing plots due to low number of seeds obtained from late flowering parents.

Results showed that both general combining ability (gca) and specific combining ability (sca) were significant suggesting that both additive and non-additive type gene actions are important for time to flower. However, the gca value was higher than sca indicating that additive type gene action is more important than non-additive type gene action. An estimate of the contributions of additve type gene action and dominance for each cross confirmed the importance of additive gene action.

K.B. Singh and Geletu Bejiga

2.1.5.10. Evaluation of elite mutants

Of the several hundred chickpea mutants identified in the induced mutation studies at ICARDA from 1987/88 to 1989/90, 152 mutants were evaluated for yield and other 14 characters during 1990/91. From these, 33 mutants were chosen and grown with three checks, ILC 482, ILC 3279 and FLIP 82-150C in a replicated yield trial during 1991/92. Results of a few selected lines are shown in Table 2.1.28. Five mutants have been selected for high yield, one for early maturity, one for tall stature, two for large seed size, one for long pod and one for cold resistance. These 11 mutants will be evaluated for yield next season.

M. Omar and K.B. Singh

Table 2.1.28. List of the mutants giving higher yield (kg/ha), earlier flowering (DFLR) and larger seed size (100 sw, g) than the original chickpea lines used for mutation at Tel Hadya, Syria, 1991/92.

Entry	Seed yield (Rank)	DFLR	PTHT	100SW
M 14241	3804 (12)	126	44	43
M 14246	3290 (29)	129	53	44
M 14248	3027 (33)	128	47	44
M 15096-4	4188 (3)	115	37	41
M 15096-5	2842 (34)	122	39	45
M 15197-3	4367 (1)	125	46	29
M 15227-5	4279 (2)	124	42	28
M 16070	3812 (10)	125	39	28
M 16221	4184 (4)	123	40	28
M 17033	3974 (8)	130	41	26
M 17240	4132 (5)	124	41	27
ILC 482	3647 (17)	126	39	28
ILC 3279	2760 (35)	130	51	27
FLIP 82-150C	3463 (33)	127	43	28
Mean	3588	126	41	30
SEm. (±)	279.6	0.408	2.22	1.26
LSD ($P \leq 0.05$)	788.3	1.150	6.25	3.55
C.V. (%)	13.5	0.563	9.48	7.19

2.1.6. Studies on Wild Cicer Species

2.1.6.1. Interspecific hybridization

Past evaluation of eight annual Cicer species revealed presence of high level of resistance for (Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode and cold). This encouraged us to make interspecific crosses using nine annual Cicer species including the cultivated species in a diallel set. It was found that only C. echinospermum and C. reticulatum could be crossed with the cultigen.

Four cultivars (ILC 482, ILC 3279, FLIP 82-150C, and FLIP 85-122C) were crossed with one accession each of C. echinospermum and C. reticulatum during 1988/89, F_1s were grown in 1989/90, and parents, F_1s, and F_2s were evaluated for a number of agronomic characters in a replicated trial during 1990/91.

There were no differences in days to flower between the means of parents, F_1s and F_2s or between the two F_1 crosses (Fig 2.1.4), but differences were found when the 8 cross combinations were compared. Differences between the 16 F_2 populations were observed in nine cross combinations.

The cultigen parents were the highest, while the wild parents were shortest (Fig 2.1.4). The mean height of the F_1s and the F_2s did not differ and was lower than that of the cultigen parents but higher than that of the wild parents. There were no differences betweeen two F_1 cross (Fig 2.1.4), but differences among the eight cross combinations were

Figure 2.1.4. a.

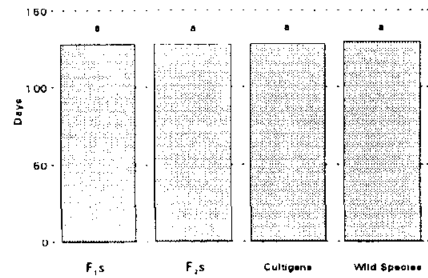


Figure 2.1.4. b.

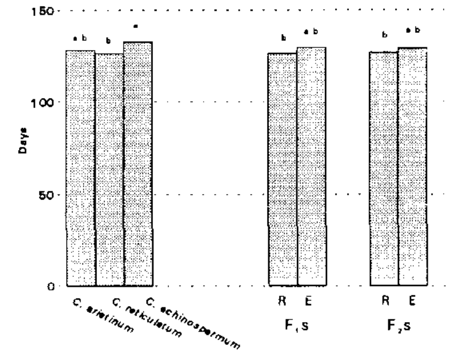
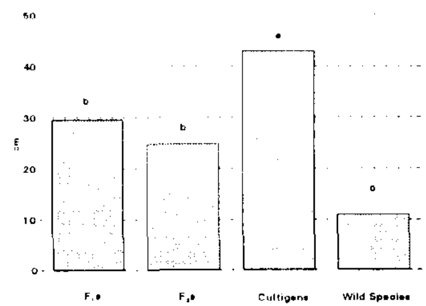


Figure 2.1.4. c.



Bars with the same letter are not different at P = 0.05 using LSD

Figure 2.1.4. d.

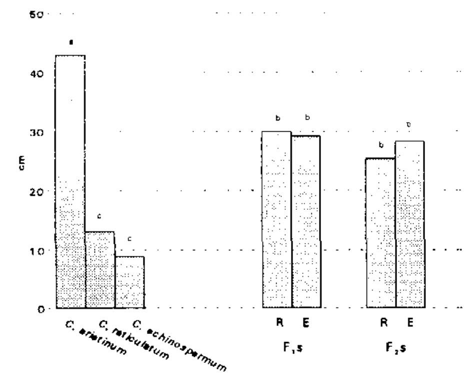


Figure 2.1.4. Interspecific hybridization of C. arietinum with C. reticulatum (R) and C. echinospermum (E). Comparison between F_1s, F_2s and parents: For (a) days to flower; (c) plant height. Comparison between parents and R x E derived F_1s and F_2s: For (b) days to flower; (d) plant height. Bars with the same letter are not different at $P \leq 0.05$ using LSD.

present. There was no variation between F_1s and F_2s, but there were variations among F_2 populations. The F_2 of C. arietinun (ILC 3279)x C. echinospermum was the tallest population.

Mean number of seeds/plant of F_1s, F_2s and of cultigen lines did not differ but they were higher than those of wild parent lines (Fig. 2.1.5). The two F_1 crosses differed (Fig. 2.1.5). Differences were seen within C. arietinum x C. reticulatum cross. C. arietinum (ILC 3279) x C. reticulatum F_1 was the best hybrid having the largest number of seeds per plant. F_2 bulks did not differ with each other. The F_2 populations including C. echinospermum did not differ from the F_1 except those involving C. reticulatum. Differences were seen within F_2 populations and C. arietinum (ILC 482) x C. reticulatum F_2 and C. arietinum (FLIP 82-150C) x C. reticulatum F_2 were the best.

Mean biological yield of the F_1s and cultigen lines was identical, but higher than that of the wild parents (Fig. 2.1.5). The F_2 did not differ from the cultigen. The two F_1 crosses also did not differ (Fig. 2.1.5), but differences were present within their cross combinations. Cross C. arietinum (FLIP 85-122C) x C. echinospermum F_1 was the best hybrid. The two F_2 populations did not differ. The C. arietinum x C. echinospermum F_2s performed better than wild parent and did not differ from the F_1 and the mean of the cultigen lines, while C. arietinum x C. reticulatum F_2s yielded less than the F_1 and did not differ from wild and cultigen parent means.

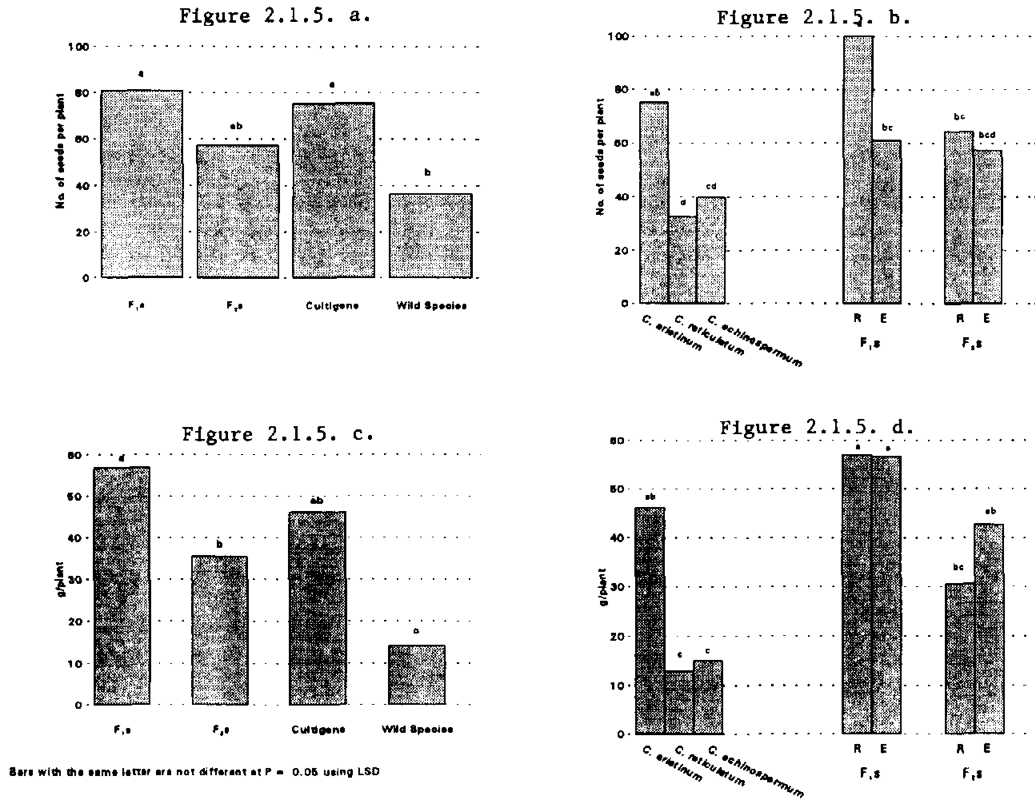


Figure 2.1.5. Interspecific hybridization of C. arietinum with C. reticulatum (R) and C. echinospermum (E). Comparison between F_1s, F_2s and parents: For (a) seeds/plant; (c) biological yield. Comparison between R and E derived F_1s, F_2s and parents: For (b) seeds/plant; (d) biological yield. Bars with the same letter are not different at $P \leq 0.05$ using LSD.

The mean seed yield of the cultigen lines was four times more than that of the wild species lines (Fig. 2.1.6). The mean yield of the F_2 was lower than that of the F_1 but higher than that of the wild species. The F_1s showed high heterosis as compared to the wild species but did not differ from the cultigen. The two F_1 crosses did not differ (Fig. 2.1.6). Difference was seen between C. arietinum (ILC 3279) x C. reticulatum F_1 and C. arietinum (ILC 482) x C. reticulatum F_1. No differences were found within the F_2 populations with the exception of C. reticulatum x C. arietinum (FLIP 82-150C) F_2 and C. echinospermum x C. arietinum (ILC 482) F_2.

The 100-seed weight of cultigens mean was more than two folds than that of the wild species (Fig. 2.1.6). The F_1 and F_2 had lower seed weight than cultigen; the F_1 performed better than the F_2. Within the F_1 crosses C. arietinum x C. echinospermum performed better than C. arietinum x C. reticulatum and did not differ from the cultigen mean (Fig. 2.1.6). Differences were present between the F_1 crosses and F_2 crosses. The cross combination C. arietinum x C. echinospermum was the best and C. arietinum (FLIP 85-122C) x C. echinospermum was the best population.

K.B. Singh and B. Ocampo

2.1.6.2. Transfer of genes for resistance from wild to cultivated species

Cyst nematode: No source of resistance to cyst nematode was found in over 9000 cultigen germplasm accessions. Later a line of C. reticulatum (ILWC 119) was found resistant which was crossed with two cultigen lines (ILC 482 and FLIP 87-69C) during 1989/90. F_2 plants were evaluated in 1990/91

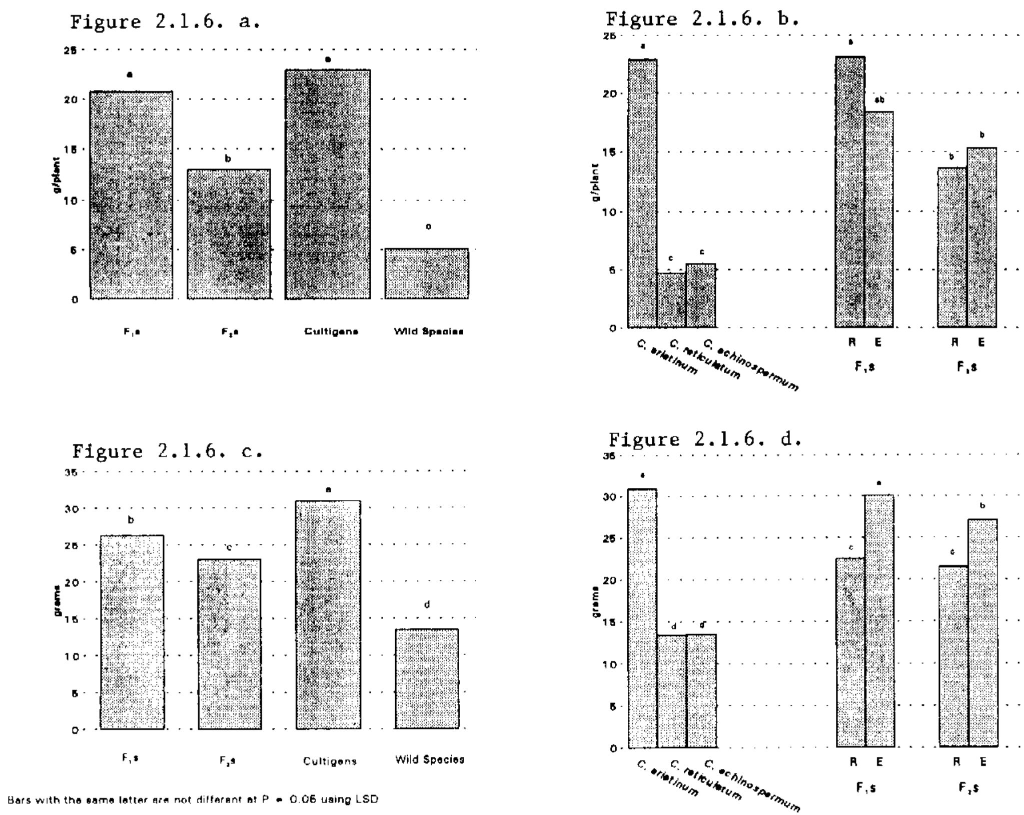


Figure 2.1.6. Interspecific hybridization of C. arietinum with C. reticulatum (R) and C. echinospermum (E). Comparison between F_1s, F_2s and parents: For (a) seed yield; (c) 100-seed weight. Comparison between R and E derived F_1s, F_2s and parents: For (b) seed yield; (d) 100-seed weight. Bars with the same letter are not different at $P \leq 0.05$ using LSD.

and 417 promising plants were found. When these were evaluated in the 1991/92 season, 114 plants were found resistant. Of these, 53 plants appeared to be agronomically superior. Their F_4 plants have been grown in the off-season of 1992. During 1990/91, four more interspecific crosses with ILWC 119 were made using namely ILC 846, ILC 863, FLIP 84-15C, and FLIP 84-92C. The F_1s were grown in the off-season of 1991 and F_2 seeds were produced. During 1991/92, 3000 F_2 plants were evaluated for cyst nematode in the greenhouse and only 9 plants with resistance were identified. These nine plants have been sown in the off-season to produce F_4 seeds.

Cold: During the 1988-89 season, a project was initiated to transfer genes for cold tolerance from the two wild species, C. echinospermum and C. reticulatum. Since then, crosses have been made each year. During the 1991/92 season, 8 F_2, 13 F_3 and 3 F_4 populations were sown in the cold nursery on October 1. The season was very cold, hence a good screening was achieved. In June 1992, 50 F_2, 50 F_3 and 20 F_4 plants were selected with same level of cold tolerance as those of wild parents. In addition, these plants had acquired genes for earliness, upright growth habit, acceptable seed type, and pod indehiscence characters. They thus appeared very promising. Eleven best plants from F_2-F_4 generations were backcrossed in the off-season. F_2 population of 11 backcrosses was grown under non-cold conditions. These will be evaluated in F_3 for cold tolerance. It seems that in three to four years, genes for cold tolerance may be transferred from wild to cultivated species.

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2.1.7. Quality and Use

2.1.7.1. Protein content in newly developed lines

The differences in the protein content of chickpea from winter and spring sowing have been studied since 1987/88. There was little differences in the protein content because of date of sowing (Table 2.1.29 and 2.1.30).

K.B. Singh

Table 2.1.29. Mean protein content (%) of the entries grown in two seasons (winter and spring) and four years (1987/88, 1988/89, 1989/90, 1990/91 and 1991/92 at Tel Hadya, Syria.

Year	No. of entries		Season	
	Winter	Spring	Winter	Spring
1987/88	120	120	20.94	19.85
1988/89	120	120	22.46	22.27
1989/90	223	225	22.74	26.09
1990/91	286	248	24.42	23.81
1991/92	308	308	21.42	22.20
Mean	-	-	22.40	22.84

2.1.7.2. Survey of usage of chickpea in Syria

Chickpea is used in many preparations in Syria. However, the percentage of chickpea consumption in different dishes is unknown. Knowledge about these can be of use in chickpea improvment reseach. Therefore, a survey was conducted to assess the use of chickpea in different preparations, to determine the chickpea quality needed for each preparation and to find out difference in usage of chickpea in villages and cities.

Table 2.1.30. Mean protein content (%) in 13 preliminary yield trials grown during winter and spring at Tel Hadya, Syria, 1991/92.

Name	No. of entries		Protein content		C.V. (S.E.)	
	Winter	Spring	Winter	Spring	Winter	Spring
PYT-L	22	22	21.50	22.20	1.776 (0.270)	1.127 (0.177)
PYT-T	22	22	21.54	22.35	1.470 (0.224)	1.479 (0.234)
PYT-E1	22	22	21.28	21.85	1.409 (0.212)	1.399 (0.216)
PYT-E2	22	22	21.56	22.17	1.793 (0.273)	0.832 (0.130)
PYT-E3	22	22	21.26	21.74	1.478 (0.222)	1.576 (0.243)
PYT-E4	22	22	20.85	21.82	2.008 (0.296)	1.219 (0.108)
PYT-E5	22	22	21.40	22.08	1.080 (0.163)	1.076 (0.168)
PYT-E6	22	22	21.53	22.48	1.666 (0.254)	1.718 (0.273)
PYT-1	22	22	21.33	22.34	1.140 (0.172)	1.319 (0.208)
PYT-2	22	22	21.30	21.97	1.051 (0.158)	1.915 (0.298)
PYT-3	22	22	21.76	22.56	1.242 (0.191)	1.195 (0.191)
PYT-4	22	22	21.49	22.48	0.981 (0.149)	1.545 (0.246)
PYT-5	22	22	21.43	22.41	1.520 (0.230)	1.471 (0.233)
PYT-6	22	22	21.69	22.33	1.459 (0.224)	1.694 (0.268)
Check	2	2	21.4	22.1		

E = Early; T = Tall; L = Large.

The survey covered 16 cities and 16 villages in Syria representing different agroecological zones and population densities. Three different questionnaires were used for survey of consumers in cities and villages and the survey of manufacturers of different dishes. Survey among city and village consumers focussed on the quantity of chickpea used for each preparation and the properties of seed needed for each. Chickpea food industry was surveyed to find out daily chickpea consumption and properties needed.

The survey revealed that chickpea is used in 38 different preparations. It is consumed by both city and village inhabitants. Consumption differs among the rich and poor families. Consumption of chickpea is more in villages producing chickpea than in cities. However chickpea is consumed in all cities. Its consumption is small to nil in those villages which do not produce it. In cities chickpea preparations are more consumed by low- and middle-income classes, whereas in villages all classes of people consume it. Maximum amount of chickpea is consumed for the preparation of Falafel in village and cities followed by Tisquieh, Hommos bitahineh, Hommos bimaraka, Riz bihommos, and burgul bihommos.

Consumption of landraces such as Darousi is decreasing and the demand for the new cultivars, Ghab 1 and Ghab 2, is increasing because of their suitability to majority of chickpea preparations.

Properties preferred by the majority of consumers in cities and villages and by manufacturers for the preparations requiring use of whole seed are medium seed of uniform size, rough shape, thin husk, beige color, and high hydration capacity. For preparations where mashed seeds are used the same properties are required, except that seed shape is not important. The uniformity of seeds is very important for large scale manufacturers of Hommos bitahineh. Non-uniform seeds give different degrees of cooking at the end of boiling period producing bad quality of the final product. Mechanical harvested chickpea being free of small stones is preferred in comparison to hand harvested produce. Stones cause damage to sieves used for chickpea cleaning and to mashing machine in the factories. Separation of stones manually is time consuming and expensive. Physical and chemical structure of cotyledons are the most important characters determining the suitability of chickpea cultivars for the preparation of Odama safra. Medium-sized seeds were found to be most suitable for Odama preparation. Survey further revealed that Ghab 1 and Ghab 2 are used in large quantities by the Syrian manufacturers in the preparation of Odama malha. An important finding of this survey was that chickpea is used in Syria as a substrate for yeast development in cake preparation.

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2.2. Molecular Techniques in Chickpea Improvement

2.2.1. Development of Non-radioactive DNA-marker Technique

In order to use DNA-markers which have already been mapped elswhere a bacterial transformation system has to be established. Single copy DNA-markers are usually inserted as foreign DNA in a bacterial plasmid vector. Plasmid DNA can be introduced into bacteria by subjecting them to a heat shock or high electric current which makes them temporarily permeable to small DNA molecules. To identify these transforms, a selecable marker (ampicillin resistance) encoded by the plasmids is used.

Thirty chickpea clones of a cDNA library supplied by Dr. F.J. Muehlbauer, Washington State University, Pullman, USA, were transformed using above technique and grown. They are maintained in a glycerol culture stored at -45°C. The amplified plasmids have been extracted out of the bacteria by mini plasmid preparation (Fig. 2.2.1). In this form they can serve as a template for labelling with the nonradioactive molecule digoxigenin.

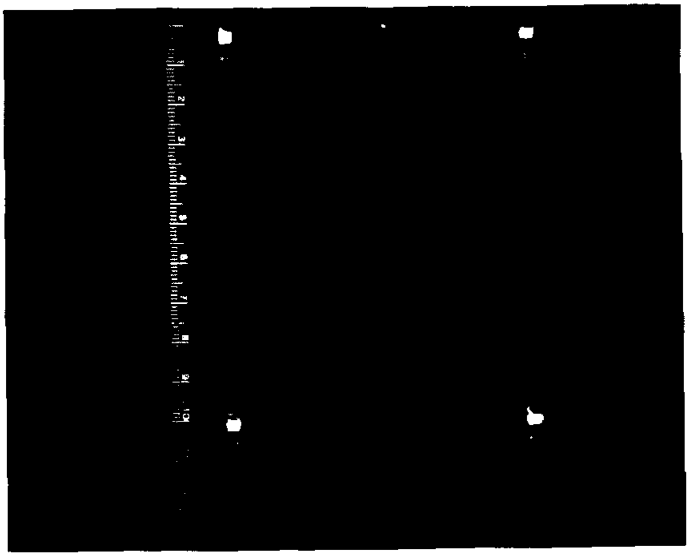


Figure 2.2.1. Optimization of the PCR reaction on the Hybrid PCR-machine for two different chickpea clones (from right to left top part of gel); lane 1 marker, lane 2, 3, 4 (first chickpea clone) 5, 6, 7 (second chickpea clone) Taq-polymerase conc. 0.5, 1, 5 units respectively, lanes 8, 9, 10 and 11, 12, 13 primer conc. 0.05, 0.1 and 0.2 μM, bottom part of gel lane 1 marker, lanes 2, 3, 4, and 5, 6, 7 dNTP conc. 50, 100 and 200 μM, lanes 8, 9, 10 and 11, 12, 13 $MgCl_2$ conc. 0, 2, 4 mM.

Using the Polymerase Chain Reaction (PCR), DNA sequences can be amplified using the bacterial Taq-polymerase. If one of the artificial nucleotides is substituded by the nonradioactive-labelled molecule UTP-digoxigenin it will be built into the double stranded DNA molecule. In comparison with the unlabelled DNA it will run slightly slower on an agarose gel. This labelled-DNA sequence can then be used as a labelled probe in a nucleic acid hybidization. We have optimized the conditions for the PCR labelling with our PCR machine (Figure 2.2.2). We are able to label single-copy sequences (DNA-marker) nonradioactively (Figure 2.2.3).

Figure 2.2.2. Amplification of 10 cDNA chickpea clones within the PCR reaction: a) identical replication (as seen, from left to right in lanes 3, 5, 7, 9, 11, 13, 15, 17, 19 and 21; b) labelled with 10% digoxigenin (as seen in lane 4, 6, 8, 10, 12, 14, 16, 18, 20 and 22). Final concentrations of single components in the reaction mixture were (100 μl): reaction buffer 1x, nucleotides ATP, GTP, CTP, units, reverse and sequencing primer pUC/M13 0.2 μM. In the labelling reaction with digoxigenin 10% of the nucleotide TTP concentration was replaced by digoxigenin-11-UTP.

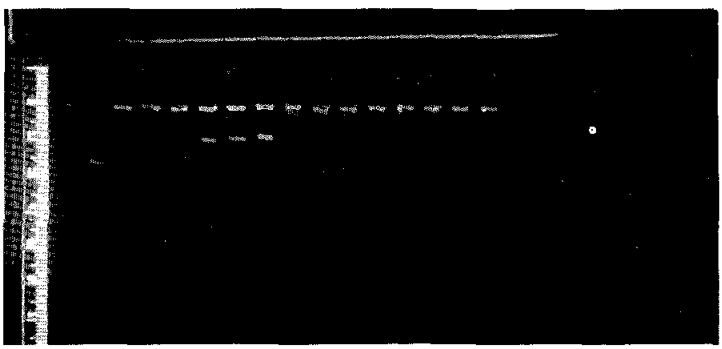


Figure 2.2.3. Miniplasmid preparation of 5 chickpea clones. Inserts were cut out with an EcoRI/HindIII restriction digestion. From left to right lane 1 pUC18 linarized with HindIII, lanes 3, 4, 5 clone C71, lanes 6, 7, 8 clone C69, lanes 9, 10, 11 clone C75, lanes 12, 13, 14 clone C81 and lanes 15, and 16 clone C93.

We are perfecting the protocols for nucleic acid hybridization of nonradioactive-labelled, single-copy probes and their detection with chemiluminescence. Nonradioactive-labelled probes which are hybridized to genomic DNA are detected with an antibody and visualized with a chemiluminescence reaction.

M. Baum and F.J. Muehlbauer (WSU, Pullman)

2.2.2. Wide Crossing

Crosses between Cicer arietinum and wild relatives except C. reticulatum and C. echinospermum are usually not possible. A wide crossing program was initiated between C . arietinum and C. bijugum, C. judaicum and C. pinnatifidum. Pre- and post fertilization barriers will be studied. We are aiming to establish polyploids which can be crossed either with diploids or with tetraploids in order to produce either fertile hybrids or to induce recombination between the chromosomes from the different species. **M. Baum and K.B. Singh**

2.2.3. DNA Marker for Variety Identification

Use of DNA-marker for variety identification will allow to follow up the distribution of newly released cultivars (Ghab1, Ghab2, Ghab3) and to check the purity of the material. Plants were sampled from seed multiplication fields within Tel Hadya. Two enzyme/probe combinations were successful to distinguish between all 3 cultivars Fig. 2.2.4. and 2.2.5. Especially the combination BamHI/$(GATA)_4$ reveals variety-typical banding patterns. Ghab1 is characterized by the presence of a band with 10,000 bp length, Ghab2 carries a cultivar-typical band of 7,600 bp length and Ghab3 shows a unique band of 8,000 bp length. The genetic variability within the cultivars and the genetic distance between them will be calculated when more plants are DNA-fingerprinted using RFLP.

F. Weigand and W. Choumane (University of Lattakia)

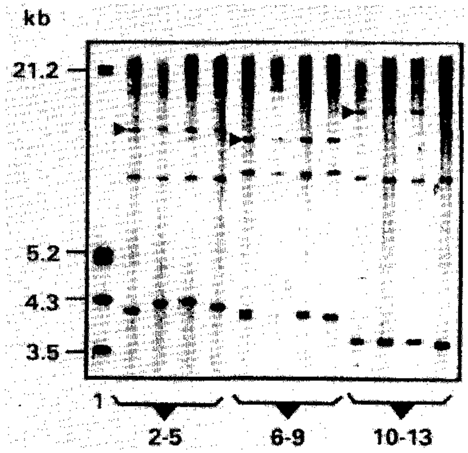


Figure 2.2.4. DNA-fingerprints of chickpea cultivars. Total DNA was digested with BamHI and probed with the digoxigenin labeled probe $(GATA)_4$. Lane 1 contains the molecular weight marker. Lanes 2-5 contain 4 individual chickpea plants of the variety Ghab3. Lanes 6-9 contain 4 individuals of Ghab2. Lanes 10-13 contain 4 individual plants of Ghab1. Black triangles mark cultivar-specific bands.

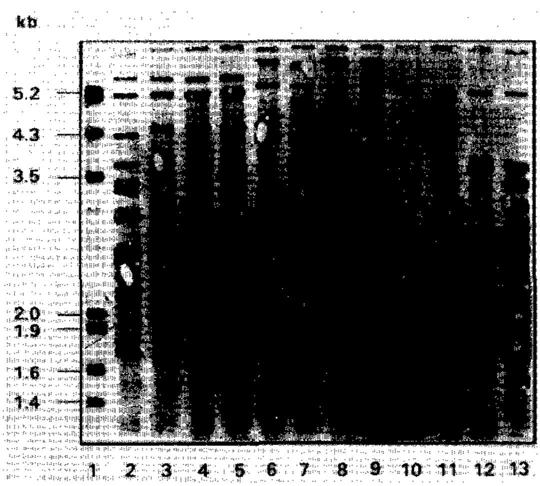


Figure 2.2.5. DNA-fingerprints of chickpea cultivars. Total DNA was digested with TaqI and probed with $(GATA)_4$. Lane 1 contains the molecular weight marker. Lanes 2-5 contains individual plants of Ghab3. Lanes 6-9 contain individual plants of Ghab2. Lanes 10-13 contain individual plants of Ghab1.

2.2.4. DNA Marker for Resistance to Ascochyta Blight

From a cross made between the Ascochyta blight susceptible line ILC 1275 and resistant line ILC 3279 a segregating F_2 population was analyzed to identify bands which correlate with the trait expression of blight resistance. Figure 2.2.6 shows DNA-fingerprints of the selfed parents. The banding patterns are nearly identical between the siblings and indicate a high degree of homozygosity within the respective parents as well as a low mutation rate at the hypervariable loci tagged by the repetitive oligonucleotide probe. Figure 2.2.7 shows the F_2 population. A close linkage between the presence or absence of a band and Ascochyta blight resistance could not yet be established.

F. Weigand, S. Ungi (ICARDA) and G. Kahl (University of Frankurt)

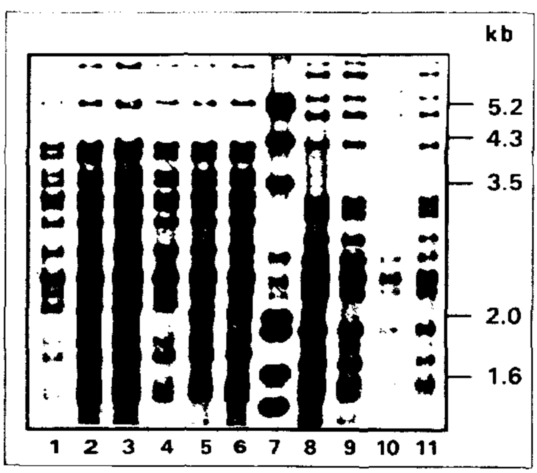


Figure 2.2.6. DNA-fingerprints of selfed siblings of ILC 1275 and ILC 3279. Total DNA was digested with TaqI and probed with $(GATA)_4$. Lanes 1-6 contain the individual progenies of ILC 1275. Lane 7 contains the molecular weight marker. Lane 8-11 contain individual progenies of ILC 3279.

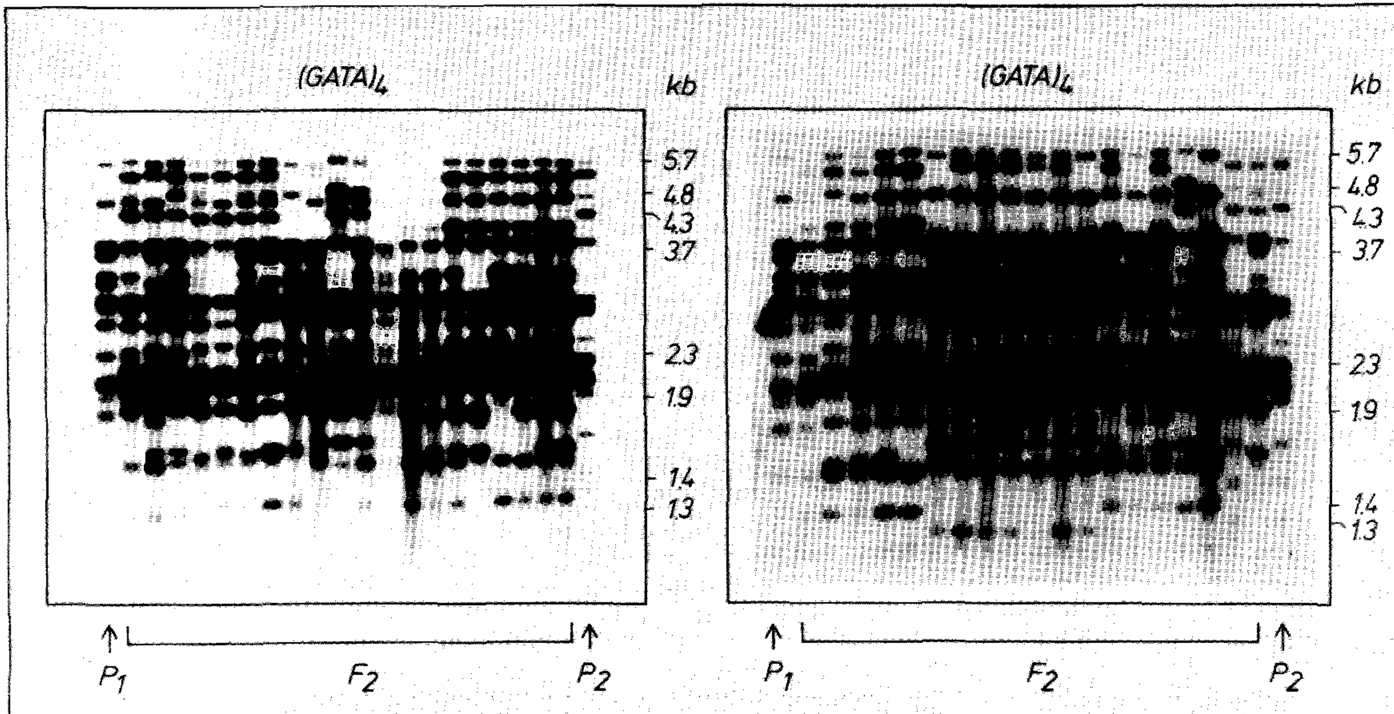


Figure 2.2.7. Oligonucleotide fingerprinting of TaqI-restricted DNA from 39 F_2 plants from a cross between chickpea accessions ILC 1272 x ILC 3279 with $(GATA)_4$.
P_1: parent ILC 1272, P_2: parent ILC 3279. λ BstE was used as molecular weight marker.

2.2.5. Variability in Ascochyta rabiei

Programs for control of Ascochyta blight and resistance breeding in chickpea necessitate a reliable identification and characterization of A. rabiei pathotypes and populations. The classical biological pathotyping technique, using a set of different host genotypes, is laborious, time consuming and requires strict standardization of test conditions. Its use is limited to express extreme differences in plant-pathogen interactions. A reliable characterization of the genetic make-up of different strains of A. rabiei, their levels of aggressiveness, their extent of variability, geographic distribution and their genotypic and phenotypic interaction(s) with the host plant is, therefore, very difficult to achieve by means of biological pathotyping.

In collaboration with University of Frankfurt, Germany a nonradioactive DNA-marker technique (RFLP fingerprinting) has been developed for genetic typing to differentiate between A. rabiei isolates. The testing of various isolates was standardized and is routinely performed using the restriction enzyme Hinf I and the digoxigenated oligonucleotide probe $(GATA)_4$. This enzyme/probe combination gives the best discriminating power to distinguish between A. rabiei isolates.

During 1992 A. rabiei samples were collected from all chickpea growing areas in Syria. These were added to the existing collection of 6 isolates obtained in 1981/82. Due to the unfavorable weather conditions in 1992 Ascochyta blight did not develop into severe disease outbreaks and new isolates could only be collected in a few locations and did not permit to apply a systematic sampling scheme. Figure 2.2.8. shows the collection sites in Syria. Newly collected isolates

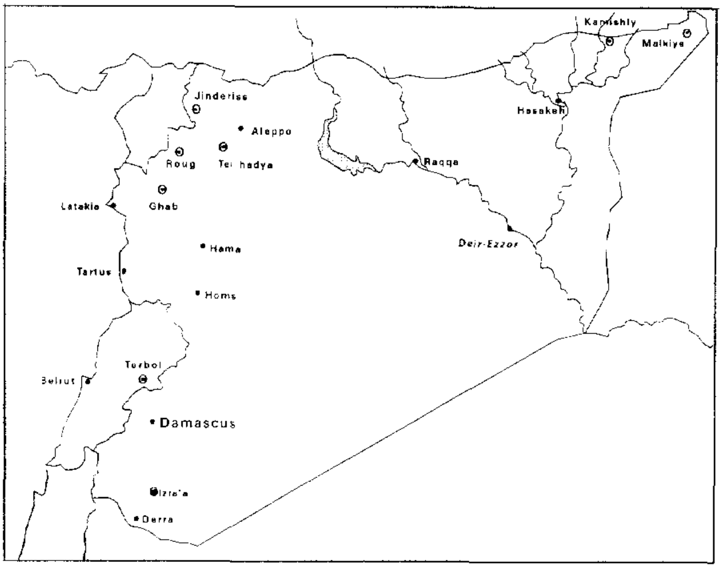


Figure 2.2.8. Map of the region where A. rabiei was sampled during 1991/1992. Collection sites are marked with an open circle.

have been cleaned and purified and were added to the Ascochyta rabiei Germplasm Catalog with the abbreviation AA for Ascochyta Aleppo and a running number as new accessions. For genetic population studies in plant pathogenic fungi a hierarchical sampling scheme has to be used. This hierarchical sampling scheme will allow to reveal the genetic variability in populations, between populations and among them. This information will help in deciding the future sampling strategy and the number of isolates to be collected per chickpea growing area to make a meaningful population study to monitor the mutation rate, frequency of sexual recombination events, shifts in population and migration of A. rabiei genotypes in the WANA region. The genetic typing of new accessions was complemented with the biological typing to characterize their level of aggressiveness. Once a new accession is shown to be distinguishable by genetic as well as biological typing it will be called a race with the abbreviation IAR (for International Ascochyta rabiei) and will be given a running number. Figure 2.2.9 shows the genetic typing of new accessions.

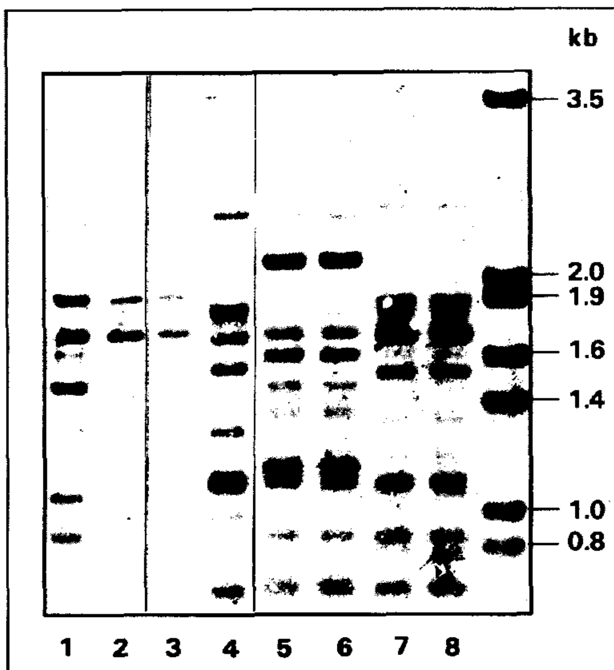


Figure 2.2.9. Genetic typing of new A. rabiei accessions from different locations in Syria: Lane 1) Tel Hadya site a (AA13), 2) Tel Hadya site b (AA15), 3) Jinderiss (AA17), 4) Ghab valley (AA11), 5) Izraa site a (AA10), 6) Izraa site a (isolated from the same lesion as AA10), 7) Izraa site b (AA8), 8) Izraa site b (isolated from same lesion as AA8). Molecular weight markers are indicated in kilobases.

The accessions from two fields close to Izraa (AA10 and AA8), Ghab valley (AA11), Jinderiss (AA17) and one new sample from Tel Hadya

(AA13) could be distingiushed from each other and they also differ from all the isolates collected during 1981/82 (see LP Annual Report 1991). A second newly sampled isolate from Tel Hadya (AA15) is indistinguishable from two isolates sampled in 1981/82. These relatively small set of data indicate that many different genotypes may exist in Syria. Migration of genotypes might occur over large distances since the same genotype was sampled in two locations about 70 km apart (Tel Hadya and Jinderiss). One new accession was isolated from Tel Hadya and is indistinguishable from 2 isolates which are used in the Ascochyta blight nursery. When 2 isolates were made out of one lesion they could not be distingiushed. The reidentification of genotypes from distant locations, after artificial release or originating from one lesion indicate a higher genetic stability of A. rabiei genotypes than expected.

The results from genotyping the new accessions were supported by the respective biological typing. Three purified host genotypes were used as differential set (ILC 1929 susceptible, ILC 482 tolerant and ILC 3279 resistant) in a standardized seedling test to determine and compare the level of aggressiveness of new A. rabiei accessions. As an example, the new accession from Jinderiss (AA17) shows the same strong aggressiveness as one genotypically indistinguishable sample collected at Tel Hadya (AA15) (Fig. 2.2.10). Such a high level of aggressiveness is contrasted by a genotypically easy distinguishable genotype from Izraa (AA9) which posses a lower level of aggressiveness (Fig. 2.2.10).

F. Weigand, A. Djandji (ICARDA) and G. Kahl (University of Frankfurt)

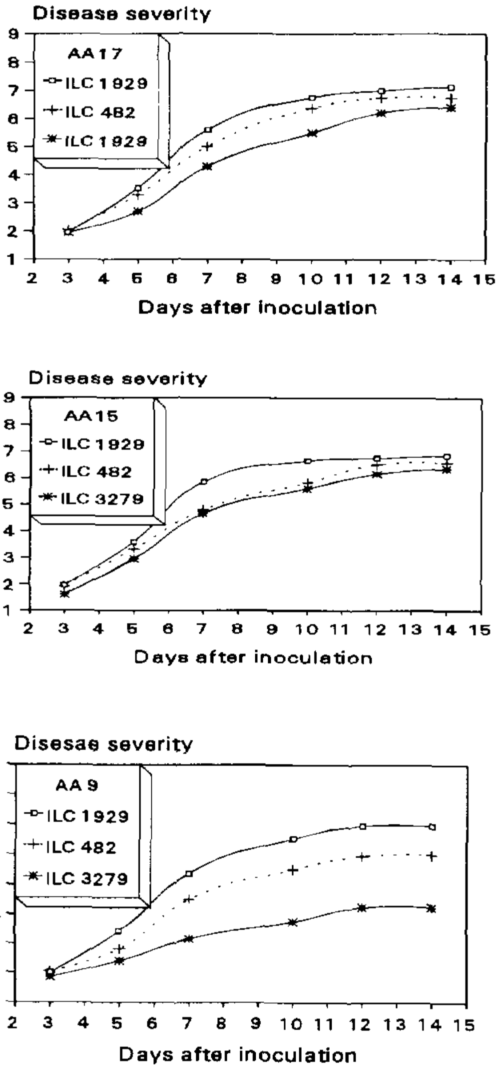


Figure 2.2.10. Biological typing of three A. rabiei accessions collected during 1991/92 at three different locations in Syria. Accession AA9 from Izra, AA15 from Tel Hadya and AA17 from Jinderiss.

2.2.6. DNA Marker for Leafminer Resistance

To identify DNA-marker(s) for leafminer resistance in chickpea, parents with contrasting reaction to Liriomyza ciceri were crossed to develop the necessary F_2 population. Figure 2.2.11 shows the trait evaluation of the parents and the respective F_2 population. The genome analysis will be conducted with the pooled DNA from F_3 seeds deriving from individual F_2 plants.

F. Weigand, S. Weigand and A. Joubi

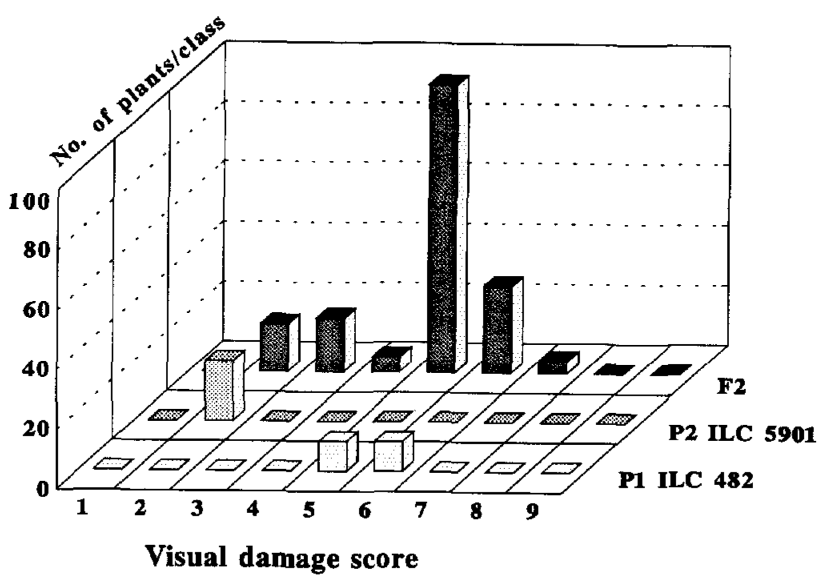


Figure 2.2.11. Distribution frequency of the visual damage score. ILC 482 was used as susceptible female (P_1) and ILC 5901 as resistant male (P_2) parent.

2.3. Chickpea Pathology

Chickpea suffers from several diseases in the ICARDA region, but Ascochyta blight is the most important. A major emphasis is therefore given to identify durable and stable sources of resistance to Ascochyta blight for use in hybridization program. Of other diseases, Fusarium wilt and other soil-borne diseases are common in parts of North Africa. Screening for wilt resistance is carried out in cooperation with national programs in Tunisia and Spain. Stunt (bean leaf roll) virus is present throughout the region, but at present it is of minor importance.

The objectives of chickpea pathology research at ICARDA are to: (1) screen chickpea germplasm for identification of sources of resistance to Ascochyta blight by using field screening technique, (2) combine efforts with chickpea breeder towards the development of high yielding and cold-and Ascochyta blight-resistant chickpea cultivars, (3) share the resistant accessions with national programs through international disease nurseries, (4) monitor the presence of pathogenic variability in Ascochyta rabiei, (5) study the epidemiology of Ascochyta blight, (6) collect information on other chickpea diseases in the WANA region through field surveys, and (7) develop cooperative research with national programs.

2.3.1. Screening for Ascochyta Blight Resistance

2.3.1.1. Segregating generations

Evaluation of chickpea segregating generations against six races of A rabiei was done in the 1991-92 season. The results of screening are shown in Table 2.3.1. Fifty-three F_6 progenies were rated 2 and 941 progenies had rating of 3. Very few F_6 progenies showed susceptible reaction which was a result of effective screening in the previous season. Many F_5 lines also showed a rating of 2, 3 and 4. Thus these large number of resistant lines allowed bulking of promising and uniform progenies as possible future cultivars. Also, thousands of plants resistant to A. rabiei in F_2 were bulk harvested to be grown in the off-season. The resistant plants in F_4 generation were harvested individually. One important achievement of this season was that many early progenies were resistant to Ascochyta blight.

Table 2.3.1. Reaction of F_2 to F_6 generations to Ascochyta blight at Tel Hadya, 1991/92

Generation[1]	Reaction on a 1-9 scale									Total
	1	2	3	4	5	6	7	8	9	
F_2 Bulk	0	0	56	48	31	21	22	7	0	185
F_4 Bulk	0	0	140	50	44	13	0	0	0	247
F_5 Progeny-L	0	0	149	20	21	9	1	0	0	200
F_5 Progeny-E	0	0	51	76	2	2	4	0	0	135
F_5 Progeny-G	0	401	1666	301	240	191	60	17	2	2878
F_6 Progeny-L	0	25	90	39	23	20	20	12	3	232
F_5 Progeny-T	0	21	259	73	10	1	0	0	0	364
F_6 Progeny-E	0	7	137	24	19	17	10	6	3	223
F_6 Progeny-G	0	0	455	153	96	81	28	12	7	832

[1] Abbreviations used were: L = large; T = tall; E = early; G = general.

2.3.1.2. Confirmation of resistance in new germplasm

ICRISAT furnished 795 kabuli and 2214 desi accessions. When evaluated in the disease nursery in the 1990-91 season, 10 lines had a rating of 3 and 17 lines a rating of 4. These 27 lines were reevaluated during 1991-92 and results are shown in Table 2.3.2. The resistance in all of them was confirmed.

Table 2.3.2. Reaction of 27 new chickpea germplasm accessions to a mixture of six races of A. rabiei.

Type of chickpea	Disease reaction of A. rabiei									Total
	1	2	3	4	5	6	7	8	9	
Kabuli	0	6	0	0	0	0	0	0	0	6
Desi	0	17	2	2	0	0	0	0	0	21
Total	0	23	2	2	0	0	0	0	0	27

2.3.1.3. Screening of breeding lines

All breeding lines (1615) developed between 1981 and 1990 had been evaluated using disease infested debris and inoculation with six races in the 1990-91 season. Four hundred and seven lines were identified as resistant with 2-4 rating. These lines were evaluated in the greenhouse and field during 1991-92 and results are shown in Table 2.3.3. In the greenhouse, 109 lines showed a rating of 2 and 225 lines a rating of 3 to 5. However, 73 lines showed susceptible reaction. In the field, 292 lines (78.1%) received a rating of 3 and 60 lines had a rating of 4. In field, only eight lines were rated susceptible. One hundred and seventy-two lines were resistant under field and greenhouse conditions.

Table 2.3.3. Reaction of breeding lines inoculated by diseased debris and a mixture of six races of A. rabiei in the greenhouse and field, Tel Hadya, 1991/92

Location	Disease reaction on 1-9 scale									Total
	1	2	3	4	5	6	7	8	9	
Greenhouse	0	109	33	50	142	64	8	1	0	407
Field	0	0	292	60	14	6	0	2	0	374

2.3.1.4. Reaction of lines in Chickpea International Ascochyta Blight Nursery

Fifty entries identified resistant against six races of A. rabiei at Tel Hadya were furnished to cooperators in 22 countries during 1991-92. These were also evaluated at Tel Hadya. Two lines were rated 2, 35 rated 3, 8 rated 4, and 3 rated 5. Only two lines had a susceptible reaction (rating 6).

2.3.1.5. Other material

In 1987-89 crosses were made for inheritance of resistance to Ascochyta blight as a part if the Ph.D. thesis of Mr. B.A. Malik from Pakistan. One of the objectives was to pyramid genes for resistance to A. rabiei from diverse sources. Some of the lines appeared very promising. The reaction of F_5 and F_6 material was evaluated in 1991/92. All 52 F_5 progenies and 229 out if 234 F_6 progenies had 2 rating. The remaining 5 F_6 progenies had a rating of 3. One hundred F_6 and 12 F_5 plants with 2 rating and agronomically superior attributes have been selected. They will be evaluated next season.

2.3.2. Susceptibility to Blight at Different Stages of Crop Growth

Information on the susceptibility to blight at different stages of crop growth is essential for selecting the appropriate stage for inoculating plants in the resistance breeding program. A study was conducted in the greenhouse (18 ± 3°C) in which nine chickpea genotypes differing in blight susceptibility were inoculated with Ascochyta blight at seedling, mid-vegetative, flowering, and podding stages. Sowings were staggered on four dates during the fall of 1991 to obtain plants in seedling, mid-vegetative, flowering, and podding stages for inoculation at the same date. A split-plot design was used with stages as main treatments and genotypes as sub-treatments. For each stage of inoculation and each genotype, 3 pots with 5 plants in each pot replicated three times were used.

The plants were inoculated by spraying a spore suspension (100,000 spores ml^{-1}) of the mixture of six races of A. rabiei and covered with plastic cages for a week to increase relative humidity to over 65%. Severity of blight was scored on a 1-9 scale one month after inoculation. The experiment was conducted between October and December 1991 and then repeated between January and March 1992.

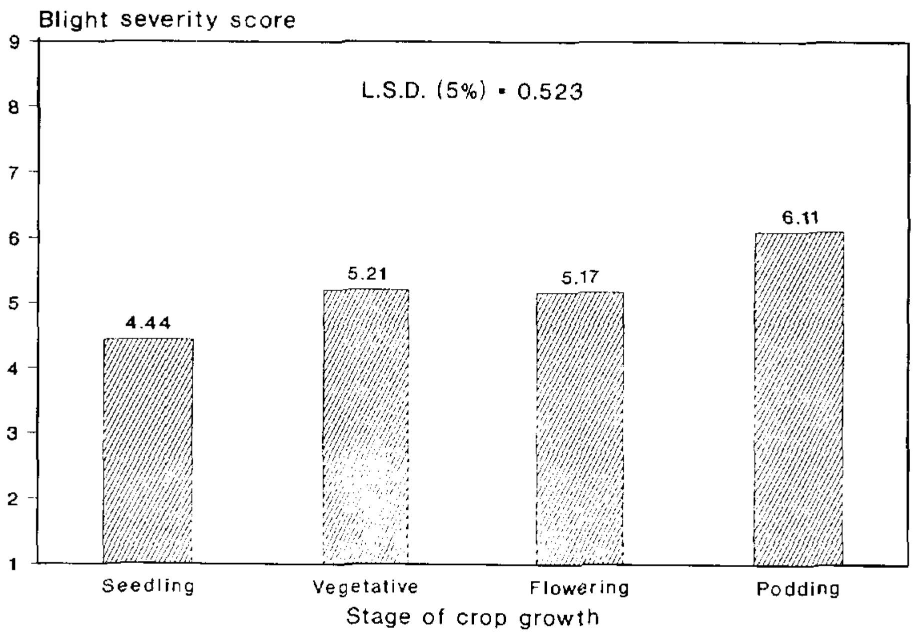


Figure 2.3.1. Mean blight severity score of nine chickpea genotypes when infested at four stages of crop growth.

The blight severity differed significantly at different satges of crop growth. The interaction between year and stage also was significant. The genotypic variance was highly significant and so was the interaction between genotype and stage of crop growth. The blight severity score was minimum (4.4) at seedling stage and maximum (6.1) at podding stage (Fig. 2.3.1). Blight severity was about the same at vegetative and flowering stage. However, at these two stages blight severity was significantly more than the seedling stage but less than at the podding stage. Therefore, it will be desirable to score genotypes at podding stage for the correct assessment of damage from the disease. This study also suggests that the crop is least damaged if attacked by the disease at the seedling stage.

K.B. Singh and M.V. Reddy

2.3.3. Components of Resistance to Ascochyta Blight

The effect of the various components of resistance on the disease has been shown to vary with the different developmental stages of the plant. Not only the latent period but also the sporulation capacity and the lesion expansion have been reported to vary between the seedling and the adult stages of the plant. The effect of the developmental stage of the chickpea plant on the expression of the components of resistance was, therefore, studied.

Sixteen chickpea genotypes of variable susceptibility levels were selected. Studies were undertaken at the seedling stage on plants grown in the growth chamber and at the flowering stage on plants grown in the greenhouse. The disease development was also followed up to the podding stage on plants in the field. A mixture of several A. rabiei isolates was used for artificial inoculations.

For the growth chamber experiment seeds were planted in sterilized soil in small flat plastic trays with 5 plants per genotype and 5 genotypes per tray. Each tray was replicated 3 times and the trays were randomly distributed in the growth chamber in a completely randomized design. The growth chamber was set on a 14h day temperature of 20°C and a 10h night temperature of 15°C. Ten day old seedlings were inoculated with a spore suspension at a concentration of 300,000 spore ml^{-1}. The plants were then covered with a plastic cover for 96 h to ensure proper infection conditions.

Three days after inoculations, regular readings were started on each plant individually at a two to three days intervals for the lesion size (LS), the appearance of the first pycnidia on the stem lesions (LP), the number (PN) and size (PS) of the pycnidia on the diseased tissues and sporulation (SPO). The methodology followed for the measurement of the disease components has been decribed before (LP Annual Report, 1991). Only the measurement of the sporulation varied slighlty. Lesioned areas were cut from the plants, weighed fresh and incubated in a moist chamber for 48 h for spore release. Every 5 plants of a genotype in a tray were pooled together and treated as a unit. After incubation, the cut diseased tissues were soaked in 20 ml of sterilized water for 4 h for spore release. Two readings on spore concentration were taken from two aliquots that were taken from the resulting spore suspension in each replicate. The resulting sporulation parameter measured after dividing the concentration obtained by the fresh weight of diseased tissue was sporulation per gm lesioned stem area. The disease severity rating (DS) was also taken at 7 and 10 days after inoculation.

In the greenhouse, ten seeds of each of the 16 genotypes were planted in sterilized soil in a 30 cm diam plastic pot. Each pot was replicated twice. The pots were randomly arranged within each replication and the replications were placed at different locations within the greenhouse resulting in an RBD. The temperature was set at 20°C in the greenhouse. At the flowering stage, the plants were inoculated with a spore suspension of the pathogen at a concentration of 500,000 spores ml^{-1}. After inoculation, the pots were covered with a plastic hood for 96 h to allow for enough humidity for infection to occur. Readings on the disease severity and the latent period (the time lapse after inoculation before the first pycnidia appear on the stems) were then taken on individual plants 6, 11, 15 and 18 days after inoculation (dai). No readings were taken beyond 18 dai since the disease no longer developed and the lesions almost stopped expanding. The diseased tissues were then selectively cut from each plant and the cut material from each genotype per replicate (10 plants) was incubated in a moist chamber for 48 h and the sporulation was then measured as in the growth chamber experiment.

In the field, each genotype was planted in a 4 X 10 m plot. The plots were laid next to each other in four rows of 4 plots each. The genotype in each plot was randomly selected. Surrounding the plots, highly susceptible chickpea genotypes were planted which acted as a check and a continuous source of inoculum. Plants were sown in December, 1991 and just after emergence in Feb., 1992, dried infected plant debris was spread in the fields. In mid April, 1992, a highly concentrated spore suspension of A. rabiei was sprayed in the field. This inoculation was repeated two more times at weekly intervals. Interrupted mist irrigation was given daily and up to a week after inoculation to ensure proper conditions for infection and disease development. Two weeks after the last inoculation, the check plants surrounding the plots were completely killed indicating a good disease establishment. At the early seedling stage, 20 plants per genotype were randomly selected and tagged. Readings were taken on these plants on disease development at the seedling, at the flowering, and at the early and late podding stages and the appearance of the first pycnidia on the stems.

Growth chamber results: At the seedling stage most genotypes showed high susceptibility to the disease. The disease severity rating 10 dai ranged between 7.56 and 2.86 with significant differences among the genotypes. The latent period varied between 5 and 13 days and for most genotypes increased with the increase of the genotype resistance. Few genotypes, such as ILC 3856, ILC 6188 and ILC 2956 however showed short latent periods with low disease severities (table 2.3.4). The LP was significantly correlated with the DSR (table 2.3.7) but the relationship was not linear and the rate of pycnidial appearance (1/LP) had a higher linear correlation with the disease rating.

Table 2.3.4. Disease severity (DS), mean latent period (LP), pycnidial size (PS) and number (PN) and sporulation per g diseased tissue (SPO) on 16 chickpea genotypes inoculated with a mixture or isolates of Ascochyta. rabiei at the seedling stage.

Genotype	DS1 (7 dai)	DS2 (10 dai)	LP (days)	LES3 (cm)	PS (um)	PN	SPO (million)
F. 81-41	6.33	7.56	5.00	0.73	114.2	111.8	37.20
ILC 3707	5.07	6.33	5.67	0.61	119.5	124.8	20.52
ILC 3568	5.46	6.23	5.85	0.90	126.5	89.9	25.05
ILC 3593	5.54	6.15	6.08	0.74	128.6	74.2	31.65
F. 84-158	3.71	4.71	6.57	0.52	117.7	39.6	5.19
F. 87-75	3.40	4.70	6.40	0.50	109.7	71.6	5.23
ILC 482	3.86	4.64	8.15	0.52	123.5	103.2	8.47
ILC 6189	3.30	4.10	7.71	0.42	135.6	76.9	4.53
F. 81-336	2.31	3.85	9.09	0.34	109.5	54.9	1.58
F. 89-1	2.75	3.67	7.66	0.40	117.2	19.7	0.52
F. 88-84	3.00	3.54	10.50	0.29	133.3	79.9	7.19
ILC 3279	2.71	3.50	10.11	0.39	109.3	88.9	3.11
F. 81-34	2.78	3.43	13.22	0.29	121.8	73.4	2.01
ILC 3856	2.30	3.30	5.00	0.89	139.3	60.3	4.75
ILC 6188	2.64	3.00	6.80	0.41	130.0	20.9	0.46
ILC 2956	2.43	2.86	7.33	0.56	116.5	21.6	0.08
Mean	3.62	4.49	7.58	0.52	121.6	69.4	5.89
LSD ($P \leq 0.05$)	0.60	0.61	1.24	0.19	10.18	33.2	-

As in the studies done on seperate races of the pathogen on a series of genotypes, the DSR was not correlated with the PS although there were significant differences among the pycnidial sizes on the various genotypes. Similar to the LP, the average PN per 5 mm lesioned tissue was correlated with the disease but it was not the best disease indicator.

The disease severity rating used in this study is based on the lesion size up to a disease rating of 4. Accordingly and as expected, the lesion size was highly correlated with the disease. As in the previous results on individual races, the lesion size at 10 dai (LES3) was the best indicator of the disease at that time with r=0.84 (Table 2.3.7).

The highest significant association with the disease rating was obtained however, with the sporulation measurements. The sporulation per gram diseased tissue at the time of pycnidial maturation had a correlation coefficient of r=0.96 with the disease 10 dai. Since the sporulation measurement was done only on diseased areas of the stems, the effect of the number of lesions on the plant on the total sporulation is eliminated. The sporulation component SPO analysed here is a direct indication of the actual sporulation of the lesions on a specific genotype.

Greenhouse results: The disease severity on the plants in the greenhouse was low indicating that the plants are more resistant at the flowering stage than the seedling stage (Table 2.3.5). This, however, could have been the result of a low inoculum level or the fact that the plants in the greenhouse were predisposed to be more resistant to the disease or the seedlings in the growth chamber predisposed towards susceptibility. The conditions in the greenhouse may also have not been always favorable to the disease since the fluctuation in light intensity and relative humidity could not be perfectly controlled. There were no clear significant correlations between the disease components LP and SPO studied and the disease severity of the genotypes. There were large variations between the individuals within the same pot or sampling unit, further suggesting that the inoculum spread was not so uniform. Still, there was a significant correlation between the disease severities 7 and 10 dai of the plants at the seedling stage and the disease severity at the flowering stage (Table 2.3.7). Neither the LP nor the SPO parameter in this experiment could reflect any level of resistance in the plants at either the seedling or the flowering stages of the plants.

Field results: The disease development in the field was followed and the four readings taken (DS1 to DS4) reflect the seedling, flowering, early and late podding stages of the plants. Table 2.3.6 shows the mean DS at the various developmental stages of the crop, the area under the disease progress curve (AUDPC) and the mean latent period (LP) of the genotypes under study. The AUDPC was calculated according to the trapezoid method while assuming that at time zero the disease reading was nill. The latent period refers only to the appearance of pycnidia on stem lesions and not leaf lesions which often produce pycnidia much earlier.

The highest disease reading of 8.4 was reached by the genotype F.81-41. The weather conditions were obviously not favorable for the disease development up to the second reading since the rating remained low for all genotypes. The rain showers that fell between the second and the third readings greatly enhanced the disease development and specially on the susceptible genotypes. As expected, the AUDPC was a good indicator of the maximum disease level reached and of the general susceptibility level of the genotype (Table 2.3.7). The highest DS reached (DS4) and the AUDPC were highly correlated with the disease level at the seedling stage, more at 7 dai than at 10 dai as well as the disease severity level at the flowering stage in spite of the low disease level obtained in that experiment (Table 2.3.7). They were highly correlated with the sporulation level of the diseased tissues at the seedling stage but not at the flowering stage. They were however not correlated with the latent both neither at the seedling and at the flowering stage.

Table 2.3.5. Disease severity (DS), mean latent period (LP) and sporulation per g diseased tissue (SPO) on 16 chickpea genotypes inoculated with a mixture of isolates of Ascochyta rabiei at the flowering stage.

Genotype	DS1 (6 dai)	DS2 (11 dai)	DS3 (15 dai)	DS4 (18 dai)	LP (days)	SPO (million)
F.81-41	1.15	1.92	2.92	3.92	15.0	8.86
ILC 3707	1.40	2.50	2.95	3.80	14.5	1.36
ILC 3568	1.45	2.85	3.45	4.15	12.7	1.63
ILC 3593	1.26	2.42	3.32	3.89	12.6	9.04
F.84-158	1.38	2.06	2.25	2.56	18.0	0.00
F.87-75	1.12	2.12	2.41	2.76	15.0	21.05
ILC 482	1.25	2.25	2.65	2.85	14.6	2.91
ILC 6189	1.63	2.56	2.81	2.81	11.8	6.98
F.81-336	1.21	2.16	2.42	2.63	14.0	0.00
F.89-1	1.74	2.16	2.37	2.74	15.6	5.56
F.88-84	1.65	2.10	2.15	2.45	14.7	2.56
ILC 3279	1.50	2.39	2.78	3.00	11.2	9.57
F.81-34	1.06	1.94	2.28	2.61	15.2	30.77
ILC 3856	1.27	2.07	2.33	2.60	14.0	7.14
ILC 6188	1.60	2.30	2.50	2.70	12.2	7.14
ILC 2956	1.50	2.39	2.56	2.78	13.0	5.88
Mean	1.40	2.28	2.66	3.05	13.8	
LSD ($P \leq 0.05$)	0.34	0.41	0.56	0.69	2.66	-

Table 2.3.6. Disease severity at four different developmental stages of the plants (DS1 to DS4), area under the disease progress curve (AUDPC) and mean latent period (LP) on 16 chickpea genotypes inoculated with a mixture of isolates of Ascochyta rabiei under field conditions

Genotype	DS1	DS2	DS3	DS4	AUDPC	LP (days)
F. 81-41	2.13	2.33	7.47	8.36	293.6	45.9
ILC 3707	2.65	3.30	6.45	6.95	281.6	43.4
ILC 3568	3.25	4.55	7.75	8.65	350.9	31.2
ILC 3593	2.40	2.85	5.89	6.95	260.2	45.1
F. 84-158	2.00	2.00	2.85	3.85	151.6	50.6
F. 87-75	2.00	2.05	3.55	4.50	172.5	58.0
ILC 482	2.30	2.60	4.00	4.25	191.6	49.2
ILC 6189	2.30	2.30	2.56	3.00	146.3	54.8
F. 81-336	1.90	2.10	3.80	4.30	175.0	56.0
F. 89-1	1.30	1.90	3.80	4.15	162.1	49.8
F. 88-84	1.60	1.85	3.50	4.45	163.9	52.5
ILC 3279	2.05	2.25	3.10	3.45	157.2	54.4
F. 81-34	2.15	3.10	5.35	5.95	240.1	44.1
ILC 3856	1.95	2.15	3.21	3.32	155.3	50.0
ILC 6188	2.70	2.75	3.20	3.95	180.6	58.1
ILC 2956	2.70	2.80	3.56	4.16	190.9	42.7

Conclusions: The significant inter-relationship between the disease reaction in the field and the disease in either the seedling or the flowering stages indicates that the primary screening for Ascochyta blight could be made at the seedling stage. Still however, some genotypes such as FLIP 84-158 and ILC 6189 were susceptible at the seedling stage but showed resitance in the field. On the other hand genotype FLIP 81-34 showing resistance at the seedling stage was susceptible under field conditions. This latter genotype also showed an exceptionally high sporulation level in the greenhouse at the flowering stage (TAB. 2) in spite of its low disease severity rating. Plants susceptible at the seedling stage usually do not survive until the adult stage if the disease pressure is high and are usually eliminated from the breeding material. Those plants showing resistance at the seedling stage could be further screened for resistance to later developmental stages.

The latent period, a very important component of resistance in many pathosystems showed a lot of variability in our study. High susceptibility is always associated with very short latent periods at least at the seedling stages. Resistance however,was not always associated with long latent periods. Similar results were also observed in studies using other genotypes and using individual races of the pathogen. This would suggest the presence of different mechanisms of resistance in the various genotypes.

The level of sporulation should be further included in the screening studies since it is gives a further indication of the resistance level of a genotype and the method used is simple. It is however important to test other methods of sporulation measurements such collecting spores over time in order to establish the best measurement method which could help in disease screening. Neither the pycnidial number nor the pycnidial size was a better measure for the disease resistance than the sporulation. The methodology used in this study for measuring pycnidial number could definitly be improved by taking the stem width of the genotype into consideration. Still, unless the number of pycnidia on the diseased lesions could be easily and accurately estimated, the sporulation measurement method used in this study would remain a more pratical for large scale screening.

Table 2.3.7. Correlation between the disease severity (DS), the latent period (LP), the lesion size (LES), the pycnidial number (PN), the sporulation (SPO) and the area under the disease progress curve (AUDPC) in the seedling stage, flowering stage and under field epidemic of Aschochyta blight of chickpea.

		A	B	C	D	E	F	G	H	I	J	K
A	DS1-seedling	1.00										
B	LP-seedling	-0.51	1.00									
C	PN-seedling	0.64	ns	1.00								
D	SPO-seedling	0.96	-0.50	0.63	1.00							
E	LES3-seedling	0.84	-0.55	ns	0.87	1.00						
F	DS4-flowering	0.90	-0.51	0.58	0.91	0.91	1.00					
G	LP-flowering	ns	ns	ns	ns	ns	ns	1.00				
H	SPO-flowering	ns	0.44	ns	ns	ns	ns	ns	1.00			
I	DS4-field	0.86	ns	0.53	0.86	0.84	0.87	ns	ns	1.00		
J	AUDPC-field	0.81	ns	0.53	0.80	0.84	0.88	ns	ns	0.97	1.00	
K	LP-field	-0.56	ns	ns	-0.55	-0.56	-0.67	ns	ns	-0.74	-0.81	1.00

* Values of r: 0.00 - 0.43 ; P >0.05 not significant (ns)
r: 0.44 - 0.56 ; P <0.05
r: > 0.57 ; P <0.01

2.3.4. Development of the Ascochyta Blight Epidemic in Field

The level of disease resistance to Ascochyta blight in chickpea is determined by the disease severity rating that a genotype receives. The mechanisms with which genotypes resist or react with susceptibility to a pathogen in the field may be different. These mechanisms, if present, would not be revealed however, by the simple scoring of disease ratings. This study was conducted to understand better the reaction of various genotypes to the different disease developmental stages of initial infection, stem lesions, girdling and breakage.

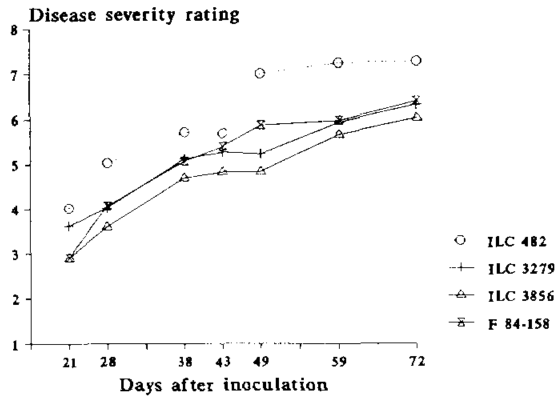
The disease development under field conditions was monitored in detail in 1991 and 1992. Four genotypes were planted in small plots in the field and the field exposed to an epidemic of the disease as described in Section 2.3.3. Thirty plants per genotypes were tagged in 1991 and 20 plants in 1992, and observed individually and at regular intervals for the occurrence and number of branches with lesions, girdling or breakage. The latent period was also estimated through the appearance of the first pycnidia on the stem lesions. The relative vigour of the plants and their developmental stages were also recorded.

Maximum disease severity reached by the 4 genotypes under study, the calculated area under the disease progress curve (AUDPC) and the estimated latent period in the field are given in Table 2.3.8. The latent period (LP50) is the time from artificial inoculation until at least 50% of the plants under study showed pycnidia on their lesioned stems.

Table 2.3.8. Maximum disease severity (Ymax), area under the disease progress curve (AUDPC) and the latent period (LP50) a) for field epidemics of Ascochyta blight of chickpea in the years 1991 and 1992.

	Ymax		AUDPC		LP50 (days)	
Genotype	1991	1992	1991	1992	1991	1992
ILC 482	7.41	4.25	357.6	191.6	22	50
ILC 3279	6.33	3.45	290.0	157.2	22	50
ILC 3856	6.07	3.31	280.6	155.3	28	50

The disease severity levels reached by the crop in 1992 is much lower than in 1991 (Fig. 2.3.2). In 1991 the initial level of disease was high (DS = 3-4), whereas it was only ca. 2 in 1992. The disease level in 1992 had not increased even twenty eight days after inoculation, when the plants were already in full-bloom. It was only after the several days of rainfall that some increase in disease severity occurred, but it stopped soon because of the sudden increase in temperature and the dry weather conditions that prevailed afterwards. The increase in the disease between 28 and 50 dai in 1992 was mainly due to an increase in the number of branches with lesions Fig. 2.3.4. This indicates an increase in the new infections. Only in ILC 482 this increase in disease level was accompanied by a shift towards lesion expansion as indicated by an increase in the relative number of girdled branches. In the other genotypes, no increase in either girdling or stem breakage was obvious. In 1991 (Fig. 2.3.3) the pattern of disease development was similar to that in 1992 although the severity was much higher. In 1991, the disease developed on all 4 genotypes steadily. However, ILC 482, unlike the other 3 genotypes showed a quick shift in the relative number of lesioned branches towards girdled or broken branches thus indicating again a quick lesion expansion rate. ILC 3856 on the other hand, showed a steady but slow development of lesions towards girdling then breakage. ILC 3279 and FLIP 84-158 did develop girdled branches but resisted stem breakage.



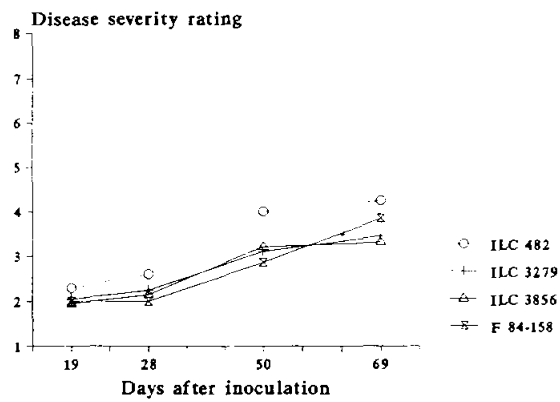


Figure 2.3.2. Disease severity rating in 4 genotypes of chickpea at different days after inoculation in the field in 1991 and 1992.

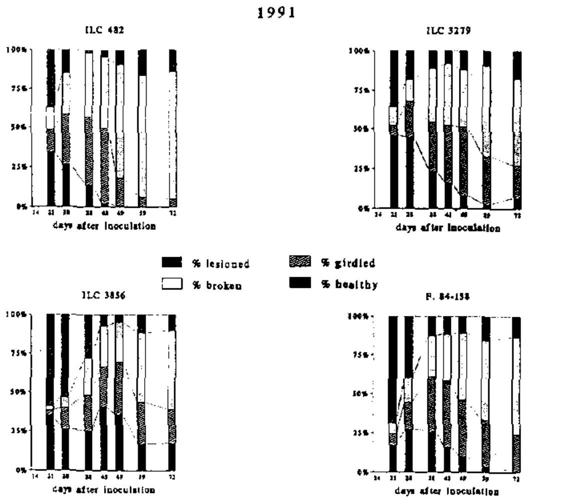


Figure 2.3.3. Progress of Ascochyta blight development on the branches of 4 genotypes of chickpea at different days after inoculation in the field in 1991.

The estimated latent period for all genotypes in 1992 was 50 days (Table 2.3.8). This is a rather long period specially when it is compared to the estimated latent periods in 1991. If the disease requires such a long time before the first spore generation is produced, the pathogen has little chance of producing several disease cycles on the crop since by the time the new infections develop, the growing season would have almost ended.

The long latent period observed in 1992 could have either been the result of the reduced lesion expansion observed or was solely influenced by the unfavorable environmental conditions. Studies done on seedlings in

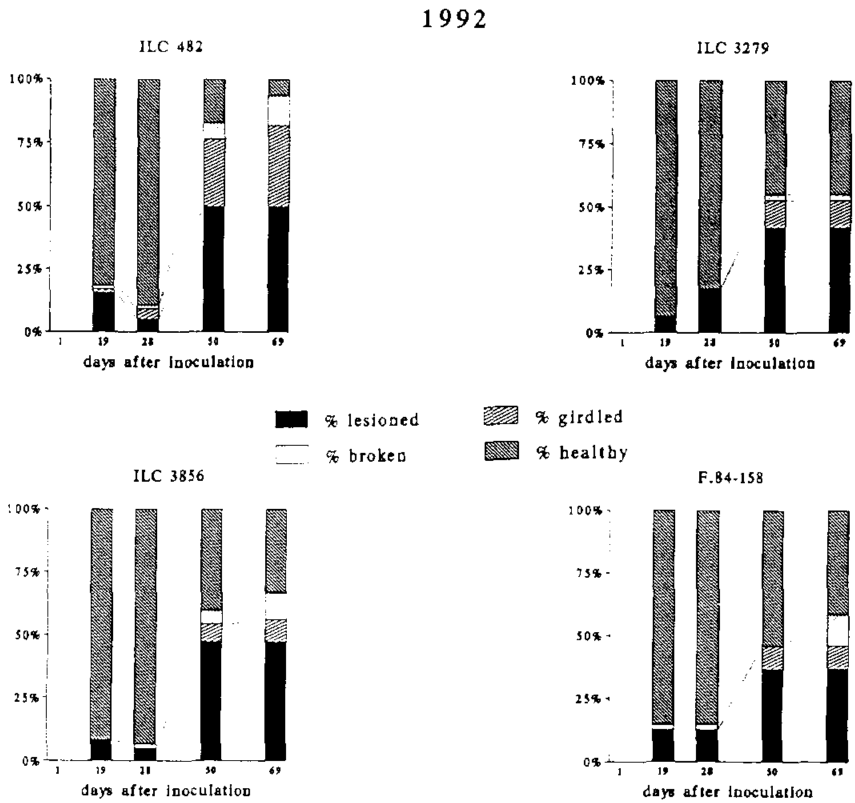


Figure 2.3.4. Progress of Ascochyta blight development on the branches of 4 genotypes of chickpea at different days after inoculation in the field in 1992.

the growth chamber indicated that these two resistance components act independently. However, the results also showed that stem lesions should at least reach the average size of 0.3 cm before any pycnidia could develop on them regardless of the resistance level of the host (see LP Annual Report, 1991). Considering that a disease severity rating of 2 indicates the presence of lesions that are <0.3 cm, no pycnidia could have developed on the stems in 1992 before 28 dai (Fig. 2.3.2). The lesion expansion would then have had its effect in delaying the latent period in this year.

The results indicate that at least two factors are critical for the actual losses that might occur due to stem breakage in chickpea. The lesion expansion rate is the first factor which seems to be high in ILC 482 and which appeared in the results of both years although the weather conditions and the disease development in these years were very different. The second factor is the level of resistance to breakage which might be the result of the stem thickness or its chemical constitution. Such a characteristic is demonstrated by the genotypes ILC 3279 and FLIP 84-158 and probably aldo by ILC 6189.

2.4. Chickpea Entomology

In the Mediterranean region leafminer (Liriomyza cicerina Rondani) is the main pest of chickpea and studies at ICARDA concentrate on its control methods and host plant resistance. Chickpea podborer, mainly Helicoverpa armigera Hb. accounts for high yield losses in some regions of India, Pakistan and West Asia, but the severity of damage varies between regions. Usually higher infestations were only recorded in the past in Southern Syria, but startig last season podborer damage has been increasing in Northern Syria as well. Therefore all experiments were also evaluated for podborer damage. In general winter-sown chickpea had low leafminer, but high podborer damage, whereas in spring-sown chickpea leafminer damage was high and podborer damage low.

2.4.1. Population Dynamics of Chickpea Leafminer and its Parasitoids

Chickpea leafminer populations (Liriomyza cicerina) were sampled by D-Vac in winter- and spring-sown chickpea plots at Tel Hadya. In winter-sown chickpea leafminer started occurring in mid April, reached a peak in mid May and disappeared with maturity of the chickpea (Fig. 2.4.1). In spring-sown chickpea leafminer only appeared in early May, but had 2 generations with a peak in mid May and early June. In winter- and spring-chickpea populations of parasitoids of leafminer, mainly Opius monilicornis and Diglyphus isaea, also reached high levels (Fig. 2.4.1). In the spring chickpeas, because of later crop maturity allowing the development of second generation of leafminer even more adults of parasitoids than of leafminer, were collected in the D-Vac samples in June indicating a high parasitization of the second generation. This would reduce the number of leafminer entering aestivation. It is not known, however, whether these parasitoids aesitivate and hibernate as well or move to other hosts. If they would aestivate and hibernate in the leafminer pupae, it might be possible to collect and store these and use them as biological control agents early in the following season. This aspect will be investigated next season.

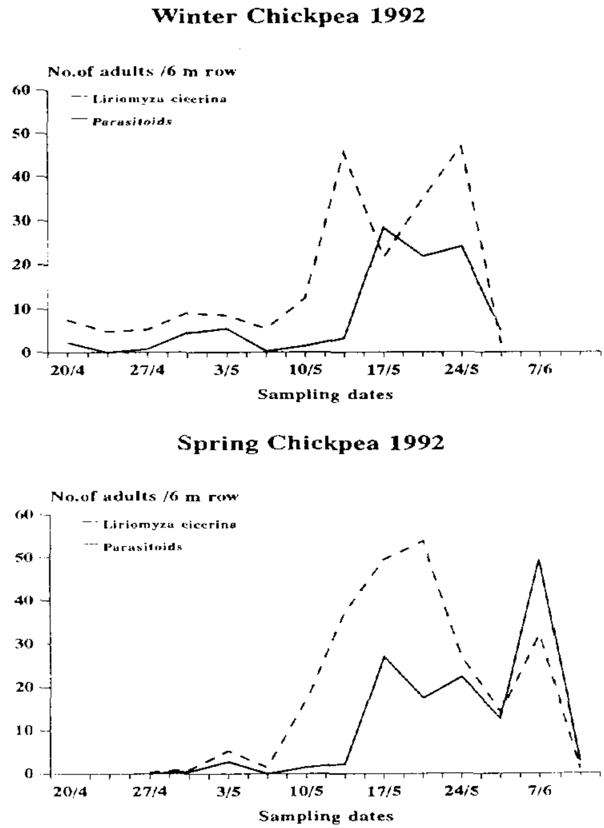


Figure 2.4.1. Development of population of adults of leafminer and parasitoids, as sampled by D-Vac at different sampling dates in winter- and spring-sown chickpea at Tel Hadya, 1991/92.

2.4.2. Chemical Control of Leafminer and Podborer

The effectiveness of neem (Azaderichita indica) seed extract applications for as a safe chemical leafminer control was further tested in winter- and spring-sown chickpea at Tel Hadya and in spring chickpea at two on-farm locations (Alkamiye and Squeilbiye). The third on-farm experiment was lost - no germination because of lack of timely rains. Two (at Tel Hadya) and three (in on-farm locations) sprays consisting of 0.5 kg neem seeds per 10 l water at a rate of 500 l/ha applied in early and late May and early June were compared with one spray of Thiodan 35 EC (2 ccl at 500 l/ha) applied in mid May. Check plots were sprayed with water (500 l/ha) on the same dates as the neem extract.

At Tel Hadya in winter- chickpea the percent mining was low, but still significantly reduced by neem and Thiodan (Fig. 2.4.2.). Podborer damage was more severe with 19.2 % pod damage in the check. Both neem and Thiodan significantly reduced the pod damage to 0.4% and 4.1%, respectively, resulting in significant yield increases from 1756 kg/ha in the check to 2014 kg/ha (Thiodan) and 2101 kg/ha (neem).

In the spring-sown chickpea at Tel Hadya the percent mining was higher and significantly reduced only by Thiodan (Fig. 2.4.2). Podborer damage was lower (7.4% in the check) and also significantly reduced to less than 0.5% by both insecticide treatments. Thus the significant yield increases by both treatments can also be accounted to control of podborer.

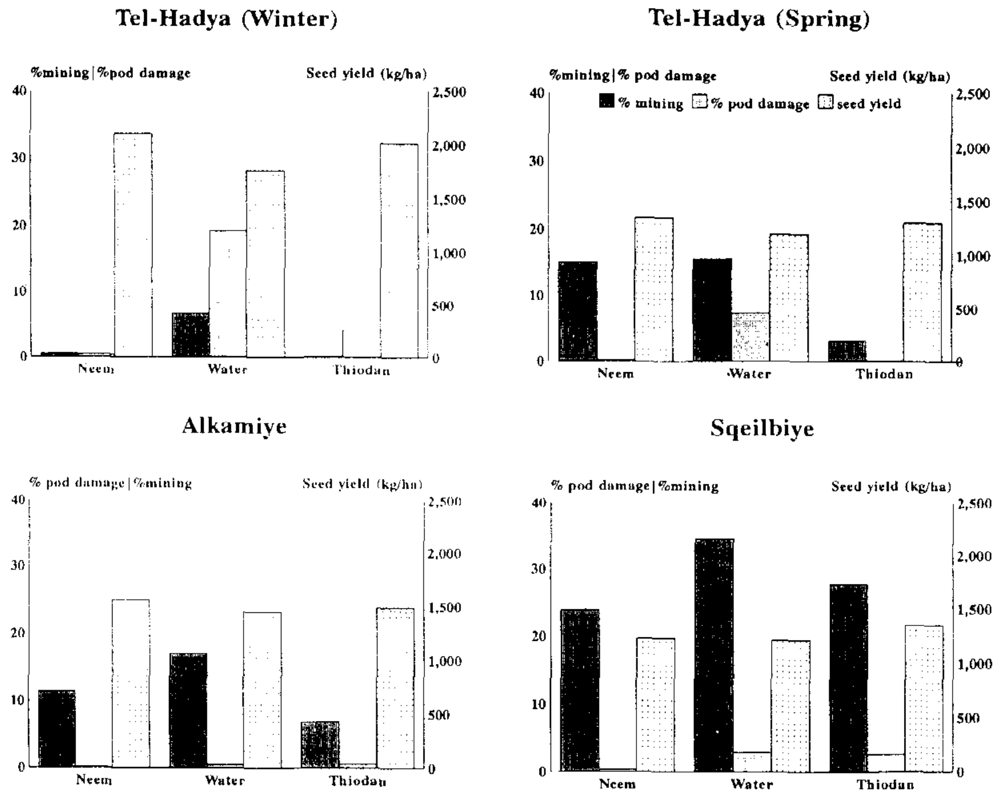


Figure 2.4.2. Effect of 3 applications of neem-seed extract as compared to one spray of Thiodan 35EC on leafminer and podborer infestation and seed yield at Tel Hadya in winter- and Spring-sown and at Alkamiye and Squeilbiye in Spring-sown chickpea, 1991/92.

At Alkamiye the percent mining was reduced by both treatments, but only by Thiodan significantly (Fig. 2.4.2). Pod damage was low (< 1 %) and the yield increases by treatments were non-significant.

At Squeilbiye the leafminer damage was highest of all locations and lower in both insecticide treatments, but not significantly (Fig. 2.4.2). Podborer damage was low, but still significantly lower in neem sprayed plots. Yield increases were non-significant.

These results confirm last years data that neem extract effectively reduces the percent pod damage in chickpea resulting in significant yield increases. Neem could provide an alternative to conventional insecticides for control of H. armigera, having the advantages of no environmental hazards, no development of resistance known, less disruptive to parasitoids. The data also show, that the alarmingly high podborer infestations were limited to Tel Hadya. It will be checked in the coming year whether it is a "research station problem", or is developing due to the increasing planting of summer crops around Tel Hadya.

2.4.3. Host Plant Resistance to Leafminer and Podborer

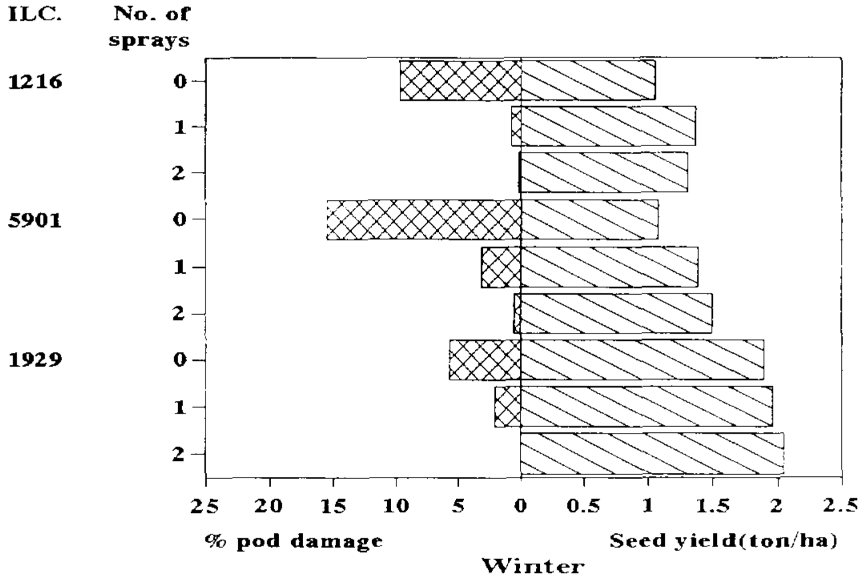
Of the previously selected 8 promising chickpea lines the two most promising lines, ILC 1216 and ILC 5901, were grown in winter and spring together with the susceptible check (ILC 1929) without and with the protection of 1 and 2 applications of Thiodan 35 EC (2cc/l).

Leafminer infestations were monitored by placing water filled trays between chickpea rows to collect larvae dropping from leaves to the soil for pupation. In winter- and spring-sown chickpea plots without insecticide application the total number of larvae per tray was significantly lower in ILC 5901. Since leafminer infestation started rather late, the damage in winter-sown chickpea was very low. In spring-sown ILC 1216 plots the number of larvae was high exceeding ILC 1929. This is probably due to the late maturity of ILC 1216, but it may also indicate that preference might be the main mechanism of resistance. One or two sprays of insecticide reduced the number of leafminer larvae.

The percent pod damage was recorded in 10 plants per plot of all treatments. Except for ILC 1929 infestation was higher in winter-sown plots (Fig. 2.4.3.). In winter sowing the highest percent pod damage was found in ILC 5901 (15.5%), lowest in ILC 1929 (5.7%), which greatly differs from last years results. It could be possible that because of its early maturity ILC 1929 escaped podborer infestation in winter-sowing, which would also explain the higher infestation in spring-sowing. One application of Thiodan reduced the pod damage significantly and increased seed yields in winter- and spring sowing. Seed yields were higher in winter sowing in all treatments. Yields of ILC 1216 and ILC 5901 were significantly lower than of ILC 1929 in all treatments.

With the increasing podborer infestations these studies are becoming more complex as it is not possible to clearly separate yield loss from podborer from that caused by leafminer.

S. Weigand



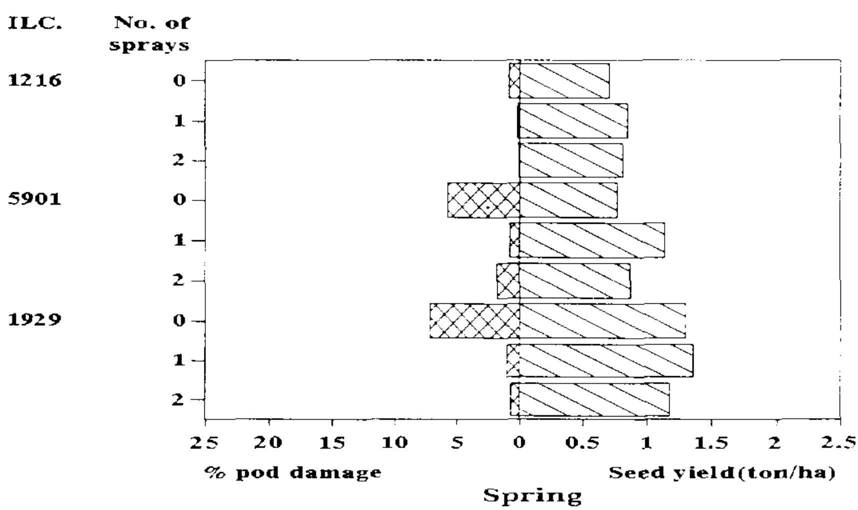


Figure 2.4.3. Percent pod damage and seed yield in 3 winter- and spring-sown chickpea lines with 0, 1 and 2 sprays of Thiodan 35EC (@ 2 ccm l^{-1}) at Tel hadya, 1991/92.

2.4.4. Mechanisms of Resistance

In a collaborative project between the Max-Planck Institut fur Biochemie, Munich, FRG and ICARDA the role of leaf exudates as possible mechanisms of resistance to leafminer was further studied. Leaf exudates of 6 Kabuli chickpea lines (ILC 3398, ILC 1929, susceptible; ILC 655 medium resistant; ILC 316, ILC 1216, ILC 5901, resistant) were collected for 2 seasons at ICARDA, and 1 season at the Max-Planck Institute and ICRISAT and analysed for the amount of malic acid and oxalic acid. The results revealed that the amount of malic acid and leaf area were related to resistance. Leaf exudates of the susceptible lines had lower amounts of malic acid than the resistant lines. Leaf area of the susceptible lines was higher than the resistant lines. The amount of oxalic acid could not be related with different degrees of resistance and thus apparently is not of importance in this respect. In ILC 5901, the line with the highest degree of resistance to leafminer, the small leaf area might be the main factor of resistance, as the amount of malic acid in the leaf exudates was low in comparison with the other resistant lines, but still higher than in the susceptible lines.

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2.5. Chickpea Biological Nitrogen Fixation

2.5.1. Nitrogen Fixation of Chickpea Cultivars in Response to Inoculation with Selected Rhizobia

The ability of chickpea to fix atmospheric nitrogen lessens its dependence on soil N and reinforces its role in the cropping systems of the region. Practices which increase symbiotic effectiveness will minimize the quantity of soil N utilized by the crop and enhance growth of the subsequent crop. Introduction of cold-tolerant, ascochyta blight resistant lines for winter sowing into new, drier production areas has been accompanied by nodulation deficiency in several areas of the Mediterranean region. In these new production areas soils are less likely to contain adequate populations of the Cicer-specific rhizobia than traditional chickpea areas, and crops may show significant yield increases when seeds are inoculated with selected rhizobial strains. The highly specific rhizobial requirement of chickpea has been found to extend to strain-cultivar specificity for N_2 fixation, implying the possibility that limited effectiveness of naturalized rhizobial populations with newly introduced cultivars may restrict genetic potential for dinitrogen fixation. Necessity for inoculation may therefore also exist where introduced cultivars, selected for high yields cannot express their full capability for N_2 fixation in symbiosis with native rhizobial populations which have developed in coadaptation with local landraces.

In trials conducted over four seasons (1987/88 to 1990/91) in Northern Syria, variations in N_2 fixation and yield of a range of chickpea cultivars inoculated with selected superior Rhizobium strains were evaluated with a view to establish base-line values for P_{fix} (proportion of crop N derived from N_2 fixation) in recommended cultivars so improvements through rhizobial strain selection and legume breeding can be quantified. Use of ^{15}N methodology and non-nodulating chickpea and barley as reference crops allowed accurate evaluation of N_2 fixation under the wide range of environmental conditions.

Eight chickpea cultivars were included in the experiments, selected for their regional use and characteristics such as cold tolerance, tall-type plant architecture, ascochyta blight resistance and large seed size. Cultivars tested included ILC 195, ILC 482, ILC 3279, ILC 5396, ILC 5414, ILC 6250, ILC 6281, and ILC 6327; only the first three were tested in 1987-88 season.

Most probable number (MPN) estimations of indigenous chickpea rhizobia populations in the field soils were low-moderate, ranging from 9.1×10^1 to 4.2×10^3 rhizobia g^{-1} soil. Low populations were due to absence of chickpea cultivation for several years. Rhizobia treatments comprised uninoculated and two strain treatments; all experiments included at least one single strain treatment (strain 39), while some included two single-strain inoculants (strains 31 and 39) or a single-strain inoculant (strain 39) and a 3-strain mixture (strains 31, 39 and 36). Strains were selected based on prior N_2-fixing performance on the concerned cultivars in aseptic hydroponic culture in greenhouse trials. Seeds were inoculated at planting using liquid application method, at a rate to provide approximately 10^6 viable cells per seed. Seasonal rainfall in field trials fluctuated from 290 to 504 mm, representing a normal range of rainfall for winter-sown chickpea.

Trial results are here reported only for the best inoculation (single strain CP 39) and non-inoculated treatments. Inoculation had no general effect on crop dry matter yields at lower rainfall (Fig.

2.5.1). At 340 mm rainfall, however, cultivars began to show differential yield effects with rhizobial inoculation, ranging from no response (ILCs 3279, 5396, 5414) to 750 kg/ha increase (ILC 6327). Under conditions of higher moisture (504 mm), the average inoculated cultivar yielded about 800 kg/ha more dry matter than when not inoculated (Fig. 2.5.1). It can also be observed that cultivar yields, which differed little at low rainfall, varied widely at high rainfall and yield response to inoculation varied from no response in cultivar ILC 5396 to 1.9 T/ha in ILC 482.

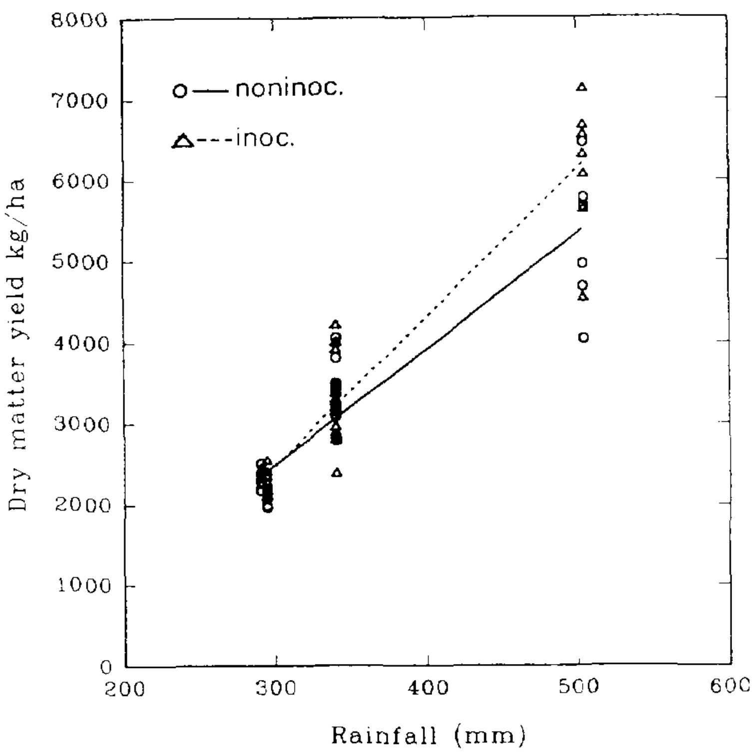

Figure 2.5.1. Effect of rhizobial inoculation on dry matter yield of chickpea genotypes in relation to seasonal rainfall, Tel Hadya, 1987/88-1990/91.

The effect of inoculation on N_2 fixation with increasing rainfall and yield are clearly shown in Figures 2.5.2 and 2.5.3. Because of wide cultivar variations in yield at higher moisture and the limited number of points on the rainfall axis, total crop N, fixed crop N, and $\underline{P}_{fix}$ have been plotted against dry matter yields. In uninoculated cultivars, $\underline{P}_{fix}$ remains relatively constant at about 60% between 2000 and 7000 kg/ha dry matter production (Fig. 2.5.2). The effect of this constant proportion of fixed- to soil-derived N in the plant means that with increasing dry matter (and N) production, the quantities of soil N taken up by the crop increase. Figure 2.5.2 indicates average soil N uptake (the distance between total N and fixed N curves) increasing from 20 kg/ha to nearly 50 kg/ha over the range of dry matter produced in the trials. In contrast, the efficiency of N_2 fixation is clearly increased at higher yield levels as a result of rhizobial inoculation (Fig. 2.5.3). In inoculated cultivars, $\underline{P}_{fix}$ increases with increasing dry matter production, reaching a maximum of 80% at the highest yield levels. Increased fixation efficiency with increasing yield results in an increasing proportion of fixation-derived N in the plant and a lower, relatively constant fraction of soil-derived N (Fig. 2.5.3).

The impact of inoculation on the relationship between dry matter and nitrogen yields for some representative individual cultivars is shown in Figure 2.5.4. In most cultivars tested, inoculation does not increase the amount of crop N per unit dry matter produced. The proportion of crop N derived from fixation is, however, often increased by inoculation. The consequences of this improvement, detectable only with N_2 fixation measurement techniques like those incorporating ^{15}N, are improved soil fertility and improved system economy.

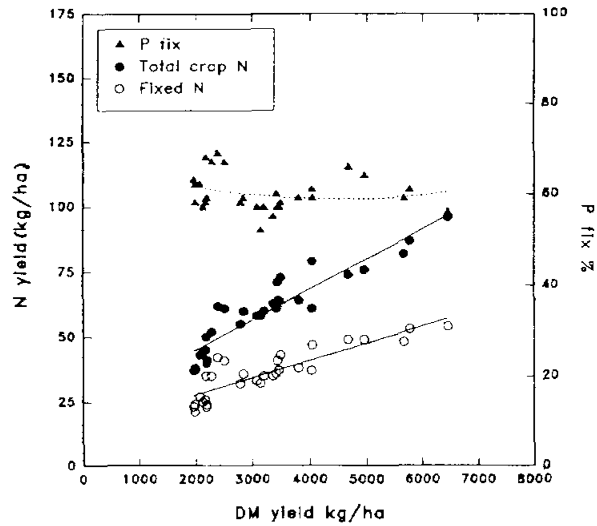

Figure 2.5.2. Nitrogen yield and source in uninoculated chickpea.

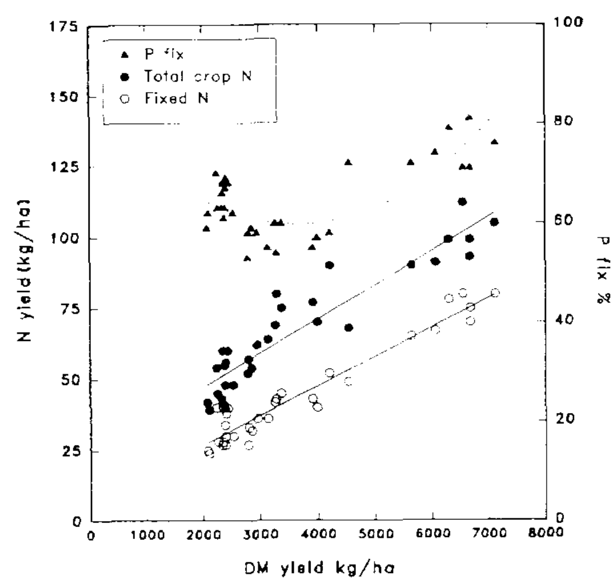

Figure 2.5.3. Nitrogen yield and source in inoculated chickpea.

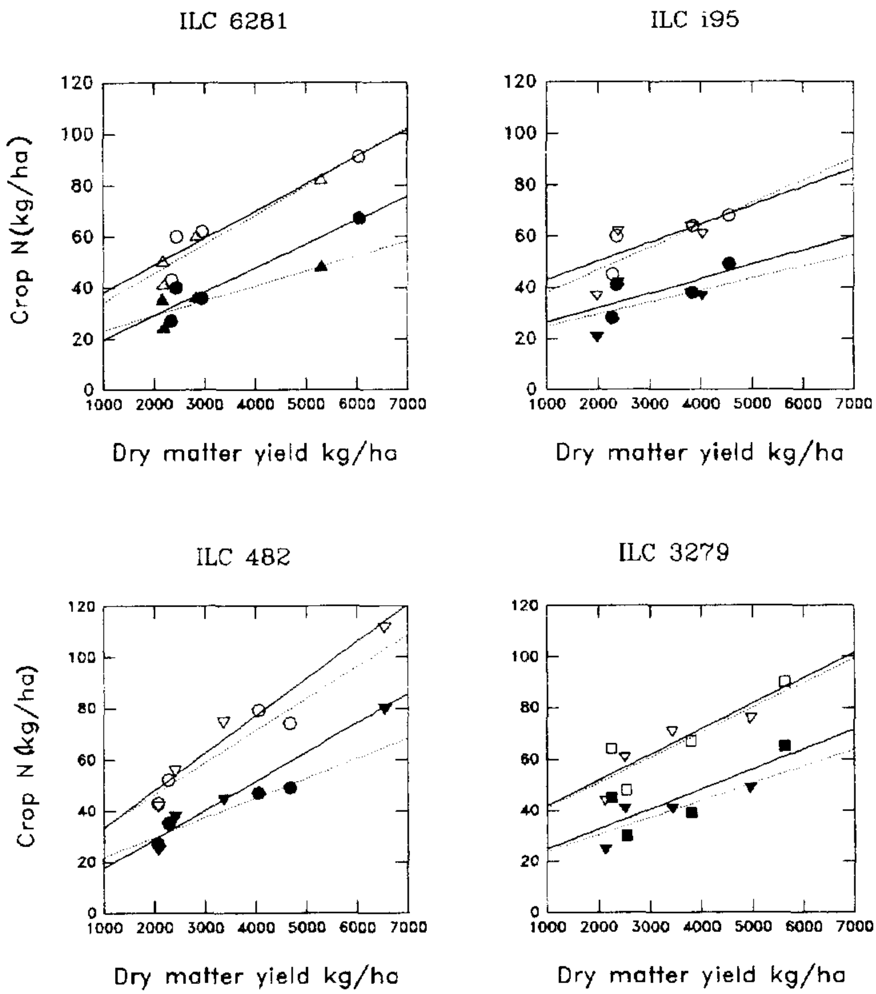

Figure 2.5.4. Relationship between dry matter yield and nitrogen yield for some representative individual cultivars.

The N_2 fixation data from these trials quantitatively indicate the effects of chickpea inoculation in Northern Syria with selected superior rhizobia. Although effects of inoculation on yield are limited, the quantities of soil N preserved could be significant in a systems context. A farmer, however, will find it difficult to adopt inoculant technology if economic rewards, such as increased yields of the legume or following cereal, are not obtained as a consequence.

The interaction between strains and cultivars for N_2 fixation efficiency, in addition to a similar interaction for competition and nodule formation, complicates the approach to wide-scale inoculation of chickpea cultivars, especially where new improved cultivars are being released on a regular basis. Two strategies may be used to increase N fixed by the chickpea crop. Selection of cultivars for high N_2 fixation with a broad range of rhizobia reduces the need for inoculation with specific strains. This approach, however, may fail where native strains are absent or ineffective. Alternatively, mixtures of highly effective strains may be used as inoculants. This approach works with some cultivars, but is dependent on strain-cultivar interaction for competitiveness in nodule formation. Investigations into these aspects of host-strain specificity are continuing.

D. Beck

2.5.2. Effect of Moisture on N_2 Fixation in Chickpea Cultivars

Of the legume crops grown in wheat-based Mediterranean rotations, chickpea is often considered inferior in N_2 fixation, possibly due in part to a limited capability of landrace varieties to efficiently fix

N under conditions of moderately low moisture availability. This may be especially true under conditions of spring sowing, where decreasing moisture availability and increasing temperatures adversely affect the capability of the crop to fix N. Characterization of the interactions of N_2 fixation and moisture in chickpea will allow development of management strategies designed to improve the N economy of soils through legume N_2 fixation.

During 1988/89 and 1989/90 seasons, field trials utilizing the line-source sprinkler for variable moisture application and incorporating ^{15}N microplots were conducted to determine the effects of variable moisture supply on N_2 fixation in 6 chickpea lines. The material tested included 4 kabuli-type lines (3 of Mediterranean origin and 1 ICARDA cross) and 2 desi lines from ICRISAT. These cultivars were part of a group of 20 cultivars tested for drought tolerance, water use efficiency and yield response to increase in moisture supply.

Aboveground dry matter and nitrogen yields were measured at physiological maturity under 8 moisture levels, ranging from 290 to 504 mm. For measurement of N_2 fixation, an isotope dilution method was used with non-nodulating chickpea line PM233 and local barley as reference crops. No rhizobia inoculant was used, as the field soil contained an adequate population of chickpea rhizobia.

At lower moisture levels cultivar yield variation was minimal, though cultivars ILC4958, FLIP 85-45C, and ICC1919 gave consistently larger dry matter and N yields between 290 and 335 mm moisture. As applied moisture increased, the variation amoung cultivars for yield increased (Fig. 2.5.5). Under increased moisture, the same 3 cultivars (4958, 85-45C, and 1919) produced the highest yields. Measurements of $\underline{P}_{fix}$ (the proportion of crop N derived from N_2 fixation) at each moisture level were not significantly different amoung cultivars, however.

Because of large cultivar variations in yield and N_2 fixed at the higher moisture levels, total crop N, fixed crop N, and $\underline{P}_{fix}$ have been plotted against aboveground dry matter yields for clearer presentation of the relationships between these characters (Fig. 2.5.6). $\underline{P}_{fix}$ increased rapidly with increasing yield at lower levels, indicating that fixation was severely limited at the lower end (Fig. 2.5.6). Fixation efficiency reaches an average maximum of 68% at about 5000 kg ha^{-1} dry matter produced. $\underline{P}_{fix}$ values were highest at the upper moisture levels in the 1990/91 trial, due to favorable distribution of rainfall above that provided by supplemental irrigation. All cultivars registered $\underline{P}_{fix}$ values above 70% at 425-455 mm moisture in this trial. The correlations between dry matter produced and N yields were high, with coefficients of 0.92 and 0.90 for total N and fixed N, respectively. This relationship indicates that N_2 fixation in chickpea, under conditions where adequate rhizobia are present, is yield driven, and implies that environmental constraints on plant yield will limit N_2 fixation.

It is interesting to note that soil N uptake by the crop, shown in Figure 2.5.6. as the area between the 2 nitrogen yield curves, changes little with increasing yield. Below 1 t ha^{-1} dry matter

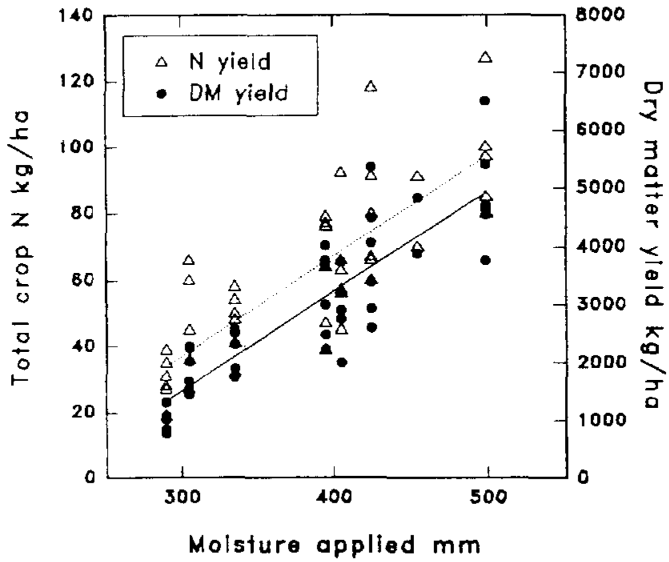

Figure 2.5.5. Relationship of moisture applied and total dry matter and nitrogen yield of above ground parts of six genotypes of chickpea at Tel hadya, 1988 to 1990.

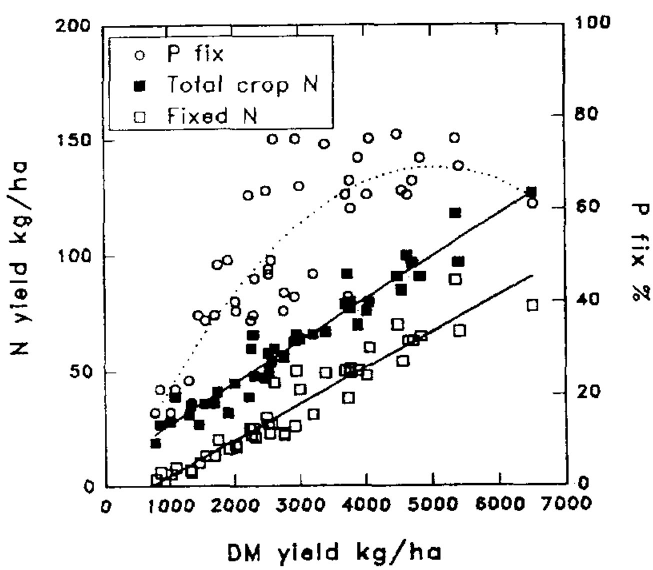

Figure 2.5.6. Relationship of chickpea dry matter yield and crop N, tel Hadya, 1988 to 1990.

production, virtually no N_2 is fixed, causing the crop to deplete the soil N pool by about 25 kg/ha. Between 4 and 5 T ha^{-1} dry matter production, where N_2 fixation efficiency is highest, soil N use is likewise about 25 kg ha^{-1}. These values approximately represent the total amount of N removed from the soil by the crop, assuming removal of seed and straw from the field at harvest, but neglect N input from roots and nodules.

There was some concern that these line-source trials, because they were spring-sown and grown with supplemental irrigation, would not truly express the relationship between available moisture, yield, and N_2 fixation because of a short growing season and rapidly increasing temperatures during reproductive phases. Figures 2.5.7 and 2.5.8 are similar to Figures 2.5.5 and 2.5.6, but in addition contain data from 8 cultivars in uninoculated treatments of 4 years of winter-sown inoculation response trials conducted in N. Syria. Most of the additional data inserts above the 2 T ha^{-1} yield level. The relationships between yield and N_2 fixation, after inserting the additional information, are virtually unchanged. These results further support the case against spring-sown chickpea, where low yields are accompanied by relatively high soil N use due to limitations on N_2 fixation.

D.P. Beck, S.N. Silim and M.C. Saxena

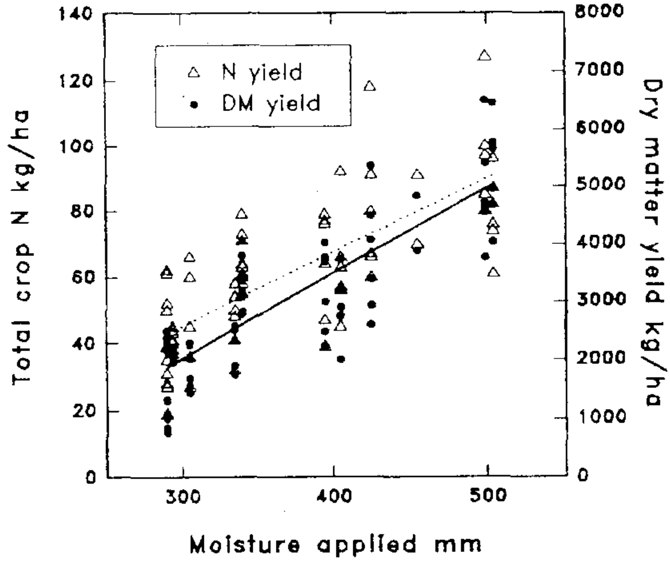

Figure 2.5.7. Relationship of moisture applied and toatl dry matter and nitrogen yield of above ground parts of chickpea genotypes at Tel Hadya (With additional data sets for high moisture supply, than in Fig 2.5.5).

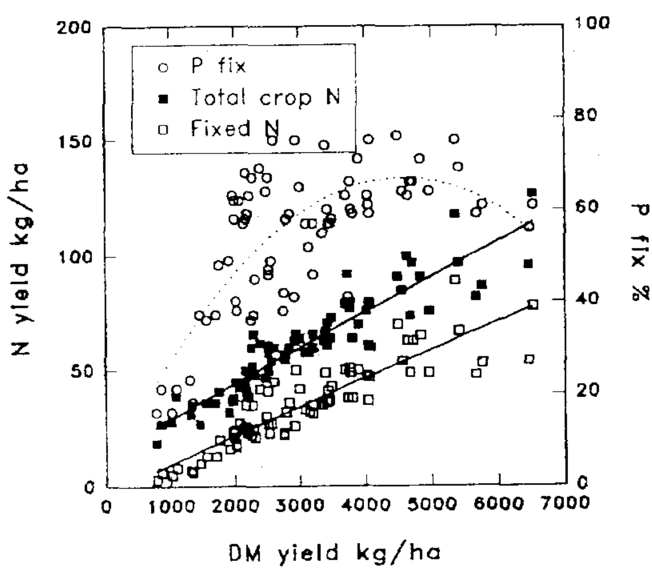

Figure 2.5.8. Relationship of chickpea dry matter yield and crop N. (With additional data sets for high moisture supply than in Fig. 2.5.6).

2.6. Chickpea Nematode Studies

The studies on common nematode pests of chickpea were continued in collaboration with the 'Instituto di Nematologia Agraria, C.N.R., Bari, Italy'. Studies involve survey and use of crop rotation to control cyst nematode in addition to screening chickpea lines and segregating populations from interspecific (C. arietinum x C. raticulatum) as well as intraspecific (C. arietinum) crosses.

2.6.1. Survey of Parasitic Nematodes in Turkey

Survey was made in the south-east and northern Turkey in May 1991 and July 1992, respectively. A total of 150 soil and root samples were collected; soil was processed with the Cobb's sieving and decanting method combined with the Baermann's funnel method. Root samples were processed with the Young's incubation method followed by Coolen's centrifugation. Nematodes in water suspension were then fixed in hot 5% formalin and identified at genus level.

Root-lesion nematodes (Pratylenchus spp. and Pratylenchoides spp.) were most widespread with Pratylenchus spp. present in 93% root samples. The nematode populations were rather high and associated with extensive yellowing and decline of chickpea crop. A cyst nematode, probably Heterodera ciceri, was found in 13% samples of chickpea crops and was distributed in several provinces. Other nematodes seem to be of little importance.

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2.6.2. Use of Crop Rotation to Control Cyst Nematode

Cyst nematode (Heterodera ciceri) of chickpea has a rather narrow host range, which includes lentil, pea and chickling. This suggests that proper crop rotations should be useful in controlling the nematode. Therefore a field trial comprising six crop sequences was started in 1986/87 to ascertain the effect of these treatments on the yield of chickpea and the dynamics of the nematode in a nematode infested field at Tel Hadya. Although the experiment was planned to end in 1990, an exceptional frost in March 1990 destroyed the final test crop (chickpea) and therefore the field was resown next season with chickpea and harvested in June 1991.

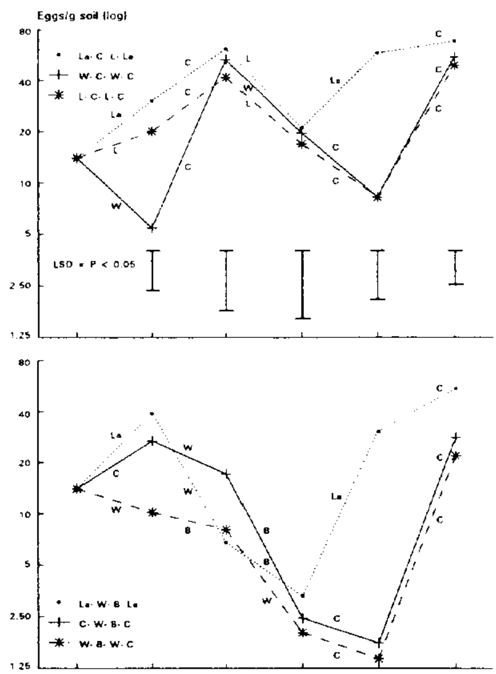

Figure 2.6.1. Effect of six crop sequences on population dynamics of Heterodera ciceri, Tel Hadya, 1986-1992. Host crops (La= Lathyrus sativus, C= chickpea, L= lentil); non-host crops (W= wheat, and B= barley).

Table 2.6.1. Effect of six crop rotations on the yield of chickpea in the fifth year on a field infested with Heterodera ciceri at Tel Hadya.

Crop rotation [1]	Biological Yield (kg/ha)	Seed Yield (kg/ha)	Straw Yield (kg/ha)	Harvest index (%)
L - C - L - C	507.6	22.4	485.8	4.60
W - C - W - C	616.8	46.6	570.2	6.92
C - W - B - C	914.0	101.4	812.6	11.82
W - B - W - C	723.0	177.4	545.6	20.42
La - C - L - La	389.2	4.6	384.6	0.91
La - W - B - La	641.8	52.4	589.4	5.16
LSD (P = 0.05)	363.2	109.6	289.1	11.25

(1) L = Lentil; C = chickpea; W = Wheat; B = Barley; La = Lathyrus

Results showed that the soil population of nematode declined by 57% after one year of cultivation of nonhost plants (Fig. 2.6.1) and by 84-88% when nonhost crops were present for 2 to 3 years. Cultivation of host plants, instead, resulted in the build up of nematode population. Grain yield of chickpea increased with the increase in the number of years without host crops and it was double, five and eight fold of that obtained in plots with continuous cultivation of chickpea, when two, three, and four year-term crop sequences were used respectively (Table 2.6.1).

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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.

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.

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, drought tolerance
South Asia and East Africa	51	20	Seed yield, early maturity, resistance to rust, Ascochyta and wilt
High elevation	14	5	Biomass, winter hardiness, attributes for mechanization

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 280 mm) and Tel Hadya (350 mm) in Syria and Terbol (600 mm) in Lebanon. The winter of 1991/92 season was colder than average with 63, 53, and 84 frost nights recorded at Breda, Tel Hadya and Terbol, respectively. The rainfall was around the long-term average in Syria but above-average at Terbol in Lebanon with 263, 353, and 860 mm received to the end of June at Breda, Tel Hadya and Terbol, respectively. Biomass followed the rainfall gradient with mean biomass yields at Breda, Tel Hadya and Terbol of 2.0, 3.0, and 4.3 t/ha, respectively. The same trend with the rainfall was observed for seed yield production with 0.7, 1.1 and 1.9 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. In general, yields in the 1991/92 season in Syria were higher than last season, because rainfall was more and lentil was little affected by the severe winter of 1991/92. In Lebanon, where rainfall was super-optimal for the crop and water was not a limiting factor in 1991/92, yields were lower than the previous season because of the long cold winter and spells of temporary waterlogging.

For seed yield the percentages of lines significantly outyielding the best check at P = 0.05 were 2.8, 1.6 and 2.4 % at Terbol, Tel Hadya and Breda, respectively. More test lines merely ranked above the best check for seed yield, representing 28, 27 and 26 % 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

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 1991/92 season.

Location	Terbol		Tel Hadya		Breda	
Total seasonal rainfall (mm)	860		353		263	
	S	B	S	B	S	B
Number of trials	7	7	12	12	8	8
Number of test entries*	145	145	243	243	167	167
% of entries sig. (P<0.05) exceeding best check**	2.8	3.4	1.6	4.5	2.4	3.3
% of entries ranking above best check (excluding above)	28.2	26.2	27.2	30.9	26.3	37.0
Yield of top entry (kg/ha)	2850	5950	1756	4846	1067	3099
Best check yield (kg/ha)	2232	4801	1309	3345	830	2073
Location mean (kg/ha)	1941	4316	1156	2965	729	1992
Range in C.V. (%)	7-17	8-13	11-21	9-21	6-18	6-14
Mean advantage of Lattice over RBD (%)	31.7	20.2	21.6	16.1	47.5	17.8

* Entries common over locations.
** Large-seeded checks: ILL 4400 long-term, 78S26002 improved; Small-seeded checks: ILL 4401 long-term, 78S26013 improved.

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 different nurseries into four 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 3.1.3. Lentil international breeding nurseries showing target regions and type of nursery.

Type of nursery	Region		
	Mediterranean	Lower latitudes	High elevation
Resistant 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	Small-seeded Large-seeded	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 1992 international trials were two 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.

In addition to the International Legume Testing Network, seed requests from NARSs for specific breeding lines and segregating populations have resulted in the despatch of 2557 seed samples to 28 countries in the last three years (Table 3.1.4).

Table 3.1.4. Destination and number of seed samples despatched on the request of NARSs of lentil breeding lines and segregating populations for the last three years. This is additional to the material distributed through the International Legume Testing Network.

Country	1990	1991	1992
Afghanistan		10	
Algeria	2		1
Argentina		2	
Australia		13	
Bangladesh			11
Bhutan			63
Canada	11		1
China	108		
Colombia	13		20
Czechoslovakia		5	
Germany	2	1	
India	3	42	56
Iran			2
Iraq			1
Italy		8	30
Japan			8
Jordan			2
Libya			1
Morocco	607	42	407
Netherlands		10	
Pakistan	17	100	69
Sudan	2		
Syria			52
Turkey		362	311
U.K.	18		
U.S.A.		1	120
U.S.S.R	22		
Yemen			1
Total	805	596	1156

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 of new breeding material for resistance to vascular wilt continued this year in the plastic house using the method developed in the 1987/88 season (FLIP Annual Report 1988).

A total of 123 lines of cultivated lentil were screened for their reaction to wilt at the seedling stage in the 1991/92 season. The lines were rated on a 1-9 scale with rating 1 = resistant and rating 9 = all plants killed. Thirty-nine lines gave ratings < 3 and will be re-screened in an adult-stage screening trial next season.

The 77 most resistant lines in the seedling test of the 1990/91 season were screened this year in pots artificially infected with the causal organism to evaluate their performance at different stages of growth. Plants were rated regularly up to maturity. Most lines were resistant at two months, confirming last year's results. But, by maturity, only 15 entries showed tolerance to wilt (rating < 5). They will be retested next season.

In addition to screening in the plastic house, we have been developing the methodology to screen in the field by preparing a wilt-sick plot. Preparation started in 1989 when we added to a field plot in Tel Hadya farm some soil from a wilt-affected area. The plot was sown in the 1989/90 and 1990/91 seasons with a uniform, rainfed crop of wilt-susceptible lentil, which was ploughed into the soil at maturity. On October 1, 1991 we sowed susceptible lentil and irrigated. The incidence of seedling wilt symptoms within the wilt-sick plot was then mapped into 5 m^2 square grid on October 30, 1991 (Fig. 3.1.1). Seedling wilt symptoms, in contrast to the commonly observed adult wilt symptoms, are not normally seen in Syria, where most lentil is rainfed and it germinates at temperatures below the fungal pathogen's optimum temperature.

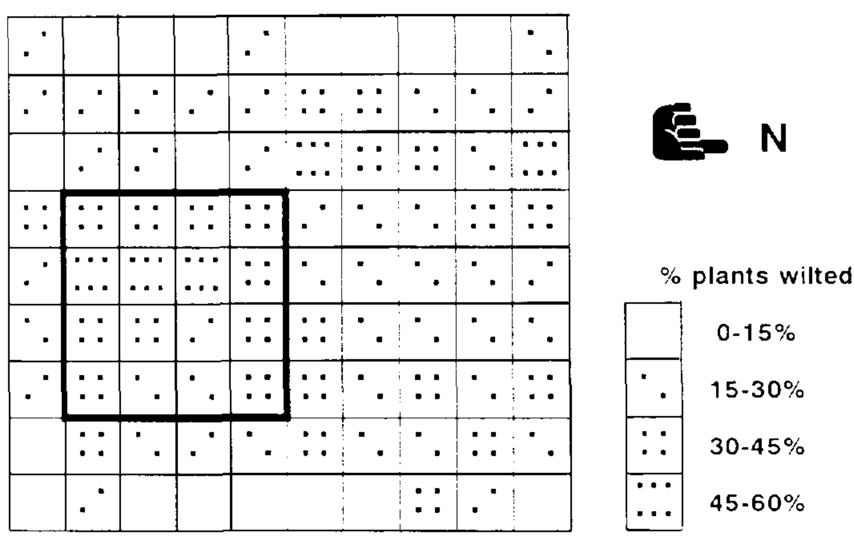


Figure 3.1.1. Distribution in the wilt-sick plot of wilt symptoms in a uniformly sown, susceptible lentil cultivar. Sampling was done in 0.25 m^2 quadrates in each cell of 5 m^2. The land used subsequently for wilt screening is enclosed in the marked square.

Within the wilt-sick area, we selected the most infected area to grow the first wilt screening experiment under rainfed conditions (Fig. 3.1.1). The trial consisted of 18 test entries selected from previous plastic-house trials to span the range of reaction to the wilt pathogen. A randomized block design was used with eight replications and a susceptible check repeated every two entries. Wilt incidence was recorded on a total of eight occasions during reproductive growth to follow disease development. Field symptoms were confirmed as due to Fusarium oxysporum f. sp. lentis from isolations made from surface-sterilized stem segments of diseased plants.

Ninety-five percent of plants of the susceptible check were killed during reproductive growth. There was a wide range in reaction among the test entries from resistant - ILL 6409 (<5% wilt incidence), through the moderately resistant - ILL 6976, 6991, 7005, and 7012 (5-15% infection), to highly susceptible (Fig. 3.1.2). Among such susceptible entries there were contrasting reactions: ILL 5750 showed a high incidence of wilt symptoms soon after flowering, whereas the incidence of wilt in ILL 6801 was slower but progressive.

The resistant lines are being shared with national programs in the international nursery - Lentil International Fusarium Wilt Nursery (LIFWN).

Earlier research had shown that seed yield losses from wilt damage were predictable on the basis of wilt incidence. Experiments were carried out during the 1992 cropping season to understand the relationship between the inoculum density of <u>Fusarium</u> <u>oxysporum</u> f.sp. <u>lentis</u> in the soil and the incidence of lentil wilt. Both laboratory and field experiments were performed at ICARDA - Tel Hadya.

In the laboratory, a contrasting pair of lentil genotypes (ILL 4605 - susceptible to wilt, and the resistant ILL 16) were grown in sterile flasks with their roots immersed in a spore suspension under a range of concentrations of microconidia from 0 - 10^6 spore ml^{-1}.

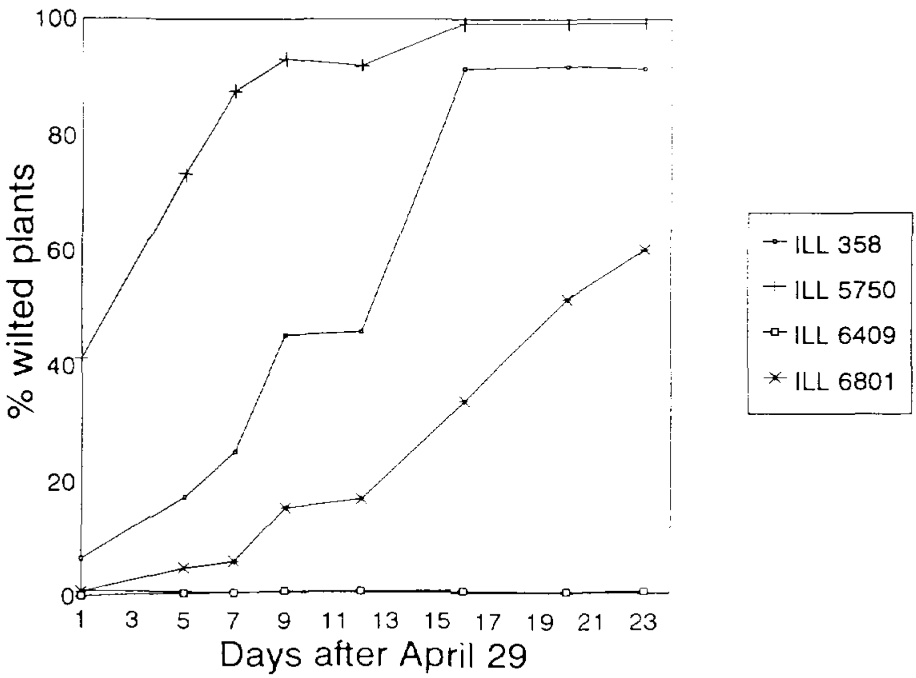


Figure 3.1.2. Vascular wilt incidence (% wilted plants) during the course of reproductive growth in four lentil lines sown in the wilt-sick plot at Tel Hadya in the 1991/92 season.

No wilting was observed at the lowest concentration (1000 spore ml) in either cultivar (Fig. 3.1.3). However, at higher concentrations ILL 4605 was more susceptible than ILL 16 and it always died before ILL 16. At the highest concentration (10^6 spore ml^{-1}) both genotypes were killed showing that the resistance of ILL 16 breaks down at high inoculum densities. A concentration of 25 x 10^4 spore ml^{-1} was found sufficient to distinguish susceptibility from resistance under laboratory conditions.

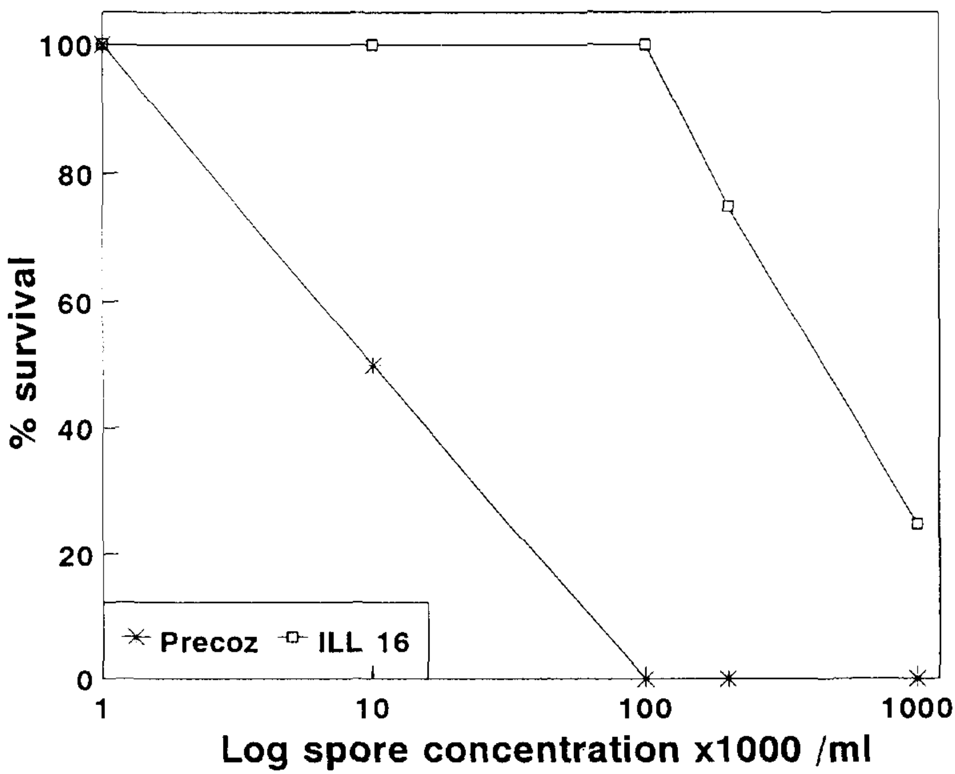


Figure 3.1.3. Percentage survival of two lentil lines (ILL 16 and 4605), contrasting in reaction to vascular wilt, on exposure to different concentrations of microconidia of Fusarium oxysporum f.sp. lentis.

Soil samples were collected from under lentils assessed for wilt incidence at crop maturity. Soil samples were diluted by 1/1000 and plated on to Kommada's selective medium to assess the colony count of Fusarium oxysporum f.sp. lentis. The experiment was carried out in five replicates.

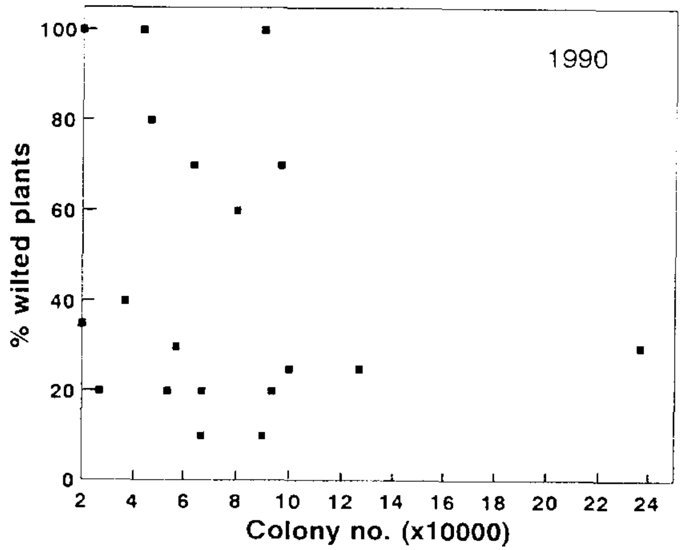
The results showed no clear relationship between the inoculum density and wilt incidence, echoing the results from the 1990 season (Fig. 3.1.4. A and B). Heavy wilt incidence was recorded in some areas with a low inoculum density, whereas low wilt incidence was recorded from some samples with high inoculum density.

The difference between the laboratory and the field in the pattern of response to inoculum density may be due to several causes such as the result of an interaction with other microorganisms in the field environment or estimation of inoculum density at crop maturity rather than at the seedling stage when the fungus penetrates the root tissue.

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 the crop's productivity, particularly in Canada, Ethiopia and 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 to the seed quality from infection in the swathe. Chemical control is too expensive for practical blight control and host-plant resistance is the most feasible and environmentally-sound means of disease management.



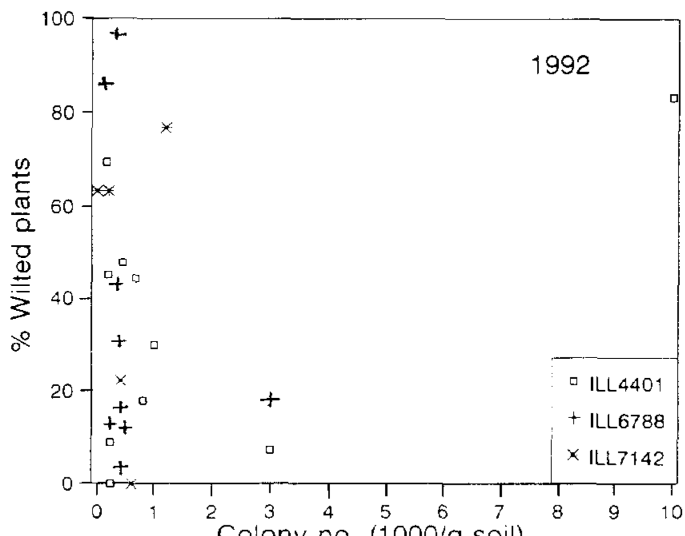


Figure 3.1.4. Vascular wilt incidence (% wilted lentil plants) on soil sampled for colony numbers using a medium selective for Fusarium oxysporum f.sp. lentis in the 1990 and 1992 seasons at Tel Hadya.

Two experiments were conducted under plastic house conditions at Tel Hadya to identify sources of resistance in cultivated lentil to a Syrian isolate of Ascochyta fabae f.sp. lentis.

In the first experiment, 138 breeding lines were screened n trays in a randomized block design with two replications and a repeated susceptible check (ILL 2580). Seedlings were inoculated after 2 weeks and inoculation was repeated weekly until the checks were heavily damaged. Disease reaction was assessed two, four and six weeks after the first inoculation on a 1-9 scale where 1 = no visible lesions observed; 3 = few scattered spots normally observed after careful examination; 5 = spots common on one leaf and/or on many leaflets; 7 = spots very common on more than one leaf, no stem girdling; 9 = extensive lesions on all plant parts accompanied by stem girdling and/or heavy defoliation.

Results of the first experiment revealed uniform susceptibility of the check over both trays and replicates and good sources of resistance to Ascochyta blight with 66, 50 and 38 lines scoring 1-3 in the first, second and third scoring (Fig. 3.1.5). Lines differed in their rates of disease development (Fig. 3.1.6).

In the second experiment, 30 lines were screened in pots for reaction to Ascochyta blight including 12 lines repeated from Experiment 1 and 18 lines tested extensively under field conditions. The experiment was in a randomized complete block design with three replicates. Plants were scored two and four weeks after the first inoculation on an individual

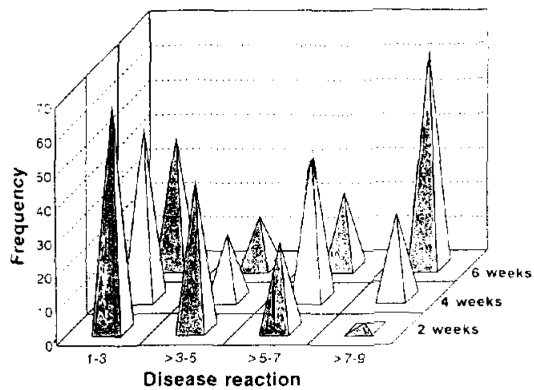


Figure 3.1.5. Frequency of different reactions to Ascochyta fabae f.sp. lentis at different intervals after first inoculation among 138 lentil lines screened in the plastic house at Tel Hadya in 1992. Disease reactions were measured on a 1-9 scale with 1 = no visible lesions observed and 9 = extensive lesions on all plant parts accompanied by stem girdling and/or heavy defoliation.

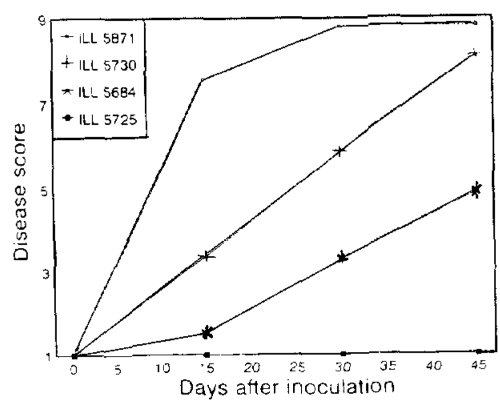


Figure 3.1.6. Rate of development of disease symptoms caused by Ascochyta fabae f.sp. lentis on four lentil lines contrasting in disease reaction in the plastic house at Tel Hadya in 1992. Disease reactions were measured on a 1-9 scale with 1 = no visible lesions observed and 9 = extensive lesions on all plant parts accompanied by stem girdling and/or heavy defoliation.

plant basis. Repeated lines reproduced the same disease reactions as in the earlier trial, confirming the reliability of the experimental procedure.

Table 3.1.5. Disease reaction of selected lentil genotypes (accession numbers - *ILL*) to *Ascochyta blight in Australia*, Ethiopia, New Zealand, Pakistan and Syria on a 1-9 scale with 1 = resistant and 9 = highly susceptible.

Acc.	Aust.	Ethiopia		N.-Z.	Pakistan				Syria			
	1991	1988	1991	1989	1986	1988	1989	1990	1984	1985	1992	1992
358	5	-	3	3	1	1	1	3	4	-	3.2	1.8
2439	5	8	3	3	-	2	3	3	-	-	7.4	4.0
2580	-	-	-	-	9	-	9	7	-	5	8.1	6.7
5480	7	8	3.5	3	-	1	1	3	-	-	2.8	3.0
5599	7	-	3	3	-	2	3	3	-	-	6.9	7.5
5684	3	-	-	-	-	-	-	1	4	-	4.9	3.2
5714	5	9	-	5	2	2	1	3	-	4	6.8	5.0
5725	7	-	3.5	3	-	2	1	3	-	-	1.0	1.2
5730	7	-	-	3	-	1	3	3	-	-	8.1	6.2
5871	-	9	2	1	5	1	5	5	-	-	8.8	8.1

Table 3.1.5 presents a summary of the disease reactions to ascochyta blight of lentil lines tested in different locations, in addition to their reaction to the Syrian fungal isolate in Experiment 2.

Two lines, ILL 358 and 5684 were resistant to highly resistant over all locations. ILL 5725 was resistant in all locations except in Australia; ILL 2439 was resistant in all locations except in Ethiopia and

Syria and ILL 5480 was resistant in all locations except in Australia and Ethiopia. This suggests the presence of different isolates of the fungus in different places - confirmation is required on this important issue - and also the presence of several different genes for resistance.

W. Erskine and B. Bayaa (Aleppo University)

3.1.1.6. Screening for resistance to rust

Rust is the major fungal pathogen of lentil in the Indian sub-continent, Ethiopia and Morocco. We initiated systematic screening for resistance two seasons ago in collaboration with the Moroccan national program in a disease 'hot-spot' at Jemma Sheim. Unfortunately, the winter in Morocco was the driest this century and no screening was possible this year.

3.1.1.7. Screening for winter hardiness

Lentil is currently sown in spring in Turkey at elevations above c. 800 m 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. An experiment to develop a field screening method was started in the 1991/92 season at Haymana research farm, located south-west of Ankara at an altitude of 1050 m above sea level. The main characteristic of this location is a long and cold winter season (with minimum air temperature of -25°C) with high snow fall. The design of the experiment was split-plot with sowing dates as the main-plot factor with a factorial of density x cultivars in sub-plots in three replications. Sowing dates were October 1, October 22, and November 12, 1991. Two seed densities were 200 seeds/m^2 and 400 seeds/m^2. Eight cultivars, including 3 resistant (Sazak 91, ILL 465, ILL 1918), 2 tolerant (ILL 468, ILL 4400), and 3 susceptible (ILL 2590, ILL 3493, ILL 5582), were used. The (1991/92) winter season was the coldest for 25 years. There was clear differentiation between sowing dates, with October 1 best for screening. Seed density also contributed to winter-hardiness with better survival at the higher density. Cultivars were also very well differentiated. Even cultivar Sazak 91, which is considered the most winter-hardy cultivar in Turkey, was cold damaged. The experiment will be repeated next season. Av extra sowing date 15 September will be added next season.

In addition to refining the selection environment, the variability for winter-hardiness in both cultivated and wild lentil germplasm was also examined in the 1991/92 season.

For the cultivated germplasm an experiment was conducted at three locations in Turkey, namely, Haymana research farm (elevation 1050 m), International Winter Cereal Research Center in Konya (elevation 1050 m), and Eastern Anatolian Agricultural Research Institute in Erzurum (elevation 1950 m). A total of 86 randomly-selected accessions of cultivated lentil were used ranging from highly susceptible to winter-hardy. At Erzurum, where winter temperatures reached between -40 C° and -50 C°, all lentils were killed. The range in reaction to winter cold was clear at Haymana but less clear at Konya. A 1-9 scale indicating 1= resistant and 9 = killed, was used to score for cold tolerance at Haymana and Konya. The highest score in one of the two replications was taken as a reaction of the entry to cold. The lowest score at Haymana was 4 with only one accession achieving that score (Table 3.1.6). 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 of the accessions were scored as 9 at Haymana; whereas, most of them were scored as 8 at Konya. The trial will be repeated next season at Haymana and at Konya. Additionally, to study associations with winter-hardiness, there will be a spring planting at Haymana to allow the measurement of a range of morpho-agronomic traits and isozyme tests will be run.

I. Kuzmenoglu (Central Anatolian Field Crops Research Institute, Ankara, Turkey) and W. Erskine

A total of 248 accessions of wild lentil, ten accessions of cultivated lentils and three accessions of <u>Vicia montbretii</u> were screened for cold resistance at Maader in Syria (33 42'N,36 08'E; c. 1400 m elevation), during the 1991/92 season. For comparison, the winter-hardy genotype ILL 4400 and the cold susceptible entry ILL 4605 were used as repeated checks after every 15 test lines. The winter was cold with below-zero minimum temperatures extending for about four months. The number of emerged plants per plot was counted before the onset of the cold and the number of surviving plants recorded after the end of the cold. The percentage of survived to emerged plants was considered as the degree of resistance.

Table 3.1.6. Scores of lentil accession for cold susceptibility at Haymana and Konya on 1-9 scale.

Score	Haymana	Konya
2		ILL (53, 662)
3		ILL (29, 632, 635, 665, 1405)
4	ILL 662	
5	ILL 635	ILL (18, 44, 48, 61, 103, 119, 191, 195, 295, 630, 1143, 1880, 2153, 2177, 2532)
6	ILL (1405, 1879)	ILL (45, 2069)
7	ILL (29, 45, 53, 61, 295, 630, 1880, 2153, 2177)	ILL (51, 442, 1196, 1215, 1372, 1516
8	ILL (48, 51, 119, 195, 343, 442, 632, 665, 780, 1143, 1197, 1399, 2215, 2532)	ILL (5, 11, 19, 66, 241, 323, 331, 343, 603, 780, 1083, 1180, 1189, 1197, 1199, 1201, 1222, 1384, 1399, 1401, 1448, 1523, 541, 1879, 2022, 2164, 2178, 2181, 2203, 2207, 2215, 2788, 4606, 5507, 5585, 5590)
9	ILL (5, 11, 18, 19, 20, 36, 44, 66, 103, 191, 241 323, 331, 358, 484, 603, 484, 603, 707, 1196, 1199, 1201, 1207, 1215, 1222, 1372, 1384, 1401, 1448, 1516, 1523, 1541, 1701, 1712, 1939, 1983, 2022, 2069, 2164, 2178, 2181, 2203, 2207, 2308, 2439, 2788, 3516, 4377, 4606, 5244, 5426, 5479, 5481, 5507, 5585, 5590, 5593, 5668)	ILL (20, 36, 358, 485, 707, 1207, 1701, 1712, 1939, 1983, 2308, 2439, 3516, 4377, 5244, 5426, 5429, 5481, 5593, 5668)

The overall distribution in cold resistance among subspecies is shown in Fig. 3.1.7. All accessions of Vicia montbretii (syn. Lens montbretii) were resistant to the cold. L. culinaris subsp. orientalis was the most resistant subspecies of Lens with a degree of resistance of 55%, on average; L. nigricans subsp. ervoides showed the lowest degree of resistance. There were some resistant accessions in each subspecies. In L. culinaris subsp. orientalis 18 accessions were resistant (accessions with >91% plant survival), one accession was winter-hardy in both L. culinaris subsp. odemensis and L. nigricans subsp. ervoides, and two in V. montbretii. There was a positive and significant correlation of altitude of collection site with resistance to cold, indicating that those accessions originating in high elevation areas were resistant to cold.

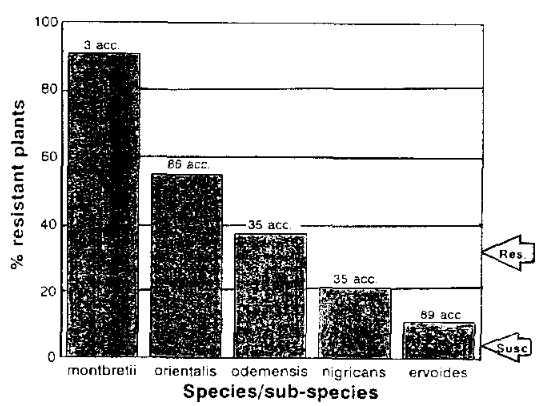


Figure 3.1.7. Winter hardiness, expressed as % resistant plants, of a total of 245 wild accessions of the four wild subspecies of the genus Lens, L. culinaris subsp. orientalis and subsp. odemensis, and L. nigricans subsp. nigricans and subsp. ervoides, and three accessions of Vicia montbretii grown at Maader, Syria over the severely cold winter of 1991/92. The winter hardiness of two cultivated lentil checks (susceptible ILL 4605 and tolerant ILL 4400) is indicated. The number of accessions screened of each taxa is shown.

The same series of accessions of wild lentil were also sown at Haymana research farm in Turkey to screen for winter-hardiness. There was a clear differentiation between winter-hardy and susceptible wild accessions. Accessions of Lens culinaris subsp. orientalis were commonly winter-hardy. The trial will be repeated next year at Haymana and at Konya in Turkey.

I. Kuzmenoglu (Central Anatolian Field Crops Research Institute, Ankara, Turkey) and A. Hamdi and W. Erskine.

3.1.1.8. Screening for iron efficiency

Iron deficiency symptoms are observed on some genotypes of lentil grown in calcareous soil. During the cold, wet winter season of 1991/92 at ICARDA Tel Hadya, iron deficiency symptoms appeared on some lentil lines originating from India; this prompted further analysis of iron-efficiency scores from cultivated lentil germplasm grown in another cool, wet season (1979/80) with the following results:

A germplasm collection of 3512 accessions originating from 18 countries was characterized for iron deficiency in a Calcic Rhodoxeralf soil at ICARDA, N. Syria in the 1979/80 season. The total rainfall was 426 mm (27 % above the long-term average) and the absolute minimum air temperature was -8.0 °C.

At 105 days after sowing, 592 accessions, representing 16.9 % of the collection, showed chlorosis symptoms characteristic of iron (Fe) deficiency. The Fe deficiency was verified by foliar application of Fe-chelate. Germplasm from different countries contrasted in iron deficiency, with those accessions exhibiting symptoms of iron deficiency mostly originating from relatively warm climates such as India (37.5% accessions showing Fe deficiency) and Ethiopia (30%) (Table 3.1.7). The only populations from Mediterranean countries showing Fe deficiency were from Syria and Turkey at very low frequencies, where the crop originated.

Table 3.1.7. Number of lentil germplasm accessions per country scored for iron-deficiency symptoms with the mean and standard deviation (SD) of scores and the percentage of accessions in each scoring class for each country in the 1979/80 season at Tel Hadya, Syria.

Country of origin	Total no. of acc.	% accessions scored				Mean score	SD
		1	3	5	7		
Afghanistan	107	92.5	7.5	-	-	1.15	0.52
Chile	182	100	-	-	-	1.0	0
Egypt	74	100	-	-	-	1.0	0
Ethiopia	247	70	23.1	6.9	-	1.74	1.22
Greece	50	100	-	-	-	1.0	0
Hungary	20	95	5	-	-	1.10	0.45
India	1317	62.5	27.3	8.0	2.2	2.00	1.47
Iran	856	98.8	1.2	-	-	1.02	0.22
Iraq	21	95.2	4.8	-	-	1.09	0.44
Jordan	32	100	-	-	-	1.0	0
Lebanon	69	100	-	-	-	1.0	0
Mexico	24	100	-	-	-	1.0	0
Morocco	14	100	-	-	-	1.0	0
Pakistan	30	96.7	3.3	-	-	1.07	0.36
Syria	181	98.9	1.1	-	-	1.02	0.21
Turkey	231	99.6	0.4	-	-	1.01	0.13
USSR	38	100	-	-	-	1.0	0
Yugoslavia	19	100	-	-	-	1.0	0
Overall	3512	83.1	12.6	3.5	0.8	1.44	1.08

Chlorosis was positively correlated with cold susceptibility. Fe chlorosis was transient as the deficiency symptoms largely disappeared during reproductive growth, coinciding with changes in soil and climatic conditions favoring crop growth.

In Indian germplasm, mild deficiency symptoms gave no loss in seed yield, but there was a major yield reduction of 47% in those accessions with the most severe symptoms. Straw yield was reduced commensurately with the severity of symptoms.

W. Erskine, N.P. Saxena and M.C. Saxena

3.1.1.9. Adaptation of lentil to moisture supply and temperature

Lentil is a rainfed crop in North Africa and West Asia where yields are limited by the amount and distribution of rainfall and by winter cold. This study aimed to quantify the effects of climatic variables on lentil seed yields through the fitting of simple empirical models to trial data of two cultivars sown at six sites from 1983 - 1989, representing 31 environments in Syria. The ranges over environments were 152 - 527 mm for total seasonal rainfall and 1 - 52 for the number of frost nights.

Preliminary results were reported in the 1991 Legume Program Annual Report. Overall, the total seasonal rainfall accounted for 40.8 % of the variance in mean seed yield with a response of 5.68 kg/ha/mm. A multiple regression model with monthly rainfall from November to May explained 67.0 % of the variance in mean seed yield. From November to February the response of seed yield to monthly total rain was below 10 kg/ha/mm; rain in March, the period of late vegetative growth, made the most important contribution to seed yield (Fig. 3.1.8). The response to April rain was negative. Response to May rain was high but its contribution to total yield was small because of low amount. At Tel Hadya (the most frequently used site), the total seasonal rainfall accounted for 79.8 % of the variance in mean seed yield, and the addition of the number of frost nights to the model improved the fit to 92.7 %. Winter cold had a smaller effect on yield than rainfall with no consistent overall effect, but with differences between regions. The cultivars contrasted in their drought responses to (78S26002 was superior to ILL 4400 at seasonal rainfall levels down to 134 mm) and the number of frost nights at Breda and Tel Hadya (78S26002 was more susceptible to cold than ILL 4400). Thus, despite the predominant influence of rainfall on yield, the genetic variability in response to moisture and cold show the scope for selection under rain-fed Mediterranean environments.

W. Erskine and F. El Ashkar (ARC Douma, Syria)

Lentil is grown under irrigation in Egypt and Sudan. The objectives of a complementary study (funded by the Nile Valley Project) were to determine the adaptation of a range of lentil genotypes to a wider spectrum of moisture regimes. Thirty-four diverse genotypes were grown for two seasons (1984/85 and 1985/86) at three locations, varying in total seasonal rainfall, in northern Syria and Lebanon (Hamdi et al., 1992). At one location (Tel Hadya, Syria), the crop was grown under two moisture regimes using supplementary irrigation.

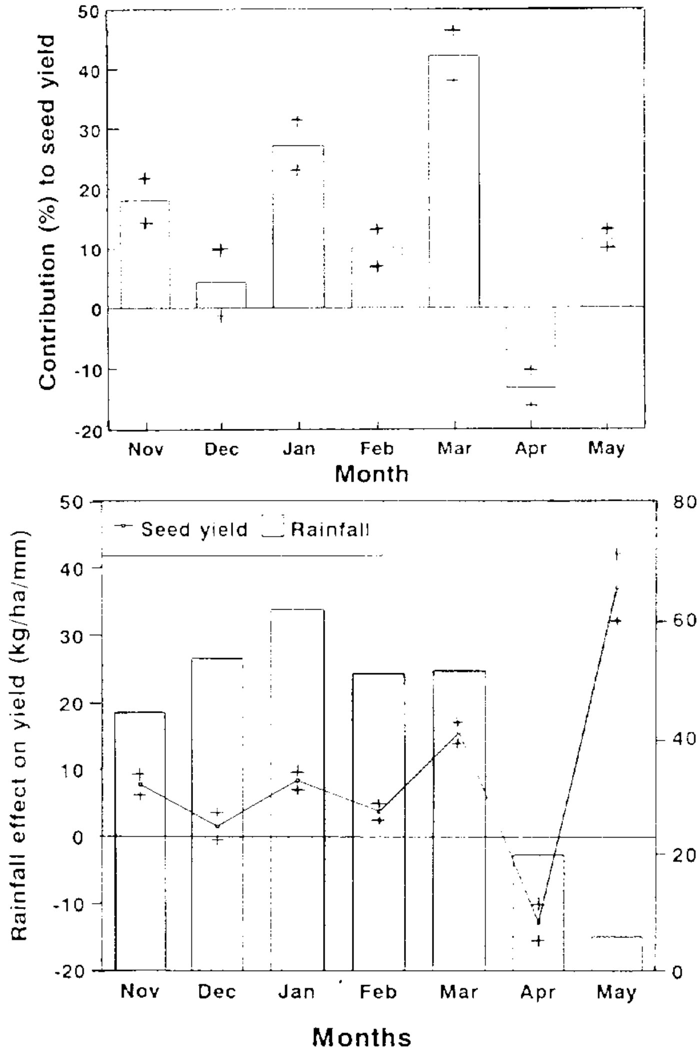


Figure 3.1.8. **A.** Response of mean seed yield (kg/ha/mm) to rainfall from November to May shown with the average monthly rainfall amounts over two cultivars and 31 environments. Standard errors (±) for responses are given.

B. Contribtuion to mean seed yield of the rainfall from Novemeber to May calcuated as the product of the monthly responses of seed yield to rain and the average rainfall totals. Standard errors (±) for responses are shown.

Preliminary results were reported in the Food Legume Improvement Program Annual Report 1986. Variation in mean seed yield/plant was largely explained (R^2 = 0.82,3 P = 0.01) by the variation in water supply. The regression of seed yield/plant on to total water supply indicated a response of 0.67 g/plant seed yield per 100 mm increase in water supply. Two supplementary irrigations (50 mm each) resulted in a 20% increase in seed yield/plant. Genotypic performance was adequately summarized by genotype means and their linear responses to different levels of moisture supply (Fig. 3.1.9). Genotypes were classified into four contrasting

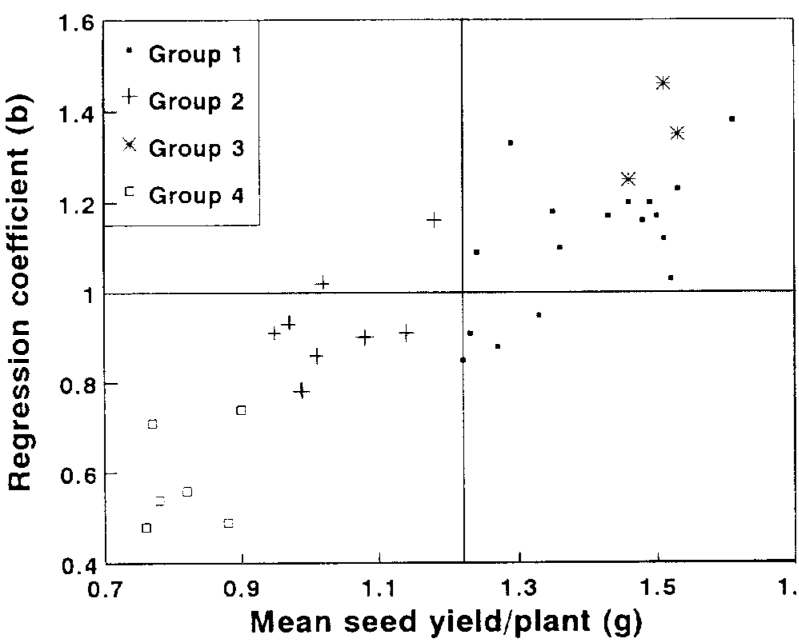


Figure 3.1.9. The relationship between the regression coefficients (b) of seed yield on environmental mean and the mean seed yield of 34 lentil genotypes. Genotypes are divided to 4 groups; group 1: widely adapted to all environments; group 2: poorly adapted to all environments: group 3: adapted to high moisture supply; group 4: adapted to dry environments.

groups according to their regression coefficients and mean yield. The first group had average stability (i.e. regression coefficient did not differ significantly from 1.0) with seed yield above the grand mean (1.22 g/plant) indicating that they had general adaptability. This group comprised 17 genotypes, primarily Mediterranean in origin. Group 2 comprised eight genotypes, with seed yields below average and regression coefficients of unity, and was composed mainly of late-maturing lines from northern latitudes. Consequently, these entries can be considered to be poorly adapted to all the test environments. Group 3 was composed of three entries (ILL 241, ILL 5523 and ILL 5527 from Syria, Australia and Hungary, respectively) with regression coefficients significantly greater than 1.0 and above-average seed yields, showing specific adaptation to wet conditions. Finally, Group 4 contained six entries with regression coefficients of less than unity and low average yield. The group comprised all the Indian and Ethiopian lines, which are early in phenology, allowing them to escape drought. Clearly, selection of genotypes for either wet or dry conditions may be usefully made.

A. Hamdi, W. Erskine and P. Gates (University of Durham)

3.1.1.10. Evaluation of wild lentil for agronomic characters

The evaluation of wild lentil for agronomic characters under field conditions continued this year with the same accessions as last season (LP Annual Report 1991). A total of 121 accessions of Lens species were sown in the field at Tel Hadya in November 1991. L. nigricans subsp. ervoides showed poor germination with germination in only five accessions out of the 39 sown. The 1991/92 season was colder than the previous season causing late flowering and an extended crop growth duration (Table 3.1.8). The cold also resulted in less vegetative growth as indicated by lower straw yield/plant in the 1991/92 season than in the previous season. Average seed yields were higher in 1991/92 than in 1990/91 in the three subspecies of L. culinaris as they were able to survive the cold and then take advantage of the above average seasonal rainfall. However, mean seed yield was lower in 1991/92 than in the previous season in L. nigricans.

Those accessions of L. culinaris subsp. orientalis that were faster to flower and mature than the earliest cultivated check (ILL 4605) last year confirmed their earliness. This precocity will be of value to the crop improvement program. However, for the other agronomic characters, there was no striking variation within the wild species for transfer to the cultigen.

3.1.1.11. Screening of wild lentil for drought tolerance

Tolerance to moisture stress is a key factor in lentil production in the Mediterranean region. In the absence of information on the tolerance of wild lentil to drought, we studied the reaction of wild Lens accessions to drought stress. A set of 121 accessions, representing all subspecies of the genus Lens, were grown for the second season in a field trial conducted at Breda (long-term annual rainfall of 280 mm) under a line-source sprinkler irrigation system. This season the moisture regime ranged from rainfed (263 mm total annual rain) to rainfed + supplementary irrigations (total water supply of 363 mm).

Table 3.1.8. Overall mean (M) and standard deviation (SD) together with the accession ranges (R) for phenological and reproductive characters of Lens species grown under field conditions at Tel Hadya in 1990/91 and 1991/92 seasons.

Characters		L. culinaris						L. nigricans			
		culinaris		orientalis		odemensis		nigricans		ervoides	
		1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
No. of accessions		10	10	48	48	8	9	11	12	28	5
Biological yield/plant (g)	M	4.0	4.4	1.7	1.0	0.8	0.3	1.5	0.4	2.0	0.8
	R	1-7	2-8	0.4-5	0.2-3	0.4-2	0.01-0.6	0.5-2	0.2-0.8	0.8-5	0.6-0.9
	SD	15.7	16.7	9.9	5.7	4.7	0.5	6.8	2.2	12.2	2.5
Seed yield/ plant (g)	M	0.8	2.0	0.2	0.3	0.03	0.07	0.2	0.1	0.3	0.3
	R	0.1-2	0.9-4	0.01-1	0.1-0.8	0.01-0.08	0-0.1	0.02-0.4	0.04-0.3	0.01-2	0-0.9
	SD	4.7	7.1	2.1	2.2	0.28	0.27	1.5	0.74	3.8	1.3
Straw yield/ plant (g)	M	3	2	2	0.7	0.7	0.3	1	0.3	2	0.5
	R	0.7-6	0.7-4	0.4-4	0.2-2	0.3-2	0.01-0.6	0.5-2	0.2-0.6	0.6-4	0.0-30.7
	SD	14.5	11.7	8.1	3.8	4.7	0.42	6.1	1.7	9.4	1.6
Time to flower (d)	M	108	117	109	112	110	108	119	127	120	122
	R	98-121	107-129	97-130	101-145	102-120	102-118	105-132	123-127	113-135	122-123
	SD	8.8	1.9	8.2	2	6.7	1.7	8.1	2.7	4.9	0.86
Time to maturity (d)	M	150	163	150	161	150	161	159	162	160	164
	R	136-157	160-165	130-166	158-170	141-158	158-167	149-161	160-169	141-164	163-165
	SD	7.3	1.8	7.3	1.8	6.3	0.6	3.7	1.7	4.6	1.9
Reproductive period (d)	M	42	46	41	48	40	52	40	35	41	42
	R	32-54	36-54	23-54	26-60	29-52	46-56	29-54	29-43	22-53	41-42
	SD	8	2.7	6.5	2.8	8	1.6	6.9	3.4	6.2	1.8

The average time to maturity under rainfed conditions of the sub-species ranged from 170 days for *L. nigricans* subsp. *ervoides* to 175 days for *L. nigricans* subsp. *nigricans* (Table 3.1.9). Irrigation prolonged the growth period for all sub-species. Among the wild lentils, subspecies *L. culinaris* subsp. *orientalis* yielded most seed and straw. As might be

Table 3.1.9. Means (M) and ranges (R) of time to maturity, seed yield (SY) and straw yield (STY) of wild *Lens* accessions grown under two water regimes at Breda in the 1991/92 season.

Species		Rainfed			Rainfed+irrigation			Seed yield increase over rainfed(%)
		Days to maturity	SY kg/ha	STY kg/ha	Days to maturity	SY kg/ha	STY kg/ha	
L. culinaris								
ssp. *culinaris*	M	173	2122	2546	181	2813	5396	33
	R	165-185	572-2850	585-3659	175-186	2406-5722	2645-7750	0-408
ssp. *orientalis*	M	172	346	780	179	7191950	108	
	R	165-187	158-779	331-1635	172-190	64-1509	318-4350	0-480
ssp. *odemensis*	M	171	155	204	177	218	366	41
	R	165-180	77-209	99-344	172-185	101-410	54-745	0-123
L. nigricans								
ssp. *nigricans*	M	175	187	323	181	393	1087	110
	R	171-181	103-410	38-881	175-186	164-738	472-2456	0-542
ssp. *ervoides*	M	170	178	177	184	242	733	36
	R	165-186	74-613	10-578	178-190	48-654	184-1830	0-364

expected, accessions of the cultivated lentil produced the highest seed and straw yields overall. Yields increased with water supply, but the percentage varied over subspecies. On average, subspecies *L. culinaris* subsp. *orientalis* and *L. nigricans* subsp. *nigricans* showed high irrigation response, and hence poor drought tolerance, as their seed yields increased by 108% and 110% over rainfed conditions, respectively (Figure 3.1.10). By comparison, the cultivated checks (10 accessions) showed a response in

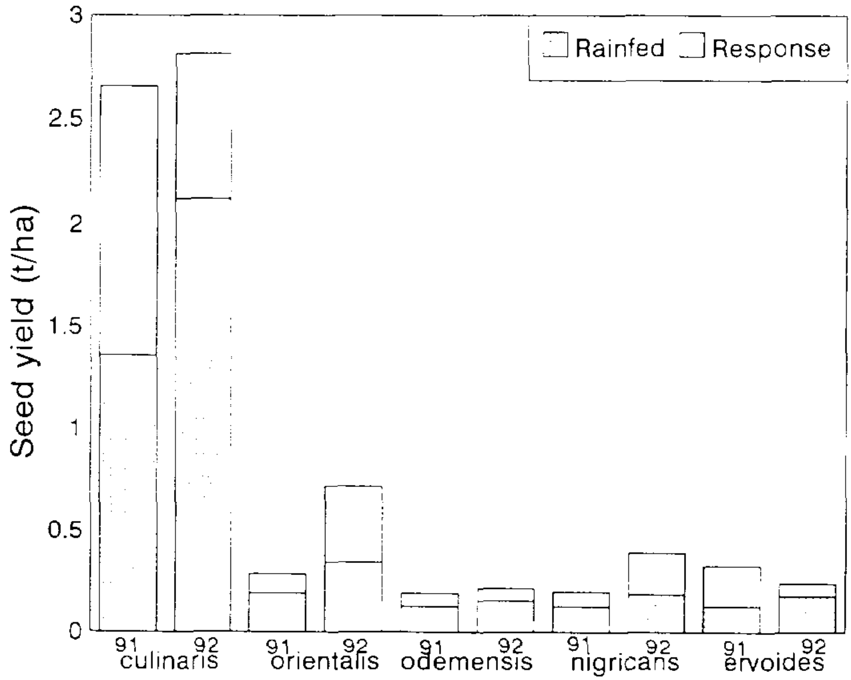


Figure 3.1.10. Average seed yield (t/ha) and its response to irrigation of the sub-species of the genus Lens from the 1990/91 and 1991/92 seasons (shown as 91 and 92 harvests, respectively) at Breda.

The genotype x water regime interactions for both seed and straw yields were significant, indicating the variability between individual accessions in response to drought stress. For example, the percentage increase in seed yield with irrigation in L. culinaris subsp. orientalis ranged from 0 % for accession ILWL 37 to 480 % with ILWL 24. The highest yielding accessions within each subspecies under rainfed conditions are given in Table 3.1.10. Accession ILWL 91 from Turkey gave the highest

Table 3.1.10. Accession number (ILWL), seed yield, straw yield and water use efficiency (WUE) of the highest-yielding accession of each Lens sub-species grown under rainfed conditions at Breda in the 1991/92 season.

ILWL	Species/ sub-species	Seed yield (kg/ha)	Straw yield (kg/ha)	WUE (kg/ha/mm) Seed	WUE (kg/ha/mm) Straw
	L. culinaris				
91	ssp. orientalis	779	1635	2.96	6.22
175	ssp. odemensis	198	248	0.75	1.08
	L. nigricans				
305	ssp. nigricans	318	881	1.21	3.35
259	ssp. ervoides	376	298	1.43	1.13
Mean of cultivated lentil		2122	2546	8.07	9.68

seed and straw yields among wild lentils of 779 kg/ha and 1635 kg/ha, respectively, and also had the greatest water use efficiency with 3 kg seed/ha per mm water supplied and 6.2 kg straw/ha per mm water supplied.

Comparing the results of the seasons 1990/91 (Legume Program Annual Report 1991) and 1991/92, the colder winter on 1991/92 prolonged the growing period by an average of 35 days in comparison to an average delay in maturity of 8 days from the effect of irrigation. Despite the cold winter of 1991/92, seed yield was generally greater than in the previous season because of the higher rainfall in 1991/92 (Figure 3.1.10).

A. Hamdi and W. Erskine

3.1.1.12. Development of scale of lentil growth stages

A scale of the stages of development was made by Erskine et al. (1991). We wished to refine this scale in anticipation of its use for data collection in the field with hand-held palm-top computers. Classically, time to flower is measured as the period from effective sowing date to the date that 50 % of plants in a plot produce their first flower. Accurate determinations of flowering time entail repeated visits to plots. This is expensive at best and often logistically impossible for trials far from home-base. The plant breeder is primarily interested in comparing the earliness/lateness of test entries with specified checks. The use of a scale of the stages of development on a single visit should give sufficient information for the comparisons of interest.

Briefly, our scale of reproductive development is built around five clearly visible stages on an individual plant: first open flower; appearance of the first pods; appearance of first 'flat' pods; appearance of first 'fat' pods (seeds full inside the pod); and appearance of first ripe pods. Each stage is divided into ten levels depending on the proportion of plants to reach the stage of development. Reproductive stages start at 1 and extend to 50. For example, the first open flower stage starts at 1 and extends to 10; the reproductive stage 1 is defined as when 10 % of plants in the plot have produced their first open flower and reproductive stage 10 is when 100 % of plants in the plot have produced their first open flower. The stages of the appearance of first pods are from 11-20, the 'flat' pod stages are from 21-30, 'fat' pod stages are from 31-40, and the ripe pod stages extend from 41-50.

The growth stages of two lines (early flowering and late flowering) are illustrated for 13 sampling dates spanning reproductive growth in Figure 3.1.11. At ten of these sampling dates differences between lines in the stage of reproductive growth were clearly visible. We intend to establish the extent of genetic and environmental variation of the scale and understand the accuracy associated with its use.

M. El Omar (ARC Idlib station, Syria), A. Hamdi and W. Erskine

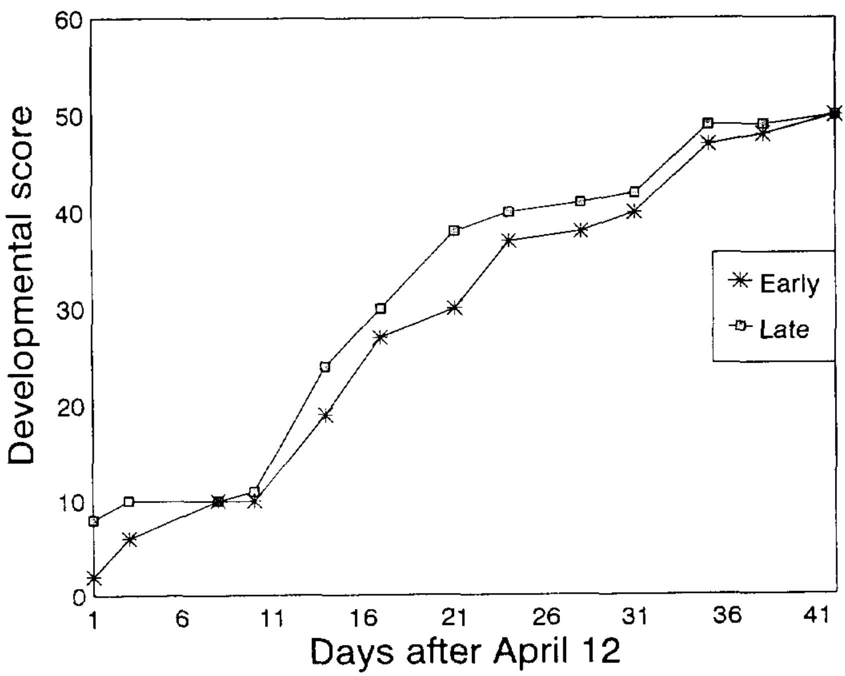


Figure 3.1.11. Developmental scores of an early flowering and a late flowering line through reproductive growth in a preliminary yield trial at Tel Hadya in 1992.

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 very few crosses are made in the region outside ICARDA.

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 Lebanon, Syria and are soon to be released in Iraq and Libya. Selections from Syrian germplasm are released for cultivation in Algeria and Tunisia. Selections from Lebanese and Moroccan germplasm are released/ in pre-release for cultivation in S.E. Anatolia in Turkey.

Table 3.1.11 lists lentil lines released as cultivars and Table 3.1.12 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 a mean of 22% more than the local check in Zone 1 (mean annual rainfall > 350 mm) and 9% more than the local check in Zone 2. Additionally, it has improved standing ability for harvest mechanization and superior reaction to vascular wilt disease compared to the local check.

On-farm trials are planned to test FLIP 84-147L (ILL 5816) and FLIP 87-5L (ILL 6195) in Jordan, and to continue the testing of FLIP 86-2L (ILL 5988) and FLIP 87-56L (ILL 6246) in Lebanon next season.

Table 3.1.11. Lentil cultivars released by national programs.

Country	Cultivar name	Year of release	Specific features
Algeria	Syria 229	1987	High yield, good seed quality
	Balkan 755	1988	High yield, good seed quality
	ILL 4400	1988	High yield, good seed quality
Argentina	Arbolito(ILL 4650x-4349)	1991	High yield, tall and early
Australia	ILL 5750	1989	High yield
Canada	Indianhead (ILL 481)	1989	Green manure
Chile	Centinela (74TA470)	1989	Rust resistant, high yield
China	FLIP87-53L (ILL6242)	1988	High yield for Qinghai Province
Ecuador	INIAP-4506 (FLIP 84-94L)	1987	Rust resistant, high yield
Egypt	Precoz (ILL4605)	1990	For intercropping in sugarcane
Ethiopia	R 186	1980	High yield
	ILL 358	1984	Rust resistant, high yield
Iraq	78S26002 (ILL 8)	1992	High yield, standing ability
Jordan	Jordan 3 (78S 26002)	1990	High yield, standing ability
Lebanon	Talya 2 (78S 26013)	1988	High yield, standing ability
Morocco	Precoz (ILL 4605)	1990	Rust resistant, high yield
Nepal	Sikhar (ILL 4402)	1989	High yield
N.Zealand	FLIP87-53L (ILL 6243)	1992	High yield, red cotyledon
Pakistan	Manserha 89 (ILL 4605)	1990	Ascochyta & rust resistance
Syria	Idleb 1 (78S 26002)	1987	High yield, reduced lodging
Tunisia	Neir (ILL 4400)	1986	Large seeds, high yield
	Nefza (ILL 4606)	1986	Large seeds, high yield
Turkey	Firat '87 (75Kf 36062)	1987	Small seeds, high yield
	Erzurum '89 (ILL 942)	1990	Spring sowing, high yield
	Malazgirt '89 (ILL 1384)	1990	Spring sowing, high yield
	Sazak-91 (NEL 854)	1991	Winter sowing, red cotyledon
U.S.A.	Crimson (ILL 784)	1991	Yield in dry areas

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.

In North Africa the line FLIP84-58L (ILL5728) has been identified by the national program for pre-release multiplication in Tunisia as a supplement to the two cultivars already released. In Algeria the national program has selected Balkan 755, Setif 618 and LB Redjas for release this year. In Libya the line 78S26002 is in pre-release multiplication.

Table 3.1.12. Lentil lines in pre-release multiplication or on-farm testing by NARSs.

<u>Mediterranean region</u>	
Algeria	ILL 468, ILL 1889
Jordan	FLIP84-147L, FLIP87-5L
Lebanon	FLIP86-2L, FLIP87-56L
Libya	78S26002
Morocco	FLIP86-15L, FLIP86-16L, FLIP87-19L, FLIP87-22L
Syria	ILL 5883
Tunisia	FLIP 84-58L
Turkey	ILL 1939
<u>High elevation</u>	
Iran	ILL 4400, ILL 4605
Pakistan	FLIP84-4L, FLIP85-7L
<u>Southern Latitudes</u>	
Ethiopia	FLIP86-12L, FLIP86-16L, FLIP86-18L
Nepal	ILL 2578, ILL 4404
Pakistan	ILL 2573
Sudan	ILL 795, ILL 813, ILL 4605
Yemen	ILL 4605, FLIP84-14L
<u>Others</u>	
Argentina	FLIP84-100L, FLIP86-12L, FLIP87-23L, 74TA19
China	ILL 504, FLIP 87-53L

Lentils in Morocco suffered less rust than in the previous seasons because of a severe drought during the winter. The following lines with resistance to rust FLIP86-15L (ILL6001), FLIP86-16L (ILL6002), FLIP86-19L (ILL6005), FLIP86-21L (ILL6007), FLIP87-19L (ILL6209) and FLIP87-22L (ILL6212) are in the catalogue trials.

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 in Pakistan in lentil breeding is now clearly visible. This season the National Lentil Trial (91/92) in Pakistan comprised the following entries:

25% lines selected directly from ICARDA trials

17% lines from ICARDA supplied crosses

8% lines from a local cross with an ICARDA parent

33% lines which are mutants from ICARDA supplied germplasm

Improved check (ex-ICARDA) and local check

Varietal releases are planned from this material this year.

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.

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 ILL 4402 currently grown in Nepal originated in Pakistan and the best introduced lines in Nepal come from the joint Pakistan/ICARDA breeding program.

In Ethiopia FLIP 84-78L (ILL5748) FLIP 86-16L (ILL6002) and are in pre-release, large-scale tests with the National Seed Registration Committee. Ada and Akaki are the areas where the released line NEL 358 is becoming very popular. FLIP85-33L (ILL 5871) and FLIP86-38L (ILL 6024) have been identified as resistant to both rust and Ascochyta blight with good seed type and yield. FLIP86-38L was previously identified in Pakistan as multiple-disease resistant.

In Sudan the large-seeded line ILL 4605 and small-seeded ILL 795 and ILL 813 were promising under farmers' conditions at Rubatab and Wad-Hamid in Northern Sudan in the 1991/92 season.

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 providing 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 lines ILL 468, -1918, -465 and -983 were tolerant and selected in descending order of merit.

The line 1066-1, a single plant selection made at Eskisehir from ILL 854, is a large-seeded, red-cotyledon line which was released as Sazak'91 for winter sowing on the central plateau of Turkey during 1991.

In Iran the lines ILL 4400 and ILL 4605 are promising in the Ardabil region.

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

In Argentina the cultivar Arbolito was released during 1991 on the basis of its high yield and stability, growth habit for mechanization and grain quality. F_6 seed from the cross Laird x Precoz was taken home by an Argentinean trainee and re-selected to produce this cultivar.

The New Zealand Institute for Crop and Food Research has indicated that it will register lentil FLIP87-53L (ILL 6243) as a variety. 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. In New South Wales the lines FLIP84-51L (ILL5722) and FLIP86-16L (ILL6002) are in multi-location testing following their selection at Tamworth over several seasons. In Victoria the best lines are FLIP84-51L (ILL5722) and FLIP84-58L (ILL5728). The most promising new selection in South Australia is FLIP84-61L (ILL5731).

Cultivar Crimson was released in USA in 1991 as a result of single plant selection of ICARDA-supplied germplasm (ILL784). Crimson is a red cotyledon variety which has been released on the basis of its high yield under dry conditions in the Palouse area of Washington State.

National Agricultural Research Systems

3.2. Application of Biotechnology

3.2.1. DNA-Markers in Lentil

With the application of polymerase chain reaction (PCR) technique, DNA sequences can be amplified using a primer which initiates the polymerase reaction. If an amplified sequence can differentiate between two parents through a polymorphism and has mendelian inheritance, this DNA-sequence may be tested for linkage to an agronomic trait. Many such polymorphisms can be so tested. In collaboration with Dr. F.J. Muehlbauer of Washington State University, Pullman, USA, RAPD (random amplified polymorphic DNA) - markers are used to establish linkage to agronomic traits in lentils. RAPD-markérs are generated after use of random DNA sequences (10 to 20 base pairs long) to prime the polymerase activity. Available markers will be used to screen for (a) rust resistance, (b) Fusarium wilt resistance, (c) seed size, and (d) cold tolerance. Segregating populations have been established in Pullman and will be used for gene tagging at ICARDA. Currently, a set of 400 RAPD-markers is being used to look for polymorphisms between lentil lines.

M. Baum, F.J. Muehlbauer (Pullman, Washington) and W. Erskine

3.2.2. Test for Somaclonal Variation in Lentil

Development of DNA marker using a F_2 segregating population depends on the availability of sufficient individual F_2 plant since F_2 plant material might have been lost during trait evaluation (e.g. seedling test against

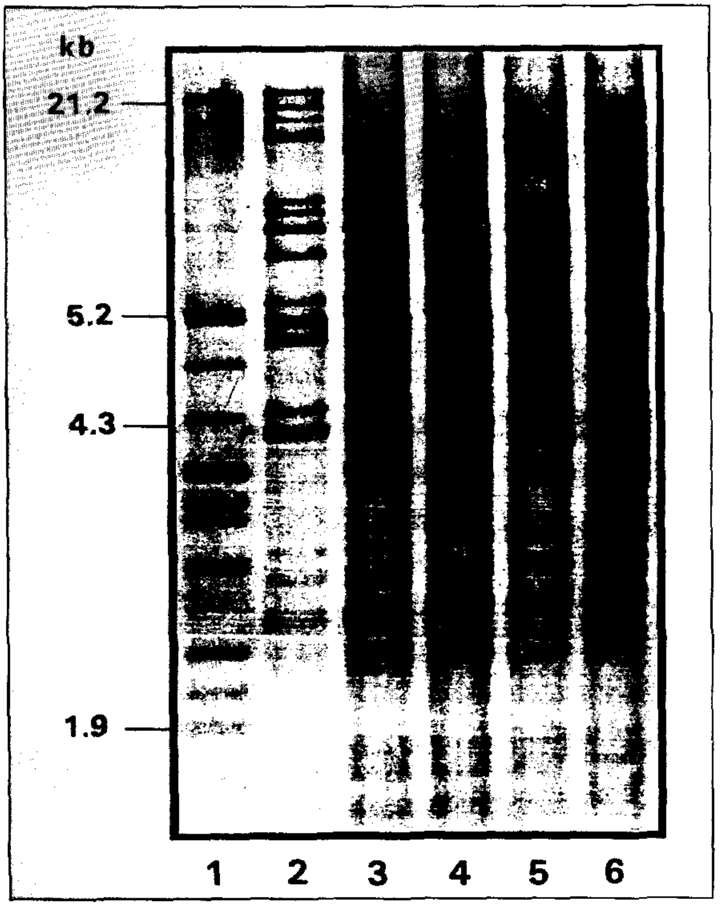


Figure 3.2.1. DNA-fingerprints of in vitro cultured lentil. Total DNA was digested with Taq1 and probed with $(GAT)_4$. Lane 2 contains the donor plant. Lanes 3-6 contain the regeneration. Lane 1 shows the molecular weight marker.

A. rabiei) and numerous seeds have to be harvested from the same plants for further trait evaluation in F_3 the DNA stocks of the F_3 individuals might be exhausted before a trait specific marker could have been developed. To overcome this bottleneck in a crop where dihaploid lines can not be produced by in vitro culture techniques recombinant inbredlines could be developed. The disadvantage of such an approach is the time required to reach at least the F_6 generation. An alternative approach might be the clonal propagation of the individual F_2 plants. In this case somaclonal variation has to be ruled out as an unwanted source of genetic variation.

To detect somaclonal variation, lentil plants were briefly exposed to tissue culture stress. Thereby, excised shoot tips were cultured in vitro until they produced roots. At the cutting sites some callus tissue developed. Regenerated plantlets were compared with the respective donor plants by DNA-fingerprinting (Fig. 3.2.1). No final conclusion can be drawn since genetic stability indicated by identical DNA-fingerprints between parents and regenerants is questionable because of one missing band in all regenerants (15 kb). Most probably the loss of this band is a technical artifact because it is very unlikely that tissue culture induced mutation should have occurred at one and the same locus in 4 independently regeneration plantless. This will be further studied.

F. Weigand and I. Mahmoud

3.3. Lentil Biological Nitrogen Fixation

3.3.1. N_2 Fixation of Lentil Cultivars in Response to Inoculation with Selected Rhizobia

With long term cultivation of lentil in areas of WANA receiving between 250 and 400 mm annual rainfall, high native populations of rhizobia nodulating lentil are expected. Surveys conducted throughout W. Asia verify this; average viable counts of rhizobia nodulating lentil are in the range of 10^3-10^5 g^{-1} soil. Existence of adequate native rhizobial populations implies that improvement in N_2 fixation through manipulation of the symbiosis via rhizobial inoculation may not be possible. Little is known regarding specificity of the crop with respect to strain-cultivar interactions, but indications by other investigators point to some degree of specificity.

Response to inoculation may occur where introduced cultivars, selected for high yields, cannot express their full capability for N_2 fixation in symbiosis with native rhizobial populations which have developed in coadaptation with local landraces. Selection of highly effective strains for a group of improved cultivars or lines then may be sufficiently beneficial to justify the practice of inoculation. It is also important to establish base-line values for $\underline{P}_{fix}$ (the proportion of plant N derived from N_2 fixation) and quantities of N_2 fixed in recommended cultivars of lentil so improvements through rhizobial strain and legume cultivar breeding and selection may be quantified. The objective therefore of this long term study was to determine the variations in nitrogen fixation and yield in lentil cultivars inoculated by a number of carefully selected Rhizobium leguminosarum strains nodulating lentil.

Five field trials were conducted in N. Syria over four seasons, 1987/88 to 1990/91. Seasonal rainfall in the field trials fluctuated between 196 and 350 mm, representing a normal range of rainfall for lentil production. Seven cultivars of large- and small-seeded types were used in the trials, chosen for their realized and potential use in the region. Cultivars included ILL 8, ILL 16, ILL 1939, ILL 4400, ILL 4401, ILL 5700 and ILL 6011.

Most probable number (MPN) measurements of indigenous lentil rhizobia populations in the test soils were high (between 6.8×10^3 and 4.6×10^4 rhizobia g^{-1} soil), due to long-term cultivation of lentil in these areas. Rhizobia treatments comprised uninoculated and two strain treatments; all experiments included at least one single strain treatment (strain 719), while some included two single-strain inoculants (strains 719 and 735) or a single-strain inoculant (strain 719) and a 3-strain mixture (strains 719, 726, and 735). Strains were selected based on prior N_2-fixing performance on the concerned cultivars in aseptic hydroponic culture in greenhouse trials. Seeds were inoculated at planting using a liquid application method, at a rate to provide approximately 10^6 viable cells per seed.

Trial results here reported are only for the best overall inoculation (single strain 719) and non-inoculated treatments. As expected, increased

N_2 fixation accompanied increased yields with increasing rainfall (Fig. 3.3.1). Inoculation had virtually no effect on average crop dry matter or nitrogen yields over the seasons. As rainfall increased, yield variability between cultivars also increased, but average yields indicate no response to inoculation. Amounts of N_2 fixed did increase with inoculation as rainfall increased, reaching a maximum increase of 14 kg N/ha (13% increase over uninoculated) at 350mm seasonal rainfall.

The large degree of variability in inoculation response between cultivars and experiments is shown in Table 3.3.1. Average nitrogen and dry matter yield responses to inoculation were negative in 1987-88 and 1989-90 seasons, and positive in other trials. It is interesting to note

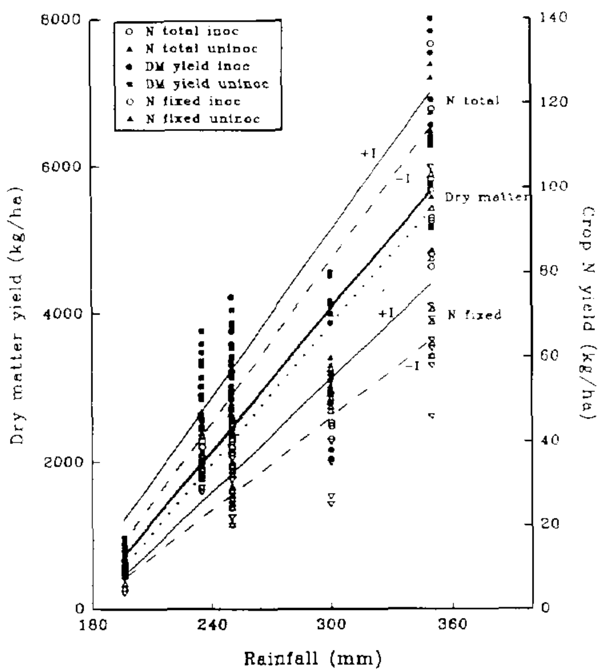


Figure 3.3.1. Dry matter, total nitrogen and fixed nitrogen yield of above ground parts of lentil as affected by inoculation and total seasonal rainfall, 1987-1991; + I = inoculated; - I = uninoculated.

that response does not seem to be connected with available moisture. Yield responses among cultivars within experiments also varied greatly. Only cultivars ILL 5700 and 6011 showed positive yield responses to inoculation in all trials, but all cultivars produced significantly increased yields due to inoculation in at least one of the trials. Given such wide variation in yield response to inoculation with carefully selected rhizobial strains, it would be imprudent to recommend inoculation at the farmer level.

Table 3.3.1. Average above ground dry matter (AGDM) and nitrogen (N) yield response of 7 lentil cultivars to inoculation with strain LE 719 in 5 field experiments, 1987-1991. Figures represent percent change from uninoculated control (parentheses indicate negative percentages).

	ILL 8	ILL 16	ILL 1939	ILL 4400	ILL 4401	ILL 5700	ILL 6011	X
1987-88, 350 mm Tel Hadya								
AGDM	(3)	3	(6)	(10)	(9)	14	6	(1)
N	(5)	(3)	(6)	(10)	(13)	16	2	(5)
1988-89, 195 mm **Breda**								
AGDM	6	3	(2)	19	8	39	18	13
N	17	10	4	23	13	43	22	19
1988-89, 235 mm **Tel Hadya**								
AGDM	1	21	11	6	13	23	16	
N	9	25	17	8	10	33	27	18
1989-90, 250 mm **Tel Hadya**								
AGDM	(10)	(3)	(8)	(17)	6	6	3	(4)
N	(12)	(5)	0	(5)	(10)	20	5	(1)
1990-91, 300 mm **Tel Hadya**								
AGDM	17	31	na	na	na	13	23	21
N	20	37	na	na	na	20	24	25

Because of increased cultivar variations in yield at higher moisture and the limited number of points on the rainfall axis, total crop N, fixed crop N, and $\underline{P}_{fix}$ have been plotted against dry matter yields in Fig. 3.3.2. Inoculation clearly has no effect on the N yield at a given level of dry matter production. $\underline{P}_{fix}$ is, however, increased by inoculation at higher levels of crop production, increasing quantities of N_2 fixed. As a result, soil N use is decreased by an average 15 N/ha. Although effects of inoculation on yield are limited, the quantities of soil N preserved could be significant in a systems context.

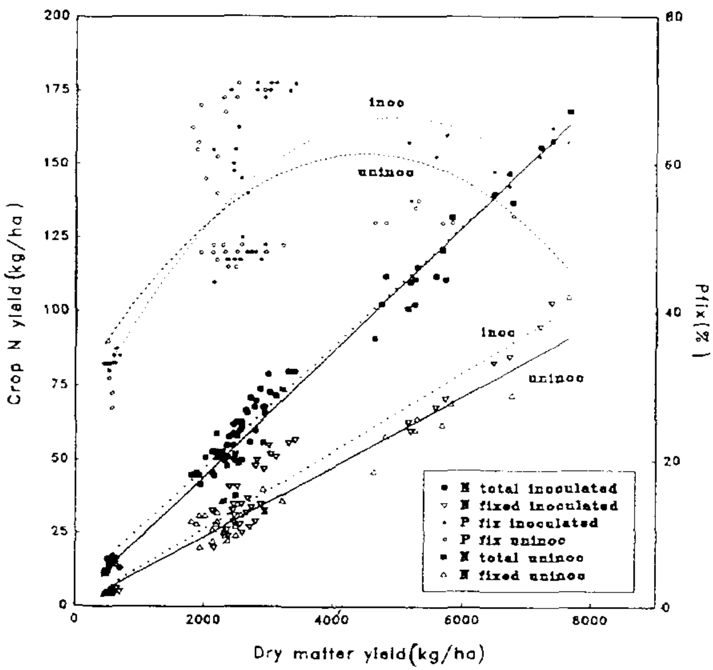


Figure 3.3.2. Effect of inoculation on total nitrogen yield, yield of fixed nitrogen and percentage nitrogen derived from fixation (Pfix) at various levels of above ground dry matter yield.

The magnitude of yield increases in some cultivars and increase in the average $\underline{P}_{fix}$ values at higher rainfall suggest that manipulation of the symbiosis via inoculation may be feasible in lentil, even where native rhizobia populations are high and moderately effective. However, better understanding of the mechanics of interactions between native lentil rhizobial populations and inoculant strains is a necessary prerequisite to more consistent results from inoculation. A farmer will find it difficult to adopt inoculant technology if economic rewards, such as increased yields of the legume or following cereal, are not obtained as a consequence. **D. Beck and W. Erskine**

3.3.2. Effect of Variable Moisture on N_2 Fixation in Lentil

Of the legumes grown in rotation in the Mediterranean region, lentil is the crop most often grown under conditions of limited rainfall. If incorporated into crop/livestock systems with a view to maximizing the advantages of fixation, lentil can arrest the decline of soil N fertility that inevitably accompanies intensive agriculture and, at the least, reduce the requirements for inputs of fertilizer N. Characterization of the interactions of N_2 fixation and moisture in lentil will allow development of management strategies designed to improve the N economy of soils through legume N_2 fixation.

During 1988/89 and 1989/90 seasons, field trials utilizing the line-source sprinkler for variable moisture application and incorporating ^{15}N microplots to measure N_2 fixation were conducted to determine the effects of variable moisture supply on N_2 fixation in 11 lentil lines. The plant material tested consisted of local landraces and crosses made at ICARDA, and included ILLs 4400, 4401, 5582, 5604, 5782, 6004, 6207, 6247, 6434, 6451, and 6784. These cultivars were part of a group of 25 lines tested for drought tolerance, water use efficiency, and yield response to variable moisture supply. Aboveground dry matter and nitrogen yields were measured at physiological maturity under 7 moisture levels, ranging between 180 and 375 mm for the two seasons. For measurement of N_2 fixation, an isotope dilution method was used with non-nodulating chickpea line PM233 and local barley as reference crops. No rhizobia inoculant was used, as the field soil contained an adequate population of chickpea rhizobia (see Section 3.3.1).

As expected, lentil yields were closely related to applied moisture (Fig. 3.3.3). Cultivar differences were significant only at the highest moisture level, where ILLs 6234 and 6247 gave the highest N and dry matter yields. Measurements of $\underline{P}_{fix}$ at each moisture level were also not significantly different among cultivars. Average $\underline{P}_{fix}$ values ranged from 36% at 180mm moisture to 68% at 345-375mm.

In order to present the relationship between yield (as affected by moisture availability) and total crop N, fixed crop N, and $\underline{P}_{fix}$, N parameters have been plotted against aboveground dry matter yields (Figure 3.3.4). Perhaps most significant is that $\underline{P}_{fix}$ values (40-50%) indicate an effective symbiosis even when moisture limits dry matter yield to below

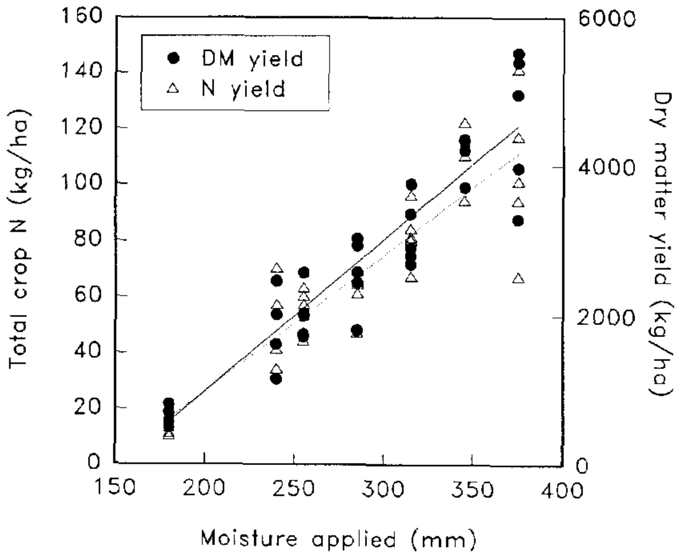


Figure 3.3.3. Effect of total moisture supply on dry matter and total nitrogen yield of above ground parts of lentil.

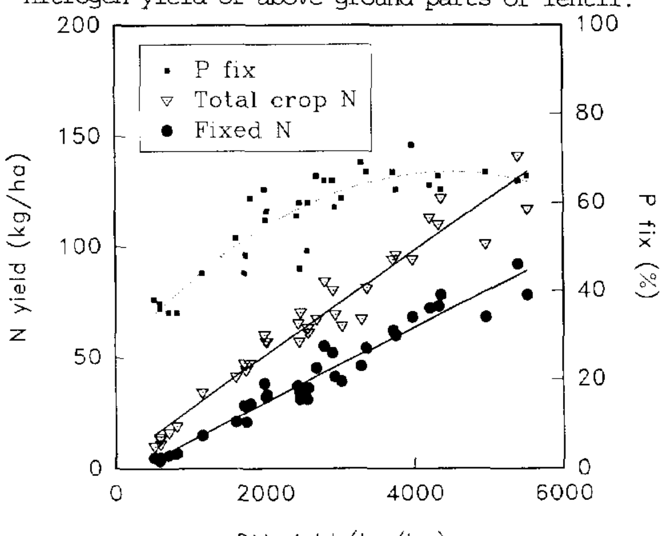


Figure 3.3.4. Total and fixed nitrogen yield and proportion of crop nitrogen derived from fixation in lentil in relation to dry matter yield.

1500 kg/ha. This results in very little soil N (indicated by the distance between the 2 N curves in Figure 3.3.4) being taken up by the crop at lower moisture levels. In sharp contrast, chickpea fixes only 15-30% of its N at yield levels less than 1500 kg/ha, and utilizes upwards of 25 kg N/ha from soil regardless of moisture availability and yield level (see Section 2.5.2). This fact undoubtedly reinforces regional farmers' decisions to include lentils in cropping systems under limited rainfall, though they might not be aware of the reasons for improved system productivity. Fixation efficiency reached an average maximum of 66% at about 4000 kg/ha dry matter produced, at which point it appears to level off (Figure 3.3.4).

Figures 3.3.5 and 3.3.6 are similar to Figures 3.3.3 and 3.3.4, but in addition contain data from 10 cultivars in uninoculated treatments of 4 years of winter-sown inoculation response trials conducted in N. Syria. Most of the additional data inserts above the 2 t/ha yield level, and because earlier sowing results in higher average yields, adds several points above the 5 t/ha yield level. The relationships between yield and N_2 fixation, after inserting the additional information, are virtually unchanged, except for an apparent drop off in $\underline{P}_{fix}$ above 5 t/ha dry matter production. At higher yield levels (ie. production at >350mm rainfall) decreased fixation efficiency will result in increased soil N uptake (Fig. 3.3.6). This information supports the regional practice of replacing lentil cultivation with chickpea at about the 350 mm rainfall level.

D. Beck, W. Erskine, S. Silim and M.C. Saxena

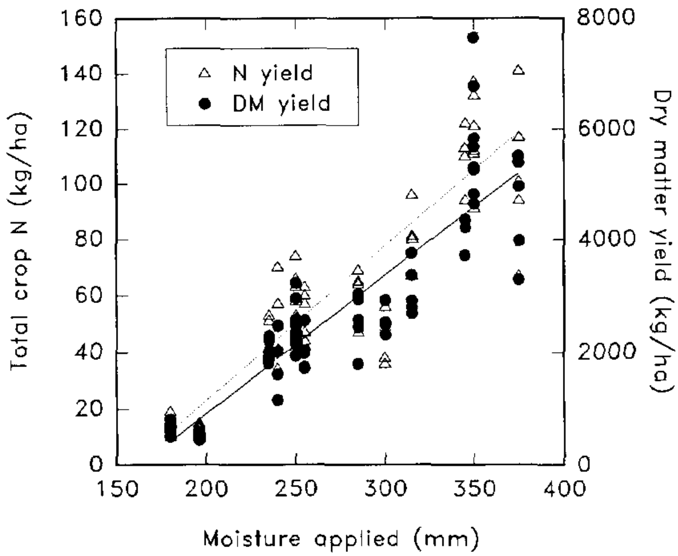


Figure 3.3.5. Effect of total moisture supply on dry matter and total nitrogen yield of above ground parts of lentil. Expanded data set.

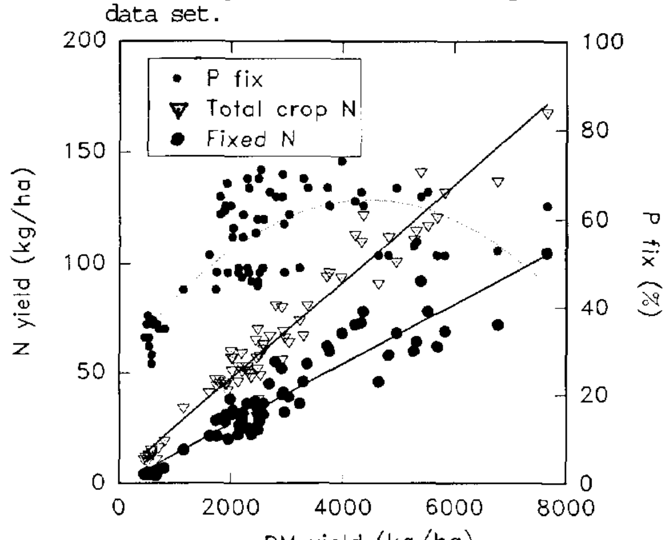


Figure 3.3.6. Total and fixed nitrogen yield and proportion of total crop nitrogen derived from fixation in relation to dry matter yield of lentil. Expanded data set.

3.4. Lentil Entomology

The effect of damage by <u>Sitona crinitus</u> on lentil yield and nitrogen fixation was further studied and also related to different moisture supply levels. For storage insect pests methods of protection were studied in the field. The experiment on yield loss assessment and economic control of aphids could not be carried out due to insufficient aphid infestation.

3.4.1. Effect of S. crinitus on Lentil Yield

Experiments on <u>Sitona</u> damage and control were conducted at Tel Hadya, Jinderess and three on-farm locations, Efes, Alkamiye and Afrin. Based on the results of previous years only one dosage of Promet (12 ml/kg seed) was compared with the check. N 15 technique was used to quantify nitrogen fixation at Tel Hadya, Jinderess and Alkamiye. At all locations Promet treatment increased lentil seed and biological yield (Fig. 3.4.1). Except for Efes (high variation) and seed yield at Tel Hadya differences were significant.

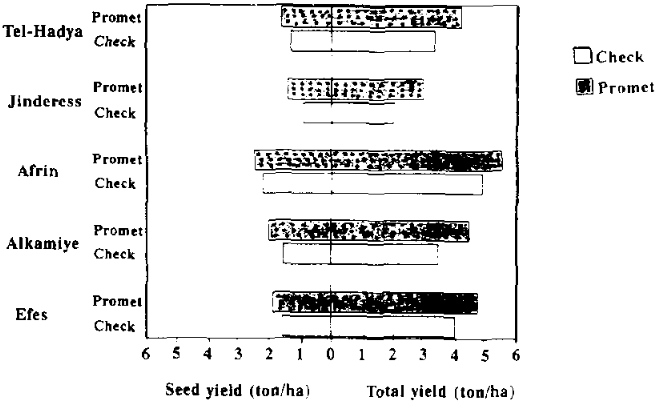


Figure 3.4.1. Effect of application of Promet on lentil seed and biological yield at 5 locations, Syria, 1991/92.

Plant samples were taken once in early May and at harvest and analysed for nitrogen content. No significant differences due to treatments were found, although the nodule damage ranged from 92 % at Alkamiye to 63% at Tel Hadya and was significantly reduced at all locations by Promet treatment (Table 3.4.1) and nitrogen deficiency symptoms were visible in check plots at several locations. The nitrogen yields, however, were significantly higher with Promet treatment at Jinderess, Afrin and Alkamiye, apparently due to yield increases rather than differences in nitrogen content. Soil samples from all treatments and locations were taken and analysed for NH_4+, NO_3- and total nitrogen content, but no significant differences between treatments were found. To further follow the effect of Sitona feeding on the nitrogen cycle soil cores were taken from all plots, which will be planted with barley in the plastichouse to observe any growth differences due to Sitona control.

Oviposition of S. crinitus was monitored by counting the eggs extracted from 100 ccm soil samples taken at 2-week intervals. This season oviposition and Sitona activity in general was delayed due to the cold and snowy winter. Whereas oviposition usually started in the beginning of January, the first eggs were only found in early March this year (Fig. 3.4.2). Likewise the peak was reached about 6 weeks later-late March/ early April instead of mid February. Promet treatment greatly reduced the number of eggs at all locations, but was less effective at Afrin.

The mean nodule damage at 3 sampling dates over a 4 weeks period is presented in Figure 3.4.3. At Alkamiye, Efes and Tel Hadya the nodule

Table 3.4.1. Effect of Promet (12 ml/kg seed, P 12) treatment on lentil plant nitrogen concentration, seed, total dry matter and nitrogen yield and nodule damage by Sitona at 5 locations in Syria, 1991/92.

Location	Treatment	%N 5/5	%N 22/5	Lentil yield kg/ha Seed	Lentil yield kg/ha Total	N yield kg/ha	% nodule damage 5/5
Tel Hadya	Check	1.26	2.41	1641	3331	80.5	63.4
	P 12	1.27	2.41	1320	4199	101.0	10.9
	S.E.M.	0.01	0.06	83.5	169.6	6.4	3.3
	LSD 5%	NS	NS	NS	763	NS	15.0
Jinderess	Check	2.74	2.35	918	2009	46.9	83.9
	P 12	2.51	2.38	1419	2955	70.2	5.4
	S.E.M.	0.04	0.05	48.4	88.1	2.5	1.3
	LSD 5%	NS	NS	217.9	396	11.1	6.0
Afrin	Check	2.55	2.45	2233	4877	119.4	74.9
	P 12	2.64	2.41	2504	5520	133.1	27.8
	S.E.M.	0.05	0.02	35.6	84.9	2.7	6.9
	LSD 5%	NS	NS	160.3	382	12.2	31.3
Alkamiye	Check	2.77	2.61	1549	3468	92.8	92.1
	P 12	2.95	2.54	2063	4468	113.2	16.3
	S.E.M.	0.09	0.05	26.3	70.9	3.5	4.5
	LSD 5%	NS	NS	118.5	319	15.8	20.4
Efes	Check	2.46	2.28	1588	3999	91.8	69.7
	P 12	2.56	2.24	1881	4746	106.1	9.6
	S.E.M.	0.14	0.07	131.9	293.5	7.9	8.9
	LSD 5%	NS	NS	NS	NS	NS	40.3

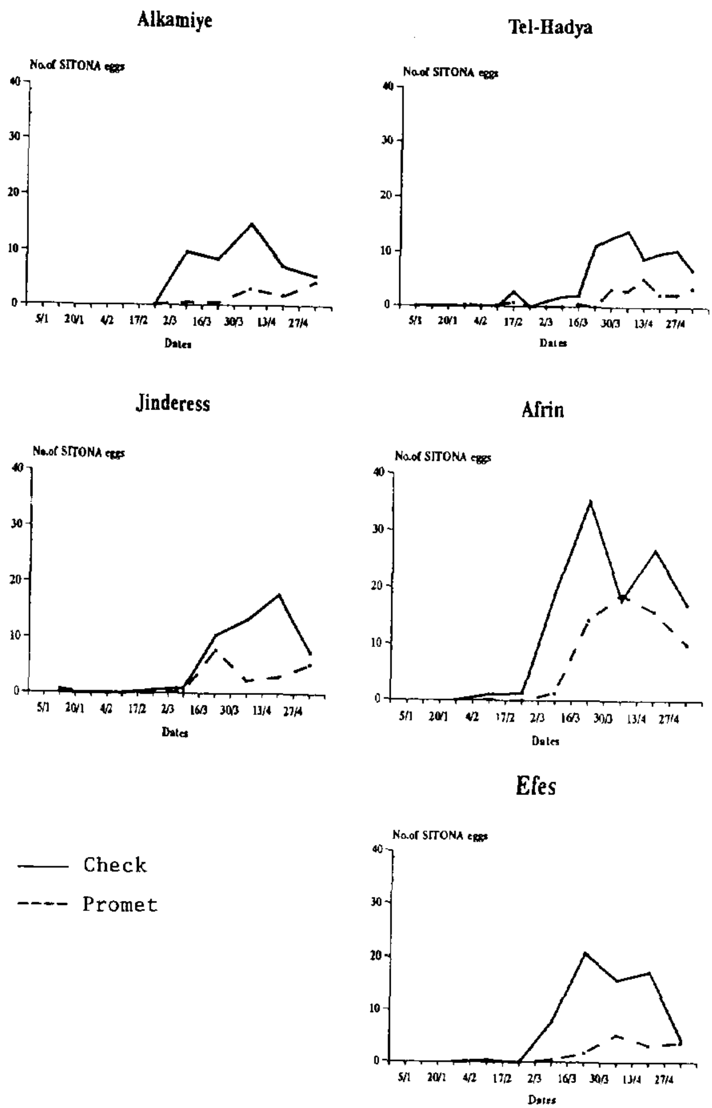


Figure 3.4.2. Mean number of <u>Sitona</u> <u>crinitus</u> eggs extracted from 100 ccm soil samples with and without Promet treatment at 5 locations, Syria, 1991/92.

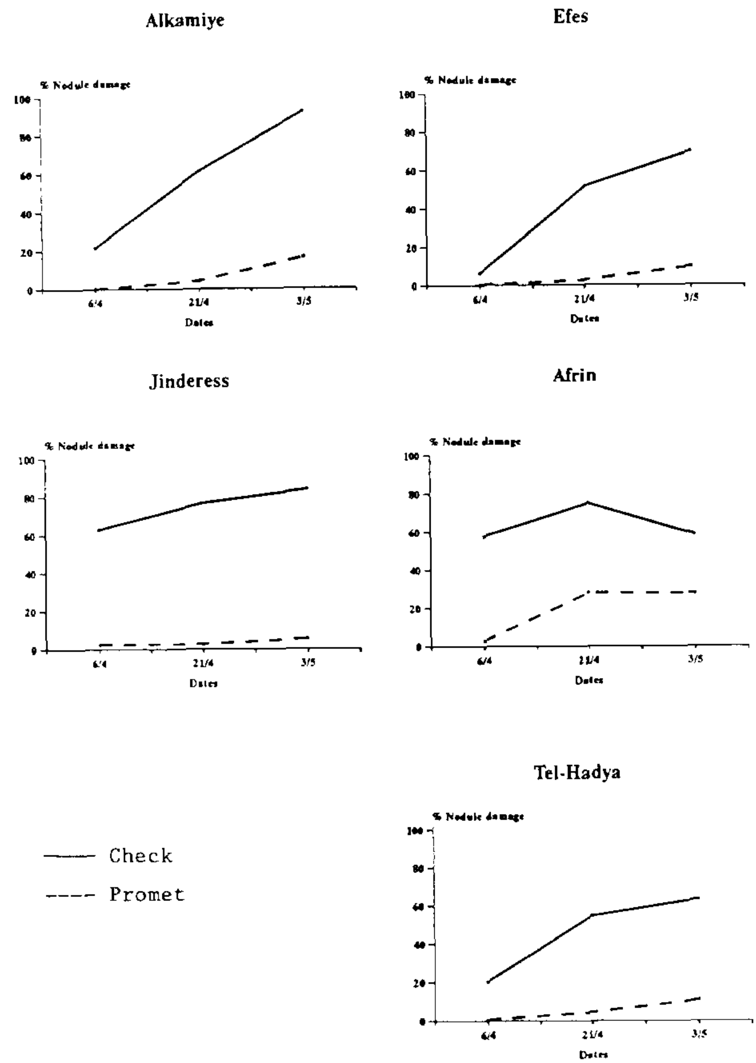


Figure 3.4.3. Effect of Promet application on Sitona damage to nodules in lentil at 5 locations, Syria, 1991/92.

damage was still low (20%) at the first sampling date in early April, whereas at Afrin and Jinderess already 60% damage was noted. This was also observed last season and might be related to higher rainfall and thus higher soil moisture at these 2 locations permitting faster development of Sitona eggs and larvae. Except for Afrin the highest nodule damage was recorded in early May, 2 and 6 weeks later than 1991 and 1990, respectively. Promet treatment significantly reduced nodule damage at all dates and locations, except for the last date at Afrin.

These results confirm the effectiveness of Promet treatment for Sitona control in lentil, and it will be included in on-farm verification trials at about 15 locations in Syria next season.

S. Weigand

3.4.2. Effect of Sitona Control at Various Levels of Moisture Supply

Past studies have shown that the nodule damage in lentil by Sitona varies with the seasonal rainfall as well as the efficacy of insecticide treatments. To quantify these relationships last year's experiment at Breda was repeated evaluating the effectiveness of Sitona control with Carbofuran and Promet at various levels of moisture supply using the line source sprinkler system. The moisture levels evaluated were 118, 91, 56 and 0 mm supplemental irrigation in addition to 263 mm rainfall. N^{15} technique was used to quantify nitrogen fixation. Plant samples were taken in early May and at harvest for nitrogen analysis.

As last season differences in seed and biological yield between treatments at the same moisture level were not great (Table 3.4.2). The nodule damage was comparatively low, between 36 and 51 percent and was significantly reduced by both treatments at all moisture levels. The plant nitrogen content showed small differences due to treatments at both sampling dates. Only at the lowest moisture level at the harvest sampling the nitrogen content under Promet treatment was significantly lower than the check and at the highest moisture level the nitrogen content of the check was lowest at both sampling dates. Carbofuran and Promet increased nitrogen yields at all moisture levels, but the increase was significant only at the 2 lower levels.

The results have shown that variation in moisture supply at Breda through supplemental irrigation does not affect nodule damage and therefore response to Sitona control treatments.

S. Weigand and M.C. Saxena

3.4.3. Control of Bruchus ervi

Different insecticides were tested in farmers fields at 3 locations (Efes, Atareb and Termanini) for their effectiveness to control Bruchus ervi, the important pest of lentil infesting the developing seeds. Two applications of Temiphone (1 ccm/l), Fastac (0.5 ccm/l) and Thiodan (1 ccm/l) at early podsetting late April and 2 weeks later were used. At maturity four samples per plot were harvested of which seed samples of 25 g were evaluated for infestation from August to November. Although infestation was relatively low this season, differences in infestation levels were found between locations and treatments. At Termanin the infestation was

Table 3.4.2. Effect of 4 moisture supply levels, Carbofuran (10 kg/ha 5% G, C 10) and Promet (12ml/kg seed, P 12) treatment on lentil plant N concentration, seed, total dry matter and nitrogen yield and nodule damage by Sitona at Breda, 1991/92.

Moisture level*	Treatment	%N 3/5	%N 17/5	Lentil yield kg/ha Seed	Lentil yield kg/ha Total	N yield kg/ha	% nodule damage 21/4
381 mm	Check	2.29	2.25	1809	5449	123.3	45.4
381 mm	C 10	2.52	2.26	1931	5939	134.0	2.5
381 mm	P 12	2.56	2.31	1727	5806	134.4	1.0
	S.E.M.	0.08	0.05	123.9	321.3	8.3	2.8
	LSD 5%	NS	NS	NS	NS	NS	9.7
354 mm	Check	2.53	2.34	1512	4420	103.6	36.4
354 mm	C 10	2.49	2.34	1646	4846	112.6	1.6
354 mm	P 12	2.64	2.34	1583	4756	111.2	0.6
	S.E.M.	0.06	0.09	156.6	295.4	7.8	4.3
	LSD 5%	NS	NS	NS	NS	NS	15.1
319 mm	Check	2.55	2.36	1299	3742	88.0	40.5
319 mm	C 10	2.52	2.33	1253	3816	88.9	4.9
319 mm	P 12	2.52	2.44	1361	3864	94.2	1.3
	S.E.M.	0.06	0.04	83.4	153.7	4.0	4.1
	LSD 5%	NS	NS	NS	NS	13.9	14.4
263 mm	Check	2.49	2.33	894	2620	61.0	51.3
263 mm	C 10	2.43	2.40	888	2671	64.1	6.2
263 mm	P 12	2.69	2.43	943	2669	64.9	1.7
	S.E.M.	0.08	0.02	27.5	41.7	0.8	3.7
	LSD 5%	NS	0.08	NS	NS	2.8	12.9
STD between 2 moisture level means for the same or different levels of Sitona control				138.1	312.9		4.9
LSD (5%)				282.5	642.5		10.5

* moisture levels were 263 mm rainfall plus 118, 91, 56 and 0 mm irrigation.

highest (8.8% seeds infested), followed by Atareb (5.3% seeds infested), whereas infestation at Efes was very low (1.4% seeds infested). Of the insecticide treatments Temiphone and Endosulfan effectively reduced infestations at all locations, whereas Fastac had little effect, confirming previous results. However, chemical control of Bruchus in lentil would only be economical in case of high infestations. It is more important to use preventive measure of not planting infested seeds.

Syrian National Program Scientists and S. Weigand

3.5. Lentil Crop Physiology

3.5.1. Effects of Plant Density on Tolerance to Frost

Plants growing at high densities in general, seem to tolerate cold damage better than the thinly populated stands of lentil. An experiment to verify these observations was conducted to relate the response of Idleb 1 lentil plants in increasing plant densities to cold at Tel Hadya. The experiment was conducted in a RBD with seven plant densities (50, 100, 150, 200, 250, 300 and 350 plants/m^{-2}) and four replications. Increasing plant densities were achieved by increasing seed rate with in a row, at a constant row to row spacing of 25 cm. Sowing was done on 14 November 1991 and harvesting on 27 May 1992. No irrigation was applied. Crop was sprayed once with a mixture of Cobox + Piremor and second time with Bravo + Piremor/or Desis to protect against diseases and insect pests. Frost damage was assessed on a 1-9 rating scale on 1 March 1992, with 1 being no damage and 9 a complete kill due to frost.

Early planted food and forage legumes experienced severe frost damage.

Planting of this trial being in November the frost effect was mild (average rating 2.4 on a 1-9 scale). Plants growing at sparse population of 50-100 plants/m^{-2} (Table 3.5.1) were relatively more severely affected

Table 3.5.1. Effects of increasing plant density on frost damage, total biological, and seed yield and harvest index. Tel Hadya.

Plants m^{-2}	Frost damage 1-9*	Total biological yield kg/ha	Seed yield kg/ha	Harvest index (%)
50	3.0	2860	1150	40.0
100	2.7	3020	1116	36.8
150	3.0	3275	1175	35.7
200	2.2	3681	1308	35.4
250	2.0	3835	1366	35.6
300	2.2	4178	1433	35.6
350	1.7	4426	1550	34.8
Mean	2.42	3610.9	1307.1	36.32
SEm $\pm$	0.23	166.9	105.6	1.63
LSD ($P \leq 0.05$)	0.68	496.1	313.9	4.86
C.V. (%)	19.06	9.25	16.17	9.02
Significance	0.006	0.00	0.56	0.366

* 1 = no damage; 9 = killed.

compared to the plants growing at 200-350 plants/m^{-2}. Frost damage was the least at the highest density of 350 plants/m^{-2}. However, no significant difference in seed and total biological yield and harvest index was observed between 200 to 350 plants/m^{-2}. HI was the highest at the lowest plant density of 50 plants/m^{-2}. Experiment will be repeated in 1992/93 but with an earlier planting date to increase the crop susceptibility to cold.

M.C. Saxena and N.P. Saxena

4. FORAGE LEGUME IMPROVEMENT

Annual forage legume crops are recognized for their potential to produce extra feed from fallow lands. They are one of the major options being considered either to interrupt barley monoculture or to replace fallow in the fallow - barley rotations. These species are sown and harvested in a single year and can be used for grazing during winter, harvested for hay in spring or harvested for grain and straw at maturity. They differ from the food legume crops only in the end use - they are used to feed livestock, whereas food legumes for human consumption.

In spite of the huge diversity of Mediterranean legume species, few have been used as feed crops, and these have received virtually little attention by breeders. Therefore, the Legume Program pays particular attention to annual feed legume species for feed production in dry areas where rainfalls are between 250 - 400 mm. These areas are between the steppe and high potential cereal growing regions in West Asia and North Africa. The low rainfall areas have very fragile agro - ecosystems and are currently threatened by further degradation because of the increasingly annual cropping of barley in response to increasing population pressure. The general objective of our crop improvement program is to develop and disseminate a range of improved feed legume crops adapted to various agro - ecological zones in the region.

In feed legume improvement, we deal with two major genera i.e. *Vicia* (vetches) and *Lathyrus* (chicklings). Within each genus we deal with several species to assess a wide range of feed legume crops for different utilization and niches. Of vetches, we are selecting and hybridizing genotypes of Vicia sativa L. (common vetch), Vicia villosa ssp. dasycarpa Ten (wooly-pod vetch), Vicia ervilia L. (bitter vetch), Vicia palaestina R., Vicia panonica GR. (Hungarian vetch) and of chicklings, Lathyrus sativus L. (common chickling or grasspea), Lathyrus cicera L. (dwarf chickling) and Lathyrus ochrus L. (DG) (ochrus vetch). There are two species i.e. Vicia sativa ssp. amphicarpa Dorth (underground vetch) and Lathyrus ciliolatus (underground chickling) characterized by producing both underground and above ground pods.

A.M. Abd El Moneim

4.1. Forage Legume Breeding

We have two approaches of developing feed legume crops (1) selection from the wild types to develop cultivated types and (2) genetic improvement by hybridization. The two approaches are illustrated in Figure 4.1.1.

Breeding for improved yield is being supplemented by improving the quality of the feed, therefore, palatability, nutritive value of the herbage, hay, grain and straw and freedom from toxic substances and feeding trials are also considered through our collaboration with PFLP.

We aim to serve national breeding programs through (1) assembling, classifying, maintaining and distributing germplasm, (2) developing and supplying breeding populations with sufficient diversity to be used in different environments and (3) coordinating international trials to facilitate multilocation testing and identification of widely adapted cultivars.

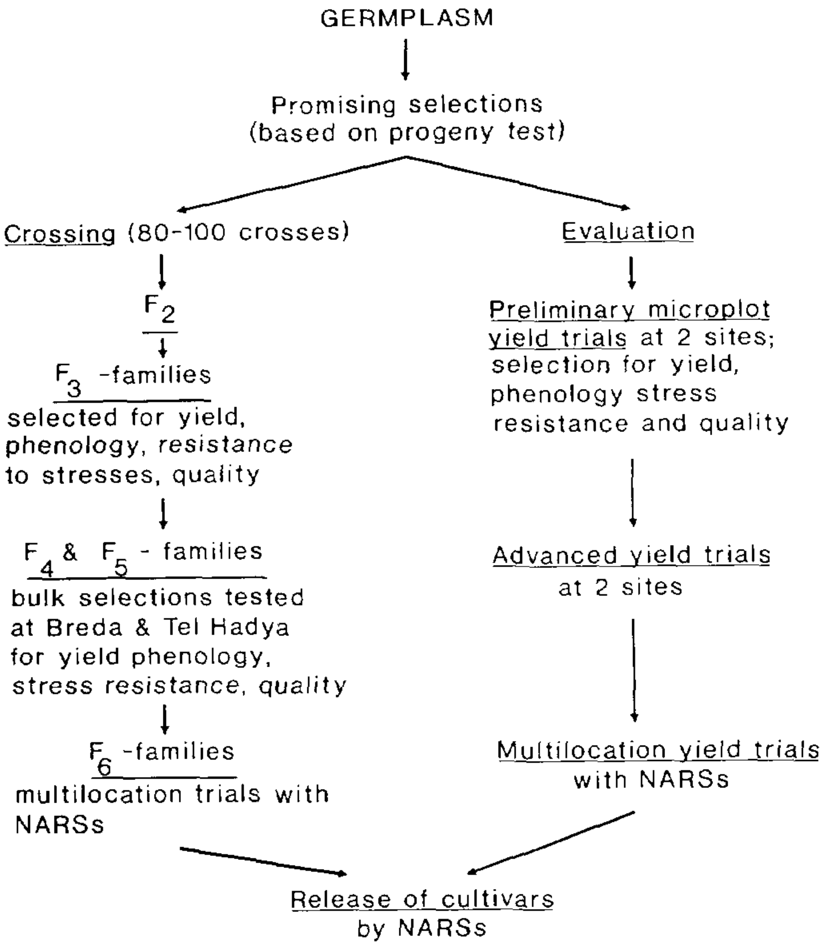


Figure 4.1.1. Germplasm enhancement of *Vicia* spp. and *Lathyrus* spp. at ICARDA.

In 1991/92 germplasm of common vetch and hungarian vetch was evaluated. Promising genotypes (selections) of Vicia sativa, V ervilia, V. hybrida, V. palaestina, V. narbonensis, Lathyrus sativus and L. cicera were tested in microplot field trials at Tel Hadya. Promising lines of V. villosa ssp. dasycarpa and non-shattering V. sativa were tested in advanced yield trials at Tel Hadya, and promising lines of V. narbonensis, L. sativus, L. cicera and L. ochrus were tested at Tel Hadya (seasonal total rainfall 332.3mm) and Breda (seasonal total rainfall 263.2mm). After screening common chickling for low neurotoxin (BOAA) content, a crossing program was initiated for improving nutritional quality of Lathyrus sativus by breeding. 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 reactions of promising lines against major foliar and root diseases were monitored. All the breeding work was done under rainfed conditions without supplementary irrigation.

A.M. Abd El Moneim

4.1.1. Germplasm Evaluation

To compare the tolerance level of various vetches and chickling species and to identify sources of tolerance to cold in each species two experiments, one with different species of vetches and the other with different species of chicklings, were conducted. Two susceptible-cum-indicator checks, IFVI 534, and IFVI 708 belonging to Vicia sativa were included for screening of vetches and IFLA 199 and IFLA 432 belonging to

Lathyrus sativus for screening of chicklings.

These test entries along with the checks were grown in randomized block design with two replications at Tel Hadya. The plantings were done on 1 Oct in 1991 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 53 days and the minimum temperature was -8.8°C on 28 Jan 1992. Visual cold tolerance ratings on a 1-9 scale were assigned after the susceptible checks were killed. The higher rating of the two replications was considered as the actual cold tolerance rating of the lines.

4.1.1.1. Vetches

A total of 100, 60, 96, 40, 103, and 99 accessions of V. ervilia, V. hybrida, V. narbonensis, V. villosa, V. peregrina, V. sativa and V. villosa, respectively, were evaluated. Almost all the accessions of V. peregrina, V. villosa, and V. hybrida were tolerant to cold whereas other species, V. ervilia, V. narbonensis, and V. sativa, had both tolerant and susceptible accessions (Figure 4.1.2). Following accessions had a rating up to 3:

Vicia sativa: Acc. No. IFVI -64, -288, -294, -303, -309, -313, -314, -315, -316, -317, -325, -326, -327, -328, -333, -334, -335, -336, -339, -372, -377, -385, -391-, 399, -403, -406, -407, -408, -416, -447, -3815, -3841.

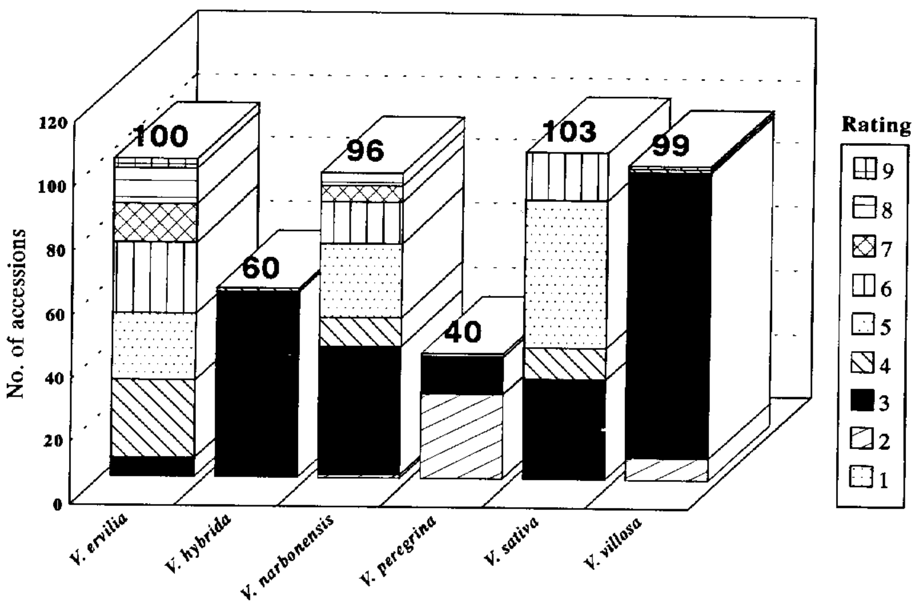


Figure 4.1.2. Cold tolerance reaction of different accessions of various <u>Vicia</u> species. Rating scale: 1 = free from damage; 9 = killed because of frost.

Vicia ervilia: Acc. No. IFVI -225, -228, -240, -263, -541, -654.

Vicia narbonensis: Acc. No. IFVI -67, -749, -1142, -1143, -1147, -1148, -1150, -1152, -2623, -2644, -2663, -2696, -2697, -2702, -2703, -2933, -3085, -3120, -3181, -3185, -3201, -3208, -3209, -3216, -3224, -3234, -3267, -3292, -3305, -3390, -3396, -3397, -3408, -3418, -3419, -3423, -3432, -3436, -3443, -3460, -3464, and -3473.

4.1.1.2. Chicklings

A total of 21, 85, 70, 47, 7, 48, 17 and 203 accessions of L. annuus, L. aphaca, L. cicera, L. hierosolimitanus, L. marmoratus, L. ochrus, L. pseudocicera, and L. sativus were evaluated. Most of the accessions of L. annuus, L. aphaca, L. cicera, L. hierosolymitanus, L. marmoratus, and L. pseudocicera were tolerant (Figure 4.1.3). All accessions in L. sativus and L. ochrus were moderately to highly susceptible for cold except one accession in L. ochrus (IFLA 109) from Portugal which was tolerant.

There was no evidence for any association between cold tolerance and origin of accessions.

R.S. Malhotra, A.M. Abd El Moneim and M.C. Saxena

Another two experiments were conducted using 81 accessions of V. sativa and 64 accessions of Vicia panonica in nursery rows in a cubic lattice design with two replicates. The accessions were scored for seedling vigour, winter and spring growth, cold effect, leafiness, time to flowering and maturity and grain yield. Great range of variability for all characters was found in the two species (Table 4.1.1). The most important

Table 4.1.1. Range, mean, standard error and coefficient of variation (CV%) for eight characters of 81 accessions of common vetch and 64 accessions of Hungarian vetch.

Character[a]	Common vetch				Hungarian vetch			
	Range	Mean	SEM±	CV%	Range	Mean	SEM±	CV%
Seedling vigour	2-6	4.5	0.70	19	4-9	7.1	0.60	15
Cold susceptibility	4-8	6.2	0.31	22	1-3	1.9	0.11	18
Winter growth	3-8	6.4	0.51	17	1-5	2.9	0.31	22
Spring growth	2-7	6.9	0.33	20	4-8	7.5	0.70	13
Leafiness	5-8	7.0	0.60	19	1-5	3.2	0.13	22
Days to start flowering	95-115	107	1.20	2.1	105-120	116	0.95	1.17
Days to 100% flowering	110-130	122	1.70	1.8	115-126	120	1.01	2.01
Days to full maturity	144-160	151	1.4	3.1	140-155	147	1.9	2.9
Grain yield (kg/ha)	550-1900	1550	73	22	400-1600	1110	57	28

[a] On visual score where 1 = poor; 9 = very good and for cold susceptibility 1 = no damage; and 9 = all plants killed by frost.

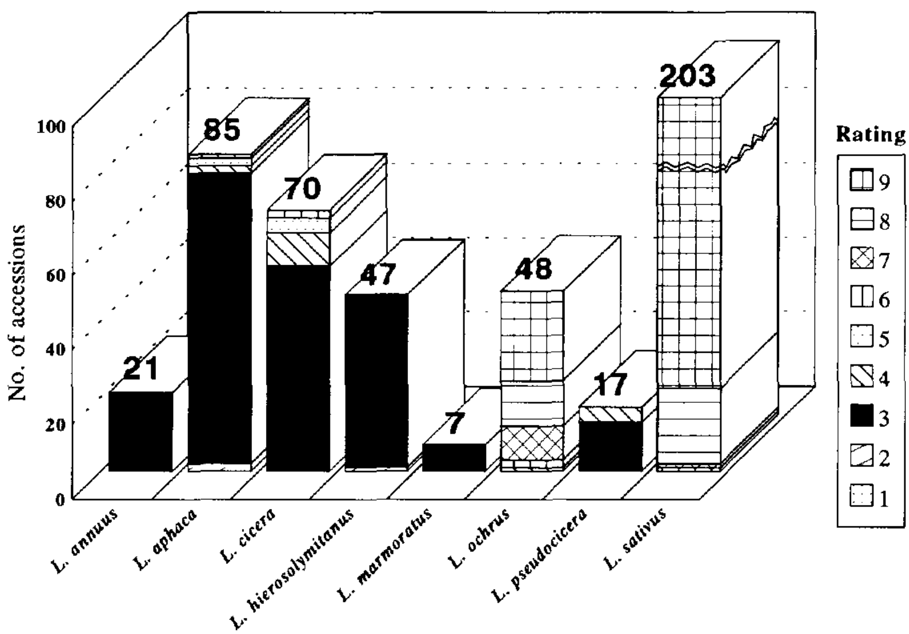


Figure 4.1.3. Cold tolerance reaction of different accessions of various Lathyrus species. Rating scale: 1 = free from damage, 9 = killed because of frost.

findings were the identification of genotypes of Vicia sativa with a high proportion of leaf retention in late spring, an important attribute in forage legumes, and cold tolerant genotypes of Vicia sativa and 16 genotypes of V. panonica with rapid winter growth.

A.M. Abd El Moneim

4.1.2. Preliminary Microplot Evaluation

The study of variation in agronomic traits is of significant practical value. It helps the breeder to establish a breeding program with defined objectives, and of itself may result in the selection of improved lines. Objective selection for herbage and seed yields and some aspects of nutritive value begins in microplot field trials in the year following germplasm evaluation.

In 1991/92 microplots of five Vicia spp. and two Lathyrus spp. were planted in Tel Hadya in 3.5 m^2 plots arranged in a triple lattice design. For all the species, seed rate was 100 kg/ha and fertilizers were applied at 40 kg P_2O_5/ha. These microplot experiments were in two sets. One was harvested at 100% flowering to determine the herbage yield and the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

Common vetch (V. sativa): Twenty five selections were tested at Tel Hadya. Herbage yield (DM) at 100% flowering varied from 1350 to 2249 kg/ha, grain yield ranged from 2105 to 1602 kg/ha and harvest index from 30-39% (Table 4.1.2). Common vetch was moderately affected by frost. Selections 2483 and 2606 showed better frost tolerance and high proportion of leaf retention than the check.

Bitter vetch (V. ervilia): Sixteen selections of bitter vetch were tested at Tel Hadya. Herbage yield varied from 2732 to 3034 Kg/ha, grain yield from 1683 to 2220 kg/ha and harvest index from 29 to 37% (Table 4.1.3).

Table 4.1.2. Herbage, biological and grain yields, harvest index (HI%) and days to flowering and maturity for 25 selections of common vetch (V. sativa) in preliminary field trials 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	2011	4727	1682	35	109	149
2484	2249	5795	2004	34	114	151
2485	1924	5594	2105	37	110	152
2486	2032	5278	1878	35	114	153
2487	1723	5243	1602	30	114	151
2488	1848	5490	1696	39	110	151
2489	1991	5588	1725	31	113	151
2490	1944	5487	1879	34	114	145
2491	1871	5199	1741	33	111	152
2492	1846	5181	1712	33	113	151
2493	1906	5329	1823	34	111	150
2494	1957	5498	1828	33	113	149
2495	1916	5569	1817	32	112	149
2496	1937	5019	1809	36	112	151
2497	2047	5726	2058	36	114	151
2498	2036	5204	1675	32	108	153
2499	1350	5360	1676	31	114	154
2500	1783	5688	1781	31	116	154
2501	1947	5182	1808	34	112	149
2502	2066	5104	1982	39	107	145
2503	1934	5384	1890	35	113	152
2504	1983	5388	2014	37	110	147
2505	2043	5186	1664	32	108	146
2506	2055	5144	1778	34	110	147
2560	1845	5599	1869	33	115	154
Mean	1930	5337	1820	34	112	151
SEM±	132	295	130	1.6	0.5	1.1
LSD (P=0,05)	380	845	320	4.6	1.4	3.3
CV (%)	12	10	12	6.4	0.7	1.3

Table 4.1.3. Herbage, biological and grain yields, harvest index (HI%) and days to flowering and maturity for 16 selections 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)	HI (%)	Days to flowering	Days to maturity
2508	2823	5325	1830	34	114	149
2509	2838	5523	1797	32	112	152
2510	2841	5302	1831	34	113	149
2511	2874	6392	2220	35	114	154
2512	2921	5146	1686	32	113	152
2513	3024	5805	2045	32	111	151
2514	2941	5668	1888	33	112	150
2515	2912	5150	1839	36	111	148
2516	2837	5337	1808	34	110	147
2517	3000	5672	1873	33	113	153
2518	2923	5226	1943	37	108	146
2519	2732	5680	1683	29	115	156
2520	3087	5946	2071	35	114	155
2521	2739	5775	1858	32	118	156
2522	2920	5386	1911	35	112	147
2563	3034	5897	1953	33	115	154
Mean	2903	5577	1889	34	113	151
SEM±	159	313	146	0.9	0.6	0.7
LSD (P=0.05)	458	905	422	2.6	1.8	2.2
CV (%)	9	10	13	3.6	0.9	0.8

Table 4.1.4. Herbage, biological and grain yields, harvest index (HI%) and days to flowering and maturity for 16 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)	HI (%)	Days to flowering	Days to maturity
2539	2072	3448	704	20	102	152
2540	1693	2466	494	20	104	154
2541	2347	3285	730	22	105	154
2542	1786	2723	471	17	106	157
2543	2479	3464	1035	29	103	153
2544	2434	3159	732	23	100	153
2545	2204	3268	781	24	105	156
2546	2595	4167	1067	25	106	154
2547	2465	3420	731	21	106	156
2548	1981	3402	592	17	102	157
2549	2488	3706	946	22	104	154
2550	2587	3833	880	23	106	154
2551	2494	3063	641	21	105	154
2552	2074	3293	553	16	107	159
2553	2233	3266	652	20	107	156
2554	2734	3764	787	21	105	157
Mean	2291	3374	736	22	104	155
SEM±	131	238	96	1.4	0.5	0.8
LSD (P=0.05)	387	688	283	4.2	1.5	2.2
CV (%)	12	13	16	8.2	0.8	0.9

Broad-podded vetch **(Vicia hybrida):** Sixteen selections of V. hybrida were tested in Tel Hadya in microplot field trials (Table 4.1.4). Herbage yield varied from 1693 to 2734 kg/ha, whereas grain yields ranged from 471 to 1067 kg/ha and harvest index from 16 to 29%. V. hybrida is characterized by a prostrate compact growth habit and slow winter growth followed by rapid spring growth, and early flowering. This makes the species suitable for grazing. The low grain yield and harvest index was partly because of the large seed loss in harvesting due to the prostrate growth habit of this species.

Palaestine vetch **(Vicia palaestina):** Sixteen selections were assessed in microplot field trials at Tel Hadya (Table 4.1.5). Herbage yield varied from 1530 to 2529 Kg/ha, whereas grain yield ranged from 147 to 678 Kg/ha and harvest index from 5 to 21%. V. palaestina was severely affected by frost because of its rapid winter growth.

Narbon vetch **(Vicia narbonensis):** Twenty five selections were tested in Tel Hadya (Table 4.1.6). The total biological yield varied from 4442 to 7561 kg/ha, grain yield from 1295 to 2827 kg/ha and harvest index from 29 to 40%. Narbon vetch showed cold tolerance with rapid winter growth, and it reached flowering and maturity 2-3 weeks earlier than other species. Harvest index was negatively correlated ($r = -0.305$, $P<0.05$) with days to flowering. These results indicate a clear need to continue search for early-maturing genotypes of narbon vetch since it could be utilized as a dual purpose crop for grain and straw in dry areas. Our observations showed that at seedling stage it was the species most resistant to bird damage among the vetches. Our observations also indicate that most of the genotypes flower and mature before the attack of broomrape (Orobanche crenata Forsk).

Table 4.1.5. Herbage, biological and grain yields, harvest index (%) and days to flowering and maturity for 16 selections of Vicia palaestina in preliminary yield trials at Tel Hadya.

Selection IFLVP	Herbage Yield (Kg/ha)	Biological Yield (Kg/ha)	Grain Yield (Kg/ha)	HI (%)	Days to Flowering	Days to Maturity
2523	2030	3277	654	18	108	151
2524	1660	2705	392	15	111	151
2525	2094	3422	485	14	112	155
2526	2490	3060	458	15	109	149
2527	2373	3741	502	13	110	152
2528	2027	3276	626	19	110	155
2529	2134	3531	598	17	110	154
2530	2322	3914	646	16	113	155
2531	2529	3425	671	19	109	152
2532	1834	3210	276	8	112	157
2533	2000	3578	459	12	111	153
2534	1921	3608	501	14	113	157
2535	1530	2545	147	5	115	157
2536	2037	3270	678	21	109	152
2537	2125	3447	417	12	111	153
2538	1937	3674	281	10	113	155
Grand Mean	2065	3311	487	15	111	154
SEM±	134	271	127	2.4	0.4	0.9
LSD(P=0.05)	394	798	372	7.1	1.3	2.7
CV(%)	14	15	20	13	0.7	1.0

Table 4.1.6. Biological and grain yields, harvest index (HI%) and days to flowering and maturity for 25 new selections of *V. narbonensis* at Tel Hadya.

Selection IFLVN	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
2561	6270	2148	34	95	132
2367	6415	2220	35	101	141
2377	6360	2329	37	99	141
2378	5655	1691	29	101	140
2379	5443	1701	31	97	136
2381	5811	1948	33	98	136
2382	6510	2373	36	93	135
2384	5915	2185	40	94	136
2385	5453	1908	35	94	133
2386	5598	1965	35	93	131
2389	5421	1887	35	94	132
2394	5319	1694	32	97	135
2395	6490	2400	37	101	140
2396	5527	1675	30	97	138
2397	7561	2827	37	101	140
2398	5585	1753	31	99	137
2460	5441	1871	34	97	134
2463	5862	2018	34	98	139
2482	5756	1882	32	96	133
2597	5096	1624	32	98	135
2598	5719	1964	34	101	143
2599	4442	1295	29	103	142
2600	5610	1702	30	99	137
2601	7531	2590	34	102	142
2602	5511	1703	30	97	140
Mean	5852	1976	33	98	137
SEM±	505	232	1.1	0.7	1.2
LSD (P=0.05)	1449	666	3.1	2.1	3.3
CV (%)	15	16	4.4	1.1	1.3

Common chickling (Lathyrus sativus): Sixteen selections of L. sativus were tested in Tel Hadya in microplot field trials (Table 4.1.7). Herbage yield varied from 1605 to 2906 kg/ha, whereas grain yields ranged from 1013 to 1828 kg/ha and harvest index from 29-41%. L. sativus was moderately affected by frost.

Table 4.1.7. Herbage, biological and grain yields, harvest index (HI%) and days to flowering and maturity for 16 selections of Lathyrus sativus at Tel Hadya.

Selection IFLLS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
587	2906	4457	1634	36	113	159
553	1605	4171	1219	31	120	170
554	1813	4388	1322	29	118	171
556	2265	4133	1428	34	119	168
557	2251	4544	1813	41	113	159
558	2104	3417	1013	29	121	171
559	2053	4118	1402	32	119	170
560	2217	4316	1402	32	118	167
561	2168	4548	1581	35	118	166
562	2611	4251	1611	38	115	160
563	2130	3882	1318	34	116	167
564	2037	3516	1124	31	120	170
565	2417	5104	1828	36	117	165
566	2270	4514	1592	35	115	160
567	2889	4704	1825	38	116	161
568	2213	4315	1367	33	117	166
Mean	2265	4274	1467	34	117	166
SEM±	217	368	179	1.6	0.5	0.8
LSD (P=0.05)	638	1062	516	4.8	1.6	2.4
CV (%)	16	15	21	8.3	0.8	0.8

Dwarf chickling (Lathyrus cicera): Nine selections were tested in microplot field trials at Tel Hadya (Table 4.1.8). Herbage yield varied from 2235-2896 kg/ha, whereas grain yields ranged from 1185 to 1916 kg/ha and harvest index from 32 to 46%. In contrast to L. sativus, L. cicera is a cold tolerant species. These results indicate the clear need to collect and evaluate native genotypes of L. cicera which might show desirable attributes of cold and drought tolerance as well as early winter and spring growth.

Table 4.1.8. Herbage, biological and grain yields, harvest index (%) and days to flowering and maturity for 9 selections of Lathyrus cicera at Tel Hadya.

Selection IFLLS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Days to flowering	Days to maturity
501	2286	3693	1527	41	117	157
569	2370	3670	1185	32	115	160
570	2623	3778	1592	42	115	156
571	2593	3759	1577	43	115	155
572	2536	4193	1916	46	114	154
573	2642	4058	1832	44	113	153
574	2235	4272	1646	38	119	159
575	2688	4308	1851	43	115	154
576	2896	3734	1626	44	114	153
Mean	2541	3940	1639	41	115	156
SEM±	189	208	120	1.2	0.4	1.4
LSD (P=0.05)	597	655	360	3.5	1.4	4.1
CV (%)	13	9	13	4.9	0.7	1.5

Table 4.1.9. is a summary of the results of microplots in 1991/92. As the forage legume species can be used for grazing during winter, harvested for hay in spring or harvested for grain and straw at maturity one can see how the various species will fit into farming

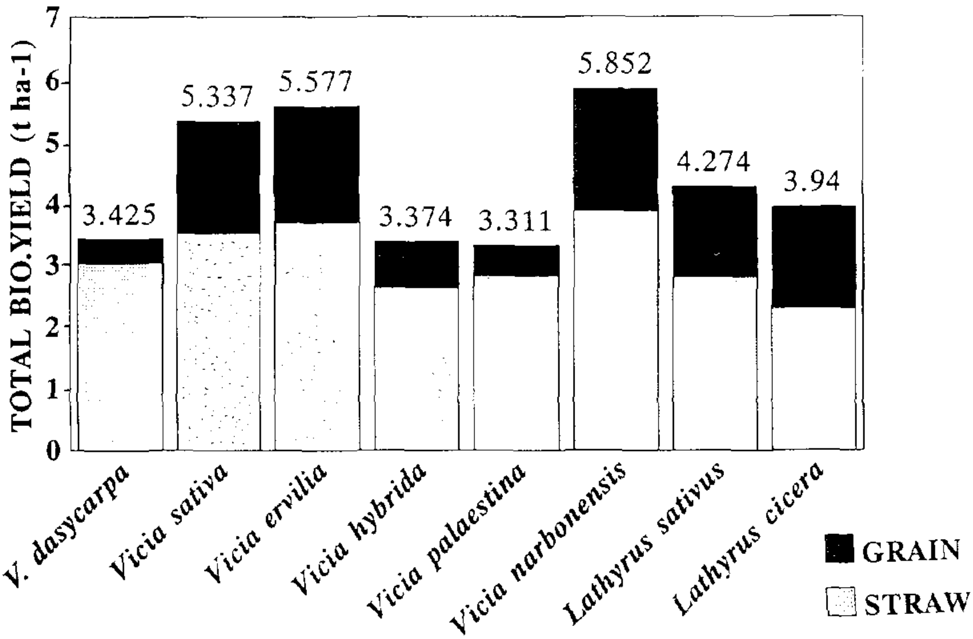


Figure 4.1.4. Overall mean yield of different forage legume species at Tel Hadya, 1991/92.

systems. The high harvest index and yield levels of V. narbonensis, V. ervilia, L. cicera and L. sativus suggest that they can be used for straw and grain. V. sativa would be recommended for hay, straw and grain production, whereas V. hybrida and V. palaestina and V. villosa ssp. dasycarpa would be suitable for grazing because of their low harvest index and grain yield (Figure 4.1.4).

A.M. Abd El Moneim

Table 4.1.9. Variation in major attributes of seven feed legume species evaluated in microplot field trials at Tel Hadya.

Species	Cold susceptibility[1]	Winter growth[2]	Days to flowering	Days to maturity	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)
Vicia sativa	4 - 8	5 - 8	107-116	145-154	1350-2249	4727-5795	1602-2105	30-39
V. ervilia	2 - 4	2 - 6	108-118	146-156	2732-3034	5146-6392	1683-2220	29-37
V. hybrida	2 - 6	1 - 3	100-107	152-159	1693-2734	2466-4167	471-1067	16-29
V. palaestina	4 - 8	2 - 6	108-115	149-157	1530-2529	2545-3914	147-678	5-21
V. narbonensis	2 - 4	6 - 8	93-103	131-143	-	4442-7561	1295-2827	29-40
Lathyrus sativus	4 - 8	4 - 7	113-121	159-171	1605-2906	3417-5104	1013-1828	29-41
L. cicera	2 - 4	5 - 8	113-119	153-160	2235-2896	3670-4308	1185-1916	32-46

(a) On visual score, where 1 = no damage; 9 = all plants killed by frost
(2) On visual score, where 1 = very slow growth; 9 = rapid growth during January - February

4.1.3. Advanced Yield Trials

Promising lines of wooly-pod vetch were tested at Tel Hadya, and promising lines of common chickling, dwarf chickling and ochrus chickling were evaluated at Tel Hadya and Breda.

Advanced yield trials of wooly-pod vetch: Sixteen lines were tested at Tel Hadya. There were differences in herbage yield, biological yield and harvest index. Herbage yield varied from 2297 to 2835 kg/ha and seed yield from 263 to 442 kg/ha (Table 4.1.10). Harvest index was very low (8-13%). Generally, seed production is low in this species because of late flowering and high flower abortion due to high temperature. Seed yield was negatively correlated ($r = -0.640$, $P=0.01$) with days to 100% flowering, but there was no association ($r = 0.108$) between herbage yield and days to 100% flowering. Wooly-pod vetch is a frost tolerant species and it is also resistant to broomrape (*Orobanche crenata* Forsk). Developing early flowering and early maturing varieties with flowering and podding occurring on early formed nodes may result in increased seed yield.

Advanced yield trials of narbon vetch: Promising lines of narbon vetch were assessed at Tel Hadya and Breda. Biological and grain yields and harvest index were measured at both sites (Table 4.1.11). Yields were greater at Tel Hadya than at Breda, the respective mean biological yields being 5358 and 3225 kg/ha, and the mean grain yield 2052 and 1282 kg/ha. In contrast, harvest index was greater at Breda than at Tel Hadya (40 vs. 38%).

Table 4.1.10. Herbage yield at 100% flowering, biological and grain yields and harvest index for 16 promising lines of wooly-pod vetch (V. villosa ssp. dasycarpa) in advanced yield trials at Tel Hadya.

Lines IFLVV	Herbage yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Harvest index (%)
2562	2428	3357	426	13
2424	2370	3270	350	10
2431	2297	3487	420	12
2437	2443	3430	419	12
2438	2528	3172	263	8
2439	2835	3587	375	10
2441	2468	3574	442	12
2442	2569	3449	412	12
2445	2508	3433	387	11
2446	2380	3168	322	10
2450	2366	3430	408	12
2451	2420	3570	429	12
2454	2512	3592	433	12
2455	2502	3462	411	12
2456	2382	3391	348	10
2457	2581	3434	401	11
Mean	2474	3425	394	11
SEM±	138	121	30	2.5
LSD(P=0.05)	407	357	89	7.1
CV(%)	10	6	18	14

Table 4.1.11. Biological and grain yields and harvest index (HI%) of 25 promising lines of narbon vetch (V. narbonensis) grown at Tel Hadya (TH) and Breda (B) in advanced yield trials.

Lines	Tel Hadya			Breda		
IFLVN	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)
2561	6267	2050	36	3129	1322	42
2380	5024	2159	42	2926	1276	43
2383	5956	2254	38	3492	1497	43
2387	4956	2212	44	2664	1247	47
2388	5164	1941	37	2794	1133	41
2390	4702	1747	37	3204	1225	38
2391	4615	1698	35	3735	1124	41
2392	5663	2243	39	2982	1257	42
2393	5131	2169	43	2958	1204	41
2461	5477	2064	38	3789	1447	38
2462	5493	2159	39	3340	1253	37
2464	5647	1695	37	2937	975	33
2465	5204	1915	37	3683	1265	35
2466	5117	1893	37	3201	1169	36
2467	5177	2032	39	3632	1434	39
2468	5918	1934	33	3895	1133	39
2469	5159	2100	40	3302	1348	41
2470	5590	2105	38	3559	1322	37
2471	5535	2094	37	3616	1366	38
2473	5415	2077	39	3648	1430	39
2474	5899	2297	39	3181	1295	41
2475	4721	2057	42	3100	1348	43
2476	4827	1933	40	3326	1329	40
2477	5507	2364	43	3382	1473	44
2478	5791	2129	37	3160	1154	36
Mean	5358	2052	38	3225	1282	40
SEM±	288	149	1.8	209	103	1.5
LSD(P=0,05)	826	427	5.2	595	293	4.1
CV(%)	12	13	8	11	14	6

Advanced yield trials in common chickling: Sixteen promising lines were tested. Herbage yield varied from 1972 to 2587 Kg/ha and from 1380 to 1810 kg/ha at Tel Hadya and Breda, respectively (Table 4.1.12). Yields were greater at Tel Hadya than at Breda. Harvest index varied from 33 to 42% and from 34 to 53% at Tel Hadya and Breda, respectively. Common chickling lines were moderately affected by frost at both sites.

Advanced yield trials of dwarf chickling: Sixteen promising lines were tested. At Tel Hadya the herbage yield varied from 1735 to 2033 kg/ha, and at Breda from 1474 to 1980 kg/ha (Table 4.1.13). At maturity, the grain yield varied from 1242 to 1784 kg/ha and from 886 to 1248 kg/ha at Tel Hadya and Breda , respectively. At Breda, dwarf chickling produced more seed and straw than common chickling, because of better and drought tolerance and early flowering.

Advanced yield trials of ochrus chickling: Sixteen promising lines of ochrus chickling were tested at Tel Hadya and Breda (Table 4.1.14). The total biological yield varied from 1424 to 2279 kg/ha at Tel Hadya and, from 1898 to 3256 kg/ha at Breda. At maturity, the grain yield ranged from 504 to 925 kg/ha and from 558 to 882 kg/ha at Tel Hadya and Breda respectively. It produced more straw and grain at Breda than at Tel Hadya. Ochrus chickling is resistant to <u>Orobanche crenata</u>, and is early flowering. It is an ideal legume for <u>Orobanche</u> infested areas. The major constraint is its sensitivity to frost spells during winter. Developing frost tolerant varieties may result in increased productivity.

Table 4.1.12. Herbage, biological and grain yields and harvest index (HI %) of 16 promising lines of common chickling (Lathyrus sativus) grown at Tel Hadya and Breda in advanced yield trials.

Lines IFLLS	Tel Hadya Herbage yield (kg/ha)	Tel Hadya Biological yield (kg/ha)	Tel Hadya Grain yield (kg/ha)	Tel Hadya HI (%)	Breda Herbage yield (kg/ha)	Breda Biological yield (kg/ha)	Breda Grain yield (kg/ha)	Breda HI (%)
587	2455	3463	1324	38	1718	2550	927	36
504	2113	3855	1628	42	1493	2698	1139	42
505	2163	3375	1259	37	1514	2362	1156	48
508	2485	4133	1724	41	1739	2893	1206	41
510	2180	3371	1800	41	1526	2359	1260	53
516	2039	3221	1183	36	1427	2254	828	36
519	2272	4327	1722	40	1590	3028	1205	39
520	2285	3596	1358	37	1599	2517	950	37
522	2161	3499	1345	38	1512	2449	941	38
527	2272	4013	1653	41	1590	2809	1157	41
528	2413	3424	1251	36	1689	2396	876	36
529	2543	3607	1457	40	1780	2524	1019	40
530	2196	3626	1409	39	1537	2538	986	38
531	2465	3270	1257	38	1725	2289	879	38
533	1972 .	3944	1621	41	1380	2760	1134	41
535	2587	4184	1436	33	1810	2928	1005	34
Mean	2287	3744	1464	39	1601	2584	950	37
SEM±	163	346	173	1.5	85	206	75	3.2
LSD(P=0.05)	470	999	499	4.4	250	606	216	9.4
CV(%)	12	16	20	7	17	15	14	15

Table 4.1.13. Herbage, biological and grain yields and harvest index (HI %) of 16 promising lines of Dwarf chickling (Lathyrus cicera) grown at Tel Hadya and Breda in advanced yield trials.

Lines IFLLS	Tel Hadya Herbage yield (kg/ha)	Tel Hadya Biological yield (kg/ha)	Tel Hadya Grain yield (kg/ha)	Tel Hadya HI (%)	Breda Herbage yield (kg/ha)	Breda Biological yield (kg/ha)	Breda Grain yield (kg/ha)	Breda HI (%)
501	1858	3818	1586	41	1579	3054	1189	38
486	1779	4339	1698	39	1512	3471	1188	34
487	1937	3954	1669	42	1646	3163	1168	36
488	1943	3333	1242	37	1651	2666	931	34
489	1949	4384	1784	41	1656	3507	1248	35
490	1843	3889	1673	43	1569	3111	1087	35
491	1965	3478	1407	40	1670	2782	984	35
492	1735	3452	1267	37	1474	2761	886	32
493	2033	3566	1508	42	1980	2852	1055	37
494	1904	3850	1481	38	1618	3080	1036	33
495	1862	3923	1511	39	1582	3138	1057	33
496	1840	3620	1545	42	1564	2608	1081	39
497	1868	3368	1407	42	1587	2694	984	36
498	1871	4135	1629	40	1590	3308	1140	34
499	1843	3676	1507	41	1566	2940	1054	36
500	1931	4318	1707	40	1641	3454	1229	35
Mean	1885	3819	1539	40	1681	3036	1082	33
SEM±	98	199	116	1.6	61	130	54	1.5
LSD(P=0.05)	290	584	343	4.6	181	377	158	4.5
CV(%)	9	11	15	7	12	14	9	6

Table 4.1.14. Biological and grain yields and harvest index of 16 promising lines of ochrus chickling (Lathyrus ochrus) grown at Tel Hadya and Breda in advanced yield trials.

Lines IFLLO	Tel Hadya			Breda		
	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)	Biological yield (kg/ha)	Grain yield (kg/ha)	HI (%)
104	2145	752	33	2929	851	30
185	2199	785	35	2583	672	27
537	2279	925	40	2614	876	33
538	2098	846	41	2982	882	30
539	2164	844	38	2521	863	34
540	2142	821	39	2831	867	30
541	2158	869	40	3256	821	26
542	1892	799	40	2533	868	35
543	1833	750	40	1898	691	39
545	1424	504	34	2940	859	30
546	1525	520	32	2151	687	30
547	1808	580	31	1976	558	28
548	2151	716	32	2530	714	27
549	1753	551	31	2449	694	30
550	1929	562	29	2536	676	26
551	1973	595	30	2364	766	33
Mean	1967	714	35	2568	772	30
SEM±	169	89	2.3	207	48	3.4
LSD(P=0.05)	498	261	6.7	609	138	9.8
CV(%)	15	21	11	14	11	19

Table 4.1.15 is a summary of advanced yield trials conducted at Tel Hadya and Breda in 1991/92. Ochrus chickling is the most susceptible species to frost damage, but because of its drought tolerance its grain yield is more at Breda than at Tel Hadya. It is recommended for mild winter areas until new genotypes with frost tolerance are available.

Table 4.1.15. Average of major attributes of four feed legume species at Tel Hadya and Breda in advanced yield trials.

Attributes	Narbon vetch	Common chickling	Dwarf chickling	Ochrus chickling
		Tel Hadya		
Frost effect[1]	1.5	3.0	1.5	3.5
Days to maturity	136	148	140	132
Total biological yield (kg/ha)	5358	3744	3819	1967
Grain yield (kg/ha)	2052	1464	1539	752
Harvest Index(%)	38	39	40	33
		Breda		
Frost effect	1.0	3.5	2	3.5
Days to maturity	132	140	130	120
Total biological yield (kg/ha)	3225	2584	3036	2568
Grain yield	1282	950	1082	851
Harvest index (%)	40	37	33	30

[1]. On visual score where 1 = no damage; 5 = nearly killed by frost, and no recovery.

Dwarf chickling and common chickling produced more biological and grain yields at both sites and they are recommended for producing grain and straw in dry areas. Under Breda conditions, narbon vetch produced 1282 kg/ha grain and 1943 kg/ha straw. These characters make it a suitable crop for producing winter stocks of straw and grain to feed sheep. In dry areas, when soil moisture is low because of large seed size and can thus establish better than other species. Its straw is nutritious because it does not lose its leaves following frost.

A.M. Abd El Moneim and Mark Ratinam

4.1.4. Evaluation for Antinutritional Substances

Chicklings (Lathyrus spp.) and narbon vetch (Vicia narbonensis) have high yield potential in areas with less than 350 mm rainfall. L. sativus is particularly adapted to droughty conditions. It represents the major component of human diets in times of drought induced famine in Asia and East Africa. One of the drawbacks of L. sativus, however, is that its excessive consumption causes "Lathyrism", a nervous disorder resulting in incurable paralysis of lower limbs. Lathyrism in human beings and domestic animal is caused by the presence of a free amino-acid known as B-(N) oxalyl-amino-L-alanine (BOAA) in the seed.

In 1988/89, promising genotypes of L. sativus, L. cicera and L. ochrus were screened for BOAA content in seeds in collaboration with Grain Research Laboratory of Winnipeg, Manitoba, Canada, using NIR method. Some genotypes were found to contain very low levels of BOAA (100-350 μg/g seeds), in comparison with others that had very high concentration. The identification of lines nearly free from BOAA encouraged us to continue our screening program in collaboration with PFLP, and to establish a breeding program for developing nutritionally safe Lathyrus spp. In 1991/92, 36 lines of L. sativus, 16 of L. cicera and 16 of L. ochrus, were analysed for crude protein (CP), neurotoxin BOAA, and protein precipitable tannin (PPT) content, catechin equivalents (CE) and trypsin inhibitor activity (TIA). BOAA was determined spectrophotometrically using the O. phthaldehyde fluorescent dye (Rao, 1978) as modified by Briggs et al. (1983). The PPT content was determined by the method of Hagerman and Butler (1978). CE was determined by Burns' (1971) method as modified by Price and Butler (1977). TIA was assayed using the procedure of Smith et al. (1980).

The species with highest and lowest CP were L. cicera (295.4 ± 18.69 g/kg seed) and L. sativus (325.0 ± 13.40 g/kg seed), respectively (Table 4.1.16 & 4.1.17). BOAA was least in L. cicera (1.26 ± 0.18 g/kg seed) and highest in L. sativus (5.63 ± 0.43 g/kg seed). Variation in BOAA content in L. sativus and L. cicera is higher than in L. ochrus. On the average, BOAA levels in L. ochrus (Table 4.1.18) and L. sativus (Table 4.1.16) were about 4-5 times higher than those in L. cicera (Table 4.1.17). The PPT levels in L. sativus (4.54 ± 0.31 g/kg seed) was similar to that in the other two species. However, there were some lines in all species without detectable PPT. Catechin equivalent (CE) which detects simple flavonoids as well as condensed tannins was no more than 6.10 g/kg seed (Table 4.1.17) except for L. ochrus (Table 4.1.18) in which CE ranged from 14.07 g/kg in IFLLO 104 to 28.50 g/kg seed in IFLLO 545. There were high variations in CE between and within species. Mean TIA in all L. sativus lines (18.6 ± 2.38 g/kg seed) was nearly similar to that of L. ochrus and twice the levels in L. cicera.

Table 4.1.16. Crude protein and anti-nutritional constituents (g/kg seed) in for 36 lines of L. sativus

Line IFLLS	CP	PPT	CE	TIA	BOAA
521	305.81	nd[1]	3.31	21.28	5.60
536	282.16	nd	5.50	18.25	4.83
588	299.70	nd	3.86	16.82	5.39
63	308.30	nd	0.83	23.22	5.50
311	310.50	nd	2.76	22.65	5.86
431	303.18	nd	2.21	19.16	4.49
433	313.02	nd	2.20	19.43	5.29
434	313.33	nd	1.10	20.28	5.90
435	309.94	nd	0.28	18.58	4.99
443	283.02	nd	0.55	19.42	4.99
450	309.17	nd	1.93	17.72	5.91
453	302.75	nd	0.88	17.41	5.40
454	288.68	nd	1.65	15.06	4.47
455	300.30	nd	1.65	15.96	3.41
462	290.81	nd	0.28	15.07	4.52
475	280.53	nd	0.27	13.88	4.36
483	291.98	nd	nd	16.54	3.97
502	296.90	nd	2.76	16.84	3.26
514	314.36	nd	3.31	18.29	4.69
524	313.04	nd	3.04	17.45	5.30
587	295.27	nd	2.74	10.60	3.60
504	337.29	4.35	3.29	18.42	5.07
505	340.84	4.43	2.75	18.70	4.97
508	329.31	4.86	1.92	18.88	5.07
510	318.67	4.17	2.47	17.73	3.75
516	338.32	4.35	2.75	17.19	4.72
519	339.07	4.59	2.19	18.17	5.77
520	321.46	5.17	4.66	15.27	4.56
522	330.04	4.17	2.74	14.14	5.06
527	346.04	4.95	4.12	14.46	5.27
528	320.20	4.86	3.57	13.86	4.76
529	321.35	4.43	3.02	13.88	4.72
530	306.07	4.27	3.02	12.15	5.89
531	328.61	4.78	2.47	13.59	4.92
533	315.13	4.59	3.02	11.55	5.26
535	312.12	4.17	0.82	14.15	4.20
Mean	324.99	4.54	2.85	15.17	4.85
SEM±	13.40	0.31	0.84	2.60	0.60
CV(%)	4.12	6.80	29.68	17.13	12.37

1 = not detected

Table 4.1.17. Crude protein and anti-nutritional constituents (g/kg seed) of L. cicera seeds

Line IFLLC	CP	PPT	CE	TIA	BOAA
501	337.46	nd[1]	5.21	6.64	1.06
486	275.78	4.29	4.70	10.18	1.17
487	293.73	nd	3.04	6.98	1.12
488	311.98	nd	3.59	8.43	1.48
489	283.62	nd	3.04	10.18	1.33
490	264.73	nd	3.03	10.74	1.07
491	292.98	nd	4.68	10.73	1.27
492	299.09	nd	3.30	8.10	1.63
493	301.15	nd	3.59	8.12	1.37
494	298.64	4.47	4.96	8.71	1.19
495	293.94	4.30	3.60	8.15	1.48
496	320.94	nd	4.70	8.14	1.43
497	277.16	nd	6.10	9.63	1.33
498	274.27	nd	3.05	9.33	1.13
499	284.13	nd	4.16	8.46	0.92
500	316.69	nd	3.05	7.29	1.23
Mean	295.39	4.35	3.99	8.74	1.26
SEM±	18.69	0.03	0.93	1.24	0.18
CV(%)	6.33	0.80	23.33	14.17	14.32

1 = not detected

Table 4.1.18. Crude protein and anti-nutritional constituents (g/kg seed) of L. ochrus seeds

Line IFLLO	CP	PPT	CE	TIA	BOAA
185	292.10	4.20	21.28	14.26	5.10
537	313.23	4.20	18.51	14.83	5.61
538	281.29	4.29	27.07	15.70	5.20
539	293.97	4.54	15.75	14.84	6.12
540	304.74	4.20	17.41	15.42	5.51
541	315.90	0.00	17.14	17.46	6.23
542	286.50	4.12	22.12	15.43	4.80
543	316.30	4.20	14.38	13.97	6.33
545	290.17	5.26	28.50	13.69	5.11
546	311.82	4.38	18.79	12.80	6.12
547	301.72	4.46	23.24	10.78	5.62
548	307.17	4.46	21.59	13.40	5.52
549	294.50	4.38	25.45	16.31	5.41
550	309.44	4.20	19.91	12.22	5.72
551	299.49	5.22	24.88	14.55	5.51
104	320.31	4.37	14.07	15.11	6.22
Mean	302.42	4.15	20.63	14.42	5.63
SEM±	11.39	0.34	4.27	1.58	0.45
CV(%)	3.77	7.62	20.70	10.93	7.93

1 = not detected

Seed weight was significantly correlated (r = -0.50, P=0.05) with CE and (r = -0.58, P=0.05) with TIA, in L. sativus, and also in Lathyrus ochrus (r = -0.52 and -0.54, respectively, P=0.05). The CP correlated significantly (P=0.01) with TIA in both L. sativus and L. cicera, with respective r values of 0.70 and -0.75.

A.M. Abd El Moneim and V. Alitor

4.1.5. Genetic Improvement

4.1.5.1. Breeding common vetch for non-shattering pod (seed retention) character

Podshattering is common in V. sativa and it restricts the use of this legume for producing feed. Our screening program for non-shattering characteristic indicated the existence of wide variation for this trait among common vetch germplasm collected from different places. Three wild accessions with almost completely non-shattering pod habit were identified and isolated for use as genetic resources in the breeding program.

Genetic studies revealed that the non-shattering trait is conditioned by a single recessive gene. Incorporation of non-shattering gene into agronomically promising lines was achieved by backcrossing. Selection was done in backcross 1 (BC1) to BC5 for non-shattering pods, erect plant type and early flowering. Five superior families: IVLVS (NS) 2565, 2558, 2557, 2014 and 1448) were selected having 95-97% non-shattering pods as opposed to 40-45% in the original cultivated lines. The practical benefits of developing non-shattering lines include increased grain yield, reduced problem of volunteers in the subsequent cereal crops, improved opportunity for mechanical harvesting and increased flexibility in the time of harvest.

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

Results of the last three years indicated that the ability of V. sativa ssp. amphicarpa to produce both aerial and underground pods increases its winter hardiness, drought tolerance and persistence under heavy grazing. The disadvantages of currently available underground vetch, limiting its utilization, are the low rate of vegetative growth, shattering of the above ground pods and the dependence of amphicarpy on edaphic conditions. In contrast, the common vetch V. sativa ssp. sativa grows well under favourable conditions but is not cold or drought tolerant and there are some promising lines with non-shattering pods.

To increase the productivity of underground vetch and to improve the drought and cold tolerance of common vetch, work was initiated in 1989/90 to combine the desirable characters from the two sub-species. Crosses were made between V. sativa ssp. amphicarpa selections 2416 and 2660 originating from Turkey and two non-shattering selections of V. sativa ssp. sativa (IFLVS 2558 and 1448). Gene markers such as colour of pod, seed, flower and straw were used to eliminate selfed plants. The high vigour was clearly observed in the F1 plants grown in 1990/91. The F1 plants had a range from 1 to 6 underground pods/plant. A total of 670 F2 plants were grown in 1991/92. They segregated to five classes, 42 plants carrying 1-3 pods/plant, 159 plants with 4-6 pods/plant, 251 plants with 7-9 pods/plant, 182 plants with 10-12 pods/plant and 36 plants with 12-14 pods/plant. The plants in the first two classes were more vigorous, like V. sativa, and had cold and drought tolerance like V. amphicarpa. The plants in the other three classes, having more underground pods, were not as vigorous as Vicia sativa ssp. sativa but were better than the original amphicarpous types. F3 lines from F2 single plants from each class were selected for further tests in 1992/93.

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

We are aiming to develop promising lines of *L. sativus* with low or zero BOAA content and high yield. So far, little work has been done to determine the genetic architecture of the neurotoxin BOAA. Having identified low BOAA content (18 to 316 μg/g seeds) lines in a breeding program to study the genetics of inheritance this toxin in *L. sativus*.

The hybridization work was initiated in 1990/91 for incorporating the character of low neurotoxin from four lines (testers) into 21 lines. Crosses were made between each tester and the 21 lines making 84 crosses. Gene markers such as flower colour, seed colour and stem colour were used to eliminate pods which might have developed from selfing and to identify F1 hybrids. Naturally self-pollinated pods from parents and F1 hybrids were harvested in summer of 1992. In 1992/93, parents, F1 and F2 will be grown to study the genetic behaviour of the BOAA content and the associated morphological characters.

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4.2. Crop Physiology

4.2.1. Chlorophyll Fluorescence Kinetics as Indicator of Frost Tolerance

Cold tolerance is a major requirement for introducing feed legume species in medium to high altitude regions in West Asia and North Africa. The technique of estimating cold or chilling tolerance using the chlorophyll fluorescence kinetics in chilled leaves would have applications in both physiological studies and in breeding programs for the selection of frost and cold tolerant cultivars. This method has advantage over the traditionally employed methods in that it is non-destructive to plant and is quick (it takes only a few seconds to record the chlorophyll fluorescence in vivo of each leaf sample).

In preliminary study, seedlings of eight selections of Lathyrus ochrus and one selection each of Vicia sativa and V. ervillia were establishment both under field conditions and under controlled conditions in the plastic house (22°C day/15° night temperature and 70% relative humidity). Under field conditions the plants got gradually exposed to cold and during the period 9 Feb to 11 Feb 1992 they were subjected to natural frost (minimum temperature from -6.2 to -4.0°C) for three days. This permitted hardening of the test seedlings growing in the open. Those plants kept in plastic house did not get this natural hardening. Seedlings at 4-5 leaf stage from each group were subjected to a freezing temperature of -10°C for four hours in a growth chamber in the dark to give frost stress. Thus three treatment combinations were obtained: T_1 = not hardened, and not stressed; T_2 = not hardened but stressed; T_3 = hardened and stressed. Plants from all these three treatments were then kept for hald an hout under dark at 0°C and thereafter the rates of fluorescence emission were measured on the fully developed excised leaf from each plant using SF31 Fluorimeter (Richard Brancher Ltd., Ottawa, Canada).

The initial (O), the intermediary (I), the peak (P) and the terminal (T), values of fluorescence emission were recorded in each case, as shown for two contrasting forage legumes - Lathyrus cohrus (frost susceptible) and Vicia ervilia (frost tolerant) - in Figure

4.2.1. Their relationship with the observed replicated field scores for frost damage during 1989/90 and 1991/92 winter seasons (Table 4.2.1) were estimated by correlation and regression analysis (Table 4.2.2).

Table 4.2.1. The scores for frost damage observed during the two coldest seasons (1989/90 & 1991/92) for the various genotypes used in the chlorophyll fluorescence experiment.

Crop & Accession/Sel No.	Scores for damage observed during 1989/90 & 1991/92 winters	
	Frost[(a)] 1989/90	Frost 1991/92
L. ochrus		
101/185	4.5	3.6
84/537	4.5	3.6
91/538	4.5	3.6
95/540	4.5	4.3
100/541	4.5	3.0
103/543	4.5	4.3
503/546	4.5	3.6
506/548	4.5	3.0
V. sativa		
2541/2560	2.5	1.0
V. ervilia		
2542/2563	1.5	1.0

A 1-5 scale was used, 1 = tolerant and 5 = susceptible and the values represent an average of 3 replicates (a) Scored after exposure to temperatures below 0°C.

Table 4.2.2. Correlation of various parameters with scores for frost damages during the winter of 1989/90 and 1991/92.

Treatment	Parameters	Correlation with score for frost damage 1989/90	frost damage 1991/92
Not hardened, not stressed	O	0.949**	0.894***
	P	0.875***	0.856**
	T	0.800**	0.766**
	I	0.867**	0.837**
Not hardened, but stressed	O	0.001	0.151
	P	0.103	0.287
	T	0.195	0.359
	I	-0.060	0.139
Hardened and stressed	O	-0.412	-0.441
	P	-0.647*	-0.653*
	T	-0.376	-0.442
	I	-0.657*	-0.658*

Significantly high and positive correlations were observed between various parameters of chlorophyll fluorescence and frost damage noticed during the 1989/90 and 1991/92 seasons when florescence was measured on unhardened and unstressed plants. The correlations were smaller and negative when various parameters were measured on hardened and stressed plants. There was no correlation of parameters measured on not hardened but stressed plants with frost damage score. Multiple regression analysis using data for unhardened unstressed plants showed that 87 and 96% variation in the frost damage score for 1989/90 and 1991/92, respectively could be accounted for by these four parameters.

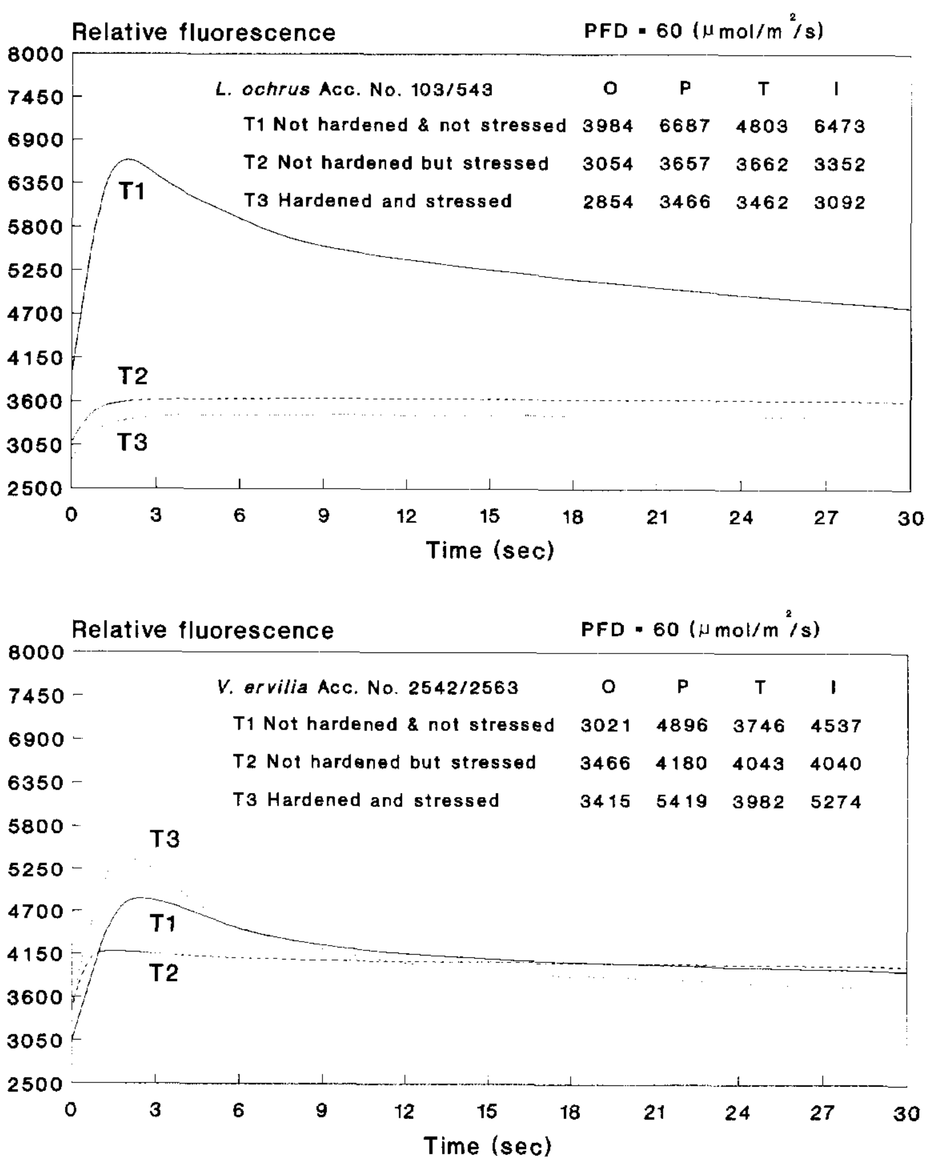

Figure 4.2.1. Relative fluorescence time curve for excised leaves of (a) Lathyrus ochrus (Acc. No. 103/543) and Vicia ervilia (Acc. No. 2542/2563) as affected by hardening and frost stress combinations. For O,P,T, and I, see text.

This preliminary study indicates that in selecting for frost tolerant genotypes one should look for lower values for all the fluorescence emission parameters measured on unhardened and unstressed plants. However, there is a need for verification of these results, using larger number of genotypes with a range of frost susceptibility in each species.

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4.2.2. Growth, Development, Yield and Water-Use Efficiency of Food and Feed Legumes

A preliminary experiment on comparison of relative differences in seed yield (SY), total biological yield (TBY), and water-use efficiency (WUE) of four feed and four food legumes crops, conducted at ICARDA center, Tel Hadya, during the 1990/91 season was reported in 1991 (Legume Program, Annual Report 1991, pages 206-216). Experiment was modified by including two more genotypes under each crop (total 4) and also irrigation treatments, to create different intensities of drought and compute drought tolerance indices for comparison of genotypes within each crop. The trials were conducted in 1991/92 season at three sites: Breda, Tel Hadya and Jinderis, which offered three contrasting environments. 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 to screen large number of genotypes.

Some important site characteristics of these three locations are given in Table 4.2.3. The 1991/92 was a cold crop year, compared to the other years since 1979 on the criteria of number of frost days. The absolute minimum temperatures at all the three sites were similar, but frost occurred more frequently at Breda.

Varying intensities of drought were created by partial alleviation of drought of the rainfed environments. Line-source sprinkler irrigation method was used to create a continuous drought gradient, ranging between nonstress (close to the line-source, with total moisture supply of 393 mm at Breda and 561 mm at Tel Hadya) and stress (rainfed with a rainfall of 263 mm at Breda and 352 mm at Tel Hadya, farthest away from the line-source) conditions. This experiment was carried out at Tel Hadya and Breda. In another experiment three intensities of drought were created at Tel Hadya by regulating the irrigation frequency, applied by moving an overhead boom of sprinklers over the treatment plots. The total moisture supply in the treatments was 552, 466, and 352 mm. At Jinderis, crops and genotypes were compared only under rainfed condition.

In the line-source method, slopes of the regression estimates of SY and TBY on the total seasonal moisture supply (rainfall + irrigation) were used as the criteria for drought resistance. In the other trial with irrigation treatments standardized residuals were computed from a multiple regression analysis by regressing stress yield (dependent variable) on days to flower and nonstress yield as (independent variables). The sign of the residuals, +ve indicating tolerance and -ve indicating susceptibility, was used as criteria. For the purpose of identifying genotypic difference, a standard residual of 1.3 or greater was used, which indicated that the observed differences indicated true effects at 80% probability, rather than were random effects.

Crop duration was longer at Breda compared to the other two sites, in spite of a less precipitation (Table 4.2.3), probably because of a little early planting but mostly due to more number of frost days (Table 4.2.4). The crop duration was the shortest at Jinderis. Averaged over the genotypes, the duration was shortest for Vicia narbonensis (Vn) and longest for chickpea.

Relative crop performance, in general, was similar at Breda and Tel Hadya, but differed at Jinderis (Tables 4.2.5, 4.2.6, 4.2.7). Vn produced the highest SY both under stress and nonstress conditions which was also the case during 1991. Yield loss, difference between rainfed yield and nonstress yield expressed as percent of nonstress yield, appeared to be relatively greater for the feed than the food legumes. It, however, did not mean low SY of these crops in rainfed conditions, as can be seen in the yield of Vn at Breda (Table 4.2.5).

Lentil and Vn produced the highest TBY (Table 4.2.6). Crop differences in loss of potential TBY were similar as in seed yield. Harvest indices (HI) were higher for food compared the feed legume. Lentil, Vicia villosa ssp dasycarpa (Vvd) and Lathyrus sativus (Ls) were the crops with the lowest HI.

Table 4.2.3. Some selected location, soil and weather characteristics of experimental sites.

Characteristic	Breda	Tel Hadya	Jinderess
Location			
Latitude (N)	35° 55'	35° 55'	36° 22'
Longitude (E)	37° 10'	36° 55'	36° 41'
Altitude (m)	350	362	231
Soil			
Soil type*	Typic calciorthid	Chromoxerertic calcic rhodoxeralf	Palexerollic chromoxerert
Clay (%)	40-44	60-63	60-61
Silt (%)	41-45	31-33	33-34
Sand (%)	15-25	4-8	4
CEC (meq/100g)	28.0	51.4	64.8
pH	8.3-8.5	8.1	7.8-7.9
EC(1:1) ds m^{-1}	0.29-5.0	0.18-0.32	0.14-0.18
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
Weather			
Rainfall (mm)	263	352	424
Long term (1979-1992) average rainfall (mm)	264	328	441
Number of frost days	73	57	51
Temperature (abs.min.)	-8.2°C	-8.8°C	-8.0°C
Nutrients applied			
P (kg/ha) as triple super phosphate	18	22.5	22.5

* Based on USDA soil taxonomy, 1975

Table 4.2.4. Crop and cultivar differences in days from sowing to flowering and from sowing to maturity.

	Crop*			Flowering			Maturity	
			Breda	Tel Hadya	Jinderess	Breda	Tel Hadya	Jinderess
1	CP V1	ILC 482	148	121	82	176	167	114
2	V2	ILC 3279	153	127	85	179	170	118
3	V3	ICC 10448	151	122	83	172	166	114
4	V4	F-83-47C	150	125	84	177	169	116
5	Lens V1	ILL 4400	136	113	75	167	158	103
6	V2	ILL 4401	137	116	77	164	156	107
7	V3	ILL 2069	136	113	75	165	157	104
8	V4	ILL 5604	139	115	76	167	158	104
9	FB V1	ILB 1814	124	105	75	172	164	116
10	V2	ILB 1811	123	107	77	170	164	117
11	V3	ILB 1270	127	106	75	171	163	118
12	V4	ILB 1266	124	108	76	171	165	116
13	Peas V1	ACC#21	150	124	83	176	161	105
14	V2	ACC#30	141	119	77	170	159	100
15	V3	ACC#3	138	116	75	166	161	101
16	V4	ACC#11	139	114	76	168	159	102
17	VS V1	#2541	139	114	82	162	157	105
18	V2	#715	141	123	85	167	162	106
19	V3	#1403	138	114	86	165	160	105
20	V4	#709	139	115	85	169	164	115
21	LS V1	#347	137	113	74	168	162	105
22	V2	#205	149	127	85	178	172	119
23	V3	#208	145	122	81	176	170	115
24	V4	#206	146	125	83	176	171	116
25	VN V1	#67	136	113	77	161	154	102
26	V2	#586	136	113	77	165	156	105
27	V3	#588	135	111	77	164	154	105
28	V4	#121	140	117	78	167	158	106
29	VVD V1	#683	137	114	81	165	162	111
30	V2	#535	138	118	86	167	163	115
31	V3	#1088	139	118	86	167	164	114
32	V4	#596	138	114	82	167	163	111
SEm (±)			0.5	0.35	1.6	0.5	0.5	1.1
LSD ($P \leq 0.05$)			1.5	1.0	4.5	1.4	1.4	3.2

* 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. Relative loss in seed yield (SY) due to drought in feed and food legumes (each crop is a mean of 4 genotype), Tel Hadya, 1991/92.

Crops	Rainfed SY (kg/ha)			Non stress SY (kg/ha)		Yield loss (%)	
	Breda	Tel Hadya	Jinderess	Breda	Tel Hadya	Breda	Tel Hadya
Food Legumes							
Chickpea (CP)	778	1628	1256	1665	2292	52	25
Lentil (Len)	781	1424	676	2064	2367	61	34
Peas (Peas)	629	1121	248	1454	1805	54	28
Faba bean (FB)	668	1698	664	1989	3053	65	43
Feed Legumes							
Vicia sativa (Vs)	643	1353	628	1921	2823	66	50
Vicia narbonensis (Vn)	1098	2497	1084	2642	4045	58	36
Vicia villosa ssp *dasycarpa* (Vvd)	489	1243	724	1756	1940	71	32
Lathyrus sativus (Ls)	724	1474	1208	1743	1496	58	-64*
S.E. (±)	52.6	158.9	133.8	52.6	158.9	2.8	20.0
L.S.D. (P≤0.05)	147.7	459.0	393.6	147.7	459.0	8.4	58.9

* Irrigation reduced seed yield

Table 4.2.6. Relative loss in biological yield (TBY) due to drought in feed and food legumes (each crop is a mean of four genotypes), Tel Hadya, 1991/92.

Crops	Rainfed SY (kg/ha)			Non stress SY (kg/ha)		Yield loss (%)	
	Breda	Tel Hadya	Jinderess	Breda	Tel Hadya	Breda	Tel Hadya
Food Legumes							
Chickpea (CP)	1868	3297	2364	3776	5969	49	41
Lentil (Len)	2361	4205	1579	5479	8581	55	48
Peas (Peas)	1344	2383	679	2904	4181	53	38
Faba bean (FB)	1438	3176	1503	3762	6055	59	46
Feed Legumes							
Vicia sativa (Vs)	1761	3058	1304	4338	6434	59	50
Vicia narbonensis (Vn)	2686	5575	2229	5612	9773	51	41
Vicia villosa ssp *dasycarpa* (Vvd)	1760	4015	1785	5561	7651	68	44
Lathyrus sativus (Ls)	2112	4016	2986	4961	7908	57	48
S.E. (±)	112.1	354.4	275.9	112.1	354.4	3.1	6.3
L.S.D. (P≤0.05)	314.8	1025.3	811.4	314.8	1025.3	9.1	18.6

Table 4.2.7. Harvest indices (%) of feed and food legumes crops with and without irrigation (each crop is a mean of 4 genotypes).

Crops	Rainfed			Non stress	
	Breda	Tel Hadya	Jinderess	Breda	Tel Hadya
Food Legumes					
Chickpea (CP)	45	45	40	44	40
Lentil (Len)	38	31	32	39	27
Peas (Peas)	51	46	25	50	42
Faba bean (FB)	51	53	32	53	50
Feed Legumes					
<u>Vicia</u> <u>sativa</u> (Vs)	45	43	35	45	44
<u>Vicia</u> <u>narbonensis</u> (Vn)	44	40	36	47	41
<u>Vicia</u> <u>villosa</u> ssp	32	26	30	31	25
<u>dasycarpa</u> (Vvd)36					
<u>Lathyrus</u> <u>sativus</u> (Ls)	36	18	30	35	18
S.E. (±)	0.8		1.7	0.8	1.4
L.S.D. ($P \leq 0.05$)	2.3		4.9	2.3	3.9

Large genotypic differences in rainfed SY and TBY were observed in all the crops (Tables 4.2.8 and 4.2.9). Judged on the criteria of standardized residuals, crops Ls, Vn and Vvd were more drought tolerant than others. Three genotypes of Ls appeared to be sensitive in SY to supraoptimal water application, as was seen in the negative slopes (Table 4.2.8).

It seems possible to combine a greater degree of drought tolerance with responsiveness to irrigation, at least in one crop <u>Vicia narbonensis</u>, where a high nonstress yield was associated with a higher slope (Table 4.2.8. V2, V3, V4). Large genotypic differences in drought resistance and susceptibility were apparent in all the three crops, Ls, Vn, and Vvd. In general, there was a good agreement in drought

Table 4.2.8. Standardized residuals of multiple regression of rainfed SY or TBY as dependant and days to flowering and irrigated SY or TBY as dependant variables; and regression estimates of slopes of a linear regression of SY or TBY on mm water applied, Tel Hadya, 1991/92 and rainfed SY and TBY (kg/ha).

	Crop X cultivar		Standarized residual SY	TBY	Yield (kg/ha) Slope±SEm	Rainfed	TBY (kg/ha) Slope±SEm	Rainfed
1	CP	V1	-0.19	-1.3	3.96 ± 0.901	1740	12.05 ± 1.809	3410
2		V2	-0.52	-1.5	2.15 ± 0.743	1291	10.23 ± 1.677	3093
3		V3	-0.26	0.30	1.35 ± 0.540	1164	4.10 ± 1.028	2113
4		V4	-0.01	-0.82	3.38 ± 0.879	2318	13.85 ± 2.449	4271
5	Lens	V1	-1.11	-1.24	4.32 ± 1.452	1359	20.68 ± 3.558	4319
6		V2	-1.1	-1.01	6.10 ± 1.025	1566	23.05 ± 2.532	4436
7		V3	-0.22	-0.56	3.72 ± 1.261	1560	17.29 ± 3.010	4345
8		V4	-0.46	-1.24	8.11 ± 1.217	1211	21.85 ± 2.798	3719
9	FB	V1	-0.16	-0.50	9.59 ± 1.313	2051	17.10 ± 1.298	3913
10		V2	-0.42	-0.11	5.03 ± 0.800	1398	10.50 ± 1.267	2635
11		V3	0.54	0.21	7.11 ± 0.679	1831	14.29 ± 1.499	3128
12		V4	-0.48	-0.16	7.49 ± 0.661	1508	14.45 ± 1.096	3027
13	Peas	V1	-0.74	0.10	4.40 ± 0.932	1841	12.15 ± 1.917	3931
14		V2	-1.4	0.07	2.33 ± 0.890	854	5.85 ± 1.800	1750
15		V3	-1.0	-0.08	1.48 ± 0.426	816	6.47 ± 0.923	1690
16		V4	-1.8	-0.12	6.31 ± 0.884	973	11.80 ± 1.819	2163
17	VS	V1	-0.33	-0.31	9.87 ± 1.085	1891	16.44 ± 2.127	4128
18		V2	-0.33	-0.63	8.62 ± 1.243	1611	19.98 ± 2.328	3460
19		V3	-1.28	-0.46	2.33 ± 0.672	923	5.94 ± 1.478	2263
20		V4	-0.92	-0.62	5.97 ± 0.843	989	15.03 ± 2.031	2381
21	LS	V1	1.11	1.22	2.49 ± 1.367	1610	16.26 ± 2.354	3979
22		V2	0.98	1.87	-2.92 ± 0.987	1180	13.15 ± 2.905	3788
23		V3	1.27	1.10	-0.49 ± 1.432	1511	17.30 ± 3.008	4155
24		V4	1.32	0.45	-2.63 ± 1.298	1596	16.29 ± 3.272	4443
25	VN	V1	2.25	1.92	2.94 ± 1.334	2258	15.66 ± 2.630	5665
26		V2	1.43	1.26	8.14 ± 1.196	2656	18.90 ± 2.527	6150
27		V3	0.89	0.68	8.59 ± 1.173	2589	18.99 ± 2.355	5478
28		V4	1.04	0.85	6.52 ± 1.304	2265	21.07 ± 2.733	5008
29	VVD	V1	0.11	-1.35	2.04 ± 0.916	1322	14.97 ± 2.633	3544
30		V2	0.69	1.51	2.36 ± 0.830	1286	15.70 ± 2.139	4005
31		V3	0.88	1.09	3.07 ± 0.925	1090	15.96 ± 2.630	4445
32		V4	0.21	-0.70	3.93 ± 1.274	1273	19.16 ± 2.888	4065

Cultivars within a crop SEm ± (0.05) 117.5 230.4

LSD (0.05) 329.7646.5

Table 4.2.9. Regression estimates of slopes for seed (SY) and total biological (TBY) yield on mm water applied and rainfed SY and TBY (kg/ha). Breda 1991/92.

	Crop X cultivar	Slope (kg/mm water)		Rainfed	
		SY± SE m	TBY ± SEm	SY	TBY
1	CP V1	9.51 ± 0.705	18.98 ± 1.321	953	2024
2	V2	4.82 ± 0.501	12.04 ± 1.410	674	2064
3	V3	6.15 ± 0.575	11.94 ± 1.284	738	2064
4	V4	6.86 ± 0.803	17.35 ± 2.164	748	2028
5	Lens V1	10.28 ± 0.767	26.85 ± 3.008	700	2033
6	V2	7.38 ± 1.003	15.02 ± 2.611	731	2134
7	V3	7.06 ± 0.881	16.41 ± 2.578	846	2665
8	V4	9.45 ± 0.976	20.08 ± 2.661	848	2611
9	FB V1	9.59 ± 1.214	17.87 ± 1.915	778	1742
10	V2	8.39 ± 0.777	15.42 ± 1.357	590	1222
11	V3	9.29 ± 0.829	14.50 ± 1.297	635	1428
12	V4	8.69 ± 0.980	16.14 ± 1.842	670	1362
13	Peas V1	9.23 ± 0.928	16.51 ± 1.426	778	1939
14	V2	5.45 ± 0.784	9.60 ± 1.356	669	1308
15	V3	6.30 ± 0.533	11.60 ± 1.018	555	1092
16	V4	5.36 ± 0.660	10.44 ± 1.201	516	1038
17	VS V1	9.02 ± 1.061	19.37 ± 2.059	748	1879
18	V2	9.33 ± 1.021	20.19 ± 2.031	644	1646
19	V3	8.32 ± 0.840	13.74 ± 1.514	669	1661
20	V4	8.14 ± 0.815	16.98 ± 2.193	510	1858
21	LS V1	8.19 ± 0.904	17.66 ± 1.868	823	2268
22	V2	4.42 ± 0.706	18.91 ± 2.150	575	1858
23	V3	5.80 ± 0.580	18.71 ± 1.676	786	2108
24	V4	7.00 ± 0.905	19.85 ± 2.022	725	2216
25	VN V1	8.67 ± 1.250	19.45 ± 2.302	1156	2845
26	V2	9.95 ± 1.407	18.50 ± 2.963	1094	2639
27	V3	9.50 ± 1.238	18.79 ± 2.552	1148	2543
28	V4	9.88 ± 1.565	18.29 ± 3.020	994	2718
29	VVD V1	8.28 ± 1.168	25.07 ± 2.975	510	1745
30	V2	6.68 ± 1.003	22.44 ± 2.816	465	1760
31	V3	6.75 ± 0.729	21.54 ± 2.675	445	1629
32	V4	8.21 ± 1.038	23.91 ± 2.895	538	1906
Cultivars within a crop		SEm			112.2
		LSD		147.7	314.8

tolerance computed by two different methods in two separate experiments. A few cross overs occurred, which may be due to differences in the total amount of water applied between the two experiments. It seems the simple method of computing drought resistance using irrigated and nonirrigated treatments is effective and would be useful in screening large number of genotypes for drought resistance, which may be difficult by using the line-source method.

Table 4.2.10. Cumulative evaporanspiration (mm water), SY, TBY (kg/ha), HI (%) and water use efficiency (kg/mm water used) for SY and TBY in four food and feed legume crops, WUE: Tel Hadya, 1991/92.

Crops	SY (kg/ha)	TBY (kg/ha)	HI (%)	ET (mm)	WUE (kg/ha/mm) SY	WUE (kg/ha/mm) TBY
V. narbonensis (#67)	2763	7146	38.8	465	6.0	154
Chickpea (ILC 482)	2331	5050	47.1	481	4.9	105
Faba bean (ILB 1811)	2785	5524	51.0	465	6.1	119
Lentil (ILL 4401)	1808	7168	26.6	475	3.9	150
V. sativa (#2541)	2831	6252	45.4	481	6.2	137
Lathy sativus (#347)	1481	5110	29.8	481	3.1	107
Peas (21)	2251	5348	42.8	477	4.9	114
V.v. dasycarpa (#683)	1544	5385	30.9	488	3.3	111
S.E.m (±)	239.5	390.2	1.60	4.5	0.54	02
LSD (P ≤ 0.05)	919.2	1304	5.36	19.8	1.80	22
C.V. (%)	30.3	16.3	10.1	3.1	27.6	142
Significance	*	*	***	NS	*	**

* Significant at P = 0.05
** Significant at P = 0.01
NS = Not significant

The total amount of water used by different crops was similar, both at Tel Hadya and Breda (Tables 4.2.10 and 4.2.11). Crops differed in WUE for SY and TBY, both at Tel hadya (Table 4.2.10) and Breda (Table 4.2.11). Vicia narbonensis had the highest WUE both in SY and TBY during 1991, a year when soil moisture conditions were less favorable. Even this year, Vn had the highest WUE in Breda and was on par with lentil and faba bean WUE for SY at Tel Hadya.

Table 4.2.11. Cumulative evaporanspiration (mm water), SY and TBY (kg/ha), HI (%) and water use efficiency (WUE: kg/mm water used) for SY and TBY in four food and feed legume crops, Breda, 1991/92.

Crops	SY (kg/ha)	TBY (kg/ha)	HI (%)	ET (mm)	WUE (kg/ha/mm) SY	WUE (kg/ha/mm) TBY
V. narbonensis (#67)	1625	4115	38.7	309	5.3	134
Chickpea (ILC 482)	1455	3028	47.8	315	4.6	96
Faba bean (ILB 1811)	1118	2511	44.2	308	3.6	81
Lentil (ILL 4401)	1198	3468	33.9	310	3.9	112
V. sativa (#2541)	1299	3185	40.8	303	4.3	105
Lathy sativus (#347)	1290	3177	39.4	313	4.2	102
Peas (#21)	1324	2842	44.0	320	4.2	90
V.v. dasycarpa (#683)	892	2903	30.0	307	2.8	93
S.E. m (±)	68.7	268.4	2.11	0.29	0.26	08
LSD ($P \leq 0.05$)	229.8	897.6	7.06	9.7	0.88	29
C.V. (%)	13.2	20.8	13.0	2.3	15.6	212
Significance	**	NS	**	NS	**	NS

* Significant at P = 0.05
** Significant at P = 0.01
NS = Not significant

In general, the results are in agreement with the findings in 1991. Studies on physiological basis of drought resistance in these feed and feed legume crops are planned for 1993.

N.P. Saxena and M.C. Saxena

4.2.3. Effect of drought on BOAA content of seeds of chickling

Seeds of chickling (Lathyrus sativus) cultivars from the drought trial, with three intensities of drought conducted at Tel Hadya (Section 4.2.2), were analyzed for percent BOAA content. Results are presented in Table 4.2.12. Percent BOAA content was the highest in the rainfed

Table 4.2.12. Effect of drought on BOAA contents in the seeds of Lathyrus sativus. Tel Hadya, 1992.

IFLLS (Acc #)	Treatment			Mean
	Stress rainfed	Moderate stress	Non stress (frequent irrigation)	
464 (208)	0.49	0.49	0.30	0.43
459 (205)	0.51	0.45	0.32	0.43
587 (347)	0.46	0.44	0.35	0.42
463 (206)	0.48	0.46	0.33	0.42
SEm (±)		0.037		0.021
F test		NS		NS
Mean	0.48	0.46	0.33	
LSD (0.05)		0.071		
SE (±)		0.18		

treatment and was the least in the treatment where drought was relieved by frequent irrigation. The four genotypes were similar in absolute %BOAA content as well as in their response to increasing drought treatments, as seen in the lack of a significant genotype x treatment interaction. This highlights the importance of environment on the neurotoxin content in the chickling cultivars.

M.C. Saxena, N.P. Saxena and A.M. Abd El Moneim

4.3. Rotation Effects of Underground Vetch (V. sativa ssp. amphicarpa)

The 1991/92 season was the third year of the rotation trial on 'underground vetch - barley' with different grazing treatments imposed on underground vetch. In this season the self-regenerated vetch was evaluated, besides the change in the seed bank. The dry herbage yield at 50% flowering stage of self-regenerated vetch in 1991/92 varied from 3258 to 3900 kg/h (Table 4.3.1) depending on the grazing treatment in

Table 4.3.1. Effect of grazing management of subterranean vetch on its dry herbage yield in the year of establishment (1989/90), yield of succeeding (1990/91) barley (as compared to barley after barley), vetch seed bank at the start and the end of barley phase, and dry herbage yield of self-regeneration vetch in 1991/92, Tel Hadya.

Yield/seed bank (kg/ha)	Subterranean vetch Grazing			No grazing	Barley	SEM±
	February	March	April			
Herbage yield* 1989/90	830	730	860	2020	-	57
Barley seed 1990/91	1966	2035	1925	1909	1599	98
Barley total shoot 1990/91	4347	4193	3947	3877	3143	215
Starting seed bank 1990/91	50	130	160	240	-	27
End of season seed bank 1990/91	32	95	141	218	-	34
Herbage yield* 1991/92	3258	3879	3708	3900	-	320

* At 50% flowering

1989/90. These herbage yield results establish the potential of this forage legume as a pasture crop. One of the major advantages of this legume is that it can tolerate a moderate level of soil disturbance during the cereal phase because of its large seed size unlike annual medics (Medicago spp.) which are naturally found in undisturbed habitats and their deep burrial because of conventional soil tillage may prevent seedling emergence.

A.M. Abd El-Moneim

4.4. Forage Legume Pathology

4.4.1. Fungal Diseases

Host resistance to major stem and leaf diseases necessary is necessary for developing productive forage legumes. In the 1991/92 season, 25 promising lines of Vicia narbonensis, 16 of V. ervilia, 16 of V. palaestina, 16 of V. hybrida, 16 of Lathyrus sativus, and 9 of L. cicera, were tested under artificial epiphytotic conditions for specific diseases. Vicia spp. were screened for resistance to powdery mildew (Erysiphe pisi f. sp. viciae), downey mildew (Perenospora viciae), ascochyta leaf spot and stem blight (Ascochyta pisi f.sp. viciae) and botrytis blight (Botrytis cinerea). Lathyrus spp. were screened for resistance to powdery mildew (Erysiphe martii f.sp. lathyri), ascochyta blight (Ascochyta pisi f. sp. Lathyri) and botrytis blight (Botrytis cinerea). A 5-point scale was used: 1 = resistant; 5 = highly susceptible.

Table 4.4.1. shows the reaction of five Vicia spp. to major diseases. None of the tested lines of V. narbonensis, V. sativa and V. ervilia showed resistance to ascochyta blight. However, most of the

lines showed moderate resistance or tolerance. Four lines of V. narbonensis showed resistance to powdery mildew and botrytis blight. Results on Lathyrus spp. in Table 4.4.2. revealed that most of Lathyrus sativus lines were susceptible to the powdery mildew and botrytis blight.

Table 4.4.1. Reaction of Vicia spp. to major diseases under artificial conditions. Number of lines under each disease category.

Crops	Disease score*	Diseases		
		Ascochyta blight	Powdery mildew	Botrytis blight
V. narbonensis	1	0	4	4
	2	2	13	9
	3	10	7	8
	4	13	1	3
	5	0	10	1
V. sativa	1	0	0	2
	2	3	0	12
	3	15	9	10
	4	7	16	1
	5	0	0	0
V. ervilia	1	0	0	0
	2	5	16	4
	3	5	0	10
	4	6	0	2
	5	0	0	0
V. palaestina	1	1	0	0
	2	4	0	0
	3	11	0	11
	4	0	11	5
	5	0	5	0
V. hybrida	1	1	0	1
	2	14	7	7
	3	1	6	8
	4	0	3	0
	5	0	0	0

* 1 = Resistant; 5 = Highly susceptible.

4.4.2. Nematode Studies

Heterodera ciceri Volvas, Greco et. DiVito is commonly found in forage legumes fields in Syria. In 1991/92, 25 lines of Vicia narbonensis, 25 lines of V. sativa, 16 lines of V. ervilia, 16 lines of V. palaestina, 16 lines of V. hybrida, 16 lines of Lathyrus sativus, 9 lines of L. cicera and 16 lines of L. sativus were tested under artificial infection in the plastic house for resistance to this cyst nematode. The infection rate was 200 eggs of cyst/g of soil. Seeds were sown in earthen pots with six replicates of each line and 3 plants per pot. At 100% flowering the plants were uprooted, roots were carefully washed and the density of nematodes measured on a 5-point scale: 1 = no galls

Table 4.4.2. Reaction of Lathyrus sativus and L. cicera promising lines to major diseases under artificial conditions. Number of lines under each disease categoty

Crops	Disease score*	Diseases		
		Ascochyta blight	Powdery mildew	Botrytis blight
Lathyrus sativus	1	0	0	0
	2	5	0	3
	3	10	4	1
	4	1	12	4
	5	0	0	8
L. cicera	1	0	0	0
	2	0	0	3
	3	3	0	4
	4	3	9	2
	5	3	0	0

* 1 = Resistant; 5 = Highly susceptible.

(resistant), 2 = light galling (moderately resistant), 3 = moderate galling (tolerance); 4 = extensive galling (susceptible) and 5 = very extensive galling (highly susceptible). Results in Table 4.4.3 revealed

Table 4.4.3. Reaction of Vicia spp. and Lathyrus spp. lines to cyst nematode. Number of lines under each category.

Crop / Species	Nematode susceptibility Score*				
	1	2	3	4	5
V. narbonensis	0	0	5	18	25
V. sativa	9	16	0	0	05
V. ervilia	0	0	1	11	46
V. palaestina	0	0	4	9	36
V. hybrida	3	13	0	0	0
Lathyrus sativus	0	0	3	11	26
L. cicera	0	0	0	5	4

* 1 = Resistant; 5 = Highly susceptible.

that several promising lines of V. sativa and V. hybrida were resistant or moderately resistant. In contract, most lines of V. narbonensis, V. ervilia, V. palaestina, Lathyrus sativus and L. cicera were susceptible or highly susceptible. Emphasis will be given in future to screen more line for resistance to cyst nematode in Lathyrus spp., V. ervillia and V. palaestina.

A.M. Abd El Moneim and M. Bellar

4.5. Forage Legume Entomology

4.5.1. Effect of Sitona crinitus on Vicia

Sitona is often seen infesting several forage legumes. To determine if Sitona infestations result in yield losses necessitating control methods, an experiment was carried out at 2 locations, Alkamiye and Jinderess using Promet seed treatment in Vicia villosa ssp. dasycarpa. Oviposition was monitored by counting the number of eggs extracted from 100 ccm soil samples taken at 2 week intervals. Oviposition started in

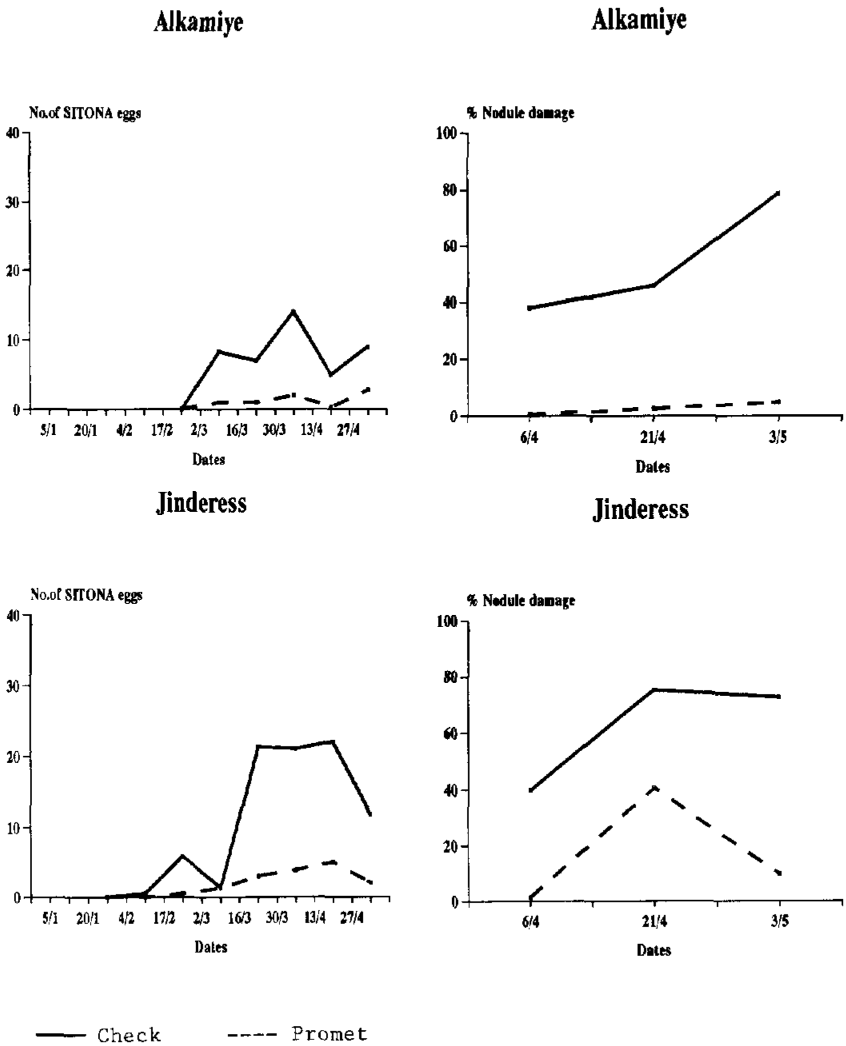

Figure 4.5.1. Mean number of Sitona eggs extracted from 100ccm soil samples and mean nodule damage in Vicia villosa ssp. dasycarpa with and without Promet application at 2 locations, Syria, 1991/92.

late February, reached the peak in early April and was effectively reduced by Promet treatment (Figure 4.5.1.). The mean nodule damage was about 75% at both locations and significantly reduced by Promet treatment, except for the 2nd samplig at Jinderess (Figure 4.5.1). At Alkamiye both Vicia seed and biological yield were significantly increased by Promet treatment, at Jinderess also both yields were higher with Promet, but only seed yield significantly (Figure 4.5.2). This first study shows that Sitona does infest Vicia and control results in significant yield increases. Further studies are needed to assess how much damage can be tolerated before insecticide treatment becomes economical and to analyse the presence of any insecticide

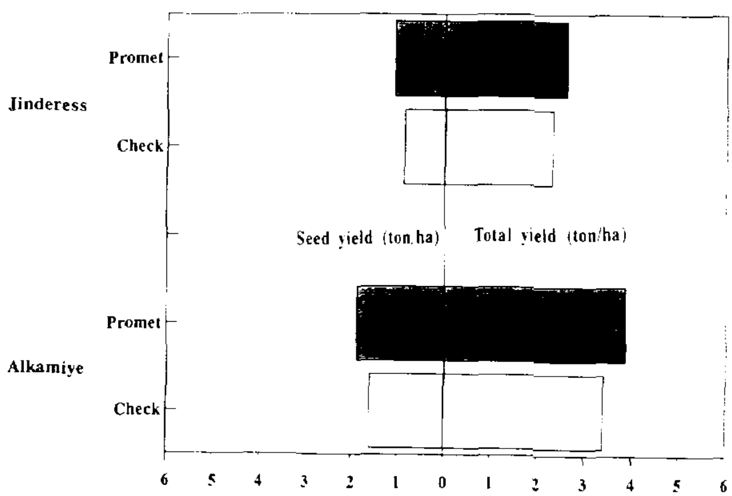

Figure 4.5.2. Effect of application of Promet on Vicia dasycarpa seed and biological yield at 2 locations, Syria, 1991/92.

residues in the forage as this might be harmful when fed to animals. However, Promet treatment for Sitona control might be an economical and safe option for seed production fields.

S. Weigand

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 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

One hundred and sixteen accessions obtained from various institutions alongwith 3 repeated checks (Acc No. 223, 224 and 225) were evaluated at Tel Hadya in an augmented block design. The data were recorded on various phenological and morphological characters. Time taken to flower ranged from 124 days for Acc No. 413 to 190 days for Acc No. 463; time taken to mature ranged from 168 days for Acc No. 437 to 216 days for Acc No. 463; and the harvest index ranged from 12.1% for Acc No. 470 to 72.8% for Acc No. 483. Seed yield varied from 0 to 3212 kg/ha. Some of the high yielding entries alongwith their seed yield, time to flower, time to mature, and harvest index are given in Table 5.1.1.

Table 5.1.1. Adjusted seed yield (YLD=kg/ha) and rank (R), time to flower (DFLR), time to mature (DMAT) and harvest index (HI) of some of highest yielding entries in pea germplasm, at Tel Hadya during 1990/91.

Acc No.	YLD	R	DFLR	DMAT	HI
372	1795	15	134	175	57.8
373	2010	10	133	173	47.1
379	1649	22	131	175	27.5
389	1913	12	137	178	48.8
390	2302	4	145	176	37.1
399	1587	25	137	177	52.8
402	1816	14	138	176	56.1
403	1705	19	134	177	35.1
405	1594	24	145	177	51.8
417	1777	16	129	172	52.5
438	2149	8	131	171	45.8
447	3212	1	140	179	57.8
448	1719	18	142	180	47.1
452	2767	2	143	183	39.8
454	1858	13	134	177	54.5
457	1601	23	140	178	53.8
458	2066	9	133	183	47.8
466	1747	17	155	189	32.8
479	2288	5	133	178	65.8
482	1705	20	136	184	57.1
483	2580	3	133	181	72.8
485	1976	11	143	180	51.8
486	1670	21	131	179	60.8
487	2198	6	138	177	61.1
223 (Check 1)	656	26	138	182	35.7
224 (Check 2)	400	27	136	178	33.3
225 (Check 3)	2193	7	141	179	57.4
Location Mean	1175		136	178	43.0
LSD at P=5% for checks	233.7				
LSD at P=5% for checks vs test entries	739.2				
CV %	21.2				

5.2. Evaluation for Cold Tolerance

Four hundred and thirty eight accessions of pea were evaluated for cold tolerance. The material was sown in the autumn on Oct 1, 1991 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 53 days and minimum temperature during the season was -8.8°C on 28 Jan 1992. 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 and 0, 0.7, 7.8, 3.6, 3.9, 2.1, 13.7, 23.7 and 44.5 percent of entries exhibited ratings of 1,2,3,4,5,6,7,8 and 9, respectively. The cold tolerant lines (with a rating of 1 to 4) are given in Table 5.1.2. A perusal of this table revealed that 25 of the tolerant lines were developed at Idaho in USA, and of the remaining cold tolerant lines four were from Afghanistan, and one each from Greece, Italy, and Bulgaria. Two other lines which were tolerant were of unknown origin. There was no association of cold tolerance with geographic origin of the line. Further the lines with anthocynin pigmentation in leaf and stem were, in general more cold tolerant.

5.3. Preliminary Yield Trial

Sixty four superior entries selected from the germplasm as well as the Preliminary Yield Trial (PYT) of 1989/90 were tested using a 8x8 lattice design during the 1991/92 season at two locations, Tel Hadya and Terbol.

Table 5.1.2. Cold-tolerant accessions (≤ 4 rating) of pea, Tel Hadya.

Acc. No.	Origin	CTR*	Name
77	Greece	4	K129
80	Afghanistan	3	79-V2
85	Afghanistan	2	503-V2
86	Afghanistan	2	643-V2
87	Afghanistan	2	653-V2
92	Finland	4	10947
111	Bulgaria	4	MG 100 545
158	Italy	3	MG 102426
184	USA (Idaho)	3	D 166-1-1 (AFTL)
186	USA (Idaho)	3	D 166-1-3-1 (N)
188	USA (Idaho)	3	D 166-1-6 (AF)
190	USA (Idaho)	4	D 166-1-14-2 (AFST)
195	USA (Idaho)	3	D 200-1-16 (N)
197	USA (Idaho)	3	D 200-4-3 (ST)
198	USA (Idaho)	3	D 200-7-4 (TL)
199	USA (Idaho)	3	D 166-1-15-1W (N)
200	USA (Idaho)	3	D 166-1-13-1W (AFST)
203	USA (Idaho)	2	D 166-1-1-13W (TL)
205	USA (Idaho)	2	D 166-1-24-6W (AF)
206	USA (Idaho)	2	D 166-1-4-2W (STTL)
207	USA (Idaho)	3	D 175-2-3-1 (TL)
210	USA (Idaho)	3	D 175-2-3-1 (AFSTTL)
211	USA (Idaho)	4	D 175-2-3-2 (STTL)
214	USA (Idaho)	4	D 175-2-3-1 (AFTL) AFAF
243	unknown	3	Fenn
244	unknown	3	Glacier
338	USA (Idaho)	3	PI 517 923
342	USA (Idaho)	3	PI 512065 (AFAF STST TLTL)
343	USA (Idaho)	3	PI 512065 (AFAF STST TLTL)
344	USA (Idaho)	3	PI 512066 (AFAF STST TLTL)
346	USA (Idaho)	3	PI 512067 (AFAF STST TLTL)
348	USA (Idaho)	3	PI 512069 (AFAF STST TLTL)
351	USA (Idaho)	4	PI 512074 (AFAF STST TLTL)
352	USA (Idaho)	3	PI 512075 (AFAF STST TLTL)
354	USA (Idaho)	3	PI 512077 (AFAF STST TLTL)
355	USA (Idaho)	4	PI 512078 (AFAF STST TLTL)

* CTR = Cold tolerance reaction on 1-9 scale (1=free, 9=killed).

Table 5.1.3. Adjusted seed yield (YLD, kg/ha) and rank (R) and days to flower of some entries in Preliminary Yield Trial at Tel Hadya, and Terbol during 1991/92.

Acc. No.	Tel Hadya		Terbol		Mean		Days to flower
	YLD	R	YLD	R	YLD	R	
54	797	29	1763	32	1280	35	140
77	1224	2	2090	19	1657	11	148
107	919	21	1684	37	1302	32	140
119	951	19	2466	10	1708	9	141
123	936	20	1514	48	1225	39	148
141	1109	7	2479	9	1794	6	145
149	1450	1	2971	1	2211	1	141
152	1145	4	2838	2	1991	2	142
160	1010	11	2728	6	1869	4	145
164	972	14	2291	12	1632	13	152
172	1045	9	2062	21	1554	17	144
177	971	15	1756	34	1363	26	143
178	1114	6	2093	18	1603	14	141
182	1051	8	2295	11	1673	10	148
240	853	24	2614	8	1734	8	141
249	838	25	1594	44	1216	40	141
264	975	12	1628	42	1302	31	137
270	868	23	1712	36	1290	33	133
281	1171	3	1647	39	1409	23	137
284	962	16	1800	30	1381	25	133
289	815	27	1084	60	949	54	133
296	1031	10	2043	22	1537	18	147
299	832	26	1044	61	938	56	129
301	806	28	2220	15	1513	19	144
379	784	33	1545	47	1164	44	141
386	958	18	2801	4	1879	3	140
424	974	13	1591	45	1283	34	138
428	884	22	2280	13	1582	16	135
446	1142	5	2032	24	1587	15	148
8	960	17	2743	5	1852	5	148
Location mean	794		1840				
LSD at P=5%	363.0		900.0				
C.V. %	28		30				

Adjusted seed yield, rank and time taken to flower for some promising entries are presented in Table 5.1.3. Adjusted seed yield varied from 297 kg to 1450 kg/ha at Tel Hadya, and 840 kg to 2971 kg/ha at Terbol. Based on the average rank over the two locations the 15 top ranking lines included Acc No. 149, -152, -141, -160, -182, -77, -386, -8, -178, -164, -119, -446, -172, -296, and -240. The best entries from this trial were promoted to Pea International Adaptation Trial (PIAT) for the 1992/93 season.

5.4. Pea International Adaptation Trial

Twenty three entries selected from PYT and PIAT conducted during the previous season were tested in this trial at Tel Hadya, Jindiress and Terbol. Several test entries yielded significantly higher than the local check. The five highest yielding entries at Terbol included Syrian Local Aleppo, Collegian, PS 210713, MG 101197, and Early Dun; those at Jindiress included Early Dun, Maitland, MG 101197, MG 102623, and Sanxi PA 292; and those at Tel Hadya included Syrian Local Aleppo, LS 1690, JI 238, MG 102623, and Collegian. On the basis of mean seed yield over all locations, Syrian Local Aleppo ranked first and was followed by LS 1690, Collegian, PS 210713, and MG 101197 (Table 5.1.4). The entry PS 510699 was the earliest to flower and mature and also exhibited highest harvest index.

R.S. Malhotra and M.C. Saxena

Table 5.1.4. Mean seed yield (YLD, kg/ha) and rank (R), days to flowering (DFLR), days to maturity (DMAT), plant height (PTHT), and harvest index (HI) of entries at Terbol, Jinderess and Tel Hadya in PIAT-92.

Entry Name	Lebanon Terbol YLD	R	Syria Jinderess YLD	R	Tel Hadya YLD	R	Mean over locations YLD	R	DFLR	DMAT	PTHT	HI
Syrian Local Aleppo	3111	1	306	11	2157	1	1858	1	138	176	54	48
LS 1690	2540	7	352	7	1981	2	1624	2	138	176	56	47
Frisson	2429	10	185	22	1111	17	1242	15	128	170	31	50
SV 51741	1746	19	204	18	926	21	959	21	133	169	27	48
Ballet	1317	23	222	16	741	24	760	23	130	172	28	48
JI 238	2619	6	269	13	1648	3	1512	6	134	177	50	47
MG 101197	2857	4	454	3	1269	14	1526	5	138	179	55	43
MG 102369	1571	21	194	21	1352	11	1039	20	130	175	49	48
MG 102583	2143	14	324	10	1481	8	1316	11	132	170	31	55
MG 102623	2476	9	407	4	1630	4	1504	7	135	177	51	47
MG 102702	2508	8	389	6	1519	7	1472	8	139	177	46	43
Maitland	2238	12	500	2	1472	9	1403	10	140	173	55	43
Collegian	2984	2	259	15	1556	5	1600	3	131	172	51	51
Derrimut	2238	13	176	23	1019	19	1144	16	129	174	40	44
Wirrega	1841	18	343	8	1556	6	1246	14	135	175	45	49
Early Dun	2619	5	528	1	1093	18	1413	9	138	173	51	42
ILP 56	1651	20	287	12	1324	12	1087	18	129	170	45	52
LE 25	2317	11	269	14	1222	15	1269	12	130	174	35	49
PS 210713	2968	3	343	9	1278	13	1530	4	131	170	32	54
PS 210688	1968	17	194	20	963	20	1042	19	127	171	44	51
PS 510203	1476	22	194	19	870	22	847	22	128	168	40	51
PS 510699	1968	16	213	17	1176	16	1119	17	125	169	42	54
Shanxi PA 292	2032	15	389	5	1361	10	1261	13	137	174	44	45
Local Check	968	24	148	24	759	23						
Location mean	2191		298		1311							
LSD at P=5%	1056.5		167.3		577.7							
C.V. %	29.3		34.2		26.8							

6. OROBANCHE CONTROL

Orobanche crenata has long been known to parasitize many leguminous food and feed crops causing dramatic yield reductions in the Mediterranean environments. The main objective of our research on this parasite is the development of effective control methods. Research in the past was conducted on identifying the effect of individual control methods so that these may be integrated to develop more effective control methods. During the 1991/92 season the experiments on integrated control of Orobanche crenata in chickpea, lentil, narbon vetch and dry pea were repeated.

6.1. Lentil

The lentil variety ILL 8 can be sown nearly 25 days later than ILL 4400 without any yield reduction on the absence of Orobanche infestation. Because of this adaptation to late sowing it is suitable for managing Orobanche by delayed sowing. To further improve the parasite control herbicide treatments having low rate of 1x7.5 g a.i./ha and 2x7.5 g a.i./ha of imazaquin (post-emergence) and 60 g a.i./ha of imazaquin (post-emergence) were tested in combination with the lentil cultivar during 1991/92. ILL 4400 was sown on 5 Nov. 1991 but ILL 8 could not be sown till 9 Jan 1992, because of weather conditions. Imazaquin was applied on 17 Feb in ILL 4400 and 25 Mar in ILL 8 plots in single-application treatments.

In the double-application treatments, application of imazaquin occurred on 30 Mar and 21 Apr in ILL 4400 and on 8 Apr and 22 Apr in ILL 8 plots. ILL 4400 was harvested on 15 May and ILL 8 on 31 May.

The treatment effects on seed and total shoot yield of lentil and dry weight of emerged Orobanche shoots are shown in Table 6.1.1. Because of excessive delay in sowing of ILL 8, the total shoot yield level was generally reduced, yet seed yield of ILL 8 was higher than seed yield of ILL 4400 when no herbicide was applied. Single application of imazaquin at early tubercle attachment stage, resulted in significant increase in seed yield of ILL 4400, whereas in ILL 8 the effect was nonsignificant. Imazethapyr applied preemergence also resulted in significant increase in the yield of ILL 4400 whereas in ILL 8 it caused seed yield reduction. The study revealed that application of imazaquin @7.5 g a.i./ha at early tubercle stage of Orobanche development controlled orobanche effectively and resulted in significant increase in seed and total yield of ILL 4400 and only total shoot yield in ILL 8.

Table 6.1.1. Seed (SY) and total shoot (TSY) yield (kg/ha) of lentil and dry weight (kg/ha) of Orobanche (ODW) as affected by integrated control treatments, Tel Hadya 1991/92.

Treatments	SY	TSY	ODW
ILL 4400			
No herbicide	236	1736	46.5
Imazaquin @ 7.5 kg a.i./ha	657	3110	4.0
Imazaquin @ 2x7.5 kg a.i./ha	245	1644	22.0
Imazethapyr	436	2043	0.0
ILL 8			
No herbicide	438	1471	0.0
Imazaquin @ 7.5 kg a.i./ha	543	1904	0.0
Imazaquin @ 2x7.5 kg a.i./ha	459	1644	0.0
Imazethapyr	146	1395	0.0
LSD at P=0.05	123.2	300.5	16.34

6.2. Chickpea

Chickpea cultivar ILC 3279 was found to have less infestation of Orobanche crenata than ILC 482 in the past studies. This difference in genotypic susceptibility of host was integrated with two herbicide treatment to develop an integrated control recommendation. The herbicide treatments included pre-emergence application of imazethapyr @ 60 g a.i./ha (given on 7 Nov 1991) and application of 2x20 g a.i./ha glyphosate at tubercle attachment stage (15 Apr and 5 May 1992). Although the overall infestation of Orobanche crenata in this experiment was low, the infestation was lesser in ILC 3279 than ILC 482, confirming past results (Table 6.1.2). Herbicide application did not have any major effect on crop yield, perhaps because of low infestation of Orobanche.

Table 6.1.2. Effect of preemergence application of imazethapyr and post-emergence application of glyphosate on seed and total shoot yield (kg/ha) of chickpea and shoot dry weight kg/ha) of Orobanche Tel Hadya 1991/92.

Treatment	Chickpea yield		Orobanche
	Seed	Total shoot	dry weight
ILC 482			
No herbicide	623	1445	3.0
Glyphosate	578	1088	11.0
Imazethapyr	398	1113	1.0
ILC 3279			
No herbicide	645	2006	2.0
Glyphosate	658	2105	1.0
Imazethapyr	459	1766	0.0
LSD (P=0.05)	246.1	494.3	6.05
ILC 482 (averaged over herbicide treatments)			4.8
ILC 3279 (averaged over herbicide treatments)			0.7
LSD (P=0.05)			7.91
No herbicide (averaged over genotype treatments)			2.30
Glyphosate (averaged over genotype treatments)			5.7
Imazethapyr (averaged over genotype treatments)			0.3
LSD (P=0.05)			4.5

6.3. Narbon Vetch

Three control methods were tested for integration: two sowing dates (6 and 26 Nov 1991), two genotypes (Acc No. 578 and 67) and three herbicide treatments (no herbicide, imazaquin at 20 of a.i./ha early post-emergence, 2 x 20 g a.i. imazaquin late post-emergence). Single application of imazaquin was done on 17 Feb 1992 in both the genotypes. The two-application treatments were given on 30 Mar and 20 Apr in Acc No. 578 and on 2 Apr and 27 Apr in Acc No. 67. The effects of treatments on seed and total shoot yield of narbon vetch and dry weight of Orobanche are shown in Table 6.1.3.

There was no major difference in the susceptibility of the two accessions of the narbon vetch to Orobanche. Delaying the date of sowing significantly reduced the Orobanche infestation. Also application of imazaquin once or two times reduced the parasite infestation significantly. Single application of imazaquin at early stage of parasite attachment caused significant increase in seed yield and total shoot yield of both the accessions of the narbon vetch at both dates of sowing by controlling the parasite. Late application of the herbicide twice although gave excellent control of the parasite but also reduced the crop yield by causing phytotoxicity.

6.4. Dry Pea

Two experiments were conducted. One dealt with the chemical control of Orobanche and the other tested the integration genotypic variation in parasite susceptibility with herbicide application.

Table 6.1.3. Effect of crop genotype, date of sowing and herbicide application on the seed yield, and total shoot yield (kg/ha) of narbon vetch and dry weight of Orobanche shoots (kg/ha), Tel Hadya 1991/92.

Treatments			Narbon vetch yield		Orobanche
Genotype	Sowing date	Herbicide	Seed	Total shoot	dry weight
Acc No. 578					
	6 Nov	None	1132	3111	69
		Imazaquin 1x20	2997	8051	0
		Imazaquin 2x20	365	1378	3
	26 Nov	None	888	3327	0
		Imazaquin 1x20	3012	7900	1
		Imazaquin 2x20	423	1412	0
Acc No. 67					
	6 Nov	None	187	1363	73
		Imazaquin 1x20	1345	5346	0
		Imazaquin 2x20	118	772	28
	26 Nov	None	291	1680	1
		Imazaquin 1x20	979	5147	11
		Imazaquin 2x20	232	953	0
		LSD (P=0.05)	290.3	393.7	9.4
Acc No. 578 (averaged over all other treatments)					12
Acc No. 67 (averaged over all other treatments)					19
		LSD (P=0.05)			19.1
Sowing date 6 Nov (averaged over all other treatments)					29
Sowing date 26 Nov (averaged over all other treatments)					2
		LSD (P=0.05)			24.0
No herbicide (averaged over all other treatments)					36
Imazaquin 20 g a.i./ha x1 (averaged over al other treatments)					3
Imazaquin 20 g a.i./ha x2 (averaged over all other treatments)					8
		LSD (P=0.05)			18.2

In the chemical control trial effects of pre-emergence (21 Nov 1991) early post-emergence (27 Feb 1992) and late post-emergence application (8 and 27 Apr 1992) application of imazethapyr; early and late post-emergence application of imazaquin and late post-emergence application of glyphosate were studied on seed and shoot dry weight of dry pea. The results (Table 6.1.4) showed that early post-emergence application of 30 g a.i. imazaquin, preemergence application of imazethapyr at 60 g a.i./ha or early post-emergence application of this herbicide at 20 g a.i./ha resulted in significant increase in the yield of dry pea and significant reduction in the parasite infestation. Glyphosate applied late post-emergence @ 2x60 g a.i./ha although reduced the parasite infestation but did not increase crop yield. Late post-emergence applications of imazaquin or imazathapyr were not as effective in controlling the parasite as when applied early-post emergence.

Table 6.1.4. Effect of various herbicide treatments on seed and total shoot yield (kg/ha) of dry pea and shoot dry weight of Orobanche Tel Hadya, 1991/92.

Treatment	Dry pea yield		Orobanche shoot
	Seed	total shoot	dry weight
No. herbicide	53	766	41
Imazaquin EP 1x30 g a.i./ha	491	2290	0
Imazaquin LP 1x30 g a.i./ha	52	646	15
Imazethapyr PRE 60 g a.i./ha	377	1422	0
Imazethapyr EP 1x20 g a.i./ha	349	1568	7
Imazethapyr LP 2x20 g a.i./ha	40	691	22
Glyphosate LP 2x60 g a.i./ha	128	733	31
LSD (P=0.05)	223.3	540.5	14.3

In the integrated control trial two accessions of dry pea (Syria Local and ACC No. 290) with earlier known differences in parasite susceptibility, were evaluated with three herbicide treatments: 1. no herbicide, 2. early post-emergence (17 Feb 1992) application of 20 g a.i./ha of imazaquin, and 3. late post-emergence (8 and 27 Apr 1992) of 2x20 g a.i./ha of imazaquin. The effects on crop yield and parasite infestation are shown in Table 6.1.5.

Table 6.1.5. Effect of dry pea genotype and herbicide application on the seed and shoot yield (kg/ha) of the crop and the shoot dry weight (kg/ha) of Orobanche, Tel Hadya 1991/92.

Treatments		Crop yield		Orobanche
Genotype	Herbicide	Seed	Total shoot	shoot dry weight
Syrian Local	No herbicide	119	680	4.0
	Imazaquin 1x20 g a.i./ha	224	1323	0.0
	Imazaquin 2x20 g a.i./ha	86	654	13.0
Acc No. 290	No. herbicide	173	581	27.0
	Imazaquin 1x20 g a.i./ha	306	1149	0.2
	Imazaquin 2x20 g a.i./ha	273	1000	0.0
	LSD (P=0.05)	265.4	884.7	33.25

Whereas no clear susceptibility differences were noticed amongst the two tested genotypes of dry pea, the imazaquin application at early post-emergence resulted in significant increase in the total shoot yield of dry pea crop. The seeds yield increase due to this treatment was not significant.

K.-H. Linke and M.C. Saxena

7. INTERNATIONAL TESTING PROGRAM

The international testing program on lentil, kabuli chickpea, lathyrus, vetches, faba bean and dry pea is a vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and trials, to the national programs in and outside the WANA region. The genetic materials comprise 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. The trials on improved production practices deal with the manipulation of the Rhizobium-legume symbiosis and weed control. 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. Through the agronomic trials, research is encouraged in the national programs on optimum agronomic practices for different agro-ecological conditions to fully realize the yield potential of their cultivars.

With shift in emphasis of ICARDA activities as per the last EPR (External Program Review) recommendation, the supply of all the yield trials and screening nurseries of faba bean to the national programs from ICARDA'S headquarter at Aleppo were discontinued and two new international trials, Lathyrus Adaptation Trial and Vetch Adaptation Trial, were started two years back. In 1992, we supplied 1057 sets of 34 different types of trials and nurseries (Table 7.1.1) to various cooperating scientists in 52 countries for conduct during the 1992/1993 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 1990/91 international nursery results, received from cooperators until 15 October 1992, are presented here.

7.1. Faba Bean

Only four nurseries were supplied for 1990/91 season. Nine locations reported the data on seed yield for Faba Bean International Screening Nursery - Determinate (FBISN-D). At most of these locations some determinate entries either exceeded or gave similar yield as the local check. The top five yielders across locations included ILB 1814 (the indeterminate check), FLIP 84-243FB, FLIP 88-10FB, FLIP 86-109FB, and FLIP 86-146FB (the determinate entries), and gave seed yields of 4423, 2823, 2331, 2075, and 2062 kg/ha, respectively. The top-yielding determinate line in this nursery gave 36.18% less yield than the indeterminate high-yielding check, ILB 1814, revealing that there was a need for further improvement in the yield potential of the determinate lines.

The results on Faba Bean International Ascochyta Blight Nursery (FBIABN), Faba Bean International Chocolate Spot Nursery (FBICSN), and Faba Bean International Rust Nursery (FBIRN) were reported from 7, 6, and

Table 7.1.1. Food legume international nurseries supplied for the 1992/93 season.

International Trial/Nursery	No. of sets
Lentil	
Yield Trial, Large-Seed (LIYT-L-93)	55
Yield Trial, Small-Seed (LIYT-S-93)	35
Yield Trial, Early (LIYT-E-93)	44
Screening Nursery, Large-Seed (LISN-L-93)	32
Screening Nursery, Small-Seed (LISN-S-93)	24
Screening Nursery, Early (LISN-E-93)	38
F_5 Nursery, Large Seed (LIF_5N-L-93)	15
F_5 Nursery, Small Seed (LIF_5N-S-93)	12
F_5 Nursery, Early (LIF_5N-E-93)	14
F_5 Nursery, Cold Tolerance (LIF_5N-CT-93)	5
Cold Tolerance Nursery (LICTN-93)	22
Ascochyta Blight Nursery (LIABN-93)	11
Fusarium Wilt Nursery (LIFWN-93)	25
Rust Nursery (LIRN-93)	14
Chickpea	
Yield Trial Spring (CIYT-Sp-93)	46
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-93)	61
Yield Trial Southerly Latitudes-1 (CIYT-SL1-93)	18
Yield Trial Southerly Latitudes-2 (CIYT-SL2-93)	19
Yield Trial Latin American (CIYT-LA-93)	22
Screening Nursery Winter (CISN-W-93)	52
Screening Nursery Spring (CISN-Sp-93)	36
Screening Nursery, Southerly Latitudes-1 (CISN-SL1-93)	15
Screening Nursery, Southerly Latitudes-2 (CISN-SL2-93)	18
Screening Nursery, Latin American (CISN-LA-93)	21
F_4 Nursery, Mediterranean Region (CIF_4N-MR-93)	28
F_4 Nursery, Southerly Latitudes (LIF_4N-SL-93)	15
Ascochyta Blight Nursery: Kabuli (CIABN-A-93)	29
Ascochyta Blight Nursery: Kabuli & Desi (CIABN-B-93)	38
Fusarium Wilt Nursery (CIFWN-93)	45
Leaf-Miner Nursery (CILMN-93)	15
Cold Tolerance Nursery (CICTN-93)	37
Forage Legumes	
Lathyrus Adaptation Trial (ILAT)	67
Vetches Adaptation Trial (IVAT)	62
Peas	
Adaptation Trial (PIAT-93)	67
TOTAL	1057

5 locations, respectively. The sources of resistance (with ratings ≤ 4 on 1-9 scale, where 1=free, 9=killed) identified at various locations are given in Table 7.1.2.

Table 7.1.2. Sources of resistance (with rating ≤ 4) to various diseases identified from various disease nurseries in Faba bean reported at different locations.

Disease	Country (location)	Sources
Ascochyta blight	Morocco (Dar Bouazza)	A 8833 (L83129)
		A 88218 (BPL 2144)
		A 88304 (3181-1)
	Portugal (Elvas)	A 8815 (BPL 818)
		A 8835 (L83129)
		A 88215 (BPL 2139)
		A 88304 (3181-1)
	Tunisia (Ariana)	A 8817 (A2-1)
		A 88175 (S83135)
		A 88187 (S 83135)
	(Ras Rajel)	A 8817 (A2-1)
Chocolate Spot		
	Tunisia (Ariana)	B 88201(ILB 3036)
Rust		
	Morocco (Zememra)	R 888 (BPL 263)
		R 8817 (BPL 484)
		R 8827 (L82014)
		R 8835 (BPL 552)
		R 8842 (BPL 571)
		R 8846 (BPL 588)
		R 8854 (BPL 627)
		R 8859 (BPL 663)
		SLL (ILB 1814)
		Rebaya-40 (ILB 365)

The Faba Bean Weed Control (FBWCT) results were reported from 3 locations and the treatment effects for seed yield were significant. Yield loss due to weeds ranged from 12.8% to 66.1%. At Cordoba in Spain there were no significant differences between seed yields under weedy check and weed-free condition, showing that weed infestation was low there. None of the weed control treatments at Elvas in Portugal had significant effect on yield. All the weed control treatments at Tajura in Libya were significantly superior to the weedy check.

The results of Faba Bean Orobanche Control Trial (FBOCCT) from Cordoba in Spain revealed that herbicide treatments were not effective in controlling Orobanche. Similarly, the results of the Faba Bean Inoculation Response Trial (FBIRT) reported from Tajura in Libya, and Santa Catalina in Ecuador revealed the absence of fertilizer or inoculation response.

7.2. Lentil

For Lentil International Yield Trial-Large Seed (LIYT-L) data from 31 locations were analyzed for seed yield. At Khroub, and Sidi Bel Abbes in Algeria; Idleb, Breda, Gelline, Izra'a, and Tel Hadya in Syria; Ghazvin, Karaj1, Karaj2 and Zanjan in Iran; and Terbol in Lebanon, some of the test entries exceeded the respective local check in seed yield by a significant (P=0.05) margin. On the basis of mean across locations the five heaviest yielding lines were 78S 26002, FLIP 87-16L, FLIP 88-6L, FLIP 85-38L, and FLIP 84-147L.

Stability analysis based on the Eberhart and Russel (1966) model for seed yield of LIYT-L entries revealed that both mean squares due to entry x location (linear) and pooled deviations (non-linear portion of genotype x environment interaction) were significant (Table 7.2.1). The perusal of stability parameters revealed that the entries 78S 26002, FLIP 87-16l, FLIP 88-6L, and FLIP 85-38L had above average mean yield, regression coefficient greater than 1, and non-significant deviations from regression, indicating thereby their specific adaptation to the high yielding environments.

Table 7.2.1. ANOVA for stability for seed yield for the entries in LIYT-L, LIYT-S, and LIYT-E conducted during 1990/91.

Source of variation	LIYT-L		LIYT-S		LIYT-E	
	DF	MS ($x10^3$)	DF	MS ($x10^3$)	DF	MS ($x10^3$)
Entry	16	148.01*	22	201.84*	14	337.33*
Location (linear)	1	223243.00*	1	168500.00*	1	145182.00*
Entry x location (linear)	16	139.75*	22	73.55*	14	477.95*
Pooled deviation	374	50.69*	391	47.24*	150	177.75*
Pooled error	768	25.22	836	26.60	336	26.84

* Significant at P = 0.05.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) from 22 locations revealed that at 8 locations namely, Dingxi in China; Tolentino in Italy; Sonora in Mexico; and Breda, Gelline, Heimo, Izra'a, and Tel Hadya, in Syria, some of the test entries exceeded the local check in seed yield by a significant margin. The five heaviest yielders across locations included FLIP 89-25L, FLIP 89-20L, FLIP 87-56L, FLIP 87-57L and FLIP 89-32L. Stability analysis for seed yield for the entries in LIYT-S (Table 7.2.1) revealed that both linear and non-linear components of GxE interaction were important. Only three entries, FLIP 89-32L, FLIP 87-55L, and FLIP 87-26L having above-average yield performance, regression coefficient equal to 1, and nonsignificant deviations from regression, had general adaptation. A line FLIP 87-57L having above average mean yield, nonsignificant deviations from regression and regression greater than 1.0 was adapted to high yielding environments.

The results of Lentil International Yield Trial-Early (LIYT-E) from 14 locations revealed that at 8 locations (Guelma in Algeria; Gansu in China; Tolentino in Italy; Sonora in Mexico; Tarnab and Faisalabad in Pakistan; Beja and El Kef in Tunisia) some 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 Precoz, FLIP 89-53L, FLIP 88-39L, FLIP 87-66L and FLIP 89-52L. Stability analysis of the entries for seed yield in LIYT-E revealed that both entry x location (linear) and deviations from regression (nonlinear) were significant (Table 7.2.1). Only one entry, FLIP 87-66L had above-average yield, nonsignificant deviations from regression, and regression coefficient equal to 1, and thus had a 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 18, 17, 25 and 12 locations, respectively. The analyses of data revealed that at 6 locations in LISN-L (Valdivia in Chile; Gazvin and Zanzan in Iran; Idleb and Gelline in Syria; and Jubeiha in Jordan), 10 locations in LISN-S (Gazvin, Zanzan and Bakhtaran in Iran; Terbol in Lebanon; Heimo, Gelline, and Tel Hadya in Syria; Beja and El Kef in Tunisia and Hymana in Turkey), 10 locations in LISN-T (Tiaret and Guelma in Algeria; Beja in Tunisia; Idleb, Heimo and Gelline in Syria; Terbol in Lebanon; Temuco in Chile; Diyarbakir in Turkey; New Delhi in India), and 5 locations in LISN-E (Tarnab in Pakistan; Sonora in Mexico, Xining in

China, Tiaret in Algeria and Beja in Tunisia) some of the test entries exceeded the respective local check by a significant margin ($P \leq 0.05$). The five heaviest yielding lines across the locations in these nurseries are given in Table 7.2.2.

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

Rank	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 90- 5L	FLIP 90-27L	FLIP 88-10L	FLIP 91-26L
2	FLIP 90- 2L	FLIP 90-26L	78S 26002	FLIP 91-27L
3	FLIP 90-13L	FLIP 89-37L	FLIP 86-35L	FLIP 91-28L
4	FLIP 90-12L	FLIP 90-30L	81S 15	FLIP 91- 2L
5	FLIP 90-14L	FLIP 90-42L	78S 26013	FLIP 86-39L

The results of Lentil International F_4-Nursery Large (LIF$_4$N-L), F_4-Nursery Small (LIF$_4$N-S), and F_4-Nursery Early (LIF$_4$N-E), were received from 4, 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 3 locations, Nishabour in Iran, General Toshevo in Bulgaria, and Hymana in Turkey. The susceptible check was killed (rating=9) at Toshevo and Hymana. Two entries, ILL 662 and ILL 1878 at Toshevo, and four entries, ILL 52, ILL 662, ILL 1878 and Local check (Kislik Yesil 21) at Hymana showed tolerant rating ($\leq$ 4).

The results of Lentil International Ascochyta Blight Nursery were received from Horsham in Australia. Five entries, ILL 358, ILL 2439, 78S 26013, FLIP 84-43L and FLIP 89-52L showed tolerant reaction (rating $\leq$ 5).

The results of Lentil International Fusarium Wilt Nursery were reported from Gelline in Syria but there was no disease infestation there this season.

The results of Lentil Weed Control Trial (LWCT) were reported from Elvas in Portugal. The ANOVA for seed yield exhibited non-significant treatment effects.

The results of Lentil International Rhizobium Inoculation Response Trial (LIRT) were reported from 4 locations, Tiaret in Algeria, Sonora in Mexico, Santa Catalina in Ecuador, and Karaj in Iran. But the treatment effects were significant only at Sonora in Mexico, where the highest seed yield was obtained when inoculation was done with strain no 420. Strain no. 414 and 481 were next in the order.

7.3. Chickpea

The seed yield data were analyzed for 20 locations for Chickpea International Yield Trial-Spring (CIYT-SP). A large number of test entries exceeded the respective local check by a significant margin (P=0.05) at four locations, namely Karaj in Iran, Tel Hadya in Syria, and Beja and Oued Meliz in Tunisia. The five best entries across the locations were FLIP 88-45C, FLIP 88-68C, FLIP 88-24C, FLIP 88-62C, and FLIP 88-70C. The stability analysis (Table 7.3.1) revealed that only entry x location (linear) component was significant. The entries FLIP 88-

24C, FLIP 88-85C, FLIP 86-41C and FLIP 88-75C, with above average seed yield and regression equal to 1.0, had average stability. Other entries, FLIP 88-45C, FLIP 88-68C, FLIP 88-62C, FLIP 88-70C, FLIP 81-293C, FLIP 88-76C, FLIP 88-8C, and FLIP 88-16C, with regression greater than unity and above-average mean yield, were with specific adaptation to high-yielding environments.

The seed yield data from 25 locations for Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-MR) revealed that at 14 locations namely Tessala in Algeria; Toshevo in Bulgaria; Larissa in Greece; Papiano in Italy; Rabba in Jordan; Jinderess, Idleb, Izra'a, Heimo and Hama in Syria; Beja in Tunisia; Antalya and Eskisehir 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 86-5C, FLIP 85-93C, FLIP 85-44C, FLIP 85-5C and FLIP 86-2C. The ANOVA for stability for seed yield indicated that mean squares due to pooled deviations were not significant and those for entry x location (linear) were significant (Table 7.3.1). The entries FLIP 84-19C, FLIP 85-75C, FLIP 88-68C, FLIP 87-95C and FLIP 81-293C had regression coefficient equal to 1, and seed yield more than the general mean, and were thus widely adaptable. The entries FLIP 88-45C, FLIP 86-41C, FLIP 88-62C, FLIP 88-16C, FLIP 88-24C, FLIP 86-13C, FLIP 88-76C and FLIP 85-54C, had regression coefficient greater than 1 and seed yield more than the general mean; they were thus responsive to favorable environments.

The results of Chickpea International Yield Trial Southerly Latitudes-1 (CIYT-SL1) was reported from 4 locations (Tres de Maio in

Brazil; Ludhiana in India; Tel Hadya and Breda in Syria) but the treatment effects were not significant.

Table 7.3.1. ANOVA for stability parameters for seed yield for the entries in CIYT-SP, and CIYT-MR conducted during 1990/91.

Source of variation	CIYT-SP		CIYT-MR	
	DF	MS ($x10^3$)	DF	MS ($X10^3$)
Entry	22	725.78*	22	1017.46*
Location (linear)	1	535818.00*	1	2708620.00*
Entry x location (linear)	22	1141.47*	22	6494.18*
Pooled deviation	276	81.35*	483	204.95
Pooled error	308	91.82	506	301.09

* Significant at P = 0.05.

The results for Chickpea International Yield Trial Southerly Latitudes-2 (CIYT-SL2) were reported from 4 locations. At three locations, Santa Maria in Brazil, Chillan in Chile, and Breda in Syria some of the test entries exceeded the local check by a significant margin. The five heaviest yielding entries across locations included FLIP 88-78C, FLIP 88-50C, ILC 2566, ILC 856, and ILC 3116.

The results for Chickpea International Yield Trial Latin American (CIYT-LA) with extra large seed were reported from 5 locations and ANOVA for seed yield revealed that at Santa Maria in Brazil, Chillan in Chile, Hermosillo (Sonora) in Mexico, and Tel Hadya in Syria, 1, 5, 4 and 6 test entries, respectively, exceeded the local check in seed yield by a significant margin (P=0.05). The five heaviest yielders across locations included FLIP 88-52L, ILC 464, FLIP 84-15C, FLIP 88-58C and FLIP 88-40C.

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 America (CISN-LA) were reported from 31, 27, 3,1, and 3 locations, respectively, and some of the test entries exceeded the local check by significant margins at 15, 10, 3, 1, and 1 locations, respectively. The five best entries across locations are given in Table 7.3.2.

Table 7.3.2. 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 89-108C	FLIP 89- 93C	FLIP 89- 34C	FLIP 89-67C	ILC 3377
2	FLIP 89- 40C	FLIP 89- 98C	FLIP 89- 62C	FLIP 89-68C	FLIP 89-116C
3	FLIP 89- 49C	FLIP 89- 23C	FLIP 89- 29C	FLIP 89-63C	ILC 97
4	FLIP 89-118C	FLIP 89-115C	FLIP 89-114C	FLIP 89-69C	ILL 3367
5	FLIP 89- 87C	FLIP 89- 78C	FLIP 89-125C	FLIP 89-85C	FLIP 89-87C

The Chickpea International F_4 Nurseries -Mediterranean (CIF$_4$N-MR) and -Southerly Latitudes (CIF$_4$N-SL) were supplied to cooperators 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.

The Chickpea International Ascochyta Blight Nursery (CIABN) results for kabuli type were reported from 17 locations and for desi+kabuli type from 12 locations. None of the entries (kabuli and desi) was tolerant to Ascochyta blight infestation across locations. Considering the frequency of occurrence of an entry among the tolerant group (with rating $\leq$ 4 on 1-9 scale), two kabuli entries (FLIP 83-71C, FLIP 84-137C) appeared best and were followed by ILC 3279, FLIP 84-79C, FLIP 84-83C, FLIP 84-93C, FLIP 84-102C, FLIP 84-112C, and FLIP 85-133C which each occurred 9 times in kabuli types. These entries thus exhibited broad-based resistance to Ascochyta blight. Similarly, among desi lines FLIP 87-507C, FLIP 87-508C, and FLIP 87-510C exhibited broad-based resistance. The differential reaction of lines at various places further revealed the presence of variability in the pathogen.

The results of Chickpea International Leaf miner Nursery (CILMN) were reported from four locations Karaj in Iran, Terbol in Lebanon, Tel Hadya in Syria and Elvas in Portugal. At all locations the susceptible check took a score between 7 and 9 on 1-9 scale (1=free, 9=highly susceptible). Out of 30 test entries, three entries, ILC 5591, ILC 5641 and ILC 5901, were rated between 1 and 5 across locations and thus possessed resistance.

The results of Chickpea International Fusarium Wilt Nursery (CIFWN) were received from 4 locations. Out of 30 test entries, 25 entries at Guelma in Algeria, three entries at Beijing in China, 17 entries at Adana in Turkey and 8 entries at Tajura in Libya took the rating of 5 or less and were tolerant. Only one entry FLIP 84-43C was tolerant across all locations.

For Chickpea International Cold Tolerance Nursery (CICTN) the cold tolerance reaction was reported from five locations. All the 40 test entries at Tel Hadya and Breda in Syria; 23 entries at Diyarbakir, 14 entries at Erzurum and one entry at Hymana in Turkey, were rated at ≤ 5 and were tolerant. Across locations, the entries ILC 1455, ILC 1463, ILC 2772, ILC 3287, ILC 5609, ILC 5658, ILC 5668, ILC 5671, FLIP 86-85C, FLIP 87-3C and FLIP 87-69C occurred most frequently among the cold tolerant lines.

The data on Chickpea Weed Control Trial (CWCT) was reported from four locations. The ANOVA for seed yield revealed the presence of significant differences between treatment means at El Safsaf in Libya and Elvas in Portugal and the yield loss due to weeds for these locations varied from 44.4% to 71.6%. Treatments T12 [pre-emergence application of methabenzthiazuron (Tribunil) at 3.0 kg a.i./ha + pronamide (Kerb) at 0.5 kg a.i./ha], T9 [pre-emergence application of terbutryn (Igran) at 3.0 kg a.i./ha plus pronamide (Kerb) at 0.5 kg a.i./ha] at Elsafsaf in Libya; and T9 [pre-emergence application of Terbutryn (Igran) at 3.0 kg a.i./ha plus pronamide (Kerb) at 0.5 kg a.i./ha] and T11 [pre-emergence application of chlorobromuron (Maloran) at 2.5 kg a.i./ha plus pronamide (Kerb) at 0.5 kg a.i./ha] at Elvas in Portugal, were among the superior treatments excelling the weedy check by a significant margin.

The results of Chickpea International Rhizobium Inoculation Response Trial (CIRT) were reported from three locations (Setif, Tiaret and Oued Smar in Algeria). The differences between treatments for seed yields, were however, significant only at Tiaret in Algeria. The treatment with Strain No. 39 gave the highest seed yield and was followed by the treatment including Strain No. 31 and Strain No. 44 which excelled the control (with application of 60 kg of K_2O and 80 kg of P_2O_5) in seed yield by a significant (P=0.05) margin.

7.4. Forage Legumes

The Lathyrus and vetch adaptation trials were supplied to cooperators for the first time for 1990/91. The results for International Lathyrus Adaptaion Trial (ILAT) were received from 3 locations (Tel Hadya in Syria, Ankara in Turkey, and Saida in Algeria). At two locations (Ankara in Turkey and Saida in Algeria) 23 and 16 test entries exceeded the local check in seed yield by a significant margin. Five best lathyrus entries across locations included three L. sativus accessions (Acc. No. 127, Acc No. 188 and Acc No. 347) and two L. cicera accessions (Acc No. 135 and Acc No. 121) with seed yield of 1712, 1708, 1626, 1625 and 1592 kg/ha, respectively.

The International Vetch Adaptation Trial (IVAT) was reported from five locations, Saida and Sidi Bel Abbes in Algeria; Domaine in Morocco; Tel Hadya in Syria; and Ankara in Turkey. At three locations Sidi Bel Abbes, Domaine, and Tel Hadya, 12, 2 and 12 test entries exceeded the respective local check by a significant margin. This trial included 17 accessions of V. sativa and 6 accessions of V. narbonensis. The five highest yielding entries across the locations belonged to V. narbonensis and included Acc Nos. 573, -565, -568, -574, and -577 with seed yields of 2480, 2297, 2261, 2177, and 2167 kg/ha respectively. Among V. sativa, the highest yielding entries included, Acc Nos. 2541, -1361, and -705 with seed yields of 1805, 1688, and 1677 kg/ha, respectively.

7.5. Dry Pea

The results of Pea International Adaptation Trial (PIAT) were reported from 11 locations. At seven locations, namely, Athalassa in Cyprus; Al Ghab, Heimo, Idleb, and Gelline in Syria; Beja in Tunisia; Tajura in Libya, some of the test entries exceeded the local check by a significant (P=0.05) margin. The five best entries overall locations included, Local selection 1690, PS 210713 Syrian Local Aleppo, Collegian and PS 21688. The ANOVA for seed yield for stability parameters based over seven environments revealed that six entries namely PS 210713, Syrian Local Aleppo, Collegian, PS 210688, MG102702, and LE 25, with above average yield performance, and deviation approaching zero, had average stability.

Table 7.6.1. Legume cultivars reported as released during 1992 by the national programs.

Crop and Country	Cultivar	Specific features
Kabuli Chickpea		
France	Roye Rene (FLIP 84-188C)	Cold, blight resistance
Morocco	FLIP 83-48C	Large seed, blight resistance
	FLIP 84-92C	Large seed, blight resistance
Pakistan	Noor 91 (FLIP 81-293C)	High yield, blight resistance
Turkey	Aydin 92 (FLIP 82-259C)	Large seed, blight resistance
	Menemen 92 (FLIP 85-14C)	Large seed, blight resistance
	Izmir 92 (FLIP 85-60c)	Large seed, blight resistance
Lentil		
Iraq	78S 26002 (ILL 8)	High yield, easy for machine harvest
New Zealand	ILL 6243	High yield, red cotyledon

7.6. Identification of Superior Genotypes by the NARS

The national program scientists participating in the Legume International Testing Program identified and reported the release of seven cultivars of chickpea, and two of lentil during 1991/92 (Table 7.6.1). In addition, several lines were identified for multilocation 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 exploitation.

National Program Scientists, R.S. Malhotra, D. Beck, W. Erskine, S. Hanounik, L.D. Robertson, M.C. Saxena, K.B. Singh and S. Weigand

8. COLLABORATIVE PROJECTS

8.1. Nile Valley Regional Program

8.1.1. Egypt

Research was continued during the 1991-92 season with special project funding from the Commission of European Communities (EEC). The cropping season was characterized by abnormally low temperature in December, January and February during which it reached as low as 0°C.

8.1.1.1. Faba bean

The early epidemic of faba bean yellow necrotic virus (FBYNV) seriously damaged faba bean crops of farmers in El-Minia and Bani Suif. This not withstanding, the faba bean area and productivity in Egypt have shown a steady increase in the last five years. The area in 1992 was 138,625 ha with an average seed yield of 2.47 t/ha.

The pilot production-cum-demonstration program was continued during the 1991/92 season, with 110 sites in Minia, 45 in Fayoum, 16 in Beheira and four in Kafer El-Sheikh governorate to compare an improved production package with the practices adopted by the neighboring farmers. Ten different sets of improved production packages were used depending on the region and production problems. As an average of all the demonstrations in Minia and Fayoum, the improved package increased the seed yield by 0.24 t/ha (29%) and straw yield by 0.11 t/ha (40%) over the farmer's practice. In Behaira and Kafer El-Sheikh the corresponding average increases were 0.64 t/ha (21%) for seed and 0.7 t/ha (11%) for straw.

The pilot production-cum-demonstration plots in Minia (using improved cultivars Giza 402 and Giza 2 , sown in early November at a seed rate of 184.5 kg/ha with a fertilizer application of 35.7 kg N and 71.4 kg P_2O_5/ha, weed control by hand or herbicide, aphid control with Pirimor if needed, and optimum water management) gave an increase of 38% in seed yield and 3.5% in straw yield over the neighboring farmers. These increases were highly economical.

In Beheira and Kafer El-Sheikh governorates where chocolate spot disease is common, the newly released disease-resistant cultivar Giza 461 was demonstrated on 12 sites. As an average of both governorates, the new cultivar yielded 21% more seed and 11% more straw as compared to standard commercial cultivar Giza 3. Another improved cultivar Reina Blanca (Giza 5), which has some tolerance to foliar diseases, gave a seed yield of 3.6 t/ha as against 4.0 t/ha by Giza 461 and 3.3 t/ha by Giza 3.

In Minia, the recommended sowing method, involving minimum tillage using rotovator to cover seeds, increased faba bean seed yield by 0.14 t/ha (25.4%) and straw yield by 2.61 t/ha (36.4%) giving an increase of LE 454/ha in the net benefit.

In the Orobanche-infested areas of Minia and Fayoum, 25 demonstrations of integrated Orobanche control were done based on the use of Orobanche tolerant Giza 402 cultivar and glyphosate. Plots in both governorates showed that, a reduced rate of glyphosate use (95.2 ml Lancer/ha in 500 liters of water at flowering stage and again 15 days later) in combination with foliar application of mineral nutrients (1% N, 1% P and 2%K) was more effective in reducing the Orobanche infestation and increasing yields compared with the earlier recommended rate of glyphosate (179 ml of Lancer/ha) which sometimes causes phytotoxicity. The seed yield increased by 46% in Minia and 45% in Fayoum and the respective increases in the straw yield were 18% and 33%. The recommended package reduced both the number and dry weight of Orobanche spikes and it was more economical than the old recommendation (Table 8.1.1).

Table 8.1.1. Marginal rate of return in the Orobanche control demonstration plots and the neighbouring farms in Minia, 1991/92.

Cost/benefit items	Neighbouring farms	Demonstration plots: High rate of glyphosate	Demonstration plots: Reduced rate of glyphosate + nutrients
Total variable cost (LE/ha)	1468	1540	1516
Seed yield (t/ha)	0.38	0.83	1.07
Straw yield (t/ha)	7.64	8.68	10.20
Revenue (LE/ha)			
From seed	613	1339	1726
From straw	611	694	816
Gross benefit	1224	2033	2542
Net benefit (LE/ha)	-244	493	1026
Difference in net benefit		737	1270
Difference in variable cost		72	48
Marginal rate of return		10.2	26.5

The researcher-managed on-farm trials focused on intercropping of faba bean with sugarcane in Minia and with sugarbeet in Beheira and Kafer El-Sheikh. Also agronomic practices for the newly released cultivars Giza 461 and Reina Blanca (Giza 5) in Beheira and Kafer El-Sheikh governorates and improved Giza 2 in Fayoum were evaluated. In Minia, intercropping of three rows of faba bean in between two rows of autumn-sown sugarcane giving 25-27 plants of faba bean/m^2 produced highest seed yield compared with single row of faba bean which gave a faba bean density of 19 plants/m (Table 8.1.2). Inoculation of faba bean with Rhizobium culture before sowing gave a significant and economic increase in yield of faba bean in this system over uninoculated seed.

Table 8.1.2. Marginal rate of return of intercropping package of faba bean with autumn-planted sugarcane in Minia, 1992. Data are mean of six demonstrations.

Cost/benefit items	Farmers package	Recommended package
Total variable cost (LE/ha)	3015	3452
Sugar cane yield (t/ha)	98.27	109.05
Faba bean seed yield (t/ha)	1.27	1.59
Faba bean straw yield (t/ha)	2.47	4.29
Revenues (LE/ha)		
Sugar cane	5896	6543
Faba bean seed	2048	2565
Faba bean straw	198	343
Gross benefit	8142	9451
Net benefit (EL/ha)	5127	5999
Difference in net benefit		872
Difference in variable cost		437
Marginal rate of return		2.0

The two newly released faba bean cultivars Giza 461 and Reina Blanca were used for intercropping in sugarbeet fields in Kafer El-Sheikh Governorate. One row of each of these cultivars was sown on the opposite side of the 90 cm spaced ridges of sugarbeet one month after sowing sugarbeet. This was compared with pure crop of sugarbeet. Intercropping did not reduce sugarbeet yield and the yield of faba bean was 565 and 463 kg seed/ha for Giza 461 and Reina Blanca respectively, resulting in an increase in the net income by 442 and 331 LE/ha respectively, over the pure crop of sugarbeet. The improved Giza 2 (selection from old cultivar Giza 2) exceeded the farmer cultivar Giza 402 by 19% and 2% for seed and straw yields, respectively in 23 demonstrations in Fayoum.

Three researcher-managed on-farm trials in newly reclaimed area in the Minia governorate (Samalot district) evaluated the performance of five promising faba bean cultivars (Giza 2, Giza 402, 311/1170/81 and Reina Blanca) with three plant densities of 17, 25, and 33 plants/m^2. The new genotype 311/1170/81 outyielded other varieties, while across entries seed rate of 25 plants/m^2 gave the highest seed yield under this condition.

Back-up research was conducted on breeding, agronomy, pathology, entomology, microbiology, Orobanche and weed control, soil fertility and plant nutrition, and nutritional quality. The major highlights are presented here, whereas details of these studies are available in the "Annual Report of the Nile Valley Regional Program - Egypt for 1991-92".

Results of multilocation yield trials in Sakha and Nubaria (north Delta) and Giza and Sids (middle Egypt) over the last three seasons (1990-1992) showed that faba bean line 900/672/89 combined resistance to chocolate spot and high yield. It is, therefore, likely to be recommended for release.

Seventy nine F_7 faba bean lines were tested for chocolate spot resistance, 15 lines were markedly resistant and six families combined foliar disease resistance with high seed yield. To identify the mechanism of chocolate spot resistance in faba bean, a study was conducted in pathology laboratory at Giza using resistant and susceptible cultivars. The resistant entries Giza 461 and ILB 938 produced high levels of phytoalexins, had low concentration of carbohydrates and showed presence of Trichoderma sp. (antagonistic agent) on the leaf surface which reduced spore germination and germ tube length of Botrytis fabae. Seven lines showed tolerance to Orobanche at Giza. Twenty three families recorded lower aphid infestation rates than the check cultivar Giza 402 in laboratory screening at Giza . The lines 739/849/90 and 749/946/90 showed high resistant reaction to aphids. All these lines were selected for further evaluation.

In weed control study at Sakha research station, pre-emergence application of Igran at 2.38 kg a.i./ha gave better weed control and highest seed yield. Combination of pre-emergence application of Igran with Fusilade at 0.3 kg a.i./ha applied post-emergence gave better control of annual grasses such as Phalaris sp. In the calcareous soils at Nubaria, Reina Blanca faba bean showed a significant increase in seed yield by 3 sprays of 2% P_2O_5 (at 30, 60 and 90 days after sowing) compared with a soil application of 35.7 kg P_2O_5/ha.

The program paid special attention to the multiplication of seeds of new cultivars, and 755 t seed of Giza 461 and 155 t seed of Reina Blanca were processed for 1992/93.

8.1.1.2. Lentil

Lentil was grown on 6400 ha in Egypt in 1991/92 with an average of 2.0 t/ha. Recent lentil demonstration efforts have encouraged farmers in the Delta region to produce the crop, and now nearly 50% of Egypt's lentil area is concentrated in the Delta region specially in the Sharkia, Dakahlia and Kafer El-Sheikh governorates. The major constraints to lentil production there are inappropriate water management, diseases, aphids and weeds.

The pilot-production-cum-demonstration program was continued during the 1991/92 season, with a total of 61 demonstrations (25 at Sharkia, 14 at Dakahlia, 15 at Kafer El-Sheikh and 2 at Beheira and 5 at Assiut governorates) to compare an improved production package with the practices adopted by the neighboring farmers. The improved package involved one irrigation 4 weeks after sowing, seed rate of 95 kg/ha, fertilizer at the rate of 35.6 kg N/ha and 71.4 kg P_2O_5/ha, weed control using Gesagard at the rate of 2.5 kg a.i./ha as pre-emergence application, control of downy mildew using Ridomil-Mancozeb 58 WP at 205 g/100 l and aphid control using Pirimor. The yield in demonstration plots over neighboring farmers was 14%, 67%, 11%, 76% and 36% higher in Sharkia, Kafer El-Sheikh, Dakahlia, Beheira and Assiut, respectively. Over all the demonstrations, the recommended package increased the seed yield by 35% and straw yield by 17% over neighboring farmers with high economic returns. The profitability of lentil increased by 8.9, 67.6, 46.0 % in Sharkia, Kafr El-Sheikh and Assiut because of the improved package.

Researcher-managed on-farm trials focused on seeding rate, irrigation methods and disease control for lentil for different cropping systems. Irrigation study showed that two surface irrigations (20 and 50 days after sowing) resulted in a significant increase in seed yield (31%) over farmer's practice of one pre-sowing irrigation simulating Nile flooding. The results of four researcher-managed on-farm trials at Sharkia and Dakahlia showed that using the fungicide Ridomil MZ (3 sprays, at the rate of 200 g/100 l) was more effective to control Downy Mildew than using of Sandovan at the same rate. The results showed also that high plant density under high seeding rate of 143 kg/ha increased disease infection when compared to a lower seed rate of 95 kg/ha.

Back-up research in lentil was conducted on breeding, agronomy and microbiology. The breeding program identified 23 promising entries out of 118 tested entries introduced from ICARDA as they outyielded the best check. Four genotypes (ILL 813, EL 42, FLIP 90-22 L and FLIP 90-26 L) showed high resistance to root rot in the disease-sick plot. The major seed- borne pathogens associated with seed were _Fusarium_ sp. and _Rhizoctonia solani_.

Screening lentil genotypes under rainfed conditions at the Northwestern Coast of Egypt was conducted with 15 entries. The variety "Precoz" was the most promising entry and it exceeded in seed yield the two local cultivars Giza 9 and Giza 370 by 104% and 143%, respectively. Evaluation of eight lentil cultivars for their nitrogen fixation ability using ^{15}N technique at Mallawy research station showed that the percentage of plant nitrogen derived from the atmosphere ranged from 45.9 to 53.3%, with Giza 9 recording the highest value.

Pre-release purification and multiplication of seed of three promising entries Precoz, Giza 29 and H5/6/81 was done.

8.1.1.3. Chickpea

As there is a great interest in introducing chickpea crop in northern Egypt, demonstrations were conducted at three locations in Assiut (the traditional chickpea area) and in the newly reclaimed areas in Beheira and Alexandria governorates using an improved production package comprising chickpea line 531, a seed rate of 95 kg/ha, and inoculation with Rhizobium (ICARDA strain 44). On the average, the improved package gave 43% increase in seed yield over the neighboring farmer and this increase was highly economical. The increase was higher in the new land in Alexandria (44.8%) than in Beheira (28.4%).

In the researcher-managed on-farm trials in Quena, Assiut, Fayoum, Beni Suef, Ismaillia, Northwestern Coast and Beheira governorates, two breeding lines (L70 and FLIP 84-80C) outyielded the farmers' check cultivar by nearly 29.8% and 18.8%, respectively.

In the back-up research on breeding, 20 accessions were identified and selected for further evaluation. Two F_4 lines from ICARDA; x89 TH 192 and x89 TH 411 had early flowering, high vigor and high seed yield equal to the yield of the local cultivar Giza 88. Inoculation with Rhizobium caused significant increase in yield over uninoculated check and nitrogen application.

National Scientists from Egypt

8.1.2. Ethiopia

The research work under the Nile Valley Regional Program in Ehtiopia was continued in 1991/92 season with the special project funding from Swedish Agency for Research Cooperation (SAREC). Research was carried out on faba bean, lentil, chickpea and dry pea, the important highland pulses in Ethiopia.

8.1.2.1. Faba bean

Pilot-production-cum demonstration program was conducted in the high and mid-altitude regions of Central Zone of Shewa. Demonstrations on 22 locations in the high-altitude region using 20 DK genotype at 200 kg seed/ha, 100 kg DAP/ha (Diamonium phosphate) and hand weeding twice resulted in yield levels ranging from 1.56 to 2.60 t/ha with an overall mean of 1.95 t/ha as against the farmers' yields ranging from 0.4 to 1.40 t/ha. The overall economic benefit over farmers' practice was 99.8% (about 939 Birr/ha) and the marginal rate of return (MRR) on investment was 329%. Demonstrations on 9 sites in the mid-altitude area of the Central Zone of Shewa using cultivar NC 58, showed a 34-65% increase (mean 51%) in yield (0.68 t/ha increase) over farmers' method with an additional net benefit of 603 Birr/ha and a MRR of 287.1%.

Back-up research focused on breeding, agronomy, pathology, entomology, microbiology and human nutrition. Based on good performance over seasons in multilocation testing, lines ALAD 160 and Coll. 111/77 are in final verification for release to farmers in the high-altitude areas. Similarly, MKI Illubor and NEB 207x74 TA-6D are to be considered for release for medium-elevation areas. In the breeding program, 220 single plants derived from one-way crosses and 131 single plants from mixed pollination of F2 generations were selected for further evaluation. In variety trial (A-set), the entry, PGRC/E 20317-1 gave the highest harvest index value. The national varietal trial (B-set) identified TA 26026-1-2-1b as most promising entry with a mean seed yield of 4.43 t/ha across 3 locations (Denbi, Kulunesa and Asasa). Development of 22 pure lines of faba bean was done in isolated mesh cages.

Buck-up research in agronomy investigated the yield effect of method and rate of seeding, rate of seeding and weeding frequency, and application of N and P fertilizers. Row sowing was better than broadcast seeding, and a seeding rate of 200 kg/ha appeared optimum at both Bekoji and Kulumsa. Twice hand weeding at 35-40 days and at 60-65 days after emergence increased the faba bean yields significantly over unweeded check and one hand weeding. Application of 9 kg N/ha and 49 kg P/ha gave the highest overall seed yield of 5.28 t/ha in Kulumsa location.

Results of surveys made in Bale highlands to assess the disease situation in faba bean revealed that chocolate spot and rust infestation was common. A total of 575 faba bean lines were screened for chocolate spot and rust at Holetta and Denbi. Six entries were rated as tolerant to chocolate spot. Early sowing reduced the damage from chocolate spot. For rust, most lines were tolerant and will be retested in coming season. In a study of the effect of plant age and soil moisture content on development of black root rot in faba bean, early seedling stage was more sensitive than other stages. Percentage of wilted plants increased from 30% in normal moisture soil to 85% in saturated soil. <u>Aphis craccivora</u>

and Helicoverpa armigera were the major insect pests but their infestation was not very high. Evaluation of various faba bean Rhizobium strains in Vertisol was made in Holleta. The highest dry matter accumulation was obtained from nitrogen application of 120 kg/ha followed by inoculation with strains 64, 50, and 51.

8.1.2.2. Lentil

Demonstration of improved production package of lentil, comprising improved variety Chalew (NEL 358), 70 kg seed/ha, mid-July sowing date and one hand weeding, was done at 17 sites in Ada, Shenkora and Gimbichu in Central Ethiopia. The improved package gave 63% increase in yield and an additional net benefit of 1129 Birr/ha with a marginal rate of return of 312% (Table 8.1.3). On-farm verification of pea aphid control in lentil at 3 locations in Shewa region showed that Pirimor 50% WP at 1 kg product/ha or Dimethoate 40% EC at 725 ml/ha increased seed and straw yield of lentil NEL-358 over unsprayed check, with marginal rate of return of 619% for Dimethoate and 117% for Pirimor.

Table 8.1.3. Average seed and straw yield (t/ha) of improved and traditional package of production of lentil in Ada, Shenkora, Gimbichu areas in Ethiopia, 1991/92.

Location	Improved package		Traditional package		Seed increase over farmer %
	Seed	Straw	Seed	Straw	
Ada	0.91	2.98	0.60	1.94	52
Gimbichu	0.98	2.52	0.62	2.63	58
Shenkora	1.03	2.69	0.56	2.29	83

Net benefit (average over the locations)
Improved package: 1129 Birrs/ha
Traditional package: 850 Birrs/ha
Marginal rate of return: 312%

Back-up research in breeding included evaluation of 39 promising lines under four environmental conditions (Alem Tena, 1600m; Debre Zeit 1900m; Chefe Donsa, 2450m; and Sinana, 2400m). FLIP 89-63L, FLIP 86-51L, 87S-93518 and local check showed wide adaptation, and yield levels ranging from 2.30-2.43 t/ha. As a result of good performance over seasons and in multilocation testing, the rust resistant lines FLIP 84-78L, FLIP 84-112L and FLIP 89-74L are in prerelease evaluation. In screening for Ascochyta blight resistance and rust resistance, 36 lines showed high level of resistance to both diseases. Four ICARDA lines were free from Ascochyta blight infection.

Waterlogging is One of the major production constraints of lentil on heavy soil. A trial was therefore continued this season at Akaki and Debre Zeit to compare the planting of lentil on broadbeds with furrow (BBF) vs. ridge and furrow (RF) planting. At the heavy soil sites of Akaki, the yield was significantly higher in BBF method of sowing compared with the RF method, because the ridges get washed out due to rain and do not permit as good a drainage as BBF system (Table 8.1.4). In other study, results showed no effect of various seed rates on grain yield of lentil planted on either BBF or RF at Akaki. Hand weeding at 30 and 60 days after sowing gave good weed control and increased yields significantly over weedy check.

In the survey of lentil diseases in the major lentil growing area in Shewa region, the major diseases observed were root rots (caused by Fusarium oxysporum, Rhizoctonia solani and Sclerotium rolfsii), rust (caused by Uromyces fabae), Ascochyta blight (caused by Ascochyta lentis), Alternaria blight (caused by Alternaria altenata) and powdery mildew (caused by Oidium spp.). Laboratory diagnosis showed that 68.3% of the root rot/wilt fungi was Fusarium oxysporum and 2.5% was Rhizoctonia bataticola.

In the field survey on insect pests, green pea aphid (Acyrthosiphon pisum Harris) was the major pest, particularly in western Shewa. In eastern Shewa predators Coccinela larvae and Syrphid fly larvae were recorded preying on green aphids.

Table 8.1.4. Effect of different methods of seed bed preparation on the mean seed and straw yield (t/ha) of lentil over 1989-91 at three Vertisol locations in Ethiopia.

Location	Seed yield		Straw yield	
	Broad bed & Furrow	Ridge & Furrow	Broad bed & Furrow	Ridge & Furrow
Akaki	1.57	1.04	3.50	2.75
LSD (P=0.05)	0.220		0.210	
CV (%)	33.3		17.3	
Debre Zeit	0.90	0.87	3.89	3.43
LSD (P=0.05)	NS		0.280	
CV (%)	15.3		16.6	
Dembi	1.14	1.16	4.13	3.67
LSD (P=0.05)	NS		0.260	
CV (%)	14.5		16.6	

8.1.2.3. Chickpea

Evaluation of Improved production package (improved chickpea variety Mariye, sown at a seed rate of 90 kg/ha in the end of August to early September, and one hand weeding) on farmers fields was done on 20 locations in Gimbichu, Shenkora, Tullubollo and Ginchi areas of Shewa administrative region. In all locations, improved package gave higher seed yields (39% increase) and an increase in net benefit of 293 Birr/ha over the farmers package.

In the backup research, yield testing of kabuli lines revealed that lines ICC 12339, 12428, and 12703 were high yielding and highly resistant to wilt/root rot diseases. A survey of different chickpea diseases in Shewa administrative regions revealed that wilt/root rot and stunt were most widespread. Stunt was more widespread at flowering stage and the incidence was higher when plant stand was low. Wilt was incited by Fusarium oxysporum f.sp. ciceri, wet root rot by Rhizoctonia solani and collar rot by Sclerotium rolfsii. A wilt and root rot-sick plot has been developed at Debre Zeit and a total of 192 local and exotic accessions were screened for resistance to both diseases. Most accessions showed high level of resistance to root rot, while only 9 entries had stunt infection less than 10%. All these promising accessions will be retested in the coming season.

The insect pests found attacking chickpea were cutworm (Agrotis ipsilon) and (Helicoverpa armigera) in Shewa region. The damage from pod borer ranged from 21% at Modjo to 53%at Tefki. Cutworm was recorded as a seedling pest of chickpea in eastern and western Shewa, causing 5-7% loss in seedling stand. Survey showed that cutworm was more common in the low-lying areas.

Studies for three seasons on seed bed preparation on heavy Vertisols confirmed the advantage of broad bed-furrow over flat sowing in increasing chickpea yields by ensuring better drainage and earlier sowing (Table 8.1.5).

Table 8.1.5. Effect of different methods of seed-bed preparation on the mean seed and straw yield (t/ha) of chickpea over 1989-91 at three Vertisol locations in Ethiopia.

Location	Seed yield		Straw yield	
	Broadbed-Furrow	Flat	Broadbed-Furrow	Flat
Akaki	2.77	1.66	3.48	2.73
LSD (P=0.05)	0.168		0.270	
CV (%)	18.7		18.3	
Debre Zeit	2.70	1.87	3.46	2.63
LSD (P=0.05)	0.125		0.120	
CV (%)	13.0		16.2	
Dembi	1.81	1.15	2.72	1.66
LSD (P=0.05)	0.180		0.210	
CV (%)	14.5		16.9	

8.1.2.4. Dry pea

Dry pea is grown extensively in Ethiopia and the crop is used for both green pods and dry seeds, the green stalks are used as feed for cattle. Evaluation of promising field pea lines in national varietal trial-A revealed that lines PGRC/E # 210851 was most stable yielding among 14 lines tested giving a seed yield of 2.70, 4.84 and 4.95 t/ha, respectively at Holetta, Bekeji and Sinana locations. It was, however, only marginally better than the best local check NC 95 Haik. The national variety trial B, again having 14 entries, revealed that the accession DMR-4 gave the highest seed yield of 1.84 t/ha, 2.82 t/ha and 5.22 t/ha at Denbi, Kulumsa and Asasa locations, respectively, as against 1.23, 1.25 and 3.31 t/h for improved check cultivar Mohanderfer.

A survey of different field pea diseases in Bale highlands revealed following diseases to be the most widespread: downy mildew (Pernospora viceae), powdery mildew (Erysiphae pisi), white rot (Sclerotinia sclerotiorum) and ascochyta leaf blight (Ascochyta psi).

According to the survey work conducted in Mendeyou, Agarfa and Gassera areas, the major insect pests of pea were pea aphid (Acyrthosiphon pisum) and pod borer (Helicoverpa armigera). Damage was higher in mehr (July to March) than in belg (March to July) season. Aphid infestation in mehr could reach 100%. A total of 200 accessions received from PGRC/E were screened for resistance to pea aphid (Acyrthosiphon pisum) at Kulumsa under natural conditions with and without spray of Pirimor. The lowest count was recorded on Acc. No. 32191. In the advanced screening of 17 accessions, lowest yield losses were noticed in lines JI 116, JI 91 and 061 K-2p-2192.

National Scientists from Ethiopia

8.1.3. Sudan

The Nile Valley Regional Program research on faba bean, chickpea and lentil was continued for the fourth season during 1991/92 with special project funding from Royal Netherlands Government. The total area of faba bean increased by about 10% this season comparing with previous season. Also the area of lentil had increased from 800 ha in 1990/91 to 2600 ha this season. The 1991/92 season was comparatively cool and very conducive to legume crops. The overall productivity of faba bean increased by nearly 80% and lentil by 30% compared with the previous season. Increased productivity of faba bean created surplus for export.

8.1.3.1. Faba bean

The pilot production-demonstration program was conducted in the Nile and North provinces as well as in the non-traditional areas. Adoption of the improved package (early sowing, frequent irrigation and weed and pest control) increased seed yield by 44%, 38%, 33% and 6% respectivey, in Aliab, Wad Hamid, Kabouchia and Sayal over the neighboring farmers, who followed traditional practices. These increases were highly economical (Table 8.1.6).

Adoption studies in the Wad Hamid (traditional areas) indicated that farmers were selective in adopting the components of the recommended production package. Adoption was better in public than in private schemes. The least adopted component of the production package was the recommended higher frequency of irrigation.

Table 8.1.6. Effect of faba bean improved package on seed yield (kg/ha) and benefits, in Sudan, 1991/92.

	Location			
	Aliab	Wad Hamid	Kabouchia	Sayal
Improved package	2950	3671	4875	3260
Farmers package	2045	2665	3674	3078
% increase over farmers	33	38	33	6
Marginal rate of return (%)		1762	1270	633

Researcher-managed on-farm trials showed that three genotypes 00616, BB7 and 00634 gave higher seed yields than local check when tested in farmer fields at six locations. The entries 00616 and BB 7, with higher yield and more adaptability, could be recommended for release in the traditional areas.

In the back-up research on faba bean breeding genotypes Bulk 1/3 and F 402/7 gave the highest seed yield for two consecutive seasons in the traditional areas. The entries BF 2/2/8/1 and ZBF 2/2 with Bulk 3/3 and BB 7 appear to be tolerant to moisture stress. These lines could be candidates for future release.

Weed infestation is a major production constraint for faba bean in the traditional growing areas of northern Sudan. Experiments revealed that Pursuit at 0.05 kg a.i./ha when tank mixed with Goal at 0.24 kg a.i./ha gave effective broad-spectrum weed control when sprayed before the first irrigation. When this chemical control treatment was supplemented with one hand weeding, it gave excellent weed control through-out the season and showed the highest seed yield increase of 43% (that is, an yield of 3.64 t/ha as against 2.53 t/ha with unweeded check). Hand weeding gave yield of 3.38 t/ha only. Stomp (@ 1.2 kg a.i./ha) could replace Goal in the above treatment combination with equal efficacy.

Leafminer (Liriomyza trifolii) continued to be the major insect pest of faba bean in the new areas in Sudan. Studies on evaluation of insecticides for leafminer control showed that Danitol-S was the best chemical. However, there was no effect on seed yield. Evisect and Neem extract were softer and permitted greater parasitism of leaf miner than other insecticides. Seed treatment with Gaucho (2g 70 SP/kg seed) tended to increase seed yield.

Seeds of four newly developed cultivars namely Hudeiba 72/2, SM-L (Selaim improved), Shambat 75 and Shambat 104 were purified under bee-proof cages for further multiplication and eventual release to farmers.

8.1.3.2. Lentil

The main production area for lentil is Rubatab but Wad Hamid and Dongola are potentially important. The area under lentil is being attempted to be increased to reach self-sufficiency of this legume. The plans are to grow 9000 ha next season. To meet this aim, an improved production package of lentil was demonstrated in Wad Hamid and Rubatab areas in the Nile province. The improved package included early sowing in the first two weeks of November, seed rate of 107 kg/ha, frequent irrigation (every 10 days), weeds and insect pest control as needed. In Wad Hamid no lentil is currently grown by farmers, hence comparison there was made with chickpea. Lentil yield there, averaged over 5 locations, was 2.65 t/ha and a net revenue of (LS 185,373/ha) ($1=120 LS) which was substantially higher as compared to that of faba bean and chickpea. At Rubatab, where farmers do grow lentil, the improved package increased yield by 62%, and the net benefit by 70% compared to traditional practice, resulting in a high marginal rate of return of 2458%. The average yields in the demonstrations in Rubatab for last three years have ranged between 1.65 and 2.36 t/ha (average 1.96 t/ha) compared to a range of 1.23 to 1.47 t/ha (average 1.39 t/ha) for neighboring farmers, giving an increase of 41%.

The package developed at Rubatab was demonstrated in Dongola. The demonstration plots had an average seed yield of 1007 kg/ha. Extremely poor yield were produced by neighboring farmers, the average being 23 kg/ha. These poor yields were mainly attributed to poor crop stand resulting from using broadcast sowing at relatively low seed rate and serious bird damage.

Back-up research on lentil breeding was carried out at Rubatab and Wad Hamid. Six promising lines were evaluated in on-farm verification yield trials in both locations. The best lines were Precoz, ILL 795 and ILL 813. Back-up research on planting methods, seed rate and weed control revealed that, no significant differences occurred between flat planting in hills 25 cm apart and broadcasting the seeds and ridging the soil into 40-cm ridges. There were no significant differences among five seed rates tested, suggesting the possibility of using the low rate of 35.7 kg seeds/ha.

Weeds caused 22% yield reduction at Wad Hamid and 32% at Rubatab in a weed control trial where Persuit herbicide was tested singly and in combination with other herbicides. In Wad Hamid, spray with Pursuit (0.05 kg a.i./ha) mixed with Stomp (1.2 kg a.i./ha) or Goal (0.24 kg a.i./ha) gave as good weed control as hand weeding. However, when Pursuit + Stomp was combined with one hand weeding the yields were the highest. In another set of experiments weeds accounted for 12 and 59% reduction in yield of lentil at Rubatab and Wad Hamid, respectively. Igran (1.5 kg a.i./ha) + Ronstar (0.71 g a.i./ha) gave highest yield at Rubatab and Igran (1.5 kg a.i./ha) + Goal (0.25 kg a.i./ha) gave highest yield at Wad Hamid.

8.1.3.3. Chickpea

Demonstration of the improved production package was continued in Wad Hamid, the main chickpea-growing area in Sudan. The improved package consisted of sowing the improved variety 'Shendi' in mid-November with a seed rate of 60 kg/ha by broadcasting and ridging, supplementary irrigation and spraying against insect pests. It was compared with the traditional practice by the neighboring farmers. The improved package gave average seed yield of 1639 kg/ha with an increase of 68% over farmers practice and 546% marginal rate of return.

The exploratory survey of chickpea production in Hawata area in Central state revealed that about 1200-2000 ha are sown to chickpea. The crop is grown on residual moisture when Rahad river recedes. The production constraints were identified and areas suggested for further research were outlined.

Back-up research on chickpea breeding was carried out at Hudeiba, Shendi and Rubatab. Ten promising lines were evaluated in on-farm verification yield trials in these locations. The best lines were ILC 631, ILC 1327 and ILC 1353. Back-up research on weed control revealed that spray with Pursuit + Goal and Pursuit + Stomp with or without hand weeding showed outstanding activity against weeds. The main disease in chickpea is root rot/wilt complex caused by Fusarium oxysporum f.sp. ciceri, Rhizoctonia bataticola and Rizoctonia solani. Screening of 92 chickpea genotypes in the sick plot for root rot/wilt diseases, six genotypes showed resistance (ICC 82001, FLIP 85-20C, FLIP 85-29C, FLIP85-30C, UC 15 and ICCV 2).

National Scientists from Sudan

8.2. North African Regional Program

As in the past, ICARDA continued its collaborative research on food legumes with the national programs in Algeria, Libya, Morocco and Tunisia with ICARDA Regional Legume Scientist based at Douyet (near Fes), Morocco. The emphasis continued on germplasm enhancement for the major production constraints, agronomic aspects, and transfer of technology. A major focus continued to be the development of national research capabilities and the strengthening of regional network activities. Only the highlights of research results for each country and the regional activities are presented here because the details are described in the country reports prepared by and available in each country.

8.2.1. Algeria

The objective of the food legume research program in Algeria is to develop high and stable yielding varieties suitable for mechanization, lack of which is currently constraining the expansion of their legume hectarage. In chickpea, research on winter sowing is being encouraged considering its advantage over the traditional spring sowing. In general, breeding for disease resistance and frost tolerance (for high elevation areas) receive high priority in the program.

8.2.1.1. The 1991/92 crop season

The weather conditions were favorable for crop growth and yield. The early rainfall received between September and November helped timely land preparation and sowing. December and January received little rainfall, but well distributed rainfall was received between February and June favouring crop growth and grain development. There were regional variations: the rainfall was sub-optimal in the central (Oued Smar and Beni Slimane) and western regions (Saida, Tiaret, Sidi Bel Abbes and Khemis Meliana), and above normal in the eastern region (Khroub, Guelma and Setif).

8.2.1.2. Germplasm enhancement

Faba bean: A limited program on faba bean was carried out for selection for yield potential and adaptation, and seed production at Sidi Bel Abbes, and for Orobanche and Botrytis resistance at Oued Smar. From the North Africa regional yield trial-large (FBNARYT-L-92), 11 entries that outyielded the check variety were selected. Similarly, eight lines were selected from the preliminary yield trials. Of the 10 lines evaluated in faba bean multilocation trial-I year (FBMULT-I), one line (S 84155-18-1-1-1) significantly outyielded all other test lines and the two checks. Variety FLIP 82-30FB was selected for purification and pre-release seed multiplication.

Chickpea: Selection work was carried out at all the nine stations of ITGC (Sidi Bel Abbes, Tiaret, Saida, Khemis Meliana, Oued Smar, Beni Slimane, Khroub, Guelma and Setif). International nurseries were grown at three stations (Sidi Bel Abbes, Saida and Khroub) and yield trials at six stations (Table 8.2.1). Preliminary yield trial was grown at all the nine stations.

From CIF_4N-W-92, seven selections each were made at Sidi Bel Abbes and Khroub. Seven selections were made from CISN-SP-92 at Saida that yielded from 2500 to 3000 kg/ha. The number of selections made from CIYT-SP-92 and -W-92 at each of the six stations is given in Table 8.2.1. Grain yields were best at Khroub. One line FLIP 85-44C was selected in five stations whereas two lines, FLIP 89-26C and 89-62C were selected in four stations. From CPYT, 86 lines were selected at nine stations, and 33 lines were selected for multilocation trials for 1992/93. From the 33 lines that were evaluated in multilocation trial-II year, 10 lines (FLIP 81-293C, -83-93C, -84-93C, -84-102C, -84-109C, -85-28C, -85-48C, -85-55C, -85-94C and -90-10C) were selected for the national yield trial next year (CPNYT-93).

Table 8.2.1. Chickpea lines selected from international yield trials at six different stations of ITGC, Algeria, 1991/92 season.

Station	Trial	No. of selections	Range of grain yield (kg/ha)
Khroub	CIYT-MR-SP/92	5	2660 to 3500
	CIYT-MR-W/92	5	2720 to 3870
Tiaret	CIYT-MR-W/92	5	2100 to 2800
Oued Smar	CIYT-MR-W/92	6	--
Beni Slimane	CIYT-MR-W/92	4	1300 to 2600
Sidi Bel Abbes	CIYT-MR-W/92	3	1300 to 1780
Setif	CIYT-MR-W/92	7	1400 to 2290

Four chickpea lines, FLIP 84-79C, -84-92C, -85-17C and -81-293C, have been identified so far for release for general cultivation.

Lentil: Selection work was carried out at seven ITGC stations. LISN-T-92 was raised at Tiaret whereas LIYT-L-92 and LIYT-S-92 at three and four stations, respectively (Table 8.2.2). LPYT was grown at all the seven stations.

Table 8.2.2. Lentil lines selected from international yield trials at four different stations of ITGC, Algeria, 1991/92.

Station	Trial	No.of selections	Range of grain yield (kg/ha)
Sidi Bel Abbes	LIYT-L-92	5	2000 to 2300
Tiaret	LIYT-L-92	1	1030
Setif	LIYT-L-92	3	2500 to 2700
Sidi Bel Abbes	LIYT-S-92	5	2500 to 2700
Tiaret	LIYT-S-92	6	1200 to 1700
Setif	LIYT-S-92	2	2800 to 2900
Beni Slimane	LIYT-S-92	7	3400 to 3800

From LISN-T-92, five lines with a grain yield of 1800 to 2000 kg/ha were selected at Tiaret. The number of lines selected from LIYT-L- and -S-92 are given in Table 8.2.2. Of the 98 lines evaluated in LPYT at seven stations, 10 were selected for the multilocation trial-I year. From the multilocation trial-II year, nine lentil lines (81S38326, FLIP 84-144L, -84-145L, -85-33L, -86-02L, 87-02L, -87-35L, -83-52L and -88-01L) were selected for the national yield trial-93 (LNYT-93). Three varieties have been identified sofar for release for general cultivation. These are Balkan 775, L.B. Redjas and Setif 618.

Pea: Only a limited program on pea is carried out at three ITGC stations, viz., Sidi Bel Abbes, Khemis Meliana and Tiaret. The majority of the varietal material comes from the Pea International Adaptation Trial (PIAT) supplied by ICARDA. Of the 13 lines that were selected from PIAT-92 at Sidi Bel Abbes, two (LE 25 and Syrian Local Aleppo) significantly outyielded all other test lines and check. Six selections were made from PIAT-92 at Tiaret (grain yield range of 1240 to 1750 kg/ha) and four at

Khemis Meliana. From the preliminary yield trial PPYT-92, two lines (MG 102369 and LE 25), with grain yields of 3300 kg/ha compared with 2900 kg/ha of check (SBA 184), were selected for testing in PMULT-I year. SV 51741, the best yielding line (4090 kg/ha), was selected for seed multiplication. Two lines, Ballet and Early Down were selected at Khemis Meliana.

8.2.1.3. Pathology

The work on food legume pathology is conducted at INA-El Harrach, and four ITGC stations, viz., Sidi Bel Abbes, Guelma, Oued Smar and Khroub. Detailed work on chickpea ascochyta blight and wilt is done at INA, whereas field screening for ascochyta blight is done at Sidi Bel Abbes, Oued Smar and Khroub, and for wilt at Guelma.

Disease surveys indicated the importance of ascochyta blight on chickpea, faba bean and lentil in Sidi Bel Abbes, Saida, Tiaret and Khemis Meliana regions. Viruses (BBMV, BYMV and BLRV) were recorded on faba bean. Parasitic plants Orobanche crenata damaged faba bean and lentil, and Cuscuta spp. damaged chickpea.

A total of 17 chickpea lines were selected for resistance/tolerance to ascochyta blight from CIABN-A-92. These included six at Sidi Bel Abbes, three at Oued Smar, and eight at Khroub. The six lines that showed tolerance in severe epiphytotic conditions at Sidi Bel Abbes were FLIP 88-83C, -88-85C, -88-86C, -88-86C, -88-87C, -89-110C, and -90-112C. Four other lines that showed tolerance to ascochyta blight in the national ascochyta blight nursery were FLIP 84-92C, -84-93C, -88-82C and 79TH-101-

2. From LIFWN-92, five lentil lines were selected at Beni Slimane. These are ILL 241, ILL 813, EL 42, FLIP 82-37L, and -90-20L. At Oued Smar, six faba bean lines with good resistance to Orobanche were selected from FBNARON-92 in Orobanche-sick plots. These included Sel 88 LAT. 18009, -18035, -18054, 8/9 72, 8/9 85 and 8/9 128. In addition, four selections (Giza 402, Lattakia, Sel 88 LAT. 18025 and -18105) were also made for Orobanche resistance from 16 lines tested in another nursery.

8.2.1.4. Agronomy

Early sowing of chickpea continued to yield higher; the best period being December in the humid zone (Oued Smar), December to January in the high plateau zone, and January in the sub-humid zone (Khroub). For lentil, the best sowing time was November to December in inland areas, and December to January in high plateau areas. Optimum plant densities for chickpea were found to be 50 to 70 plants/m² for coastal and subcoastal areas, and 35 to 50 plants/m² for high plateau areas. In chickpea, 50 cm row to row spacing facilitated mechanical weeding and provided better grain yields. For lentil, 180 to 210 plants/m² were found optimum planting densities. Herbicides Igran + Kerb provided the best weed control in lentil.

Algerian National Program Scientists and S.P.S. Beniwal

8.2.2. Libya

8.2.2.1. Trial sites and crop season

Experiments were conducted at different locations to cover different agrogeographical regions: Tajoura and Zahra in the Western region, Misurata in the Central region, El-Safsaf and El-Marj in the Eastern region, and Sebha in the Southern region of Libya. Like the previous season, the 1991/92 crop season also received sub-optimal rainfall (250 mm) in the Western region which adversely affected crop growth and productivity. This encouraged wilt/root rot diseases in chickpea, and virus diseases and chocolate spot in faba bean. The Eastern region received high amounts of rainfall (900 mm) during the growing season which encouraged the development of ascochyta blight in chickpea.

8.2.2.2. Germplasm enhancement

Faba bean: Five trials/nurseries conducted included national yield trial-small seed (FBNYT-S-92) and -large seed (FBNYT-L-92), North Africa regional yield trial-large (FBNARYT-L-92) and adaptation trial (FBAT-92). No significant yield differences were obtained among varieties in FBNYT-S-92, FBNYT-L-92 and FBAT-92, although Reina Blanca was the best yielder (5300 kg/ha) in FBAT-92. In FBNARYT-S-92, six lines, viz., FLIP 85-28B, S83118-12-2-1, B87149, FLIP 84-46FB, -84-48FB and S 82002-11-1-1, yielded significantly better than the other test lines and the checks. Similarly in FBNARYT-L-92, five entries, viz., Aquadulce, Reina Blanca, S 822030-7-1-1-, 647-2, and FLIP 84-118FB, significantly outyielded the local check and the other test entries.

Chickpea: Three trials were conducted. The chickpea international yield trial-winter-Mediterranean region-1992 (CIYT-W-MR-92) with 24 entries was conducted at El-Safsaf station. The grain yield ranged from 360 to 1880 kg/ha. FLIP 89-38C and FLIP 89-29C were significantly higher yielding than the standard check, ILC 484. The lowest yielder was FLIP 89-26C. Ten lines were selected for the national yield trial next year (CPNYT-W-

93-B). These were FLIP 89-38C, FLIP 84-29C, FLIP 84-62C, FLIP 88-82C, FLIP 86-42, FLIP 86-6C, FLIP 89-63C, FLIP 89-78C, FLIP 85-93C, and FLIP 85-5C. The chickpea regional yield trial-92 with 16 genotypes was planted at El-Marj station. The grain yield ranged from 130 to 680 kg/ha. Six genotypes FLIP 83-48C, FLIP 84-144C, FLIP 83-71C, FLIP 82-150C, FLIP 84-145C, and ILC 3279 were selected. The highest yield was obtained from variety FLIP 83-48C (680 kg/ha). In the chickpea adaptation trial planted on 17 November at Sebha station, the local cultivar was the highest yielder (1800 kg/ha). Seed shrinkage was observed in test cultivars due to high temperatures prevailing at the pod filling stage. The trial will be planted earlier next season.

Lentil: Three trials were conducted. The lentil international yield trial-small seed-92 (LIYT-S-92) with 24 entries was grown at El-Safsaf station. Nine entries, which were not significantly different from each other, yielded more than the other varieties including the check. The lentil adaptation trial-1992 (LAT-92) with four lentil genotypes was grown at Sebha station. Due to seedling mortality, high shattering and high temperature, very low seed yields were obtained. The results indicated that Sebha area is not suitable for growing lentils.

Pea: Three trials were conducted. The pea international adaptation trial (PIAT-92) was raised at Zahra and Sebha stations. No useful yield data could be obtained because of bird and wild animal damage at Zahra and physical mixture of different lines at Sebha because of excessive growth and narrow row spacing. The trial will be repeated during the next season at both stations. However, several entries at Sebha (Blanda, Calypso, Solara and Chantal) appeared promising. From the national yield trial (B) with 13 entries conducted at Tajoura station, seven entries Wirrega, Local Sel. 1690, Syrian Local, MG 102583, Solar, MG 102623 and PS 510203 yielded 1800, 1600, 1400, 1100, 1000, 1000, and 900 kg/ha, respectively. These yields were significantly better than these of other test entries and the check.

8.2.2.3. Pathology

Emphasis in pathology continued on chocolate spot and rust of faba bean, and ascochyta blight and wilt of chickpea. In the faba bean rust nursery-1992, three entries (R 8810, R 888 and R 8824) maintained their moderate resistance to the disease. These will be yield-tested in the next season. In the faba bean chocolate spot nursery-1992, three entries (B 88140, -88111 and ILB 1814) showed good resistance to the disease. These will also be yield tested during the next season.

The chickpea international ascochyta blight nursery-A-92 (CIABN-A-92) was evaluated at El-Safsaf under artificial epiphytotics. The susceptible check (ILC 263) was completely killed by the disease. Only six lines rated resistant (rating <5 on 1-9 scale): FLIP 90-112C, FLIP 88-87C, FLIP 89-62, FLIP 88-86, FLIP 89-110C, and FLIP 84-133C. Five lines were moderately resistant (rating 5): FLIP 84-93C, -88-85C, -88-82C, -88-83C, and -89-27C. However, all the five test lines in the national ascochyta blight nursery-1992 (FLIP 87-51C, -83-47C, -87-504C, -87-507C, and -84-112C) at the same station were killed along with the local susceptible check.

Fourteen chickpea lines were tested in the North Africa regional ascochyta blight trap nursery-92 (CPRABTN-92) at EL-Safsaf station. Five lines were rated 2-3 on a 1-9 scale. These were ILC 195, -3279, FLIP 84-92C, ILC 482 and -182. However, in the chickpea internationl fusarium wilt nursery-1990 (CIFWN-90) at Tajoura station, all the lines were killed due to severe wilt.

8.2.2.4. Agronomy

The faba bean date of planting x row spacing trial with four sowing dates (1 Oct, 15 Oct. 1 Nov. and 15 Nov) and four inter-row spacings (30, 40, 50 and 60 cm) was conducted in a randomized complete block design with four replications for the second year at Zahra. Sowing between 1 Oct and 1 Nov with 30 cm row spacing gave better grain yields than 15 Nov sowing. This trial is concluded and the result will be verified at stations and farmers' fields during the 1992/93 season. In the faba bean planting density trial-91 conducted at Zahra station with four inter-row (30, 40, 50 and 60 cm) and four intra-row spacings (5, 10, 15 and 20 cm), no significant grain yield differences were observed between treatments. The faba bean weed control trial-1992 (FBWCT-92) was conducted at Zahra and Sebha stations. Of the eight treatments at Zahra tested, the weed-free treatment yielded highest (2100 kg/ha), while treatments no. 8 (Kerb + Tribunil, preemergence) and 6 (Kerb + Fortrol, preemergence) gave higher grain yields (1900 and 1800 kg/ha, respectively) than other chemical treatments. At Sebha, only seven treatments were tested. Treatment No. 6 (Kerb + Maloran, preemergence) gave highest grain yield of 3400 kg/ha compared with the weedy-check that yielded 2000 kg/ha.

In the chickpea weed control trial-1992 (CPWCT-92), seven weed control treatments were tested at El-Safsaf. These were : (i) weedy-check, (ii) weed-free, (iii) hand-weeding twice, and preemergence application of (iv) Maloran + Kerb, (v) Igran, (vi) Igran + Kerb, and (vii) Tribunil + Kerb. Weed free, hand-weeding twice, and Tribunil + Kerb treatments proved good. Igran treatment caused phytotoxicity and reduced yield.

Libyan National Program Scientists and S.P.S. Beniwal

8.2.3. Morocco

8.2.3.1. The crop season

A severe drought occurred in most parts of Morocco due to very little or no rainfall from November to January. The effect was especially severe in the "favorable-rainfall" zone of the country where complete crop failures occurred. The effects were less severe in the Pre-Rif and parts of Chaouia regions. Because of the drought, the development of chocolate spot, ascochyta blight and Orobanche on faba bean was rather limited. Very little or no ascochyta blight developed on chickpea, and no rust developed on lentil.

8.2.3.2. Germplasm enhancement

Germplasm enhancement countinued to be the major objective of the national food legume program in Morocco. The national program continued to receive chickpea and lentil material from ICARDA in the form of international nurseries and yield trials. It was the third and last year of the ICARDA/INRA-Morocco faba bean improvement program at Douyet.

Faba bean: The objective of the faba bean program are to **(i)** develop high and stable yielding varieties with resistance to Orobanche, chocolate spot, ascochyta blight, rust and stem nematodes with acceptable quality traits, (ii) alter plant architecture and ideotype to control vegetative growth, flower and pod drop and convert faba bean into a self-pollinated crop, and (iii) identify appropriate cultural practices to increase yield, reduce cost of production and/or increase farmer's revenues. Because of the drought situation at Douyet which is the major site for all the faba bean improvement research in Morocco, all the trials and nurseries failed. However, the segregating populations and crossing block entries were saved by limited tank irrigation. Two Orobanche-tolerant faba bean lines (Sel. 88 Lat. 18009 and -18035) were tested in the faba bean national catalogue trial (NCT)

Chickpea: The objective of the chickpea program continued to (i) characterize and evaluate germplasm for desirable characters including adaptation to both winter and spring sowing, and (ii) develop large-seeded, high and stable yielding varieties with ascochyta blight and leaf-miner resistance for the winter sowing as well as for dual season (winter and spring). Thus, as per the objectives, the major thrust was on the evaluation of different types of materials for yield and ascochyta blight resistance. A total of 600 chickpea lines were tested for desirable traits through different nurseries and trials. These consisted of five nurseries (including ascochyta blight and leaf miner nurseries), three preliminary yield trials, one advanced yield trial (for both winter and spring), a national yield trial, and a North Africa regional yield trial.

A total of 168 national germplasm accessions were also evaluated. Also, base seed increase was done. All the trials and nurseries were harvested except for spring-sown trials at Jemaa Shaim which failed due to sub-optimum rainfall.

Winter-sown chickpea outyielded spring-sown crop at all locations except at Douyet where late season rainfall during March-June specially benefitted spring sown crop. At Merchouch, in spite of sub-optimal rainfall early in the season, winter-sown crop gave nearly 40% more production than spring-sown crop. Winter sowing was most promising at Jemaa Shaim where spring-sown planted chickpea did not give any seed yield. Three chickpea lines (FLIP 84-79C, -84-145C, and -84-182C) were in the first year of the national catalogue trial (NCT) whereas FLIP 84-93C was in the second year of testing. Two chickpea cultivars, FLIP 84-92C, and -83-48C were released for general cultivation under the names 'Douyet' and 'Rizki', respectively.

Lentil: The primary objective of the lentil improvement program is to (i) develop early, erect and high and stable yielding varieties with resistance to rust and good quality characteristics, and (ii) develop appropriate cultural practices with special emphasis on mechanical harvest. Genetic material utilized in the lentil improvement program involved germplasm collections of local and introduced genotypes, lines provided by ICARDA for evaluation, and lines from previous screening nurseries and preliminary yield trials selected for further evaluation. A total of about 500 lines were tested through different nursery and yield trials. These consisted of a rust screening nursery, four preliminary trials (LIYE-92, LIYT-S-92, and LIYT-L92, and LPYT-S-92), an advanced yield trial (LNAYT-92), two national yield trials (LNYT-S-92 and LNYT-L-92), and a North Africa regional yield trial. Base seed of 32 lentil lines was multiplied in small plots at Sidi El Aidy.

Lines selected from different trials included six from LIYT-E-92, five from LIYT-S-92 and five from LIYT-L-92 for LPYT-93; seven lines from LPYT-S-92 for LAYT-93; one line from lentil North Africa yield trial for LNYT-93. Because of the unfavorable weather conditions, about half of the lines from LNAYT-92 and LINYT-92 will be retested during the 1992/93 crop season. Lentil lines ILL 6002, -6209 and 6212, that completed two years of testing in the national catalogue trial (NCT), were found to do well in the semi-arid region of Morocco. They will be considered for release for this region. Line ILL 6001 now has completed two years of testing in NCT and a verdict on its future is awaited. Two lentil lines, viz., FLIP 86-16L and 86-21L were in the first year of NCT.

8.2.3.3. Pathology

Major emphasis in pathology continued to be on screening for resistance to chocolate spot, ascochyta blight and Orobanche in faba bean, ascochyta in chickpea, and rust in lentil. Drought adversely affected natural disease development in the field. However, 40 entries of the CIABN-A-92 were screened under artificial inoculation conditions in a glasshouse at Settat. Lines that showed moderate resistance (a score of 5 or less on a 1-9 scale) included FLIP 83-48C, -83-71C, -83-98C, -84-79C, -84-80C, -84-

83C, -84-92C, -84-112C, -85-86C, -85-114C, -85-118C, -85-148C, -88-85C and -89-49C.

8.2.3.4. Agronomy

All the agronomy trials on faba bean at Douyet failed because of the drought. Results of a chickpea trial at Douyet indicated that variety FLIP 84-92C at 50 cm row to row spacing with pre-emergence Igran treatment for weed control provided better grain yields over farmer's local variety.

Moroccan National Program Scientists and S.P.S. Beniwal

8.2.4. Tunisia

8.2.4.1. The crop season

The weather in general was favorable for crop growth and development. Rainfall was well distributed over the crop season. The Le Kef region received rains during the spring as well. The minimum temperatures during January were below zero at Beja and Le Kef. All this resulted in delayed maturity but good crop growth and grain yield. The general weather conditions encouraged chocolate spot and ascochyta blight in faba bean, and ascochyta blight and wet root rot in chickpea in certain areas.

8.2.4.2. Germplasm enhancement

Faba bean: A total of 13 yield trials and nurseries were conducted on faba bean large and small. Of these, nine were conducted both at Beja and Oued Meliz. For faba bean-large, mean yields were 4390 kg/ha and 4080 kg/ha at Beja and Oued Meliz, respectively. For faba bean-small, mean yields at these locations were 3680 kg/ha, and 3979 kg/ha, respectively.

At Beja, faba bean-large lines S 83182-1, M 82025-39, MB 89 FB 11 and S 83181-53 yielded 5500, 5400, 4800 and 4600 kg/ha, respectively, compared with 4500 kg/ha of the Local large (Fig. 8.2.1). At Oued Meliz, faba bean-small lines S 83181-53C, S 83182-22, MB 89 FF 11, M 82025-39 and S 83182-1 yielded 5400, 5500, 5300, 4800 and 4500 kg/ha, respectively, compared with 3800 kg/ha of the Local large (Fig. 8.2.1). Two lines of

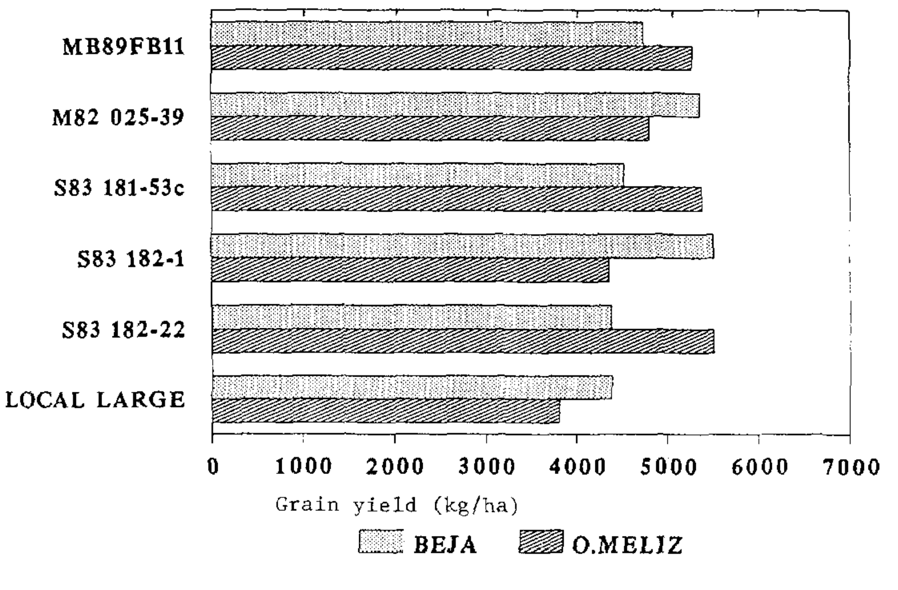

Figure 8.2.1. Yield performance of some selected large faba bean cultivars at Beja and Oued Meliz stations in Tunisia, 1991/92 crop season.

faba bean-large S 83182-22 and S 82113-8 were selected for pre-release multiplication and registration. The former has 100-seed weight of 158 g (better than Aquadulce) and a 19% higher grain yield than Aquadulce. It has green pods and is less susceptible to ascochyta blight than Aquadulce. Line S 82113-8 has a 100-seed weight of 126 g, and it yielded 15% higher than the local cultivar over a 5-year period (1988-92). It provided a 21% yield advantage over the local variety in dry areas. It's green pods are similar to those of Chemlali, and it is tolerant to ascochyta blight.

A number of high yielding lines in faba bean-small seeded type were identified. These included FLIP 84-59FB, POL 10, LPF 044 and POL 3 (Fig. 8.2.2), and yielded 5500, 5300, 5100 and 5000 kg/ha, respectively,

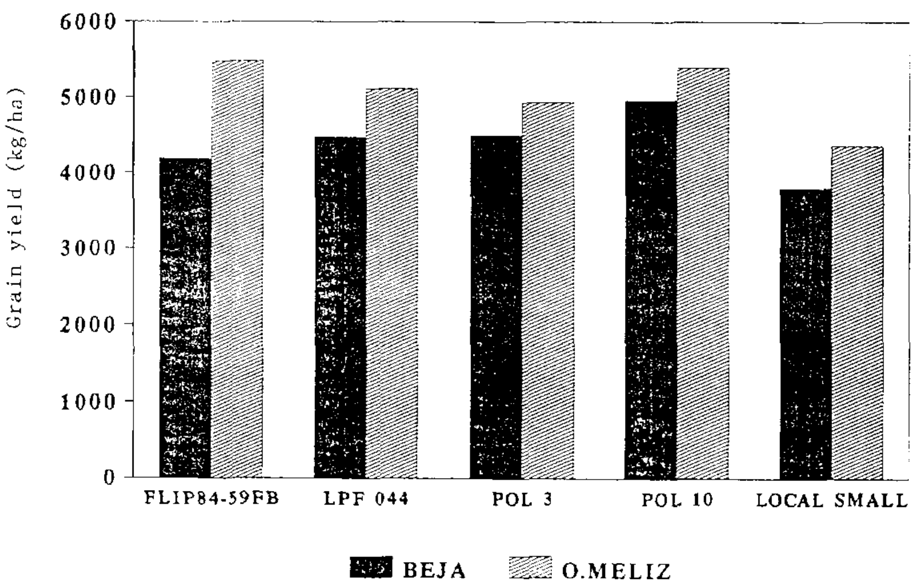

Figure 8.2.2. Yield performance of some selected small faba bean cultivars at Beja and Oued Meliz stations in Tunisia, 1991/92 crop season.

compared with a yield of 4300 kg/ha of Local small at Oued Meliz. At Beja, these yielded 4200, 4900, 4400 and 4500 kg/ha, respectively, compared with a yield of 3800 kg/ha of Local small. Line FLIP 83-106FB was discarded for further use because of its susceptibility to ascochyta blight. Two of the above lines, FLIP 84-59FB and POL 3 were selected for pre-release multiplication and registration. FLIP 84-59FB has 100-seed weight of 58 g compared with 52 g of Local small. It outyielded the local cultivar by 10% over a 5-year period (from 1988-92). In favorable years, it provided a 16% yield advantage over the local check. It is tolerant to ascochyta blight. Line POL 3 has 100-seed weight of 55 g. It outyielded the local variety by 17% over a 5-year period (1988-92) and provided a 14% yield advantage in favorable years. It has tolerance to ascochyta blight and exhibits a wide adaptation.

Chickpea: The mean yield of 2850 kg/ha was obtained from winter chickpeas at Oued Meliz. The figure for Beja was only 1040 kg/ha which was due to some trials falling on wilt-affected portions of the field. Line FLIP 90-170C was the highest yielder (5600 kg/ha) under winter sowing at Oued Meliz whereas line FLIP 90-13C was the highest yielder (4800 kg/ha) at Beja. Among spring-sown chickpea lines at Beja, line FLIP 90-12C was the highest yielder (3350 kg/ha). The two lines identified for registration earlier, viz., INRAT 88 (FLIP 84-92C) and INRAT-87 (FLIP 84-79C) yielded 3000 and 2500 kg/ha, respectively, in winter sowing at Oued Meliz (Fig. 8.2.3). However, only one line, INRAT 88, will be registered.

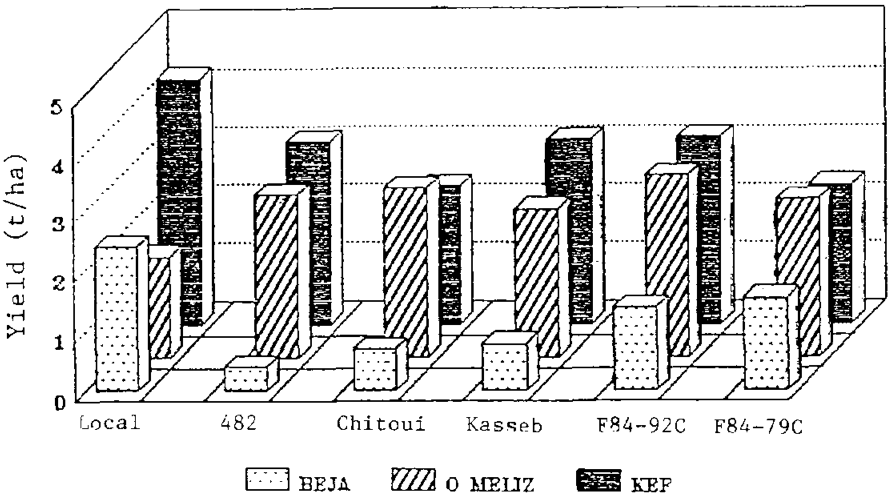

Figure 8.2.3. Yield performance of some selected chickpea lines at Beja, Oued Meliz and Kef stations in Tunisia, 1991/92 crop season.

Lentil: In lentil, mean yields at Beja, Oued Meliz and Le Kef were 2070, 2660 and 1770 kg/ha, respectively. The highest yielders were FLIP 86-35L at Beja (3900 kg/ha) and Oued Meliz (3160 kg/ha) and FLIP 90-27L at Le Kef (2630 kg/ha). Yields at Le Kef were low possibly because of excessive humidity prevailing during the spring. The good performance of FLIP 84-58L was confirmed (Fig. 8.2.4). It yielded 21% more than Nefza and 42% more than Nsir (ILL 4400). Thus, it is selected for pre-release multiplication and registration. Also, good performance of UJ 85 was *confirmed as it outyielded Nsir by 17%. This variety is early and thus* useful for late-planting situations. It is of a macrosperma type.

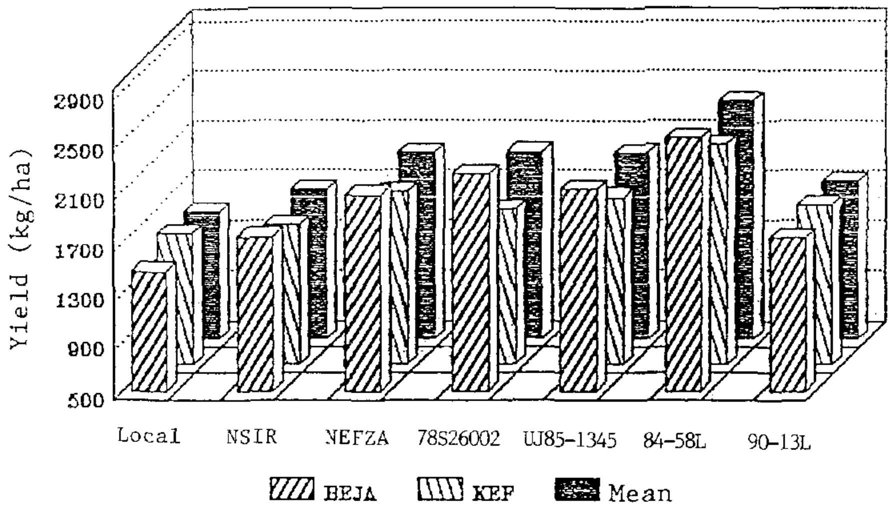

Figure 8.2.4. Yield performance of some selected lentil lines at Beja, Oued Meliz and Kef stations in Tunisia, 1991/92 crop season.

Pea: Good mean trial yields were obtained at Beja (2410 kg/ha) and Oued Meliz (2650 kg/ha) compared with Le Kef (1810 kg/ha). Line PS 210713 was the highest yielder (3500 kg/ha) at Beja, line Dindole at Oued Meliz (3360 kg/ha) and Collegian at Le Kef (2270 kg/ha). Mean yields of these three lines were 2540, 2700 and 2760 kg/ha, respectively, at Beja, Oued Meliz and Le Kef.

8.2.4.3. Pathology

In faba bean, work on Orobanche (both O. foetida and O. crenata) included screening for resistance, integrated control, and seed-load studies. Of the BPLs tested for O. foetida during the 1990/91 and 1991/92 seasons, two lines (BPL 324 and -407) showed resistance, and 10 lines (BPL 011, -016, -017, -190, -214, -226, -248, -467, -484, and -486) showed moderate resistance. Also, two lines (S 18054-S and 8/9-128) from the North Africa regional Orobanche nursery and one line from Egypt (402/29/84) also showed good resistance and high yield potential. All these lines along with other promising ones will be retested during the 1992/93 crop season.

A field trial on integrated control of O. foetida on large-seeded local faba bean was conducted at Beja using three herbicides (Imazethapyr, 75 g a.i./ha, pre-emergence; glyphosate, 2x70 g a.i./ha, post-emergence; and imazaquin, 2x15 g a.i./ha, post-emergence, at the parasite attachement stage and 15 days later) combined with two sowing dates (normal, 11 Nov and late, 20 Dec). Application of imazaquin combined with late sowing permitted a total control of Orobanche. Imazaquin applied at the normal sowing date and imazethapyr at late and normal sowing date gave the best yields. The growth of faba bean plants was adversely affected by glyphosate and imazaquin.

In a pot study at INRAT, Ariana the reaction of Aguadulce, Sel 88. Lat. 18035 and 8/9-128 to different infestation levels of O. crenata was evaluated. Results obtained confirmed the resistance of Sel 88. Lat. 18035 and 8/9-128 to O. crenata. With the highest level of inoculum

(904.8 mg of Orobanche seeds/pot), the line 8/9-128 seems to be more resistant to O. crenata than Sel. 88. Lat. 18035. Increasing Orobanche inoculum level resulted in a decrease in the dry weight of faba bean plant; this decrease was more conspicuous in Aguadulce than in the resistant lines.

Good resistance to ascochyta blight (A. fabae) was identified in faba bean lines 29H and BPL 472. Lines S 84176-3-1-1-1 and BPL 365 showed resistance to stem infection and tolerance to pod infection. Ten isolates of A. fabae were studied for their cultural characteristics like morphology, growth, sporulation and size of spores on three media. The same isolates will be used for their pathogenicity and phytotoxicity using their toxins on isolated chloroplasts.

Large-scale field screening of chickpea for ascochyta blight resistance was done at Beja and Oued Meliz. Only 5% of the lines tested at Beja and 2% of the ones tested at Oued Meliz showed a rating of less than 4 on a 1-9 rating scale (Fig. 8.2.5). Variety INRAT 87 showed 4.4

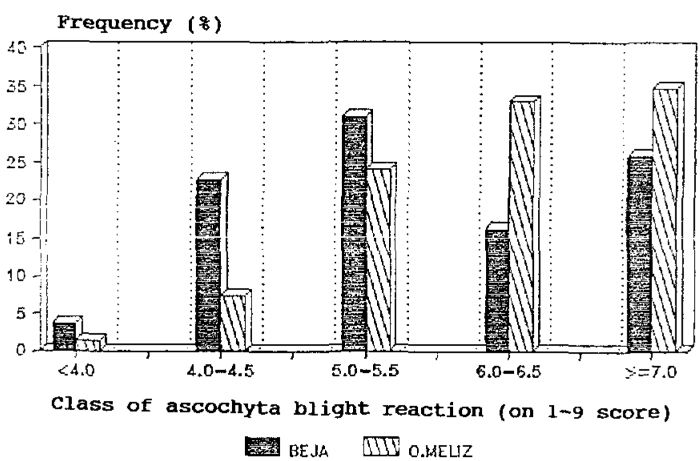

Figure 8.2.5. Frequency of chickpea lines in different classes of reaction to ascochyta blight (based on 1-9 score) when tested at Beja and Oued Meliz stations in Tunisia, 1991/92 crops season.

and 5.1 rating at Beja and Oued Meliz, respectively. Similar ratings for INRAT 88 were 4.8 and 5.8. For chickpea wilt, 17% of the 524 lines tested showed no wilt incidence (Fig. 8.2.6). Three percent of the lines showed 1-20% wilt, whereas 79% of the lines showed more than 51% wilt.

The use of A. rabiei toxins on isolated chloroplasts was perfected as a screening technique for resistance to ascochyta blight. The results obtained showed highly positive correlations with those of the field screening.

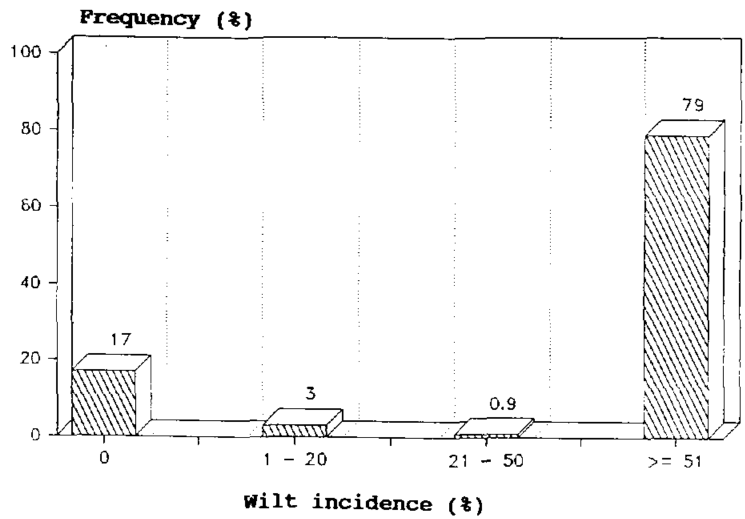

Figure 8.2.6. Frequency of 524 chickpea accessions/lines to wilt reaction when tested in a wilt-sick plot at Beja in Tunisia, 1991/92 crop season.

8.2.4.4. Transfer of technology

Demonstration of the improved package in winter sowing of chickpea with two new varieties (INRAT 87 and -88) resulted in a 100% yield advantage over the spring-sown chickpea. Demonstrations of varieties with improved cultural practices (date and density of sowing, and weed control), conducted in different governorates in the northern parts of the country with the assistance of Office des Cereales and the IFAD Technology Transfer Project, gave useful results.

H. Halila, other Tunisian National Program Scientists and S.P.S. Beniwal

8.2.5. Provision of trials and nurseries to the national programs in North Africa

Relevant germplasm of faba bean, chickpea, lentil and pea was provided to the four national program in the form of international trials, nurseries

Table 8.2.3. Number of yield trials, screening nurseries, segregating populations nurseries in food and feed legumes provided to the national programs in North Africa, 1991/92.

Country	Number of trials/nurseries														
	Yield trials[a]					Nurseries[a]		Segragating populations[a]		Total[a]					
	C	L	P	V	Lt	C	L	C	L	C	L	P	V	Lt
Algeria	11	9	3	3	3	14	11	2	1	27	21	3	3	3
Libya	1	1	2	-	-	1	1	2	-	2	2	2	-	-
Morocco	3	3	-	2	2	6	3	2	-	11	6	-	2	2
Tunisia	4	4	2	-	-	29	7	1	-	34	11	2	-	-
Total	19	17	7	5	5	50	22	5	1	74	40	7	5	5

[a] C = chickpea; L = lentil; P = pea; V = vetch; and LT = lathyrus.

and segregating populations details of which are summarized in Table 8.2.3. Theses trials/nurseries complemented the national and regional trials/nurseries that were developed in collaboration with the national programs.

8.2.6. Regional Yield Trials and Nurseries

Several regional yield trials and nurseries developed by the participating countries were conducted during the 1991/92 crop season (Table 8.2.4). These included two yield trials in faba bean (FBNARYT-L and FBNARYT-S), one in chickpea (CNARYT), one in lentil (LNARYT), one Orobanche nursery in faba bean (FBNARON) and one ascochyta blight trap nursery (CPABTN) and one wilt trap nursery (CPWTN) in chickpea. Detailed results will be reported in a separate report and only a summary of results are presented here.

Table 8.2.4. Regional yield trials and disease nurseries carried out in North Africa, 1991/92.

Activity	Responsibility	Location*/Country
A. Yield trials		
1. FBNARYT-L-92	Morocco	DY (Morocco); TS (Algeria); OM (Tunisia); ZH (Libya)
2. FBNARYT-S-92	Morocco	DY (Morocco); OM (Tunisia)
3. CPNARYT-92	Tunisia	MC,JS (Morocco); TS (Algeria); BJ,OM (Tunisia); SF (Libya)
4. LNARYT-92	Morocco	MC,JS (Morocco); ZD (Algeria); BJ,OM (Tunisia)
B. Disease nurseries		
1. FBRON-92	Morocco	DY (Morocco); OS (Algeria); BJ (Tunisia)
2. CPABTN-92**	Tunisia/Algeria	Dy,MC (Morocco); SBA (Algeria); BJ (Tunisia); SF (Libya)
3. CPWTN-92**	Tunisia	IH (Morocco); SBA (Algeria); BJ (Tunisia)

* DY=Douyet; TS=Tessala; OM=Oued Meliz; ZH=Zahra; MC=Marchouch; JS=Jemaa Shaim; BJ=Beja; SF=Safsaf; ZD=Zidene; SBA=Sidi Bel Abbes; IH=IAV H-II-Rabat.

** In collaboration with the UNDP/Maghreb Disease Project.

8.2.6.1. Faba bean

The FBNARYT-L-92 with 24 entries including two checks was planted at four locations in the four countries (Table 8.2.5). Results could not be obtained from Douyet (Morocco) because of the drought. Best mean yield of 3993 kg/ha was obtained from Oued Meliz (Tunisia) followed by Tessala (Algeria) of 2640 kg/ha and with lowest (1060 kg/ha) from Zahra (Libya). Over the three locations, variety L 82007-11-3-1-1 was the top yielder (2940 kg/ha) followed by FLIP 87-147FB, S82 2030-7-1-1, Aquadulce and 79S4.

The FBNARYT-S-92 with 24 entries including a local check was planted at Zahra (Libya), Oued Meliz (Tunisia) and Douyet (Morocco) (Table 8.2.6). Results from Douyet were not available because of drought. Over the two locations, line FLIP 85-28FB was the top yielder (3990 kg/ha) followed by S 83118-12-2-1, FLIP 84-48FB, -85-85-FB and -84-46FB.

The FBRON-92 with 17 entries, including two Orobanche susceptible checks, was grown at Beja (Tunisia), Oued Smar (Algeria) and Douyet (Morocco) (Table 8.2.7). Results from Douyet were not available due to drought. In Tunisia, the susceptible checks (Seville and Aquadulce) showed 5.3 Orobanche shoots/plant. In Algeria, Seville and Aquadulce developed 13.6 and 20.9 shoots per plant, respectively. The six lines that were considered resistant in both Tunisia and Algeria (< 3.5 shoots/plant) were 8/9 72, 8/9 85, 8/9 128, Sel.88 Lat.18054-S, -18035-S and -18009-S.

Table 8.2.5. Seed yield of lines in the faba bean North Africa regional yield trial-large-1992 (FBNARYT-L-92).

Line	Yield (kg/ha)			
	Algeria (Tessala)	Libya (Zahra)	Tunisia (Oued Meliz)	Mean
FLIP84-107FB	3207	1080	3956	2748
FLIP84-147FB	2385	870	4369	2541
FLIP87-26FB	2260	1200	4544	2668
FLIP87-70FB	2929	1120	3344	2464
FLIP87-140FB	2561	1140	4075	2592
FLIP87-147FB	2951	1050	4538	2846
S82113-8	2890	950	906	2582
79S4	3090	810	4319	2740
80S44027	2661	720	4194	2525
80S80028	2891	860	4088	2613
REINA BLANCA	2730	1300	3938	2656
S82408-1-2-3	3117	940	4019	2692
L82007-11-3-1	2426	930	5463	2940
80S43587	2761	1100	3756	2539
647-2	2402	1320	3950	2557
663-4	2606	970	3644	2407
666-2	2828	960	3300	2663
FLIP83-24FB	2916	1140	3856	2337
FLIP84-118FB	2524	1260	4256	2687
S822030-7-1-1	2716	1360	4338	2805
REINA BLANCA	2629	1470	3850	2650
AQUADULCE	2443	1660	4275	2793
LOCAL LARGE			2538	
MATEUR			3331	
SEVILLE	2088			
NEW MAMMOTH	1342			
Local check I		850		
Local check II		350		
Mean	2640	1059	3993	2564
CV %	----	----	9.89	----
SE±	----	----	394.9	----

Table 8.2.6. Seed yield of lines in the faba bean North Africa regional yield trial-Small-1992 (FBNARYT-S).

Line	Yield (Kg/ha)		
	Libya (Zahra)	Tunisia (Oued Meliz)	Mean
FLIP82-9FB	1050	4200	2625
FLIP83-106FB	1640	4400	3020
FLIP84-46FB	1960	4950	3455
FLIP84-48FB	1850	5825	3838
FLIP84-59FB	1440	4969	3205
FLIP84-13FB	1490	4869	3180
FLIP85-28FB	2450	5544	3997
FLIP85-48FB	1600	4906	3253
FLIP85-85FB	1590	5488	3539
FLIP86-86FB	1570	4444	3007
B87148	1660	3963	2812
B87149	1970	4081	3026
B87249	1520	3413	2467
B87259	1200	3825	2513
S82 002-11-1-1	1800	4950	3375
S82 004-38-2-2	1450	5281	3366
S83 118-12-2-1	2070	5631	3851
L81 007-20-3-1-1	1500	4375	2938
L82 012-21-1-1	1330	5013	3181
L83 149-25-6-5	1360	4706	3033
L83 150-77-1-1	1180	4325	2753
18035	1010	3981	2046
18009	1130	3600	2365
Local small		3969	
Local small	890		
Mean	1530	4614	3080

Table 8.2.7. Results of the regional faba bean Orobanche nursery-1992 (FBRON-92).

Entry	No. of Orobanche shoot per plant		Orobanche susceptiblity rating (1-9 scale)	
	Beja	Oued Smar	Beja	Oued Smar
1. Sel88 Lat.18009-S	0.7	3.5	1	1
2. Sel88 Lat.18009-M	1.4	6.2	3	5
3. Sel88 Lat.18009-L	2.1	10.1	5	3
4. Sel88 Lat.18025-S	1.2	5.7	3	3
5. Sel88 Lat.18025-M	1.1	4.1	3	3
6. Sel88 Lat.18035-S	0.6	2.9	1	1
7. Sel88 Lat.18035-M	1.1	5.0	3	3
8. Sel88 Lat.18054-S	0.5	3.3	1	3
9. Sel88 Lat.18054-M	1.5	5.8	3	3
10. Sel88 Lat.18035-L	1.5	6.0	3	3
11. Sel88 Lat.18105-S	1.4	5.9	3	3
12. Sel88 Lat.18105-M	1.2	4.6	3	3
13. 8/9 72	0.4	4.3	1	1
14. 8/9 85	0.4	2.2	1	1
15. 8/9 128	0.7	3.6	1	1
16. Seville	5.3	13.6	9	9
17. Aquadulce	5.3	20.9	9	8

8.2.6.2. Chickpea

The CNARYT-92 with 16 entries was grown at Tessala (Algeria), Safsaf (Libya), Jemaa Shaim and Merchouch (Morocco), and Beja and Oued Meliz (Tunisia) (Table 8.2.8). Best mean yield (4793 kg/ha) across locations was obtained from Safsaf (Libya) followed by 2760 kg/ha at Oued Meliz (Tunisia) and with lowest of 510 kg/ha from Jemaa Shaim (Morocco). The lines that are common in the best five yielders in different locations were FLIP 84-144C, -82-150C, -84-79C, -84-146C, -84-93C, -83-48C, -84-92C, -84-182C and -84-145C. Over the six locations across the four countries, FLIP 83-48C was the top yielder (2264 kg/ha) followed by FLIP 84-144C, -84-182C, -82-150C and -84-79C. The mean yield of FLIP 84-92C, which is already released in Algeria and Morocco and identified for registration in

Tunisia, was low because of its poor yield levels in Morocco due to the drought situation.

Table 8.2.8. Results of the chickpea North African regional yield trial-1992 (CNARYT-92).

Line	Yield (kg/ha)						
	Algeria	Libya	Tunisia		Morocco		Mean
	(TS)[1]	(SF)[1]	(BJ)[1]	(OM)[1]	(JS)[1]	(MC)[1]	
FLIP84-146C	1010	1300	1582	3192	6701	1473	1537
ILC 195	868	4200	350	2225	590	1230	1577
FLIP84-144C	1294	5300	1832	3067	440	1340	2212
FLIP83-46C	677	4200	857	2357	---	----	2023
FLIP83-71C	677	5300	500	2382	430	1060	2022
FLIP85-56C	844	3400	1490	2417	290	1200	1607
FLIP85-17C	1003	4100	1007	2132	390	630	1544
FLIP84-93C	778	4900	365	3025	670	1590	1888
FLIP83-48C	892	6800	1257	2757	420	1460	2264
FLIP83-47C	1082	4400	740	2992	290	1270	1796
FLIP84-79C	1056	4800	1207	3450	670	1270	2076
FLIP84-182C	969	5200	2575	2275	540	980	2090
FLIP82-150C	1190	5900	1400	2407	650	970	2086
FLIP84-145C	793	5900	650	2407	400	1720	1979
ILC 3279	708	6000	400	2757	580	1320	1961
FLIP84-92C	1090	5000	575	3242	670	1010	1931
FLIP85-93C	----	----	----	----	460	1150	805
Mean	933	4793	902	2755	510	1229	1854
SEm±			725	657			
CV%	22.5	31.7	80	23			

[1] TS = Tessala; SF = Safsaf; BJ = Beja; OM = Oued Meliz; JS = Jemaa Shaim; and MC = Marchouch.

The CPABTN-92 with 14 chickpea lines to study race situation in A. rabiei was raised at Safsaf (Libya), Douyet (Morocco), and Beja and Oued Meliz (Tunisia) (Table 8.2.9). The disease reaction of 12 lines was similar at all four locations except for only two lines, ILC 182 and ILC

482 that were resistant (3 rating out of the maximum of 9) at Safsaf but were susceptible (8 and 9 rating respectively) at Oued Meliz and Beja. This difference in reaction will be studied further during the 1992/93 crop season.

Table 8.2.9. Results of chickpea regional ascochyta blight trap nursery-1992 (CPBTN-92)

Entry	Ascochyta Blight (1-9 scale)			
	Libya	Tunisia		Morocco
	Safsaf	Beja	Oued Meliz	Douyet
Amdoun-1	6.0	9.0	9.0	7.0
ILC 72	5.0	6.0	7.0	5.0
ILC 182	3.0	5.5	9.0	5.0
ILC 191	9.0	---	---	5.0
ILC 195	2.0	5.0	5.0	5.0
ILC 200	5.0	---	---	3.0
ILC 263	8.5	9.0	9.0	8.0
ILC 482	3.0	8.0	---	5.0
ILC 484	9.0	---	9.0	5.0
ILC 1929	8.0	9.0	9.0	8.0
ILC 3279	2.5	6.0	5.0	5.0
FLIP84-72C	4.0	5.0	5.0	4.0
FLIP84-92C	3.0	3.5	4.5	5.0
PCH 46	9.0	9.0	9.0	7.0

The chickpea regional Fusarium wilt trap-nursery-1992 with 12 genotypes was grown at Beja and Mateur in Tunisia, and Guelma and Sidi Bel Abbes in Algeria. No results were obtained from Sidi Bel Abbes. At Beja, in the wilt-sick plot, variety L 550 showed 100% wilt incidence, whereas Annegeri and Chaffa only 15%. At Mateur, 41% wilt incidence was found in L 550 as against 29%in Annegiri and 40% Chaffa. The pathotype of <u>Fusarium oxysporum</u> f.sp. <u>ciceri</u> at both the locations was therefore similar. At

Guelma in Algeria, interestingly JG 62 showed 50% wilt incidence indicating presence of one of the four races of the wilt reported from India. Annegiri and Chaffa showed 50% wilt incidence each. The nursery with additional chickpea genotypes will be grown during the 1992/93 season.

Table 8.2.10. Results of the chickpea regional fusarium wilt nursery-1992 (CFWIN-92).

Variety	Wilt incidence (%)		
	Tunisia		Algeria
	Beja	Mateur	Guelma
CPS1	0.0	0.0	0.0
C 104	NP	NP	0.0
WR 315	0.0	0.0	0.0
BG 212	0.0	0.0	0.0
C 235	0.0	0.0	0.0
JG 74	0.0	0.0	0.0
Chaffa	8.0	40.0	50.0
L 550	100.0	41.0	0.0
K 850	NP	NP	0.0
Annegeri	15.0	29.0	50.0
Amdoun 1	0.0	0.0	0.0
JG 62	0.0	0.0	0.0

NP= No plant emergence.

8.2.6.3. Lentil

The LNARYT-92 with 16 lentil lines was grown at four locations, two each in Tunisia (Beja and Oued Meliz) and Morocco (Jemaa Shaim and Merchouch) (Table 8.2.11). The best mean yield across locations was obtained from Beja (2056 kg/ha) followed by Oued Meliz (1346 kg/ha), Marchouch (1054 kg/ha) with least at Jemaa Shaim (886 kg/ha). The lines common in the best five yielders at different locations were ILL 6002, -6001, -6209,

Table 8.2.11. Results of the lentil North African regional yield trial-1992 (LNARYT-92).

Line	Yield (kg/ha)				
	Tunisia		Morocco		Mean
	Beja	Oued Meliz	J. Shaim	Merchouch	
ILL 6001	2425	1562	680	1320	1497
ILL 6002	2982	1522	960	1310	1694
ILL 6209	2700	1428	530	510	1292
ILL 6212	1550	1022	670	1650	1223
ILL 5700	1657	1372	1130	1260	1355
ILL 5562	1482	1377	1180	1230	1317
ILL 5883	1832	1152	640	930	1139
ILL 4605	3200	1067	780	820	1467
NYLON	1325	1255	1050	1500	1283
FLIP84-58L	2690	1772	----	----	2231
FLIP84-106L	1790	1555	960	1310	1403
FLIP87-21L	1907	1255	790	960	1228
FLIP87-20L	2590	1255	600	1070	1379
78S26002	1700	1338	1320	1360	1429
ILL 4400	1540	1317	790	630	1069
ILL 4606	1525	1288	440	50	825
FLIP86-21L	----	----	620	960	790
Mean	2056	1346	826	1054	1320
SE±	601	407	----	----	----
CV%	29	30	----	----	----

Nylon, FLIP 84-58L and 78S26002. Over the four locations across the two countries, ILL 6002 was the top yielder (1694 kg/ha) followed by ILL 6001 (1494 kg/ha), ILL 4605 (1467 kg/ha), 78S26002 (1429 kg/ha), and FLIP 84-106L (1403 kg/ha).

National Program Scientists in the Region and S.P.S. Beniwal

8.2.7. Training Activities

Different types of training opportunities provided included (i) group training at Aleppo, (ii) group training in the region, (iii) individual training at Aleppo, and (iv) participation in international conference (Table 8.2.12). A special mention may be made of the ICARDA-supported

Table 8.2.12. Type of training activities in food legumes provided by ICARDA to the national programs in North Africa, 1992.

Training	No. of participants			
	ALG	LIB	MOR	TUN
A. Group training at ICARDA HQ				
1. Insect control in legumes and cereals	1	1	-	1
2. Breeding methodology in legumes	1	1	-	-
3. Legume diseases control	1	1	-	-
4. Mechnical harvest of legumes	1	1	-	-
B. Group training in the region				
1. Winter chickpea technology transfer (SBA, Algeria)	14	3	3	3
2. Biometrics and computer use (Tunis, Tunisia)	1	1	1	1
C. Individual training	3	2	1	-
D. Participation in International Conferences				
1. International Food Legume Research Conference-II, Cairo, Egypt	2	1	4	3
2. Durable Resistance, Wegeningen, The Netherlands	-	-	-	1
Total	24	11	9	9

participation of 10 food legume scientists from the region in the Second International Food Legume Research Conference (IFLRC-II) in Cairo. Three of them were coauthors of the invited papers and five presented poters in the conference. One of the senior food legume scientists from Tunisia, Mr. H. Halila was elected to represent Near-East region in the Steering Committee of the IFLRC-III.

Opportunities for scientific interaction were provided to the food legume scientists of the region through (i) exchange of scientific visits, (ii) participation in sub-regional courses and group training courses, and international conferences, and (iii) through the regional coordination meeting.

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

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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.

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./Ph.D.	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. Elias Zerfu	M.Sc.	Haryana	Ethiopia
6. Heiko Schnell	Ph.D.	Hohenheim	Germany
7. Christiane Weigner	Ph.D.	Hohenheim	Germany
8. Marja van Hezewijk	Ph.D.	Amsterdam	The Netherlands
9. Eckhard George	Ph.D.	Hohenheim	Germany
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

* 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

Abd El Moneim, A.M. 1992. Agronomic potential of three vetches (Vicia spp.) under rainfed conditions. J. Agron & Crop Sci. (In press).

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10.2. Conference Papers

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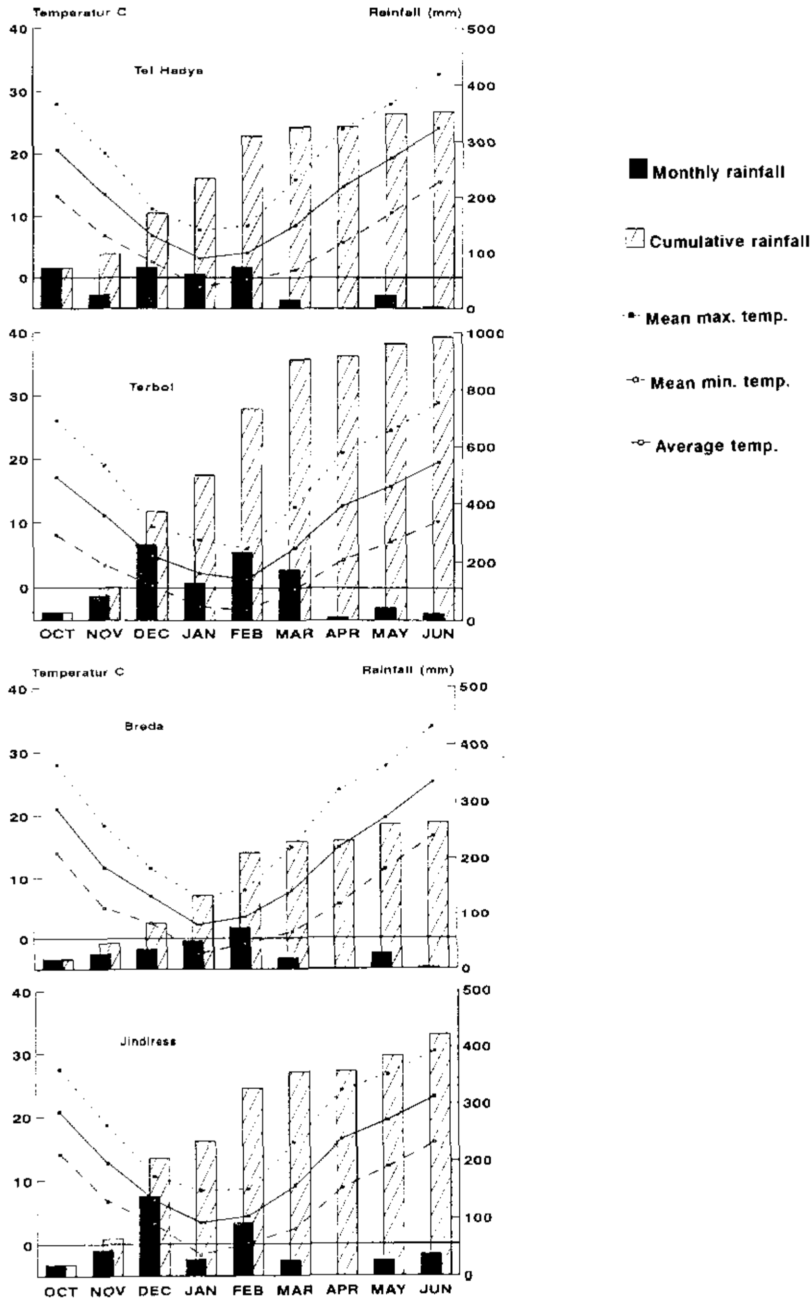
11. WEATHER DATA 1991/92



12. STAFF LIST

M.C. Saxena	Program Leader
Ali Abd El Moneim	Forage Legumes Breeder
M. Baum	Molecular Biologist
D. Beck	Microbiologist
S.P.S. Beniwal	Legume Scientist (Morocco)
W. Erskine	Lentil Breeder
M. Habib Ibrahim*	Senior Training Scientist
M.T. Mmbaga	Chickpea Pathologist
K.B. Singh**	Principal Chickpea Breeder (ICRISAT)
F. Weigand*	Consultant Molecular Biologist
S. Weigand	Entomologist
R.S. Malhotra	International Trial Scientist
Bassam Bayaa	Consultant Pathologist (University of Aleppo)
Ahmed Hamdi	Post. Doc. Fellow Lentil Breeding
B. Abu Irmaileh	Visiting Scientist Orobanche Control
Mamdouh Omar	Visiting Scientist Chickpea Breeding
Mark Ratinam	Post doc. Fellow Forage Legumes Breeding
N.P. Saxena	Visiting Scientist Crop Physiology
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Ibrahim Ammouri	Research Assistant
Suheila Arslan	Research Assistant
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Joana Haidar	Training Assistant
Samir Hajjar	Research Assistant
Hasan El-Hasan	Research Assistant
Abdulla Joubi	Research Assistant
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Murhaf Kharboutly	Research Assistant
Imad Mahmoud	Research Assistant
Hani Nakkoul	Research Assistant
Nabil Trabulsi	Research Assistant
George Zakko	Research Assistant
Riad Ammaneh	Senior Research Technician
Amir Farra	Senior Research Technician
Fadwa Khanji	Senior Research Technician
Pierre Kiwan	Senior Research Technician (Terbol)
Moaiad Lababidi	Senior Research Technician

Raafat Azzo	Research Technician
Bunian Abdel Karim	Research Technician
Aida Djanji	Research Technician
Khaled El-Dibl	Research Technician
Hani El-Derbi	Research Technician
Mohammed El-Sayed Hawilo	Research Technician
Mohammed Issa	Research Technician
M.I. El-Jasem	Research Technician
Siham Kabalan	Research Technician
Nidal Kadah	Research Technician
Joseph Karaki	Research Technician (Terbol)
Ghazi Khatib	Research Technician (Terbol)
Omar Labban	Research Technician
Muhammed Maarawi	Research Technician
Aida Naimeh	Research Technician (Terbol)
Abdel Rahim Osman	Research Technician
Diab Ali Raya	Research Technician
Hasna Boustani	Secretary
Mary Bogharian	Secretary
Kinda Butros	Secretary
Nuha Sadek	Secretary
Naaman Ajanji	Driver
Asaad Omar El-Darwish	Fieldman
Hussain El-Humeidi	Fieldman
Abdulla El-Khaled	Store Attendant

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* Left during the year

** Proceeded on sabbatical leave October 1992