GENETIC RESOURCES UNIT

Annual Report for 1994 and 1995

ICARDA

About ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA's mission is to meet the challenge posed by a harsh, stressful, and variable environment in which the productivity of winter rainfed agricultural systems must be increased to higher sustainable levels; in which soil degradation must be arrested and possibly reversed, and in which the quality of the environment needs to be assured. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility in West Asia and North Africa for the improvement of wheat, chickpea, forage and pasture—with emphasis on rangeland improvement and small ruminant management and nutrition—and of the farming systems associated with these crops.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa.

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

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

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within West Asia and North Africa, with whom ICARDA has close collaboration. Thus, the report was not prepared in accordance with the established format guidelines, nor was it edited by staff of Communications, Documentation and Information Services. Maps used in this report are intended to show only research data, and not the political boundaries.

CONTENTS

1. GENETIC RESOURCES ACTIVITIES

1.1. Introduction and highlights

This report represents work carried out at the Genetic Resources Unit (GRU) of ICARDA in the seasons 1993–94 and 1994–95. During this period the GRU continued its normal activities in germplasm collection, acquisition, characterization, preliminary evaluation, and in-depth evaluation in collaboration with ICARDA's Germplasm Program (GP) scientists and the NARS. In addition, documentation of genetic resource holdings, short-term and long-term conservation of germplasm, and distribution of germplasm sub-samples to users was also carried out. All the above mentioned activities were accomplished despite the loss of two senior staff members, i.e., cereal curator and plant taxonomist, as well as the transfer of the virologist and his support staff to the GP during these two years. These changes in the staffing of the Genetic Resources Unit are also partially responsible for the production of this combined Annual Report for the two seasons in lieu of separate ones in the past. The monthly precipitation, air temperature, and frost events for the season 1993–94 are reported in Tables A1, A2, and A3, respectively in the Appendix. And, the monthly precipitation, air temperature, and frost events for the season 1994–95 are reported in Tables A4, A5, and A6, respectively, also in the Appendix. The following are the highlights for the two years.

Germplasm exploration, collection and acquisition

In 1994 and 1995 the collecting effort in countries of the West Asia and North Africa (WANA) region and beyond continued. The major results of some of these missions are mentioned below:

1) Survey and collection trips in Syria and Lebanon revealed the alarming extent and the causes of genetic erosion in wheat wild progenitors. There is an urgent need to conserve representative populations of wild progenitors of cultivated wheats, i.e., *Triticum urartu, Triticum baeoticum, Triticum dicoccoides, Aegilops speltoides* and *Aegilops tauschii* in their natural habitat (*in-situ*).
2) Database surveys have indicated that Gaziantep Province in Southeastern Anatolia, Turkey, was very poorly represented in the global and national *ex-situ* collections of wheat wild progenitors.

Therefore, two national institutions, Aegean Agricultural Research Institute (AARI) Menemen, Izmir and Central Research Institute for Field Crops (CRIFC), Ankara together with ICARDA agreed to conduct a joint collection and survey mission to fill this gap. The United Nations Environmental Program (UNEP) provided the financial support. The exploratory mission revealed that Gaziantep province is very rich in wild progenitors of wheat and barley. The mission yielded a total of 154 bulk samples of cereal wild progenitors and relatives, the most important being 31 samples of *Triticum baeoticum*, 17 *Triticum urartu*, 18 *Triticum dicoccoides* and 7 *Triticum araraticum*. The presence of araraticum wheat populations in the southwest of Gaziantep Province is a new finding which extends the known area of the species geographical distribution. Most wild wheat populations were also sampled as single plants for genetic diversity studies (1225 single plant samples). Eleven sites were identified for possible *in-situ* conservation projects. It was concluded that the Gaziantep Province of Turkey should be considered a high priority area for wheat wild progenitors biodiversity conservation in the Fertile Crescent, the center of diploid and tetraploid wheat origin.

3) The eco-geographical surveys in Morocco and Tunisia yielded 1120 new accessions (accs.) of forage and pasture legumes and ample data on species distribution and their natural habitat characteristics. In Tunisia the survey was conducted in collaboration with NARS researchers and CLIMA (Center for Legumes in Mediterranean Agriculture, Perth, Australia) as phase II of the collaborative project. This, along with the first mission in 1992, provided coverage for the major areas of cropping in Tunisia for pasture and forage legumes from rainfalls of 200 to 1000 mm. During this mission 902 accs. from 16 genera and 71 species of pasture and forage legumes were collected at 91 sites. Two major observations were: (i) Forest areas were extremely overgrazed, with complete extinction of genetic resources of legume species. And (ii), *Hedysarum* species, especially *H. coronarium*, were common on high pH, heavy clay vertisols (40 sites) and were tolerant of heavy grazing. *H. spinosissimum* was

found in the lower rainfall areas, whereas *H. coronarium* was distributed over the full range of rainfall patterns. These species have a significant potential for both forage and pasture improvement in North Africa because of their high biomass production, large number of pods and their tolerance to overgrazing.

Lathyrus ochrus was abundant, while *L. cicera* was rare. Narbon vetch, *Vicia narbonensis*, was found concentrated in an area circling Bizarte. *Scorpiorus muricatus* and *S. vermiculatus* were common species found on the mission.

4) Collection of legume germplasm was conducted on the Indian sub-continent during 1995 to fill in gaps in the ICARDA collection. Bangladesh: A total of 138 samples were collected from 17 districts as follows: *Lathyrus* (62), lentil (39), faba bean (6), pea (21) and vetch (21). Pea samples were mostly found as weeds in lentil fields. The six accs. of faba bean (*Vicia faba*) are the first samples from Bangladesh in the ICARDA collection. They may possess some unique traits. Nepal: Over 700 samples of legumes were collected, including large seeded faba beans in the mid-hills, and small seeded ones in the 'terai' (plains adjoining the border with India). The largest number of samples collected were lentils (140), pea (116, including var. *arvense*), *Lathyrus* (90), and desi type chickpea (70). Also, a large number of pasture and forage legumes of *Vicia* and *Medicago* were collected as weeds in the pulse crop fields.

A summary of new germplasm introduced at GRU at ICARDA is given in Table 1. Reports on new germplasm collected and introduced during 1993−94 and 1994−95 is included in Section 1.2. Table A7 in the Appendix gives the status of ICARDA germplasm collections by species as of June 1994. Table A8 in the Appendix gives the status of ICARDA germplasm collections by origin as of December 1994 (with a small increase in total number of numbers during the six additional months), whereas the status of the ICARDA collections as of December 1995 are given in Table A9 in the Appendix. A summary of germplasm collections made by GRU in 1993−94 is reported in Table A10 also in the Appendix.

Table 1. Germplasm introduced at GRU/ICARDA in 1994 and 1995

Crop	Collections by GRU 1994	Collections by GRU 1995	From other sources 1994	From other sources 1995	Total 1994	Total 1995
Barley	12	7	1103	101	1115	108
Wild barley	21	53	20	11	41	64
Durum wheat	30	7	207	73	237	80
Bread wheat	25	3	40	1	65	4
Wild wheat	34	88	10	59	44	147
Aegilops	56	56	-	1	56	57
Cereals	**178**	**214**	**1380**	**246**	**1558**	**460**
Chickpea	1	2	731	160	732	162
Wild *Cicer*	-	1	7	-	7	1
Lentil	17	184	3	77	20	261
Wild *Lens*	12	49	-	-	12	49
Faba bean	15	100	2	73	17	173
Food legumes	**45**	**336**	**743**	**310**	**788**	**646**
Medicago	293	86	-	-	293	86
Vicia	240	129	-	153	240	282
Lathyrus	74	169	-	1151	74	1320
Others	577	300	8	36	585	336
Forage legumes	**1184**	**684**	**8**	**1340**	**1192**	**2024**
Grand total	**1407**	**1234**	**2131**	**1896**	**3538**	**3130**

Germplasm management including multiplication, characterization and evaluation

During the 1993–94 a total of 2281 cereal accs. from the genebank were multiplied and rejuvenated, and in the 1994-95 season a total of 3416 cereal accs. were multiplied and rejuvenated making a grand total of 5697 cereal accs. Similarly, during both seasons a total of 7901 food legumes and 4437 accs. of forage legumes were multiplied and rejuvenated (Table 2).

Table 2. Germplasm multiplication, characterization and evaluation in 1993–94 and 1994–95

	Multiplied	Characterized &/or evaluated	
Crop	**(accs.)**	**(accs.)**	**(traits)**
Barley	2223	2975	16-20
Wild barley	73	235	12
Durum wheat	2305	65	11
Bread wheat	565	159	11
Wild wheat	531	1120	15
Cereals	**5697**	**4554**	-
Chickpea	2702	270	38
Wild *Cicer*	263	260	31
Lentil	1898	345	34
Wild *Lens*	8	-	-
Faba bean	3030	-	-
Food legumes	**7901**	**875**	-
Medicago spp.	1992	1241	28
Vicia spp.	1509	2307	37-59
Lathyrus spp.	361	-	-
Trifolium spp.	192	180	6
Others	383	286	10-30
Forage legumes	**4437**	**4014**	-
Grand total	**18035**	**9443**	-

During 1994, a total of 8012 accs. of cereals and legumes were tested for viability in the germination room of GRU. During 1995, a total of 9343 barley, durum wheat, and chickpea accs. were tested for viability. The results of these tests are reported in Section 1.6. Towards the end of 1995 over 47% of the total ICARDA collection (approx. 109,000) had been tested for viability. During the two seasons 1993−94 and 1994−95 a total of 5175 cereal accs. and 3172 food and forage legume accs. were characterized and evaluated. These numbers include those accs. included in experiments on in-depth evaluation for specific traits carried out in collaboration with GP scientists.

Evaluation of single plant progenies derived from natural populations of wild einkorn, *Triticum baeoticum* and *Triticum urartu*, and wild emmer wheat *T. dicoccoides*, revealed high or moderate yellow rust resistance. In addition, all 95 wild einkorn single plant progenies were highly or moderately resistant to leaf rust. However, none of these wild material was highly resistant to stem rust. Resistance to common bunt was found in all three wild species. Accessions with multiple resistance to two or more pathogens were identified as valuable donors of genes in hybridization programs. Details of work carried out at the GRU in germplasm characterization, evaluation and utilization is reported in Section 1.3.

Germplasm conservation and distribution

The GRU at ICARDA, which is holding the mandate crop germplasm collections in trust under the auspices of the FAO, continued, through germplasm acquisition, characterization, documentation and distribution, to contribute to the global effort of conserving and utilizing plant genetic biodiversity.

For instance, a total of 2018 cereal samples were added to the genebank through collections and acquisition during 1993−94. In all during 1993−94 and 1994−95 a total of 6668 new accs. were added to the genebank. These new additions raised the Center's genebank holdings to over 111,000 accs. (Table 3).

Table 3. Status of ICARDA collections by origin (December 1995)

	Cereals	Food legumes	Forage legumes	Total
WANA	36167	17058	19286	72511
Other countries	17815	9218	7603	32397
Unknown origin	968	1766	1344	4078
TOTAL	**54950**	**28042**	**28233**	**111225**

During 1993–94 and 1994–95 more than 30,000 seed samples were distributed from ICARDA's genebank to users; out of these over 15,000 samples were distributed within ICARDA and the remaining were sent worldwide (Table 4). During 1994–95 these were despatched as follows: WANA 6859, Australia 269; USA and Canada 431; Europe 1158; and Asia (India and China) 1144. Moreover, 5000 chickpea and 1800 lentil accs. were sent to ICRISAT and NBPGR in India, respectively, for safety duplication.

Germplasm documentation and seed stock control system

Detailed information on the current status of genebank accs. is essential for their proper management. To achieve a high standard of conservation, GRU developed and added a seed stock control module to its germplasm database. It includes information on weight and number of seeds in the active and base collections; seed viability; location of the material in cold room; safety duplication in other collections; designation for conservation in the FAO network; need for testing for 'pathogen-free' and 'virus-free' status; and a record of distribution of samples to the users. During 1994 and 1995 the stock of all collections, more than 111,000 in total, was determined and computerized and distribution of samples since 1989 was registered. The software developed helps to monitor the stock and assist the genebank manager in handling seed movement. In addition, seed distribution records provide the curators with much needed information about the demand and utilization of germplasm as well as the most up-to-date information on status of collection of a particular crop type. For example, Table 5 gives the status of ICARDA's wheat genetic resources collections at the end of December 1995 which was generated from information made available from the database.

Table 4. Distribution of ICARDA's genetic resources germplasm to users in 1994 and 1995

	Cereals	**Food legumes**	**Forage legumes**	**Total**	
User	**No.**	**No.**	**No.**	**No.**	**%**[a]
WANA	4647	4672	1925	11244	34.6
	1221[c]	**3443**	**1334**	**5998**	**19.8**
ICARDA	3988	574	1679	6241	19.2
	3902	**2361**	**3171**	**9434**	**31.1**
GRU	2654	4058	3772	10483	32.3
	4114	**4577**	**3029**	**11720**	**38.6**
Total	11288	9304	7376	27968	86.2
WANA	**9237**	**10381**	**7534**	**27152**	**89.5**
Other	1378	1553	1557	4488	13.8
	856	**1833**	**491**	**3180**	**10.5**
Grand	12666	10857	8933	32456[b]	100
Total	**10093**	**12214**	**8025**	**30332**[b]	**100**

a: Percent of grand total; b: Grand total
c: Bold types are figures for 1995.

Through the use of the seed stock control system it was also easy to monitor the distribution pattern of ICARDA's genetic resources. For example, during 1993−94 a total of 32,456 seed samples from the genebank were distributed to users at ICARDA, in the West Asia and North Africa (WANA) region, and elsewhere. For more information on the seed stock control system and the genetic resources documentation system see Section 1.5.

Table 5. Database-generated summary of the ICARDA wheat genetic resources collection (as of December 1995)

Wheat germplasm type	ICARDA collected	ICARDA breeders' lines	Total No. of accs.
CULTIVATED SPP.			
Durum wheat	438	1961	18028*
Bread wheat	470	1607	7811*
Triticum spp. (primitive)			468*
Subtotal	943	3568	26307*
WILD SPP.			
Aegilops spp.	1730	-	2901*
Triticum spp.	441	-	1427*
Subtotal	2171	-	4328*
GRAND TOTAL	**3105**	**3568**	**30635***

NB:- * Includes accs. collected by ICARDA and breeders' lines

Genetic resources support research

New developments in two alien gene transfer projects, conducted in collaboration with the University of Tuscia, Viterbo, Italy, are described in Section 1.4.1. Both projects were carried out using cytogenetic techniques of chromosome engineering. The first one concerns the transfer into bread and durum wheat of a powdery mildew resistance gene (Pm13) derived from *Agropyron elongatum* chromosomal segment containing both the Lr19 leaf rust resistance gene and Yp, a gene for yellow flour pigmentation. The second one involved assessing genetic variability in *Triticum urartu* accs. using RFLP (Restriction Fragment Length Polymorphism) and PCR (Polymerase Chain Reaction) analysis. Both tests showed a high degree of polymorphism among the accs.

Genetic diversity within the genus *Lens* as revealed by allozyme polymorphism (Section 1.4.2.) showed that genetic diversity in cultivated lentil, *L. culinaris,* appears to be low relative to the wild species. The structure of genetic variation in *L. nigricans* suggests a complex situation and the differentiated cytotype appears to be more closely related to all the other taxa than to its conspecific.

Genetic variation in wild lentil, *Lens orientalis* ssp. *orientalis,* studied through the use of RAPDs (Section 1.4.5.) revealed that collection missions should be targeted to increase the number of accs. from genotype cluster 6 and more samples should be obtained from both northern Turkey and southwestern Turkey as these appear to have a relatively high degree of diversity. Accessions from Iran are also under-represented in the collection.

A number of other experiments relating to genetic resources support research supported by core funds as well as special project funding are reported in Section 1.4.

Seed Health Laboratory (SHL)

The SHL has met its objectives in ensuring the safe movement of germplasm during the two season, and carried out research on the improvement on the technique for detection of *Pyrenophora graminea* in barley seeds. The new blotter method (Section 1.4.8.) is simple, repeatable, rapid, economic in cost, and gives reliable results within 3 days compared to 9 days needed in the freezing blotter test recommended by the International Seed Testing Association (ISTA), Zurich, Switzerland. It reveals higher percentage of infected seeds in the same seed lot, and pathogens can be easily distinguished from the seed as saprophytic development was enormously reduced.

Training and international cooperation

A number of short courses were conducted jointly with IPGRI and the GRU of ICARDA. A specialized training course on "Pasture Forage Legumes Identification" was organized in collaboration with the Center for Legumes in Mediterranean Agriculture (CLIMA) and GRU, ICARDA in April 1995. A training course on "Collection and Conservation of Dry Land Genetic Resources" was organized jointly by UNEP, IPGRI and GRU, ICARDA in November 1995.

In addition to the above, individual training was provided to NARS scientists of WANA countries in various aspects of genetic resources conservation work. More details are provided in Section 3.1. The SHL also played a significant role in providing training. For instance, during 1993–94 three scientists from the Syrian Quarantine Department were trained at SHL on various aspects of seed health testing and field inspection. In addition, during 1994–95, in-country training courses on seed health testing were carried out in Pakistan and Egypt. More information on these training activities is reported in Section 3.2.

Details of research carried out at the Department of Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy, under the special project "**Enhancing wheat productivity in stress environments utilizing wild progenitors and primitive forms**" funded by Italy is reported in Section 1.4.1. The collaborative work is being carried out under the supervision of Dr Carla Ceoloni and Prof. Enrico Porceddu.

Research on "**Measurement of biodiversity within the genus *Lens***", funded by ODA, UK, and conducted jointly with GRU/ICARDA is reported in Sections 1.4.2., 1.4.4., and 1.4.5. This work was carried out by Ms Morag Ferguson under the supervision of Dr Larry Robertson.

Since the transfer of the Virology Laboratory to the GP there is only the Seed Health Laboratory associated (SHL) associated with the GRU. The work of the SHL in observation of quarantine regulations for in-coming and out-going seeds is reported in Section 2 and its research work in development of new methods of detection of pathogens can be found in Sections 1.4.7. and 1.4.8. The SHL operates under the supervision of Dr Ahmed El-Ahmed.

A complete list of scientific publications produced by GRU staff and their co-authors is reported under Section 4. And, lastly, the GRU staff list is to be found under Section 5.

J. Valkoun and GRU staff

1.2. New germplasm collected or introduced in 1994 and 1995

1.2.1. *Survey and collection of wild wheat biodiversity in Gaziantep province, Turkey 1995*

In response to the UNCED's Agenda 21 and the Convention on Biological Diversity (CBD) ICARDA has undertaken, in collaboration with NARS, a systematic survey, collection and description of genetic diversity of wheat's wild progenitors and closely related species in the region of their origin and maximum biodiversity, the Near East arc. To fill the gaps in the information on geographical distribution and the genebank holdings a survey and collection mission was launched in Gaziantep province, Southeast Anatolia, Turkey. The mission was conducted by ICARDA jointly with the Aegean Agricultural Research Institute (AARI), Menemen, Izmir and the Central Research Institute for Field Crops (CRIFC), Ankara, in June 1995. It was financially supported by the United Nations Environmental Program (UNEP) and the mission had the following objectives: i) to survey and collect natural populations of wild progenitors and close relatives of wheat and barley; ii) to sample natural populations of wild *Triticum* spp. for genetic diversity studies; and iii) to identify suitable populations for *in situ* conservation in the original habitat.

Ten days of survey and collection revealed that Gaziantep province is very rich in wheat and barley wild progenitors. All four wild *Triticum* species were present in a number of sites (Fig. 1). The collections resulting from the mission are summarized in Table 6. In total, 154 populations were sampled in bulk and 1225 single plants of wild wheat were collected for genetic diversity analyses. Wild *Triticum* spp. were collected from 32 sites, with altitude ranging from 465 to 1035m asl and annual rainfall ranging from 350 to 720 mm. Eight sites were identified as suitable for *in-situ* conservation of wheat and barley wild progenitors. The mission findings can be summarized in the following observations on the target species:

Triticum baeoticum

With 31 collection sites (see Table 6), it was the most abundant wild wheat in Gaziantep province. The plant prefers basaltic soils and vertisols and is not well adapted to low rainfall environments. Could be a dominant species in undisturbed habitats. High morphological diversity was found in many sites.

Triticum urartu

Shows preference for low-rainfall and disturbed habitats. Out of the 17 populations collected, only one was growing in relatively undisturbed habitat. Low variation in spike forms is typical of the Gaziantep province populations. A white-spiked race is a very successful colonizer of roadsides, field borders and ditches. It may be weedy, but this could not be verified, because the adjacent cereal fields had been harvested.

Triticum dicoccoides

It is well adapted to relatively undisturbed habitats and can become, jointly with *T. baeoticum*, a dominant species of natural grasslands. Diversity of spike colors was found in some populations but spikes were invariably glabrous, and no pubescent spikes were detected in the Gaziantep province populations.

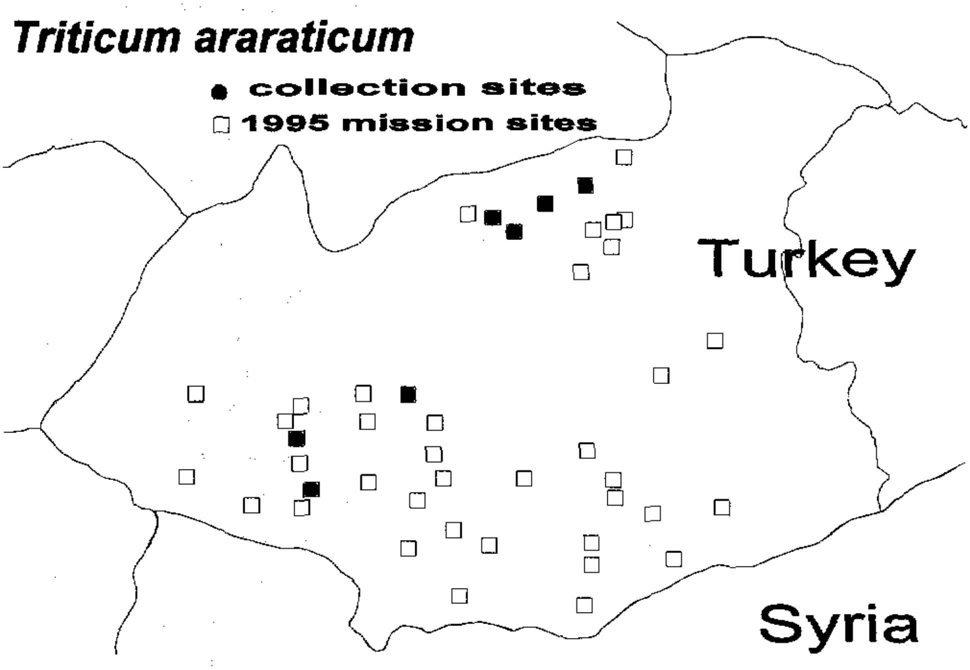

Fig. 1. Four newly discovered sites where *T. araraticum* was found in the northern part of Gaziantep province (Turkey)

Triticum araraticum

One of the major objectives of the mission was to confirm the presence of *T. araraticum* in Gaziantep province far to the west from other araraticum wheat sites. The only previously reported observation of the species is by the 1976 Japanese mission in the north of the province. The present mission not only confirmed the araraticum wheat occurrence with four new sites north of the province, but also discovered three species sites in the southwest of the province; the southernmost one is only some ten km from the Syrian border (Fig. 1). The species prefers higher rainfall habitats (all sites have more than 500 mm annual rainfall). However, it was not a dominating species on these sites. The highest morphological diversity was observed within a population in the relatively undisturbed site 35, where some plants had pubescent spikes of different color. *T. araraticum* genotypes possess a broad spectrum of disease resistance genes.

Aegilops speltoides

This species is the donor of the G genome of *T. araraticum* and *T. timopheevi* and the tentative donor of the B genome of *T. dicoccoides* and cultivated durum and bread wheats. Subspecies *speltoides* was more frequently met than ssp. *ligustica*, 23 versus 15 sites, respectively. The two subspecies seem to differ in ecological requirements. Subspecies *speltoides* can tolerate calcareous soils, while ssp. *ligustica* is not abundant in such habitat. However, the latter may dominate in grasslands on basaltic soils in sites with more than 500 mm rainfall. The best developed ligustica 'meadows' were found in the vicinity of Akcaburc village in the north of Gaziantep province.

Hordeum spontaneum

The wild progenitor of barley may be encountered in a wide range of habitats. It was the most frequent target species encountered, being present in 36 sites out of the total 44 collected. *H. spontaneum* shows preference for limestone derived soils, and is well adapted to low rainfall and low-fertility soils. It is not abundant in basaltic soil grasslands.

Table 6. Wild cereal species collected in Gaziantep province (Turkey) during the 1995 mission.

Species	No. bulk samples (populations)	No. single head samples
T. baeoticum	31	583
T. urartu	17	292
T. dicoccoides	18	290
T. araraticum	7	60
Ae. speltoides		
ssp. *speltoides*	23	-
ssp. *ligustica*	15	-
H. spontaneum	36	-
Aegilops spp.	5	-
Triticum spp.	2	-
Total	**154**	**1225**

Other cereal wild relatives

The Gaziantep province is also rich in *Aegilops* spp. In addition to *Ae. speltoides*, which was a target species, the most frequent species encountered were *Ae. triuncialis, Ae. biuncialis* and *Ae. columnaris.* Other species also found were *Ae. umbellulata, Ae. caudata* and *Ae. neglecta. Hordeum bulbosum* was ubiquitous, especially in overgrazed areas.

Conclusions

The Gaziantep Province has a large area of basaltic soils, 123 187 ha, i.e., 16.1 % of the total land. These with extensive colluvial soils (131,662 ha, 17.2 %) and sufficient rainfall (350-750 mm) provided suitable habitat for wild wheats. Natural grasslands in the north and in locations remote from villages in the south and southwest were relatively undisturbed and may be suitable for *in situ* conservation. The mission results indicate that Gaziantep province in Turkey should be considered a priority area for wheat wild progenitors biodiversity conservation in the Near East arc, the center of diploid and tetraploid wheat origin.

M. Peskircioglu and M. Begenc (AARI), J. Valkoun and B. Humeid (GRU)

1.2.2. Collecting wild relatives of wheat and barley in Lebanon 1994

The first collection mission in Lebanon took place from 21 to 23 May 1994. It was a mission of short duration and was conducted jointly by ICARDA and the Agricultural Research Institute (ARI), Tel Amara, Lebanon, with the participation of Prof. J. Giles Waines, University of California, Riverside, USA. The main objective was to complete the survey and collection of wild *Triticum* spp. in Lebanon which started in 1993. During this mission, some of the collection sites sampled in 1993 were revisited and single plants were collected for genetic diversity studies. The mission output is summarized in Table 7.

Table 7. Wild relatives of cereals and *Lens* spp. collected in Lebanon in 1994

Species	Population bulks	Single plants
Aegilops caudata	1	
Aegilops cylindrica	2	
Aegilops searsii	1	
Aegilops vavilovii	3	
Triticum baeoticum	3	77
Triticum dicoccoides	8	246
Triticum urartu	6	114
Hordeum spontaneum	5	
Lens orientalis	3	
Total	**32**	**437**

A total of 17 wild *Triticum* spp. populations were identified and collected. Among the most interesting findings was the presence of *Triticum urartu* at a very high altitude (over 1800 m asl.) where no other wheat wild relatives, including *Aegilops* spp., were found. Overgrazing is ubiquitous and the wild *Triticum* spp. populations are being rapidly eroded in the entire country. The only exceptions are *T. urartu* weedy races near Baalbek. Rachaya district in West Beka'a province is still relatively rich in wild wheat biodiversity but all populations are greatly affected by overgrazing. Nevertheless, sites 4, 6 and 7 in Rachaya district and the high altitude site 12 in the Baalbek district may still be suitable for *in situ* conservation.

As Lebanese cereal landraces were poorly represented in the ICARDA germplasm collection, a second collection mission was conducted by Agriculture Research Institute (ARI), Tel Amara, Lebanon, with ICARDA's support between 4 and 6 July 1994. The target area included Akkar, Batroun, Koura, Zgharta and Tripoli districts. In all, 12 barley, 30 durum wheat, and 25 bread wheat landrace accs. were collected during this mission.

S. Khairallah (ARI), J. Giles Waines (UC Riverside), J. Valkoun and M. Hamran (GRU)

1.2.3. Exploration and collection of wild relatives of wheat and barley in Syria 1994.

Two collection missions were conducted by a team which consisted of scientists from ICARDA, University of California - Riverside, and the Agricultural Research Center (ARC), Douma. The first mission was targeted towards the Jebel Al Arab area in southern Syria and the second mission was directed towards northeastern Syria. The output of the two missions is summarized in Table 8.

I. Mission to southern Syria

A short trip was conducted June 10-11, 1994 to survey the current status of wild wheat and barley populations in the Jebel Al Arab, Sweida Province in the south Syria and collect germplasm from new sites. In all seven "old" sites, which were sampled in 1991-1993, were inspected and 11 wild cereal populations were collected at six new sites. The highlights were:

1. A small population of *T. dicoccoides* was found in Hama province. This may be a link between wild emmer populations in Beka'a valley in the south and northern dicoccoides populations in the vicinity of Azaz, Aleppo province.
2. Extensive *T. dicoccoides* populations south of Salkhad, Sweida province seem to be relatively safe from disturbance and are, therefore, ideal for *in-situ* conservation.
3. Sympatric populations of wild wheats *Triticum urartu* and *T. dicoccoides* near Sha'af village, which were previously identified as suitable for *in-situ* conservation, are now in threatened. The long-term fallow has been mostly ploughed and the remaining stands display symptoms of overgrazing.
4. Degradation of the natural vegetation by overgrazing is ubiquitous in the area between Saleh and Mimas. There were no wild wheats to be found, only sporadic *Hordeum bulbosum* still survive and the bare land is affected by soil erosion.
5. A new site with a diversity of morphological forms of *T. dicoccoides* was found close to Busan. Plants with pubescent spike, which are rare in the Jebel Al Arab populations, were present in relatively high frequency.
6. Large and diverse populations of both *T. urartu* and *T. dicoccoides* wild wheats between Shibki and Sa'at have probably been lost. This is because of destruction of the original habitat due to fallow replacement and a large-scale soil reclamation project in which the stony uncultivated land is transformed into fields. A few plants survive in the field dividers which are, unfortunately, too narrow and heavily grazed to provide a safe refuge for the original populations.
7. A large and diverse population near Um Dubieb was found in good shape and should be considered for *in-situ* conservation.
8. A new marginal population of *T. dicoccoides* was discovered in a low-land and low-rainfall site in the vicinity of Mthuni, 11 km north of Shahba. It was sympatric with a population of *Aegilops searsii.*

II. Mission to northeastern Syria

The major objective of the mission was a search for wild *Triticum* populations which were reported from trips conducted in beginning of the 1980s but were subsequently not found in two joint ICARDA and ARC, Douma missions in 1990 and 1991 and it was feared that both *T. urartu* and *T. baeoticum* were extinct in the northeastern part of Syria. The other objective was an exploration of wild *Triticum* and *Aegilops speltoides* sites discovered last year northeast of Aleppo close to the Turkish border. In addition, the mission included a visit to the Jebel Abd Al Aziz to search for the presence of wild relatives of wheat and to an area south of Resafe, Raqqa province, to explore populations of *Aegilops tauschii*. The highlights were:

1. A new form of *T. urartu* with pubescent spikes was found near Sandi, in the north-east of Aleppo Province. This is the first report of a pubescent form in this species.
2. The other diploid wild wheat, *T. baeoticum*, was found in the same site near Sandi, for the first time in that part of Aleppo province.
3. One plant of *T. compactum*, an obsolete hexaploid wheat form, was found among durum wheat plants in a field and a single spike was collected.
4. Large populations of *Ae. speltoides* ssp. *speltoides*, as well as *Ae. triuncialis, Ae. biuncialis* and *Ae. umbellulata* were found at Tel El Hawa in the vicinity of Sandi.
5. Populations of the putative donor of the B genome of durum and bread wheats, *Ae. speltoides*, especially those of ssp. *ligustica*, the awned form, are common along the Turkish border between Ras Al Ain and Kamishli, Hassake province. Since all land there is cultivated the populations are restricted to roadside. Although the wild *Triticum* were reported from the region earlier, only a small population of *T. urartu* was found near Amouda. This is rather disappointing, because the area is adjacent to the Ceylanpinar state farm in Turkey, which was selected by the GEF project as an *in-situ* conservation area for its biodiversity of wheat wild relatives.
6. Both subspecies of *Ae. speltoides* are abundant east of Karachok. The diploid wild *Triticum* species, *T. urartu* and *T. baeoticum* are relatively frequent at Ain Diwar in the northeastern extremity of Syria and the plants were very strong and tall.

7. Five *Aegilops* species were found in the dry Jebel Abd Al Aziz. There are large populations of *Ae. crassa* and *Ae. vavilovii* on the southern slopes in the proximity of Rajem As Seeb in a six-year old almond plantation where grazing has been excluded.

Table 8. Number of populations sampled and bulk and single plant samples collected in Syria in the 1994 collection missions

Species	Populations	Bulks	Single plants
Triticum urartu	7	4	93
Triticum baeoticum	4	3	61
Triticum dicoccoides	6	1	271
Hordeum spontaneum	16	12	124
Aegilops speltoides ssp. *speltoides*	11	11	60
Aegilops speltoides ssp. *ligustica*	9	9	-
Aegilops searsii	1	-	26
Aegilops crassa	5	5	-
Aegilops vavilovii	5	5	-
Aegilops tauschii	3	2	16
Aegilops kotschyi	1	1	-
Aegilops triuncialis	8	8	-
Aegilops biuncialis	4	4	-
Aegilops umbellulata	3	3	-
Lens orientalis	1	1	-
Total	**84**	**68**	**651**

8. The presence of the D genome donor of bread wheat, *Ae. tauschii*, in a low-rainfall region south of Raqqa was confirmed and an additional site was identified almost 60 km south of the Euphrates river. Other D genome *Aegilops* species, either *Ae. crassa* or *Ae. vavilovii* or both, also occur on the tauschii sites. These *Ae. tauschii* populations represent the southwestern extremity of the geographical distribution of the species. This

unique ecotype is adapted for survival in less than 200 mm annual rainfall, winter cold and late spring high temperatures, as well as low fertility soil.

Conclusions

There is an urgent need to conserve *in-situ* representative populations of wild progenitors of cultivated wheats, i.e., *T. urartu, T. baeoticum, T. dicoccoides, Ae. speltoides* and *Ae. tauschii* in their natural habitats. Suitable sites have already been identified in Sweida and Aleppo Provinces. Additional exploration is needed to locate sites in the Anti-Lebanon mountains and Hassake Province.

Unique morpho- and eco-types of wheat wild progenitors exist within Syrian populations, which makes them globally important from the biodiversity conservation point of view. Research on genetic diversity in newly sampled populations of diploid wild wheats and D genome *Aegilops* spp. is essential for formulating a conservation strategy. More detailed exploration of the northeastern extreme of Hassake province, Karachok and the proximity of Malkie and Ain Diwar is necessary, as well as additional search for *Ae. tauschii and* other D genome *Aegilops* spp. in the steppe south of the Euphrates river.

Kh. Obari (ARC, Douma), J. Giles Waines (UC Riverside), J. Valkoun, M. Hamran and I. Abou Maizer (GRU)

1.2.4. Survey and collection of cereal wild progenitors in Jordan 1995

The mission was conducted as a joint effort of the National Center for Agricultural Research and Technology Transfer (NCARTT), Amman, Jordan, ICARDA and the United Nations Environmental Program (UNEP) to survey and conserve in Jordan drylands genetic diversity of wild progenitors and close relatives of two important cereals, wheat and barley. A total of 63 bulk and 276 single plant samples were collected during the mission. However, the most significant result of the survey was the observation of relatively large *T. dicoccoides* populations at Qasidiye in southern Jordan. This discovery moves the southern limit of the species' geographical distribution by 200 km. Moreover, these populations grow in mixed stands with *T. urartu* in the southernmost area of its geographical

distribution. On a visit to the experimental fields of the University of Jordan, Amman, twelve plants of *T. urartu* were found among a wild wheat accession (acc.) which was collected as *T. dicoccoides* at Ibeen, Irbid province. This is a first finding of the urartu wheat from northern Jordan and the acc. may be the missing link between the urartu population in the Hauran and Jebel Al Arab in southern Syria and the Qasidiye population in southern Jordan.
M. Syouf (NCARTT), J. Valkoun and B. Humeid (GRU)

1.2.5. Collecting legumes on the Indian Sub-continent 1995

A concerted effort was made to fill in the gaps in ICARDA's legume collections by undertaking collection missions to Bangladesh and Nepal, both countries known for their diversity in genetic resources of legumes. These missions were carried out in collaboration with the NARS, Bangladesh Agricultural Research Institute (BARI) and the Nepal Agriculture Research Center (NARC), respectively, and The Center for Legumes in Mediterranean Agriculture (CLIMA), Western Australia.

Bangladesh

While there has been extensive collection of khesari (*Lathyrus* spp.) and lentil in some areas of Bangladesh, researchers have recognized the need for further collections to cover areas not previously sampled and to increase the genetic variability available for crop improvement programs. Peas (*Pisum* spp.) have only been collected to a limited extent and faba bean (*Vicia* spp.) has not been previously collected in Bangladesh.

Khesari is known to have a neural toxin, Oxyalyl Diamino Propionic Acid (ODAP), responsible for the disease of lathyrism, which results in an irreversible paralysis of the limbs. There is a need for studies of why farmers grow khesari for human consumption in light of this disease, how much is consumed, in what form it is consumed, and of any special techniques used in it's preparation which may nullify or reduce the detrimental effects of the toxin.

Table 9. Distribution of germplasm of lathyrus, lentil, faba bean, pea and vetch collected during March 1995 in Bangladesh by district

District	No. thana	No. sites	Germplasm collected					
			Lath.	Lent.	FB	Pea	Vetch	Total
Dhaka	1	2	1	-	1	-	-	2
Mankiganj	2	4	4	1	1	-	1	7
Manshiganj	1	2	1	2	-	-	1	4
Comilla	1	1	1	1	-	1	-	3
Barisal	5	9	9	1	-	-	2	12
Pirojpur	1	1	1	-	-	-	-	1
Patuakhali	2	7	7	-	-	-	-	7
Borguna	2	7	7	1	-	-	1	9
Jhalakathi	1	1	1	1	-	-	-	2
Faridpur	7	21	13	18	-	5	6	42
Maguara	2	2	2	2	-	2	-	6
Gopalgonj	1	2	2	2	-	-	1	5
Rajbari	2	4	3	3	-	2	2	10
Tangail	3	5	4	4	4	-	4	16
Mymensingh	4	4	3	3	-	2	2	10
Jamalpur	2	2	2	-	-	-	-	2
Sherpur	1	1	1	-	-	-	-	1
Total	**38**	**75**	**62**	**39**	**6**	**10**	**21**	**138**

A total of 138 legume germplasm accs. of lathyrus, lentil, faba bean, pea and vetch (Table 9) were collected from 75 sites located in 17 districts with a total of 38 Thanas (district subdivisions). These districts were from three major regions: (1) South Central (Barguna, Barisal, Perojpur, Gopulganj, Patukhali, and Jhalakathi), (2) Central (Faridpur, Munshiganj, Comilla, Dhaka, Manikganj, Rajbari, and Magura), and (3) North Central (Sherpur, Jamalpur, Mymensingh, and Tangail). There were a total of 75 sites surveyed (Fig. 2). The six accs. of faba bean are the first to be collected in Bangladesh (Fig 3). They were concentrated in the Tangail district, with some found in Dhaka district as well. The majority of the accs. were of lathyrus (62) followed by lentil (39). The 21 accs. of *Vicia sativa*, with the exception of the one collected in a faba bean field, were found as weeds in lentil fields.

The faba bean germplasm collected may be unique in its characteristics as it is outside the normal range of environments the crop is normally grown in. This first ever collection of faba bean in Bangladesh may prove to be valuable germplasm for several important traits such as earliness and heat tolerance. A short, more through collection mission to cover this area of faba bean biodiversity at a later date should be considered.

Fig. 2. Distribution of legume collection sites in Bangladesh, 1995.

Lathyrus is cultivated because it can be grown in relay with rice and the farmers have no other alternative to fit into their farming system. The waterlogging tolerance of faba bean is also important for its use in farming systems in Ethiopia. Surprisingly, most farmers mentioned drought as one of their major production constraints. The total farm size varied from 0.08 to 22.26 ha with a mean size of 2.46 ha. More than 75% of the farms were of 3.15 ha or less (Fig. 4). The family size varied from 3 to 35 individuals with an average of 8.65. There was a significant positive correlation of family and farm size (r=0.43*). The number of cattle owned varied from 0 to 22 with a mean of 4 cattle per farmer. There was a highly significant correlation of family size and the number of cattle owned also (r = 0.54**).

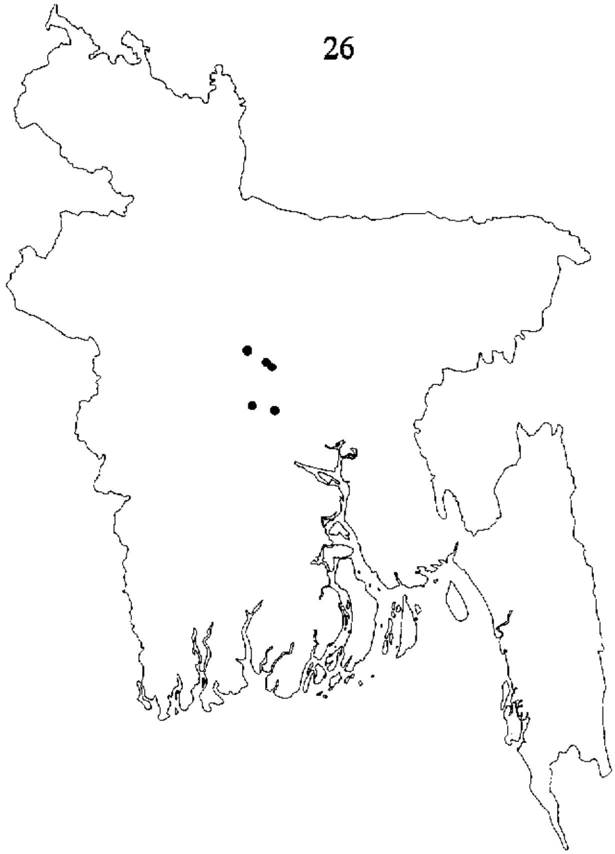

Fig. 3. Distribution of *Vicia faba* (faba bean) collection sites in Bangladesh in 1995

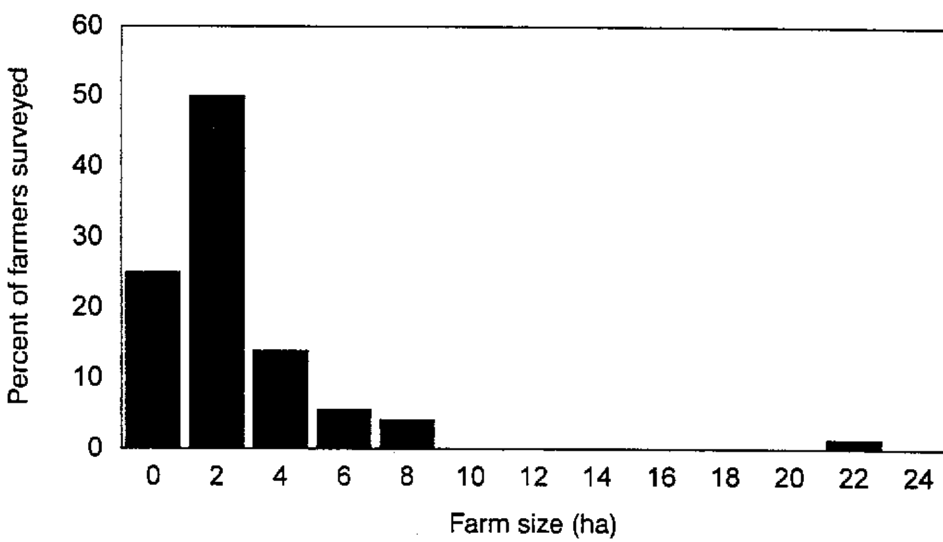

Fig. 4. Distribution of farm size of farmers surveyed during collection mission in Bangladesh in 1995

The farmers surveyed clearly do not prefer to consume lathyrus because of the ODAP toxin. They prefer to sell lathyrus for cash and buy alternative pulse crops for consumption. They did not mentioned any preferred dishes made with lathyrus. Lathyrus is commonly used as feed for large ruminants, including cows, in Bangladesh both as straw as well as grazing. There was a marked preference for lentil among the farmers and this should be investigated in urban areas. We also observed split vetch being sold as lentil.
M.A. Malek and C.D. Sarwar (BARI), L.D. Robertson (GRU), and J. Berger (CLIMA/University of Western Australia)

Nepal
In Nepal, lentil is the most important pulse with half of the area under production. *Lathyrus sativus* L., known as 'khesari' or 'latari', accounts for 11.8% of the area and 9.8% of the production of pulses. Generally, the distribution of *L. sativus* also follows that of lentil, however, it is cultivated more in the southern part, in the 'terai' towards the border with India, which remains water-logged for long periods. Lathyrus is preferred where conditions necessitate late sowing in areas with water-logged conditions. While pea is not as important crop on a national scale, it can be important in localized areas. Faba bean is grown in the mid-hills and throughout the tarai (plains). There has been some collection of lathyrus and lentil but little of pea and faba bean in Nepal. Researchers have recognized the need for further collections of all three to increase the genetic variability available for crop improvement programs.

The tarai was covered in two parts, (1) West and Far West, and (2) East and Central region. Ninety-five sites were covered by the Western group and 69 sites by the eastern group for a total of 164 sites (Fig. 5). A total of 714 accs. of legumes were collected, including cool season, tropical and forage legumes (Table 10).

Faba bean had been expected in the mid-hills where it was found. However, it was extensively distributed throughout the tarai also (Fig. 6). The largest number of accs. collected were of lentil (140 accs.) which were extensively distributed throughout the tarai. Also, lathyrus was represented by a large number of accs. (90) also distributed throughout the tarai. Pea (including var. *arvense*) was

Table 10. Distribution of pulses and other legumes collected in Nepal in 1995

Crop/Genus	No. of accs.
Faba bean	93
Lentil	140
Lathyrus	90
Pea	99
Pea (arvense)	17
Chickpea	70
Black gram	44
Mung gram	9
Pigeon pea	29
Cowpea	3
Soybean	13
Fenugreek	51
Vicia species	19
Others	19
Total	**714**

well represented in the collection with 116 accs. collected. Chickpeas (desi types) were also collected (70 accs.). A large number of pasture and forage accs. of *Vicia* spp. and medics (mostly *polymorpha* spp.) were collected as weeds in the pulse crops.

Faba bean types found in the mid-hills were the large seeded broadbean types. Small seeded faba beans were found in the tarai, with both black/purple and cream colored seed which was found in most cases as a mixture. These types are also grown in India in kitchen gardens. In most places this was the pattern of cultivation in the tarai though several large fields of the crop were also seen. Lathyrus was not commonly grown as a crop in many areas and was often collected as a weed in other pulse crops. There has been much propaganda about the crop in Nepal. Often farmers said they were apprehensive about growing the crop since they feared arrest or they felt they would not be allowed to sell the produce in the city. Several farmers had heard that lathyrus can cause paralysis and were

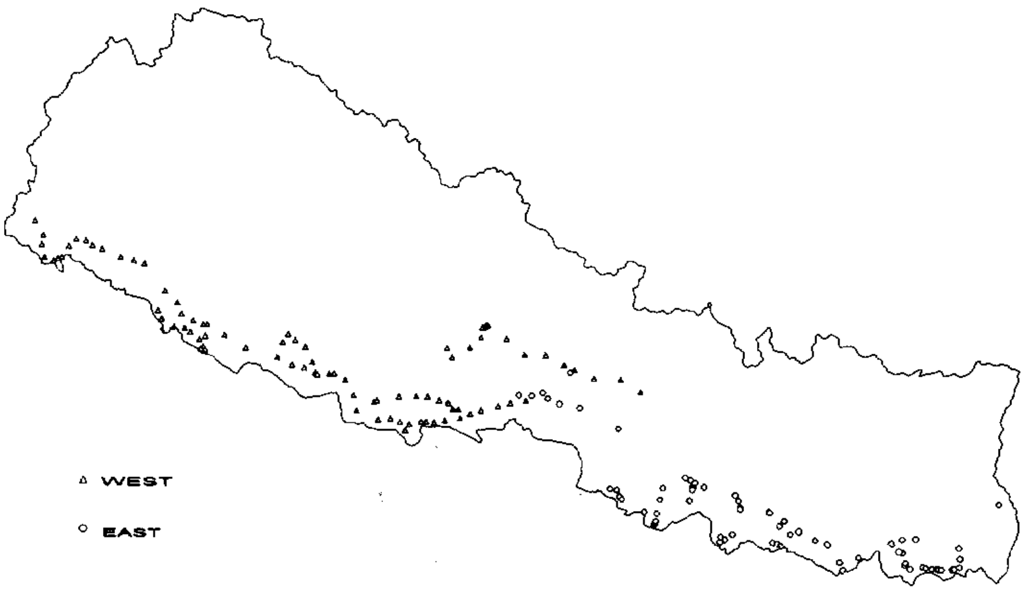

Fig. 5. Distribution of legume collection sites in Nepal, 1995

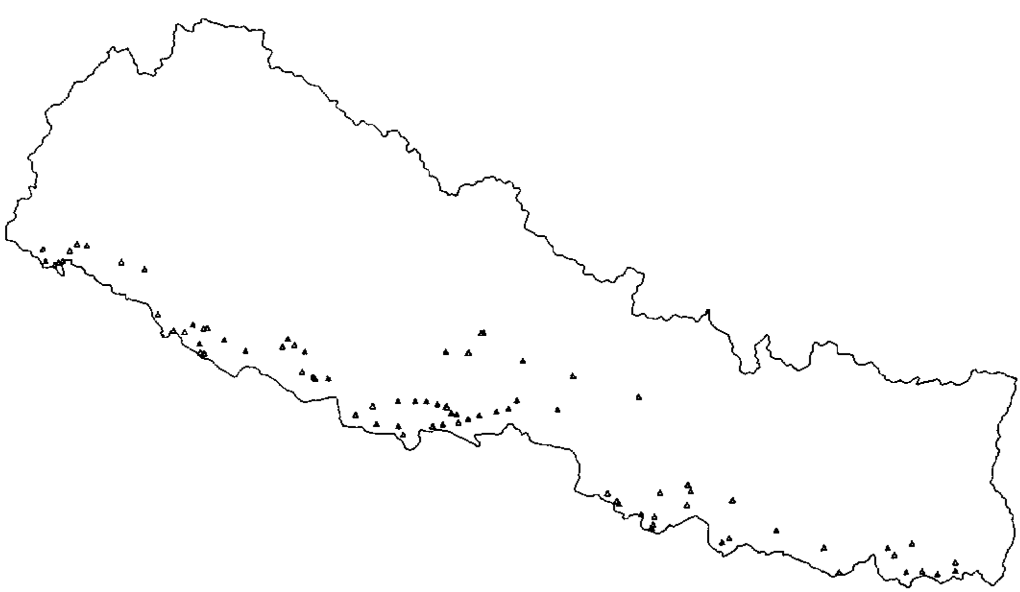

Fig. 6. Distribution of *Vicia faba* (faba bean) collection sites in Nepal, 1995

afraid to eat the crop. Also it was common to find the opinion that it causes gastric problems. The areas of lathyrus in the tarai have shrunk at a rapid pace. All pulse crops were mostly grown as mixtures of pulses and also as mixtures of pulses with linseed, mustard, and cereals. Many times a large mixture of all was seen on the threshing floors. Lentils were the most common pulse and were the most preferred for consumption. All lentil landraces collected were very small seeded.

R. Shresta (NARC), L.D. Robertson (ICARDA-GRU), C. Francis (CLIMA), C. Piggin (ACIAR), R. Pandy, M.S. Gupta, and P.K. Rana (NARC)

1.2.6. Ecogeographic survey of native pasture and forage legumes (Phase II): Northern and coastal Tunisia 1994

In 1992 the Institut National de la Recherche Agronomique, Tunisia (INRAT)-Forage Program and ICARDA-GRU had conducted a joint collection mission in central Tunisia, roughly between two lines: Sfax-Kasserine and Kef-Sousse. This mission took 12 days and resulted in 375 accs. of nearly 50 species (Table 11). Data were collected on eco-geographical descriptors, including soil characteristics determined from soil samples from each collection site. The majority of the sites (central Tunisia) are from areas of low to moderate rainfall and moderate fertility, one of the major objectives of the first phase of the collection mission.

The second phase of collection in Tunisia covered the area approximately north of the line Kef-Sousse, including the northern and eastern coasts. This, along with the first 1992 mission, provides coverage for the major areas of cropping in Tunisia for pasture and forage legumes with rainfall of 200 to 1000 mm. CLIMA developed a collaborative proposal with ICARDA, "Development and Conservation of Plant Genetic Resources for the Western Mediterranean Region" which was funded by the Australian Center for International Agricultural Research (ACIAR) to support the collection, conservation and utilization of genetic resources of forage and grain legumes in the North African region. This mission was supported by funds from the above-mentioned project.

Table 11. Pasture and forage germplasm collected in Tunisia during the 1994 mission

Taxa	No. of accs.
Anthyllis spp.	16
Astragalus hamosus	24
Astragalus sesameus	1
Astragalus spp.	3
Coronilla atlantica	1
Coronilla reponda	1
Coronilla scorpioides	7
Dactylis glomerata ssp. hispanica	1
Hedysarum coronarium	41
Hedysarum spinosissimum	7
Hippocrepis multisiliquosa	12
Hippocrepis unisiliquosa	13
Lathyrus latifolius	1
Lathyrus ochrus	31
Lathyrus spp.	1
Lotus corniculatus	5
Lotus creticus	1
Lotus edulis	31
Lotus ornithopioides	27
Lotus spp.	2
Lupinus albus	1
Lupinus pilosus	2
Lupinus spp.	1
Medicago aculeata	2
Medicago blancheana	21
Medicago intertexta ssp. ciliaris	48
Medicago intertexta ssp. intertexta	12
Medicago italica	5
Medicago laciniata	1
Medicago littoralis	7
Medicago minima	3
Medicago murex	11
Medicago murex ssp. ovata	1
Medicago noeana	1
Medicago orbicularis	9
Medicago polymorpha ssp. polymorpha	29
Medicago polymorpha ssp. vulgaris	38
Medicago rigidula	28
Medicago rugosa	3
Medicago sativa	1
Medicago scutellata	7
Medicago soleirolii	4
Medicago tornata	4
Medicago truncatula	17

Table 11. (Con'td)

Taxa	**No. of accs.**
Medicago turbinata	5
Medicago spp.	18
Melilotus infestons	1
Melilotus neopolitana	1
Melilotus sulcatus	4
Melilotus spp.	1
Pisum sativum	4
Scorpiurus muricatus	2
Scorpiurus muricatus ssp. muricatus	34
Scorpiurus muricatus ssp. sulcatus	31
Scorpiurus vermiculatus	36
Tetragonolobus purpureus	14
Trifolium alexandrinum	11
Trifolium angustifolium	9
Trifolium arvense	1
Trifolium campestre	2
Trifolium cherleri	14
Trifolium clusii	13
Trifolium fragiferum	30
Trifolium glomeratum	7
Trifolium nigrescens	1
Trifolium pratense	1
Trifolium procumbens	7
Trifolium repens	2
Trifolium resupinatum	43
Trifolium scabrum	10
Trifolium stellatum	7
Trifolium striatum	3
Trifolium subterraneum	5
Trifolium tomentosum	15
Trifolium spp.	3
Trigonella foenum-graecum	3
Trigonella maritima	1
Trigonella monspeliaca	2
Vicia laxiflora	1
Vicia lutea	2
Vicia lutea ssp. hirta	13
Vicia lutea ssp. lutea	2
Vicia monantha	2
Vicia narbonensis	16
Vicia sativa nigra	20
Vicia sativa sativa	11
Vicia spp.	18
Vicia villosa	3
Total	**375**

Objectives

1. To complete the sampling of the genetic diversity of natural populations of annual forage and pasture legumes in Tunisia with the further goal to conserve and utilize this germplasm. This willresult in a solid representation of the genetic variation available in Tunisia for the important pasture and forage legumes.
2. To relate distribution of species and genetic characteristics of forage and pasture legumes to soil, climate, and natural vegetation with a view to establishing improved pastures and forages in the farming systems of Tunisia.
3. To use ecogeographic analyses of the data collected to pinpoint areas where species are mainly distributed to provide a basis for future work on developing *in-situ* conservation.
4. Ecogeographic data will be combined with genetic diversity analyses to provide information of the relation of ecological factors on genetic diversity of various species.
5. Analyses of the ecogeographic data will be used to develop distribution maps of species with the goal to provide information to be able to select species and ecotypes for village based farmer seed production. These also will provide guidance in what to put in seed production nurseries at research stations for testing for different agriculture zones. Therefore, species and ecotypes may be selected that can be used to allow the ICARDA developed sweepers, threshers and scarifiers to have their desired impact.

The mission

Populations were collected of the important pasture and forage species at intervals of 10-20 km along a collection route in northern and coastal Tunisia during 5 to 20 June, 1994. Approximately 30-50 plants were collected per ecotype, depending on availability, to adequately sample the variation available. Emphasis was given to collecting complete passport data and accurately recording the exact location each collection site geographically by use of Global Positioning System (GPS) apparatus, and its ecological characteristics.

At each collection site data was collected on slope, aspect, altitude, and associated species. Existing climatological data will be obtained of each collection site and added to the database. The climatological data will include rainfall, minimum January temperatures and maximum June temperatures. Soil samples were taken from the top 30 cm of soil for mechanical analysis and tests of pH, $CaC0_3$, soil color, available phosphorus and total nitrogen. Seed of ecotypes collected was divided into half, one half was kept in Tunisia and the other taken to ICARDA for multiplication, evaluation and germplasm conservation. Where samples could be taken for Australia without quarantine restrictions, an additional sample was split for direct introduction into Australia.

Germplasm collected

During this mission 902 accs. of pasture and forage legumes from 16 genera and 71 species were collected. The largest number of accs. were of *Medicago* with 20 species and of *Trifolium* with 19 species. This material was collected from 91 sites in northern and coastal Tunisia (Fig 7).

Observations on genetic erosion and distribution of species

1. During the 1994 mission in Tunisia, forest areas were extremely overgrazed and no genetic resources of legumes were found.
2. In general, *Vicia* and *Lathyrus* spp. were much rarer than in Morocco because of the intensity of agricultural production with heavy use of agricultural machinery and herbicides, which has caused loss of diversity. For example, *L. cicera* and *L. sativus* were rare in both the 1992 and 1994 collection missions.
3. The areas of acid soils were few and localized, hence, species of *Lupinus* were rare and only one sample of *L. albus* and two samples of *L. pilosus* were found.
4. *Hedysarum* species, especially *H. coronarium* were common on the high pH, heavy clay vertisols (40 sites) and were tolerant of heavy grazing. The Hedysarium species were found to be sympatric with *Medicago ciliaris*. *H. spinosissimum* was found this mission and the previous mission, mostly in the lower rainfall areas (Fig. 8), whereas *H. coronarium* was distributed over the full range of rainfall. These species have a significant potential for both forage and pasture production in North Africa because of their heavy biomass production, large production of pods and their good tolerance to overgrazing.

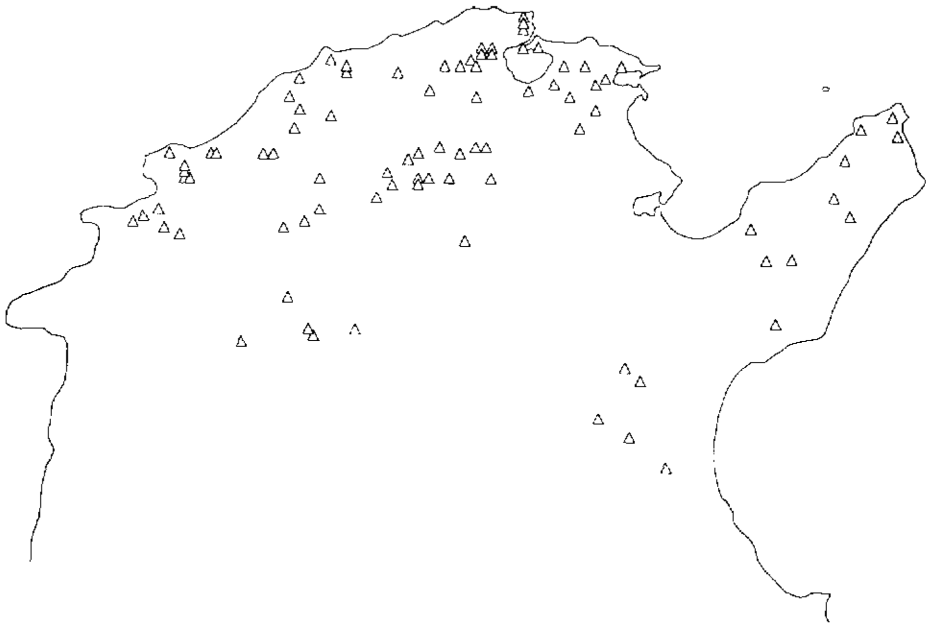

Fig 7. Distribution of legume species collection sites in Tunisia in 1994

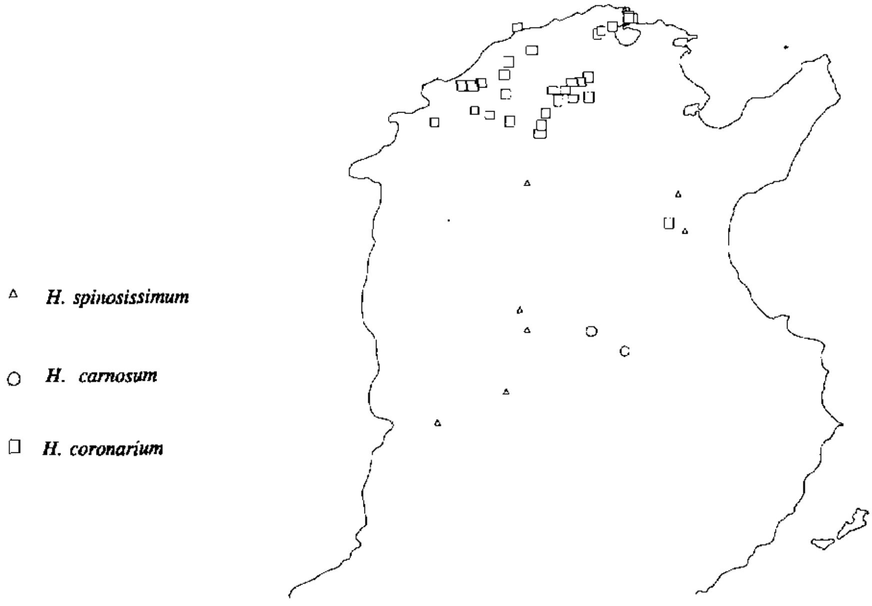

Fig. 8. Distribution of *Hedysarum spinosissimum* collection sites in Tunisia during collection missions in 1992, 1994 and 1995

5. Perennial *Trifolium* species were rare, except for strawberry clover (*T. fragiferum*), which was found at 30 sites. *T. subterraneum* was found at only four sites.
6. *V. narbonensis* was found concentrated in an area circling Bizerte (Fig. 9) with 16 accs. It was also found in north central Tunisia and close to Tabarka. *L. ochrus* was the only common species of *Lathyrus* in the northern and coastal regions (Fig. 10) and was found at 31 sites. It was much more common than in the Moroccan collecting missions of 1993 and 1994. However, *L. cicera* was not found in Tunisia in 1994 and was found at only two sites in 1992, whereas it was a common species of *Lathyrus* found in Morocco in 1993 and 1994.
7. *Scorpiurus muricatus* and *S. vermiculatus* were common dominant species in the area of the mission. These were also common in the dryer areas of the 1992 mission.

Soil samples were collected from each site and were shipped to ICARDA for analysis of their chemical and physical properties. The Tunisian counterparts agreed to collate data on rainfall, minimum January temperatures and maximum June temperatures on a long-term basis (for as long a period as possible). These data will be analyzed to determine the effect of eco-geographical factors on species distribution.

The potential of *Hedysarium* species for forage production was impressive. There is a strong case to investigate this genus in more detail. Work will be initiated at ICARDA for isolation of *Rhizobium* for *Hedysarium* this coming season. CLIMA and ICARDA will follow up to develop a special project(s) for development of this genus as a forage crop in both North Africa and Australia.

Future collection

There are two potential targets for further missions. The first would be for a specific mission to increase the number of samples of *Hedysarium* spp., especially to go further south than the original 1992 mission (south of the Sfax-Kasserine line). The second potential for further missions would be a specific mission for *Vicia* and *Lathyrus* species. Because of low rainfall, which reduced the length of the growing season, the current mission missed collecting some samples of these species due to shattering. It would be

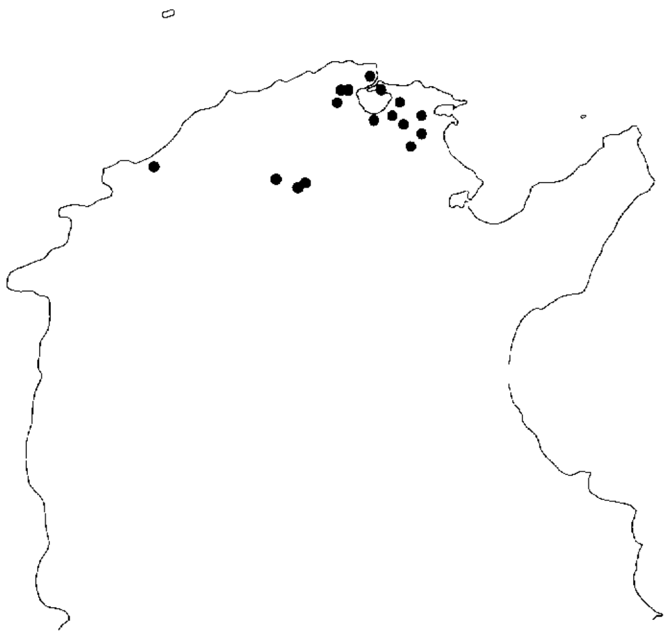

Fig. 9. Distribution of *Vicia narbonensis* collection sites in Tunisia in 1994

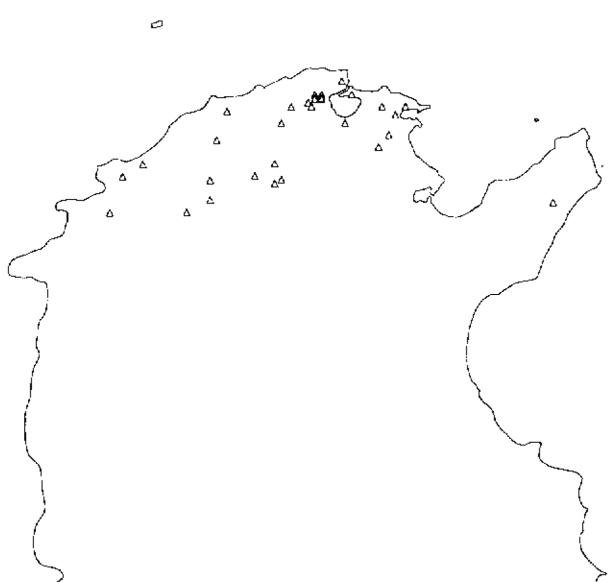

Fig. 10. Distribution of *Lathyrus ochrus* collected in Tunisia in 1994

imperative to provide funds to the Tunisian counterparts to make preliminary survey(s) and monitor the progress of the development of the season to ensure that the mission has a timely start to enable collection of these species before shattering commences.

A. Zoghlami and H. Hassan (INRAT), B. Reid (CLIMA) and L.D. Robertson (GRU)

1.2.7. Collecting legumes of economic importance in Morocco 1994

This collection tour followed the previous mission in 1993 and was designed specifically to cover those areas which, due to drought in 1993, had insufficient plant material for collection in that year. These areas were around Marrakech, Settat, Ketama, Al Hoceima, Taza and Fes. This collection focused more specifically on landraces of economically important species in North Africa such as *Lens*, *Vicia faba*, *Vicia ervilia* and *Pisum*, which are commonly harvested for grain in the regions visited.

The collections covered a total of 2400 km and rainfall regions of 270−1100 mm. In all, 62 sites were added to the previous 174 sites in eight days of collection. Two major geographical areas were involved:

1. Checaouen, Ketama, Al Hoceima, Taza and Fes (33 sites).
2. Rabat, Settat and Marrakech (29 sites).

Hand-held GPS units were used to accurately fix location of collection sites. Soil samples were routinely collected as part of an ongoing eco-geographical survey of North Africa being conducted jointly with CLIMA.

In all, 209 accs. were collected (Table 12), adding to the 450 accs. collected previously in 1993. It is easily the most comprehensive collection of Vicieae from the North African region.

Because landraces are likely to yield the most immediately useful germplasm in agronomic terms, considerably more emphasis was placed on grain legume landraces than during the 1993 collection.

As found last year, the size and complexity of the *Vicia sativa* genepool was a major feature. Landraces of grain legumes were collected from farmers' field crops or crop residues and were represented by the following species: *Vicia faba* (15 accs.), *Lens culinaris* (15 accs.), *Pisum sativum* (11 accs.), *Vicia ervilia* (15 accs.).

The Utilization and distribution of the grain legumes

Farmers in the Rif Mountains have a long tradition of using grain legumes on rotations. Of the total crop area as much as 15 to 20% appeared to be sown to legumes: *Vicia ervilia*, *Vicia faba*, *Cicer arietinum* (as a spring sown crop), *Lens culinaris* and *Pisum sativum*. Berseem clover was a forage crop used occasionally in the region. By contrast, in areas where cereal cultivation was efficient and mechanized, as around Meknes, the use of grain legumes was very restricted (perhaps 1 to 2% of crop area). This no doubt reflects the yield, cost and risk factors which in the farmer's opinion clearly favors cereals for a short term profitability.

Cereal cropping in these areas is intensive and more or less continuous. The development of higher number of more reliably yielding varieties of grain legumes must nevertheless remain a priority for these regions.

Species distribution

With exception of a small area around Chechaouen, soils were strongly alkaline and generally loams and clay loams around pH 8.5. Soils were often typically shallow and stony. Isolated patches of deeper richer soils were favored for faba beans and peas while *Vicia ervilia* was typically sown on the stony shallow soils.

Surprisingly, lentils were sown in much lower rainfall areas (5 accs. at 300 to 350 mm) and poorer soils than might have been expected for this valuable cash crop. As a consequence, many of the lentil genotypes should be both early and drought-hardy and potentially valuable.

Lathyrus cicera (9 accs.) was fairly widespread but local ecotypes seemed to shatter freely. This species nevertheless deserves further research. It is the most drought tolerant *Lathyrus* spp. and recent data (Enneking, unpublished) indicates that it is relatively low in the neuro toxin ODAP.

Lathyrus ochrus (5 accs.) was typically vigorous and an occasional contaminant of pea crops. Its vigor, seed size and grain yield suggest the species to be one of considerable promise if its inherent ODAP problems can be overcome.

Table 12. List of 209 legume accs. collected in Morocco 1994

Genus	Species	Subspecies	Accs.
Astragalus	spp.		2
Bizarrely	pelecinus		4
Cicer	arietinum		2
Hippocrepis	unisiliquosa		5
Lathyrus	angulatos		1
Lathyrus	apahaca		3
Lathyrus	cicer		9
Lathyrus	clymenum		4
Lathyrus	ochrus		4
Lathyrus	saxatilis		1
Lens	culinaris		15
Lotus	creticus		5
Lupinus	angustifolius		3
Lupinus	cosentinii		2
Medicago	orbicularis		2
Medicago	polymorpha		3
Medicago	tornata		4
Medicago	truncatula		1
Melilotus	spp.		1
Ornithopus	compressus		3
Pisum	arvense		1
Pisum	sativum		11
Scorpiurus	sulcata		1
Trifolium	alexandrinum		1
Trifolium	angustifolium		1
Trifolium	cherleri		1
Trifolium	clusii		1
Trifolium	fragiferum		2
Trifolium	isthmocarpum		6
Trifolium	repens		1
Trifolium	resupinathum		4
Trifolium	scabrum		1
Trigonella	foenum graecum		2
Vicia	ervilia		15
Vicia	faba		15
Vicia	hirsuta		1
Vicia	lathyroides		1
Vicia	lutea		7
Vicia	onobrychis		1
Vicia	sativa	sativa	24
Vicia	sativa	nigra	21
Vicia	tenuisima		1
Vicia	villosa	dasycarpa	9

Further collection

While the 1994 tour completes the originally projected plan, there is still considerable scope for collections of grain forage legumes in the Anti-Atlas mountains. The soils are typically neutral or slightly acid, and with low winter temperatures and low rainfall (<400 mm) the regions provides an opportunity for a further collection.

C. Francis (CLIMA), N. Saidi, A. Lahlou, and M. Bounejmate (INRA-Morocco), N. Maxted (University of Birmingham), S. Christansen (PFLP) and L.D. Robertson (GRU)

1.2.8. Collection of *Vicia* and other legume species in Syria 1994 (with special emphasis on *V. sativa* ssp. *amphicarpa*)

A collection mission for legumes with special emphasis on *Vicia sativa* ssp. *amphicarpa* and other species of *Vicia* was conducted in collaboration with ARC, Douma in May-June 1994. The team covered Hassakeh province, mainly in the Jabal Abdul Aziz area. A total of 104 accs. of six genera from 37 sites were collected (Table 13). The majority of these were of *Vicia* spp. (73) with approx. 30% of these being *V. sativa* ssp. *amphicarpa*. The latter accs. along with previous collections give extensive coverage in Syria of this species (Fig. 11) which has potential as a self-regenerating forage crop because of its underground pods. The collection also included *Lathyrus* spp. (20), *Lens* spp. (5), *Pisum sativum* (2), *Medicago radiata* (3) and *Lotus edulis* (1).

Kh. Obari and M. El-Khoudra (ARC, Douma), A. Shehadeh (GRU) and K. Street (GP)

1.2.9. Collection of wild lentil germplasm in Spain 1994

A collection mission was carried out, between 29 May and 12 June 1994 in collaboration with Prof. J. Cubero from the University of Cordoba to collect seed of *Lens nigricans* cytotype, a wild relatives of the cultivated lentil. It was aimed specifically at the collection of seed for the purpose of studying within population variation in order to assess the potential of *in-situ* conservation. It forms part of a larger study of variation within the genus *Lens*.

The mission was restricted to Andalucia, southern Spain and regions around Cordoba, Baena, Antequara, Ronda and Granada were visited. In total six populations were sampled. The location of the populations is shown in Fig. 12 and brief site ecology and the number of plants collected per population given in Table 14. Unfortunately, when the seeds were grown out the two seeds collected from Cabra failed to germinate. The sampling strategy was to collect dry unshattered pods from approximately 20 individual plants per population whenever possible. Seed from individual plants was kept separate to allow the study of within population variation. Soil samples were taken from each site.

Lens nigricans appears to be extremely rare and exists in small, localized populations. It is a poor competitor, found in previously disturbed habitats but which in recent years have remained undisturbed. It appears to be susceptible to grazing damage. Small plants were found in dry habitats (Lucena and Cabra), often growing close to rock outcrops. Larger plants and populations were found in locally humid habitats near Villamartin and on the Bosque river near Ubrique, often in shady areas. This region receives the highest rainfall in Spain (1000 mm). Populations were found more frequently on calcareous soils, but also on basalt (Villamartin).

M. Ferguson (GRU) and E. Hajj Moussa (University of Cordoba, Spain)

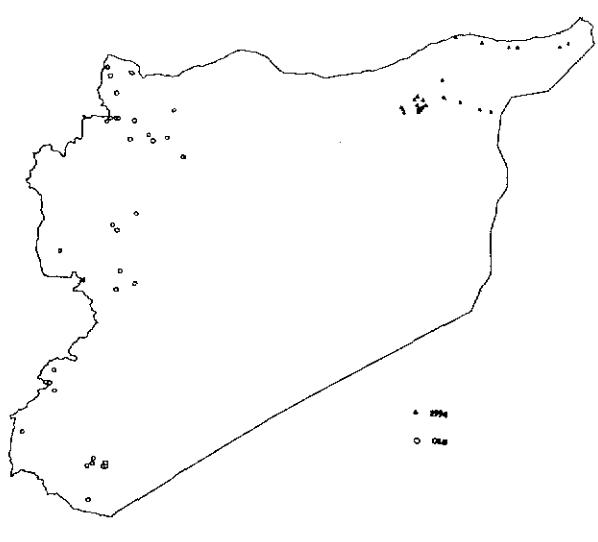

Fig. 11. Distribution of *Vicia sativa* spp. *amphicarpa* collected in Syria in 1994 and previous missions

Table 13. Legume species collected in Syria during 1994

Taxa		No. of accs.
Vicia		73*
	cuspidata	1
	ervilia	2
	monantha	19
	narbonensis	6
	sativa	1
	sativa ssp. *amphicarpa*	27
	sativa ssp. *nigra*	2
	sativa ssp. *sativa*	7
	spp.	8
Lathyrus		20*
	inconspicuus	14
	pseudocicera	5
	spp.	1
Lens		5*
	culinaris	2
	orientalis	3
Pisum sativum		2
Medicago radiata		3
Lotus edulis		1
Total		**104**

* Total no. of species collected.

1.2.10. Collection of wild lentils (*Lens* spp.) in Sweida province, Syria 1995

A mission was undertaken by ARC, Douma in collaboration with ICARDA to collect wild *Lens* species from the Sweida region, particularly around Jebel al Arab, in southern Syria. The objective was to collect *Lens culinaris* ssp. *orientalis* and *Lens odemensis* seed specifically for the study of within population variation. An understanding of within population variation is a fundamental requirement for effective conservation both *ex-situ* and *in-situ*. The mission was held over a three day period in late May 1995.

Seed from six populations of *L. odemensis* and three populations of *L. culinaris* ssp. *culinaris* was collected. The area was extensively cultivated and populations were only found on the few ungrazed rocky outcrops and field borders that still exist. They were associated with grasses and *Vicia*. Ecogeographic characters of the nine populations are summarized in Table 15.

The dry remains of a large population of *L. odemensis* was found on the clods in a recently ploughed field giving striking evidence of the threat that these wild populations face. Another extremely large population, which formed a mat of vegetation, was unfortunately sandwiched between two vineyards leaving it extremely vulnerable to the plough.

Gh. Meer Ali (ARC, Douma), M. Ferguson and A. Ismail (GRU)

Table 14. The site, site ecology and 123 plants sampled from six ecologically diverse populations in Spain during the 1994 collection mission

Site	Site ecology	Plants sampled
Villamartin	Abandoned olive orchard, locally humid	26
Ubrique	Near El Bosque river, humid, calcareous soils	30
Moron de la Frontera	Near river, humid, calcareous soils	15
Lucena	Summit of hill, arid, calcareous soils	35
Lucena	olive grove on hillside, calcareous soils	15
Cabra	Hillside, on rock, arid	2
Total		**123**

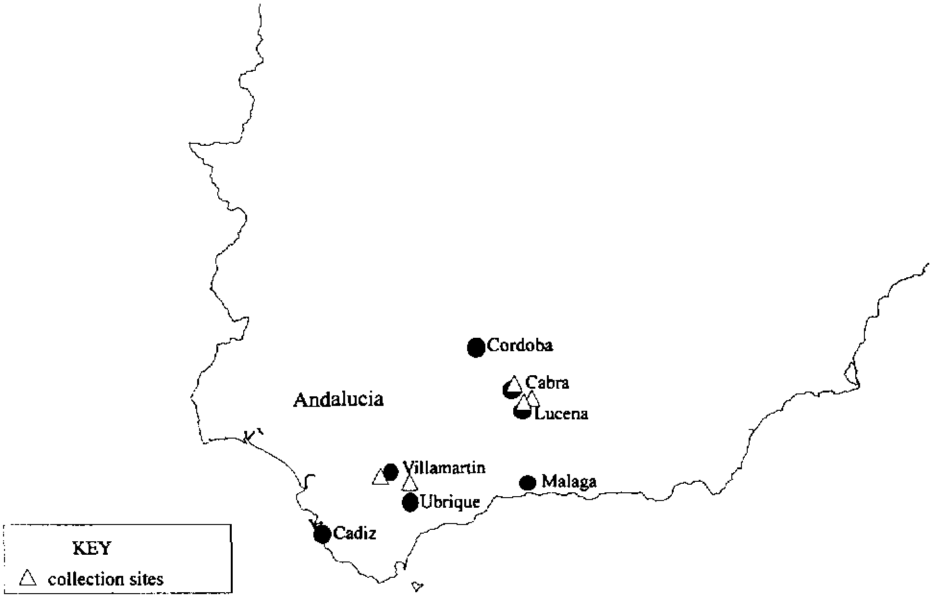

Fig. 12. Sites where *Lens nigricans* was collected in Spain in 1994

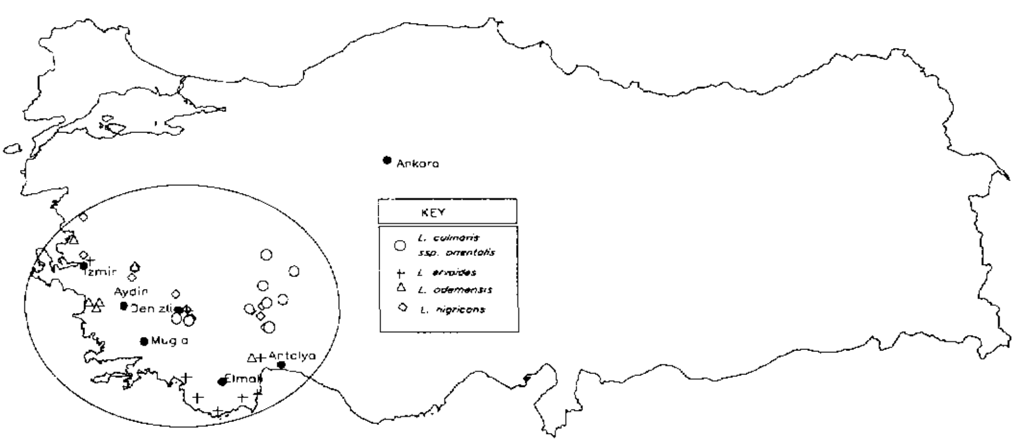

Fig. 13. Collection sites for wild *Lens* spp. in Turkey, 1995.

Table 15. Summary of ecogeographic characters of *Lens* populations located in the Sweida Region

Character	*L. odemensis*	*L. nigricans*
No. populations	6	3
Percent assoc. with grasses	100	100
Percent basalt	100	100
Slope percent > 16°	100	33
Size of area > 10 m^2	100	67
Percent clay soil	10	100
Percent rocky habitat	67	67

1.2.11. Collection and ecogeographic survey of wild *Lens* species in southwest Turkey 1995

Southwest Turkey was identified as an area of high genetic diversity for wild *Lens* taxa (ICARDA, 1992), yet this region was under-represented, in terms of the number of accs., in the ICARDA collection. It is only in Southwest Turkey that the distributions of all four wild taxa of the genus *Lens* (*L. culinaris* ssp. *orientalis*, *L. odemensis*, *L. ervoides* and *L. nigricans*) overlap. The Aegean Agricultural Research Institute (AARI), in collaboration with ICARDA, undertook an ecogeographic survey and collection missions in this region with four main objectives: i) to increase the number of accs. of each taxon conserved *ex-situ*; ii) to collect samples for the analysis of within-population variation in order to assess the potential for *in-situ* conservation; iii) to determine habitat preferences for each species and the major determinants of their distribution; and, iv) to evaluate the threat of genetic erosion to each species. An understanding of within-population variation is a fundamental requirement for *in-situ* conservation. It allows the determination of minimum population size for the conservation of genetic diversity and enables plant population dynamics to be monitored, to ensure that the genetic variation is being conserved.

A survey mission was carried out, from 23 April to 6 May 1995, to locate the populations prior to collection. When populations were located, the following site descriptors were recorded: latitude, longitude, altitude, aspect, angle of slope, water relations, parent rock, soil texture, soil depth, area over which the population was distributed, dominant species, characteristic species, plant population density, land use and grazing pressure. In addition, stage of development was noted, and herbarium specimens and rhizobium samples were taken.

Due to extreme variation in development of different populations in different environments, two collections missions were undertaken. The first from 28 May to 7 June 1995 and the second from 14 to 20 June 1995. Seeds were collected from between 20 and 30 individual plants of each population. Seed from each plant was kept separately for the measurement of within-population variation. A bulk sample was also taken.

Genebank additions and assessment of *in-situ* potential

The distribution of populations surveyed and collected is shown in Fig. 13. In total 9 populations of *Lens culinaris* ssp. *orientalis*, 8 populations of *L. ervoides*, 13 populations of *L. nigricans* and 7 populations of *L. odemensis* were located, surveyed and collected. Of these, single plant seed was collected, for diversity studies, from 8 populations of *L. culinaris* ssp. *orientalis*, 5 of *L. ervoides*, 11 of *L. nigricans* and 4 of *L. odemensis* in order to assess the potential effectiveness of *in situ* conservation for *Lens* species.

Habitat preferences

Site characteristics are listed in Table 16. All sites of *L. culinaris* ssp. *orientalis* were inland above 500 m in altitude. This was also the predominant situation with *L. nigricans*. This is in contrast to *L. ervoides*, in which only 38% of populations were found inland and above 500 m. *L. odemensis* was evenly distributed across altitude and distance from the coast. There did not appear to be any trends according to aspect, except in *L. ervoides* in which 63% of accs. were located on south-facing slopes.

All populations were found on soils that drain freely. A high proportion were on steep slopes, except for *L. culinaris* ssp. *orientalis* (33%). *L. ervoides*, *L. nigricans* and *L. culinaris* ssp. *orientalis* were found predominantly on limestone parent rock (88, 54 and 78%, respectively), thus facilitating free drainage. Most

(71%) *L. odemensis* populations were found on alluvial parent rock. A high proportion of all populations of all species were found on thin, stony soils. All *L. odemensis* populations were found on soil less than 20 cm deep.

L. ervoides and *L. nigricans* are frequently associated with woodland (88 and 69%, respectively), particularly that of *Quercus* and *Pinus*; *L. ervoides* is particularly associated with mature woodland with large, sparsely distributed pine trees often mixed with *Quercus* shrubs. *L. nigricans* on the other hand was more often associated with young pine plantations, particularly in the Burdur area. *L. culinaris* ssp. *orientalis* and *L. odemensis* are associated to a lesser extent with woodland, but are often associated with grasses, e.g., *Avena* and *Aegilops*. *L. ervoides* and *L. odemensis* were the earliest developing. This is not surprising as these two species are generally found at lower latitudes close to the coast.

The threat of genetic erosion

Parameters which may be useful in determining the relative threat of genetic erosion to a species are, firstly, the degree of association of the species with disturbed (including grazed) habitats (since habitats are becoming increasingly disturbed), and secondly, the number and size of the populations.

The low association of all species with disturbed habitats indicates their vulnerability. *L. ervoides*, *L. odemensis* and *L. culinaris* ssp. *orientalis* populations were found associated with fruit tree orchards (olive and apple) in 13, 14 and 11% of cases, respectively. Populations were never encountered in areas of moderate or intense grazing. Grazing damage was evident, however, on 38% of *L. ervoides* populations and 28% of *L. odemensis* populations. The vast majority of sites were in protected, ungrazed areas. These areas are becoming fewer and fewer. The association of *L. nigricans* with young pine forests may be purely due to the fact that these are the only relatively undisturbed, protected areas remaining. It would be useful to monitor these populations to see how they adapt as the trees get larger, and the habitat changes. It would be interesting to assess the soil seed bank in terms of *Lens* seed and also monitor the establishment of populations in newly protected areas.

Table 16. Summary of ecogeographic characters of *Lens* populations surveyed and collected in 1995

Taxon	No. populations	% coastal (<20 km from coast)	% inland (>20 km from coast)	% above 500 m	Grazing pressure (% of sites affected)	Slope >16° (%)	Parent rock		Soil type (% stony)	Soil depth < 20cm (%)
							Limestone (%)	Alluvial (%)		
L. culinaris ssp. *orientalis*	9	0	100	100	0	33	78	11	44	22
L. ervoides	8	63	38	38	38	88	88	13	63	50
L. nigricans	13	8	92	85	0	77	54	31	46	54
L. odemensis	7	57	43	42	28	100	14	71	57	100

Species	Habitat (% associated with woodland)	Dominant tree species			No. plants per population			Size of area ($<10m^2$)	Development stage (%) at survey			
		Pine	Quercus	Fruit trees (olive/apple)	<100 (%)	100-500 (%)	>500 (%)		Vegetative	Flowering	Podding	Shattering
L. culinaris ssp. *orientalis*	44	33	44	11	33	33	33	33	*0	*100	*0	*0
L. ervoides	88	75	75	13	50	50	0	25	0	25	63	13
L. nigricans	69	46	15	0	23	54	23	31	31	38	31	0
L. odemensis	43	29	43	14	57	29	14	71	0	43	57	0

* Only based on 4 of 9 accessions

Only 7 populations of *L. odemensis* were located, 71% of populations being found in an area less than 10 m^2. Two-thirds of the populations had less than 100 plants and only one had more than 500 plants. The majority of populations of the other taxa covered an area greater than 10 m^2. Only one population, of *L. culinaris* ssp. *orientalis*, covered an area greater than 100 m^2. One-third of the populations of *L. culinaris* ssp. *orientalis* had more than 500 plants, yet half of the *L. ervoides* populations had less than 100 plants and none had more than 500 plants, once again indicating a vulnerable situation. Caution should, however, be taken when using data relating to population size and number as indicators of genetic erosion as these may be natural attributes of the species in the region.

In conclusion, the number of accs. preserved *ex-situ* from this region was substantially increased. Sufficient seed was collected from each taxon, for the study of within-population diversity, in order to establish the potential of *in-situ* conservation for wild *Lens*. Based on the grazing pressure, number of populations located, area covered by each population and the number of plants per population, *L. odemensis* and *L. ervoides* are the taxa most threatened by genetic erosion.

N. Acikgoz and S. Cinsoy (AARI) and M. Ferguson and A. Ismail (GRU)

1.2.12. Collection of vetch, lathyrus and other legumes in Morocco 1995

While the 1994 collection mission completed the originally projected collection plan for Morocco for the ACIAR-funded genetic resources project, this collection mission was undertaken to collect pasture and forage species in the Anti-Atlas mountains, with special emphasis on the Vicieae species. The soils are typically neutral or slightly acid. This region also has mild winter temperatures and low rainfall (<400 mm). The agriculture is characterized by water harvesting, small fields and terracing of steep hill sides. This collection was jointly undertaken by ICARDA (Syria), INRA (Morocco) and CLIMA (Australia) from June 9 to June 15, 1995.

Area surveyed

A total area of 4000 km was surveyed. The predominant and often sole perennial woody species is the endemic *Argania spinosa*. The altitude varied from sea level to 1305m amsl and the rainfall from 150 to 400 mm. The season was extremely dry, with no rainfall until the end of February.

A total of 38 sites were sampled. Provinces collected were Safi, Essaouira, Chichaoua, Agadir, Tiznit, Chtouka Ait Baha, Marrakech and Taroudant. This mission, along with the 1993 and 1994 missions, gives good coverage of the Vicieae in Morocco (Fig. 14), whereas before the 1993 mission there were less than ten Moroccan ecotypes of the Vicieae in the Moroccan national collection and none were available in the ICARDA germplasm collection.

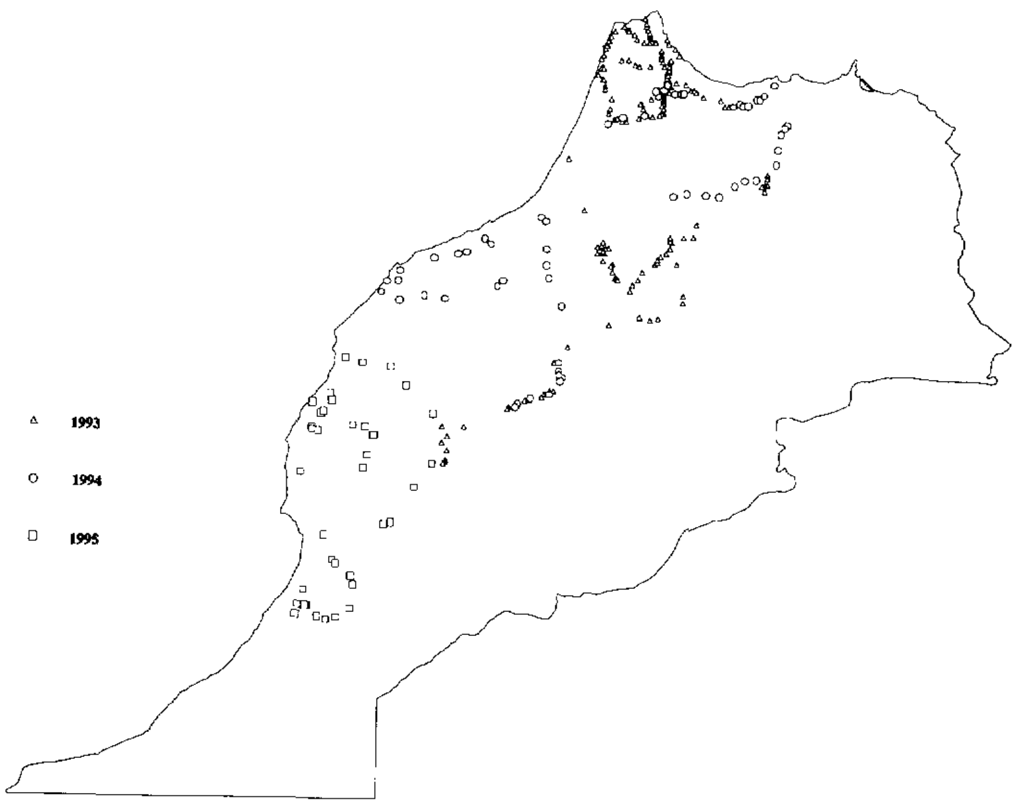

Fig. 14. Distribution of collection sites in Morocco of legumes for legume collection missions in 1993, 1994, and 1995

Table 17. Summary of legume species collected in Morocco in 1995

Taxa	No. of accs.
Astragalus	
boeticus	5
hamosus	7
intercedens	1
spp.	3
Biserrula pelecinus	2
Coronilla scorpioides	18
Hippocrepis unisiliquosa	9
Lathyrus	
aphaca	1
cicera	11
clymenum	2
Lens culinaris	1
Lotus spp.	11
Lupinus	
angustifolius	3
atlanticus	5
spp.	1
Medicago	
aculeata	10
c.v. murex	1
lacinata	10
litt. x trun.	1
littoralis	12
lupulina	1
polymorpha var. polymorpha	11
polymorpha var. vulgaris	1
tornata	1
truncatula	4
Melilotus sulcata	20
Scorpiurus	
muricatus var. muricatus	25
muricatus var. sulcatus	1
vermiculatus	1
Tetragonolobus purpureus	3
Vicia	
c.f. monantha	1
faba	2
hybrida	4
lutea	2
lutea var. hirta	6
monantha	20
sativa ssp. amphicarpa	1
sativa ssp. nigra	11
sativa ssp. sativa	18
villosa	3
spp.	1
Unknown	2
Total	**255**

Species collected

Over the course of the mission, around 255 accs. were collected (see Table 17) from approximately 25 taxa with about 30% of these being *Vicia* and *Lathyrus* species. Rhizobia nodules were collected from *V. monantha*, *V. sativa* ssp. *amphicarpa*, and *Lupinus atlanticus*. These will be used by the ICARDA microbiology laboratory for isolation of rhizobia and will be subsequently distributed to CLIMA and INRA.

Species adaptation

1. *Scorpiurus sulcata*, *Melilotus sulcata* and *Coronilla scorpioides* were the most common non-Vicieae species, found in 26, 20 and 18 sites, respectively.2. As in 1993 and 1994, the *Vicia sativa* complex was found to be widely spread. However, in these dry environments, *Vicia monantha* was as frequent. *Vicia monantha* appears to be tolerant of the drier conditions which was reflected in its widespread distribution in this area and its higher biomass and seed production. One acc. of *V. sativa* ssp. *amphicarpa* was found that was collected from underground pods.

3. The region covered by this mission is a potential area for the production of *V. ervilia* as this species is tolerant of low rainfalls and poor and shallow soils.

M. Bounejmate, S. Nezha, A. Lahlou (INRA), D. Enneking (CLIMA), and L.D. Robertson (GRU)

1.2.13. Collection of *Hedysarum* rhizobia in Central and Northern Tunisia 1995

Following the 1994 mission of the Institut National de la Recherche Agronomique, Tunisia (INRAT) Forage Program and ICARDA GRU in central Tunisia (1.2.6.) a second mission was planned in Tunisia in 1995 for the area approximately north of the line Kef-Sousse, including the northern and eastern coasts and resulted in 902 accs. from 16 genera and 71 species of pasture and forage legumes. Data were collected on eco-geographical descriptors, including soil characteristics determined from soil samples from each collection site. These missions provide coverage for the major areas of cropping in Tunisia for pasture and forage legumes, from rainfalls of 200 to 1000 mm. The mission in 1994 and this mission in 1995 were both supported by the collaborative project on "Development and Conservation of Plant Genetic Resources for the Western Mediterranean Region" between ICARDA and CLIMA and funded by the ACIAR.

Hedysarum coronarium was found to be common in the high pH, heavy clay vertisols in these two missions and was tolerant of heavy grazing. The *Hedysarum* spp. were found to be sympatric with *Medicago ciliaris*, *H. spinosissimum* and *H. carnosum* and were encountered mostly in the lower rainfall areas and also showed tolerance to heavy grazing. These species have a significant potential for both forage and pasture production in North Africa because of their heavy biomass production, large production of pods and their good tolerance to overgrazing.

A major problem faced with utilization of these species is the specificity of the rhizobia associated with them. Researchers have reported that strains that nodulate one species will not be effective with another and that strains from one location for a particular species are not effective with other accs. of the same species collected from different locations. When these *Hedysarum* species were grown at ICARDA for seed multiplication, no nodulation was observed for any acc.

Objective

The objective of this mission was to reconnoiter the area covered by the previous two collection missions, in 1992 and 1994, to obtain rhizobia from accs. by collection of nodules and soil directly from the root area of the species and the specific acc. concerned. These samples will be used for rhizobia isolation in the ICARDA Microbiology Laboratory and strain specificity tests will then be conducted to develop a collection of useful rhizobia for the concerned *Hedysarum* species.

The mission

During late May 1995, populations of *Hedysarum* species were sampled along the same routes taken by two previous missions. Approximately 30-50 plants were sampled per ecotype, depending on availability, to adequately sample the variation available. These accs. will be used for the strain specificity testing after isolation of rhizobia. For each acc. of *Hedysarum*, rhizobia nodules and/or soil directly from the root zone of the plant were taken for isolation of rhizobia. Coordinates from the previous missions were used to relocate sites for *Hedysarum* species using a hand-held GPS unit. Approximately half of the sites were sampled on previous missions and half were new sites for 1995.

During this mission 42 samples of three *Hedysarum* species and two samples of *Vicia narbonensis* were collected (Table 18). *V. narbonensis* was collected by the team whenever encountered because of the lack of germplasm from North Africa of this potentially important grain and feed legume species. The geographic distribution of *Hedysarum* species generally follows the previous two collections with *H. coronarium* in the north on the heavy clay soils and *H. spinosissimum* and *H. carnosum* distributed over the drier sites in the central part of Tunisia (Fig. 15). Samples of seed and rhizobia collected were obtained from these sites.

Seed collected of ecotypes was divided into half, one half was kept in Tunisia and the other taken to ICARDA for multiplication, evaluation and germplasm conservation. Nodules and soil samples for isolation of rhizobia were taken to ICARDA for isolation of rhizobia. After isolation and strain specificity tests, these will be provided to INRAT and CLIMA.

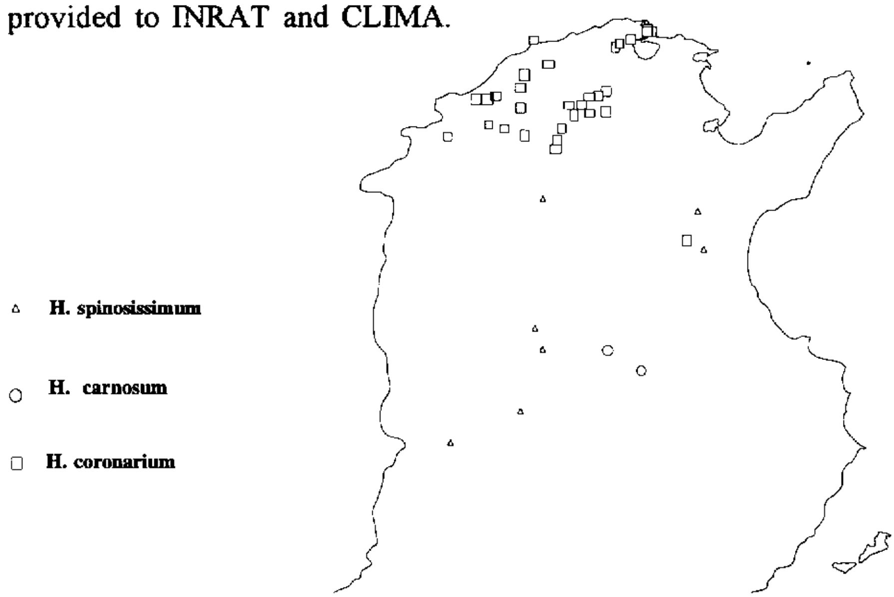

Fig. 15. Distribution of collection sites for rhizobia for *Heydsarum* spp. in Tunisia in 1995

Table 18. Distribution of *Hedysarum* spp. and *V. narbonensis* collected in Tunisia in 1995

Taxa	No. of accs.
Hedysarum carnosum	2
Hedysarum coronarium	31
Hedysarum spinosissium	9
Vicia narbonensis	2
Total	**44**

The potential of *Hedysarum* species for forage production was again impressive. There was severe drought in the central part of Tunisia, however, *H. spinosissimum* and *H. carnosum* survived the drought and the resultant heavy grazing. There is a strong case to investigate this genus in more detail and strains of rhizobia collected in this mission should enhance the utilization of this genus for pasture and forage production.

Mission follow-up

Work will be initiated at ICARDA for isolation of rhizobia for *Hedysarum* from the collected nodules and soil samples this coming season. CLIMA and ICARDA will follow up to develop a special project(s) for development of this genus as a forage crop in both North Africa and Australia. There is potential for future collection to increase the number of samples of *Hedysarum* spp., especially for *H. spinosissimum* and *H. carnosum*, south of the Sfax-Kasserine line.

A. Zoghlami and H. Hamata (INRAT) and L.D. Robertson (GRU)

1.2.14. Collecting legume germplasm in Iraq 1995

The northeastern arc of the Fertile Crescent is relatively not as well explored for plant genetic resources as the other parts. Hence when ICARDA scientist Gustave Gintzburger visited Iraq in early May 1995 he took the opportunity to collect legume germplasm with the cooperation of Sabbah Omar, Head of the National Iraqi Herbarium (NIH) and Kasim K. Kasim (IPA agronomist, forage legume evaluation). The team visited the Sinjar mountains, a crop plant diversity hot-spot, and collected 14 legume samples: *Hippocrepis*

(1), *Lathyrus* spp. (3), *lens orientalis* (1), *Medicago* Spp. (2), and *Vicia sativa* (7). However, the timing of the collecting mission was too early for that particular season and hence the two NARS scientists completed the collection later in mid-June the same year.
S. Omar (NIH, Iraq), K.K. Kasim (IPA, Iraq) and G. Gintzburger (PFLP)

1.3. Germplasm characterization, evaluation and utilization

1.3.1. Characterization of durum wheat landraces

A total of 65 accs. of durum wheat (*Triticum durum*) landraces from Iran (3), Iraq (56), Lebanon (5) and Syria (1), were planted in the post quarantine area at Tel Hadya for characterization. The landraces were planted with four standard ICARDA checks (Cham 1, Omrabi, Haurani and Senatore Cappelli) on November 23 in non-replicated two−rows plots. The plots were 1m long with row and plot distance of 0.45m and 0.9m, respectively. The materials were scored for the following characters: growth vigor, growth habit, awnedness, tillering capacity, plant height, spike density, number of days to heading, number of days to maturity, plant waxiness, 1000-kernel weight and reaction to naturally occurring yellow rust (*Puccinia striiformis* West f.sp. *tritici*) races at Tel Hadya. Results of the evaluation are shown in Table 19. The landraces from the three countries, Lebanon, Iran and Syria behaved in a similar fashion as far as heading and maturity was concerned. Materials also produced taller plants, but were later in heading and maturity than the checks Cham 1, Omrabi and Haurani, except Senatore Cappelli, a well-known Strampelli-bred Italian durum variety with medium earliness for maturity period which behaved almost identical to the test material in the three characters reported. This behavior could be due to some common genes between the landrace material and the Italian variety.

J. Valkoun and B. Humeid

1.3.2. Characterization of bread wheat landraces

A total of 159 accs. of bread wheat (*Triticum aestivum*) landraces from Iran (20), Iraq (127), Lebanon (2) and Pakistan (10) were planted in the post-quarantine area at Tel Hadya for characterization. The landraces were planted with three checks (Cham 4, Sonalika and Mexipak) on November 23, for materials originated from Iran, Lebanon, Pakistan and on December 9, for material from Iraq, in non-replicated two−row plots. The plots were 1m long with row and plot distance of 0.45m and 0.9m, respectively.

Table 19. Mean values for durum wheat landraces in 1993–94

Country/traits	Heading (days)	Maturity (days)	Plant height (cm)
Lebanon	137.0	175.0	111.6
Iran	140.0	179.0	117.3
Syria	137.0	174.0	112.0
Cham 1	122.7	164.7	76.0
Omrabi	120.7	164.7	88.7
Haurani	128.0	166.7	90.7
Senatore Cappelli	137.0	179.0	112.0

The following characters were scored: growth vigor, growth habit, awnedness, tillering capacity, plant height, spike density, number of days to heading, number of days to maturity, plant waxiness, 1000-kernel weight and yellow rust (*Puccinia striiformis* West.f.sp. *tritici*) reaction to naturally occurring races at Tel Hadya.

Preliminary results of the characterization indicated that the Iranian material had a significantly greater plant height but insignificant differences with the other material in heading and maturity when compared to the four checks (Table 20). The observations regarding the check Senatore Cappelli made above also apply here.

J. Valkoun and B. Humeid

1.3.3. Characterization of barley landraces in 1993–94

Three sets of barley (*Hordeum vulgare)* landrace nurseries for the core collection were planted during 1993–94 season. The principal objective of this study was to characterize barley landraces from different countries for building a core collection.

The first set consisted of 175 accs. (104 two–row type and 71 six–row type) coming from 13 countries (Table 21) which was planted in six rows 2m in length, with 0.45m between rows and 1.35m between plots. The following traits were scored on plot basis:

Table 20. Mean values for three important characters of agronomic importance in bread wheat landraces during the 1993–94 season

Country/traits	Heading (days)	Maturity (days)	Plant height (cm)
Lebanon	140	174	113
Pakistan	131	173	101
Iran	142	178	99
Cham 4	126	169	69
Sonalika	116	166	84
Mexipak	126	167	80

Growth habit, leaf color, growth class, powdery mildew (*Erysiphe graminis*) reaction, number of days to heading, row type, hoodedness/awnedness, awn roughness, yellow rust (*Puccinia striiformis*) reaction, leaf rust reaction, homogeneity of the plot, plant height, scald reaction, number of days to maturity, spike density and flag leaf width.

Three accs. (120789, 121659, and 120797) from the Yemen had 121 days to heading, the earliest in the group. On the other hand, three accs. (119884, 118677, and 118679) from Iran had the highest, 159 days. As can be expected the three accs. from the Yemen and Iran were also the first (161 days) and the last (196 days) to mature. However, it was observed that acc. 120797 also had the shortest plant height of only 83 cm leading to the speculation that it may be an introduced improved cultivar rather than a pure landrace. The plant height in this set of barleys ranged from 83 to 138 cm, making available a wide range of samples for this character to the breeder.

Forty-four accs. in the first set which were resistant to naturally occurring yellow rust (*Puccinia striiformis*) races at Tel Hadya and are listed in Table 22 together with their countries of origin. This resistant material will be tested in a yellow rust screening nursery in collaboration with GP to confirm the resistance in subsequent seasons.

Table 21. First set of barley accs. with their origins planted during 1993–94

Country (code)	No. of accs.
Afghanistan (AFG)	1
Algeria (DZA)	4
Egypt (EGY)	2
Iran (IRN)	13
Iraq (IRQ)	2
Jordan (JOR)	24
Libya (LBY)	28
Pakistan (PAK)	19
Tajikistan (TJK)	2
Turkmenistan (TKM)	2
Tunisia (TUN)	21
Yemen (YEM)	56
Yugoslavia (YUG)	1
Total	**175**

The second set comprised of 210 barley landraces (145 six–row type and 65 two–row type) from twenty countries which were planted in three rows 1m in length with 0.45m between rows and 1.35m between plots. This material was scored for the same traits as above except leaf rust and scald reaction. This set was unique because of the dominance of samples from the newly-independent central Asian republics (Table 23).

The summary statistics for the characters of plant height (cm), number of days to heading, and number of days to maturity is also given in Table 23. There was considerable variation for each of these three important characters. The minimum plant height in this set was 78 cm in acc. No. 115806 from Pakistan and 104089 from Tajikistan. The tallest sample was acc No. 104080 from Azerbaijan. Three accs. 115768, 111026, and 118688 from Pakistan, Saudi

Arabia, and the Sudan, respectively, had the lowest days to heading 127. The highest days to heading 165 were found in three accs. 104057, 100104, and 104833 from Afghanistan, the Ukraine, and Georgia, respectively. Two accs. No. 111026 and 118688 from Saudi Arabia and Sudan, respectively, had the lowest days to maturity, 165. However, 56 accs., Afghanistan (2), Iran (6), Pakistan (1), Turkey (28), Russia (4), Georgia (2), Turkmenistan (2), Armenia (3), Ukraine (3), Kazakstan (1), and Azerbaijan (4) had the highest days to maturity of 196.

Table 22. List of 44 barley accs. resistant to yellow rust (*Puccinia striiformis* West.f.sp. *tritici*) at Tel Hadya

Jordan	**Pakistan**	**Tunisia**	**Iran**
121646	120091	120849	118677
	107639	120851	118679
Libya	107667	120855	121649
119185	107676	120860	
120660	107679	120863	
120663	107707	120873	
120665		120878	
120666	**Yemen**	120905	
120675	121653	120919	
120683	120753	120923	
120693	120754	120928	
120695	121655	120944	
121648	112783	120948	
120713	121657	120951	
120727	121660		
	120804		

The following 188 accs in the second set were resistant to yellow rust: Afghanistan (19), Algeria (7), Cyprus (1), Egypt (7), Iran (28), Pakistan (16), Saudi Arabia (2), Sudan (1), Syria (3), Turkey (64), Japan (1), Russia (7), Georgia (3), Turkmenistan (10), Uzbekistan (4), Armenia (3), Ukraine (3), Azerbaijan (5), and Kazakstan (1).

Table 23. Summary statistics for three important characters in second set of 210 barley landraces

Country of origin (country code)	No. of accs.	Plant height (cm)				Days to heading				Days to maturity			
		Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD
Afghanistan (AFG)	20	107	83	132	13	146	137	165	7	181	167	196	6
Algeria (DZA)	10	118	93	128	7	146	137	151	3	185	177	187	3
Armenia (ARM)	3	124	113	133	5	142	140	143	2	196	196	196	-
Azerbaijan (AZE)	5	115	100	140	13	142	133	151	6	191	176	196	8
Cyprus (CYP)	1	110	103	115	-	159	159	159	-	178	177	179	1
Egypt (EGY)	13	110	90	128	10	150	142	159	4	180	177	186	3
Georgia (GEO)	3	119	105	128	8	142	137	151	4	186	179	196	7
Iran (IRN)	29	111	83	143	14	137	137	137	-	184	167	196	8
Kazakstan (KAZ)	1	108	105	110	3	149	149	149	-	196	196	196	-
Kyrgyzstan (KGZ)	1	125	118	133	8	144	131	157	13	186	186	186	-
Pakistan (PAK)	19	104	78	130	12	140	123	151	12	180	167	196	6
Russia (RUS)	7	120	103	138	11	139	133	151	4	192	183	196	6
Saudi Arabia (SAU)	3	106	93	113	7	148	140	157	5	176	165	186	8
Sudan (SDN)	4	100	93	115	6	146	137	164	7	173	165	179	7
Syria (SYR)	5	107	95	123	8	149	133	159	6	180	179	186	3
Tajikistan (TJK)	2	98	78	118	18	147	133	157	12	180	179	183	2
Turkmenistan (TKM)	10	112	88	128	11	140	137	142	1	185	176	196	6
Turkey (TUR)	67	109	82	135	15	149	140	160	8	186	176	196	2
Ukraine (UKR)	3	113	90	123	11	159	145	165	6	194	179	196	6
Uzbekistan (UZB)	4	102	95	110	6	146	139	155	6	183	179	186	3
Total	**210**												

The third set comprised a total of 348 barley landraces (265 two-row type and 83 six-row type) from 10 countries: Armenia (14), Cyprus (7), Iraq (22), Lebanon (1), Morocco (149), Oman (44), Pakistan (1), Saudi Arabia (3), and Syria (106). This material was planted in two rows 2m in length, 0.45m apart, and a distance of 1.35m was maintained between adjacent plots. The traits recorded were identical to those for the second set.

There was considerable variation for characters dependent on the environment. Two landraces from Oman (acc. No. 116115 and 116117) had the minimum days to heading, 108 days. The maximum number of days to heading was 165 days for three landraces from Syria (114540, 114542, and 114544). The minimum number of days to maturity was 164 days for 15 landraces including one each from Saudi Arabia (111026) and Morocco (115004) and the rest from Oman (115956, 115957, 115958, 115086, 116086, 116093, 116102, 116103, 116114, 116115, 116116, 116117, 116119, and 116121). It is important to note from breeding point of view that Omani material matured even before some of the Syrian material had headed. The maximum number of days to maturity was for a Syrian landrace (114526). The minimum plant height was 80 cm for a sample from Syria 115932 and the maximum was 133 cm for Armenia (100095, 100098, 109380), China (109371) and Morocco (115017).

There were 321 accs. in the third set which were resistant to yellow rust: Armenia (13), China (1), Cyprus (7), Iraq (22), Lebanon (1), Morocco (149), Oman (21), Pakistan (1), Saudi Arabia (1), and Syria (105).

J. Valkoun and B. Humeid

1.3.4. Evaluation of barley landraces in 1994–95

During the 1994–95 season a large set of 2242 accs. of barley landraces received or collected from different countries was planted in the post-quarantine area at Tel Hadya. The main objective of this study was to characterize the germplasm in the eco-geographical conditions of northern Syria. The material was planted in non-replicated plots in two rows of one meter each, with 0.45m between rows and 1.35m between plots. Six barley varieties with known characteristics were included as systematic checks: Tadmor, Steptoe, Harmal, Roho, Arar, and Radical. Their overall performance in comparison to the evaluated material is also given in Table 24. A number of traits were recorded on a plot basis: Growth habit, growth class, row-type, awn color, awn roughness, kernel covering, grain color, lemna color, number of days to heading, number of days to maturity, plant height, spike density, hoodedness/awnedness, lodging resistance, spikelets per spike, kernel weight, leaf color, flag-leaf width, powdery mildew reaction and grain filling period. The summary statistics for days to heading, days to maturity and plant height for this collection is given in Table 24. The mean days to heading and plant height (cm) of the 2242 barley landraces by their countries of origin is shown in Fig. 16.

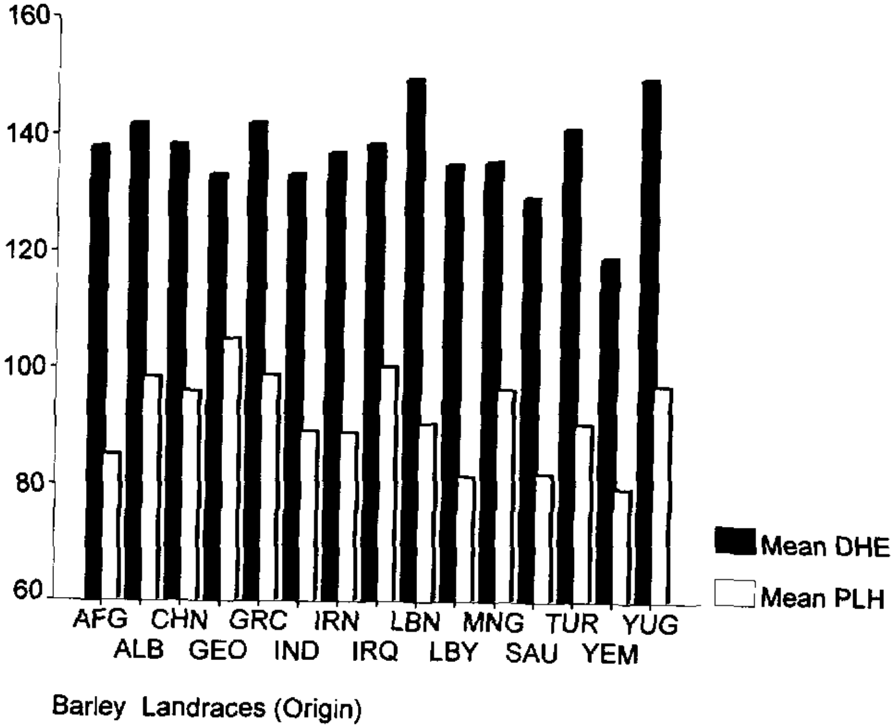

Fig. 16. Mean days to heading and plant height for 2242 accs. of barley landraces evaluated during 1994–95

Table 24. Summary statistics for three characters in 2242 barley landraces evaluated in 1994–95

Country of origin (country code)	No. of accs.	Plant height (cm)				Days to heading				Days to maturity			
		Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD
Afghanistan (AFG)	124	85	60	123	12	138	122	161	9	183	167	195	6
Albania (ALB)	35	98	70	113	10	142	125	162	11	187	171	203	7
China (CHN)	222	96	38	120	10	138	119	161	8	182	167	204	6
Georgia (GEO)	55	105	89	120	8	133	124	157	9	174	167	188	6
Greece (GRC)	444	99	70	118	8	142	122	164	9	188	173	201	5
India (IND)	43	89	70	110	11	133	115	157	11	174	167	188	7
Iran (IRN)	229	89	70	118	9	137	119	160	12	177	167	190	6
Iraq (IRQ)	34	100	80	120	9	138	124	157	9	176	167	184	6
Lebanon (LBN)	12	90	83	103	6	150	149	157	2	184	180	185	2
Libya (LBY)	234	81	43	123	16	135	119	157	7	173	165	189	5
Mongolia (MNG)	29	82	80	110	8	135	126	145	6	176	175	180	2
Saudi Arabia (SAU)	13	82	68	93	8	129	119	157	11	167	157	175	8
Turkey (TUR)	756	90	55	118	11	141	122	168	9	187	167	200	6
Yemen (YEM)	7	79	73	83	4	119	119	119	0	159	157	162	2
Yugoslavia (YUG)	5	97	88	113	9	150	143	157	7	187	185	189	2
Total	**2242**												
Checks													
Arar (6R)	17	93	85	100	5	126	124	129	2	170	167	175	4
Radical (6R)	20	79	63	88	7	152	148	157	3	185	183	188	2
Tadmor (2R)	21	80	73	90	4	129	131	138	3	173	169	180	3
Harmal (2R)	21	86	73	100	7	124	119	126	1	169	167	175	3
Roho (6R)	18	84	72	92	6	126	124	129	2	170	167	180	4
Steptoe (6R)	19	99	80	113	9	154	142	157	4	186	173	188	3

The minimum days to heading, 115, were for a landrace from India (acc. No. 102379) and the maximum was 168 (122830) for a landrace from Turkey. The minimum days to maturity was 157 for the following accs.: 122938 and 122939 (Saudi Arabia), 122941, 122951, 122952, and 122953 (Yemen). An acc. from China was the last to mature at 204 days (122143). The latter acc. also had the lowest plant height of only 38 cm, whereas the tallest accs. were 121963 (Afghanistan) and 123039 (Libya) at 123 cm.

J. Valkoun and B. Humeid

1.3.5. Characterization of wild barley

A set of 235 accs. of wild barley (*Hordeum spontaneum* L.) from 18 countries were characterized at Tel Hadya during the 1993−94 season. They were as follows: Afghanistan (3), Azerbaijan (1), China (6), Cyprus (2), Egypt (1), Iran (20), Iraq (3), Jordan (56), Libya (4), Pakistan (2), Palestine (41), Russia (2), Syria (67), Tajikistan (2), Turkmenistan (9), Turkey (6), Uzbekistan (1), and unknown origin (9). The material was planted in unreplicated experiments with 1 to 4 rows (depending on the amount of seed material available). The rows were 2m long and a distance of 0.45m was kept between rows and 1.35m between plots. The following observations were recorded: Growth habit, leaf color, growth class, number of days to heading, yellow rust reaction, flag-leaf width, powdery mildew reaction, plant height, peduncle length, peduncle extrusion, awn length and spike length.

The simple statistics of the characterization results are given in Table 25. Seven samples, 5 from Syria (acc. Nos. 180807, 180847, 180852, 180897, 180913) and one each from Afghanistan (180047) and China (181360) had the maximum 160 days to heading, whereas Acc. No. 181329 from Libya had the minimum of only 130 days. The maximum awn length of 19.7 cm was recorded in acc. No. 180743 from Palestine. The maximum peduncle length of 62 cm. was recorded in an acc. from Jordan (181215) whereas the minimum of 23 was observed in acc. 180973 from Palestine. The maximum peduncle extrusion was 32 cm for acc. 180887 from Syria and the minimum was 3 cm in acc. 180973 from Palestine. The maximum plant height of 147 cm was observed in acc. 181174 from Iran and the minimum was 74 cm in an acc. 180973 from Palestine. The maximum spike length was 17.6 cm in acc. 180084 from Pakistan whereas acc. 181186 from Iran had the lowest with only 6 cm.

Table 25. Summary statistics of 235 accs. of wild barley (*H. spontaneum*) characterized during 1993–94 season at Tel Hadya

Character[a]	Mean	Min.	Max.	SD
DHE	145	130	160	6
FLW	1.5	2.0	3.0	0
AWN	11.2	4.3	19.7	3.2
GCL	2	1	3	1
GHA	2	1	3	0
LFCO	2	1	4	1
PEDEX	17	3	32	6
PED	42	23	62	7
PLH	119	74	147	14
POM	5	3	9	1
SPL	11.8	6	17.6	1.93
YRR	2	0	9	3

[a] DHE= Days to heading; FLW= Flag-leaf width; AWN = Awn length (cm); GCL= Growth class; GHA = Growth habit; LFCO = Leaf color; PEDEX = Peduncle extrusion; PED = Peduncle length; PLH = Plant height; POM = Powdery mildew reaction; SPL = Spike length (cm); and YRR = Yellow rust reaction.

The experiment was also scored visually for resistance to naturally occurring plant pathogens such as yellow rust (*P. striiformis*) and powdery mildew (*E. graminis*). Accs. from Afghanistan, Azerbaijan, Russia, Uzbekistan, Tajikistan, and Turkmenistan did not show any symptoms of yellow rust. The sample from Egypt was completely susceptible and the rest were moderately resistant to moderately susceptible on a scale of 0 to 9; 0 = highly resistant and 9 = highly susceptible. All accs. showed symptoms of powdery mildew attack to a varying degree. However, only the acc. from Sudan was completely susceptible, whereas the rest were moderately resistant to moderately susceptible.

J. Valkoun and B. Humeid

1.3.6. Yellow rust reaction in natural populations of wild *Triticum* species in 1993−94

Wild progenitors of wheat can be donors of useful genes in wheat breeding programs because their chromosomes are homologous to those of cultivated durum and bread wheats and, consequently, a gene transfer is feasible. The wheat progenitors, wild einkorns - *Triticum urartu* and *Triticum baeoticum and* wild emmer - *Triticum dicoccoides*, have coexisted with fungal pathogens much longer than the cultigens and during that time they may have accumulated resistance genes to different diseases.

In 1993−94 season a large number of single plant progenies of wild *Triticum* spp. were planted in the field for utilization in genetic studies. As the season was favorable to yellow rust of wheat (*Puccinia striiformis* West. f.sp. *tritici*), the pathogen inoculum spread from a nearby yellow rust nursery and a heavy epiphytotic developed in the whole experimental field. This opportunity was used for a study of the natural population structure of the wild wheats in relation to the yellow rust response.

The single plant progenies were planted at Tel Hadya on 17 November 1993 in an unreplicated design with two systematic durum wheat and two bread wheat checks (Cham 1 and Haurani, and Cham 2 and Cham 4, respectively). Two−row plots were 1.5m long with 0.3m between−row and 1.2m between plot distance.

The single-plot progenies represented one population of *T. baeoticum*, 12 *T. urartu* and eight *T. dicoccoides* populations from the western part of the Fertile Crescent including provinces of Jordan (Irbid, Tafila), Syria (Aleppo, Damascus and Sweida) and Turkey (Gaziantep, Urfa). Some populations of different species were sympatric, i.e., two or three species were collected in the same site. The sympatric origin is indicated by identical superscripts at the population acronyms in Table 26.

Disease response of the single plant progenies was evaluated twice at the end April and beginning May 1994 using a scale, based on percentage coverage of a single plant progeny with rust pustules, i.e., disease severity. The scale ranged from 0 (no disease symptoms) to 9 (100 per cent of the leaf area covered with rust pustules).

The results of the evaluation, which are summarized in Table 26, indicate that a large proportion (>40%) of the single plant progenies possess resistance to yellow rust. It can be assumed that genes conferring the resistance are highly relevant to wheat breeding programs for the Near East region because the inoculum applied in the nearby infection nursery, which was the initial sources of the epiphytotic, was a mixture of local pathotypes, but also present in neighboring countries.

No conclusions can be made on species characteristics of *T. baeoticum*, since only one population was included in the analysis. However, the R and MR reactions of TB_ALP1 fit in the pattern observed by other authors, who repeatedly reported the species as being resistant to fungal diseases.

T. urartu populations display a distinct geographical pattern of diversity in the disease response. Those from Aleppo province (TU_ALP1-4) were completely resistant to yellow rust, since their single-plant progenies were classified either R or MR, whereas populations from Jordan and Sweida province in the south of Syria were susceptible, except TU_SWD4, which included moderately resistant progenies. Turkish populations are situated between the two extremes having intermediate reactions.

The occurrence of yellow rust resistant populations in *T. urartu* is an important finding, as the species was claimed by several authors, including Vavilov, to be highly susceptible to the disease.

The wild emmer, *T. dicoccoides*, is different from *T. urartu* in three aspects: i) no population is completely resistant; ii) the geographical pattern of the disease response is just opposite, i.e. Jordanian and south Syrian populations were more resistant than the Allepian one, in which all single-plant progenies were entirely susceptible; iii) the within-population variation in the disease severity is higher. Some populations (TD_SWD3 and TD_SWD4) include all five categories, ranging from R to S.

A rather surprising evidence was obtained from a comparison of disease reaction data of sympatric populations of different species. For example, a site 40 km north of Aleppo yielded three resistant populations of wild einkorn, TB_ALP1, TU_ALP1 (collected from the site in 1985, seven years before TU_ALP2), TU_ALP2 and the high susceptible wild emmer population TD_ALP1. The other sympatric couple, TU_SWD4 and TD_SWD5, show a similar tendency, since the former is the most resistant urartu population in Sweida *province, whereas the latter is the most susceptible* dicoccoides population (Table 26).

Single plant progenies classified either R or MR belong to three *different species and* 14 different sites distributed in diverse environments in the western part of the Fertile Crescent region. Since our previous studies revealed a high within-population genetic diversity and geographical differentiation among populations of *Triticum urartu* and *T. dicoccoides* it can be assumed that the resistant reaction may have a diverse genetic basis. Consequently, the natural populations of wild *Triticum* spp. from the center of wheat origin could be a rich sources of genes which are badly needed by breeders in their never ending race with the high variable pathogen, the yellow rust fungus.

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1.3.7. Evaluation of wild wheat relatives

Three hundred twenty-five accs. of diverse *Aegilops* spp. from 10 different countries were evaluated at Tel Hadya during the 1993 – 94 season in the isolation block as follows: Armenia (1), China (17), Greece (1), Iran (215), Iraq (25), Jordan (3), Lebanon (50), Pakistan (3),Syria (9), and unknown origin (1). This collection represents a wide spectrum of *Aegilops* sub-taxa (Table 27).

This wild germplasm was planted in non-replicated plots of 5 rows each which were 2m long. A distance of 0.45m was maintained between rows and 1.35m between adjacent plots. Four *Aegilops* spp. with known characteristics were included in the experiment systematic as checks: *Ae. vavilovii* (acc. No. 400067), *Ae. triuncialis* (400021), *Ae. searsii* (400061) and *Ae. biuncialis* (400831). A suite of qualitative and quantitative characters were evaluated on a plot basis. The descriptors were: Growth habit, early vigor, plant waxiness, leaf shape and size, leaf attitude, flag-leaf attitude, yellow rust (*Puccinia striiformis* West.f.sp. *tritici*) reaction, number of days to heading, number of tillers, number of productive tillers, plant height, spike length, flag-leaf length, flag-leaf width, and number of spikelets per spike. The summary statistics for three important characters from the breeders' point of view for wide crossing such as plant height (cm), days to flowering and spikelets per spike are given in Table 27. The bar-chart for mean days to heading for the 17 *Aegilops* species in given in Fig. 17.

The *Aegilops* spp. were also scored for reaction to naturally occurring yellow rust races at Tel Hadya. *Ae. comosa, Ae. speltoides, Ae. geniculata* and *Ae. neglecta* were completely resistant; *Ae. biuncialis, Ae. cylindrica, Ae. peregrina, Ae. columnaris, Ae. crassa,* and *Ae. juvenalis* were moderately resistant; and *Ae. caudata, Ae. searsii,* and *Ae. kotschyi,* were moderately susceptible to susceptible, respectively. The most resistant accs. will be tested in a yellow rust screening nursery in collaboration with GP to confirm the resistance.

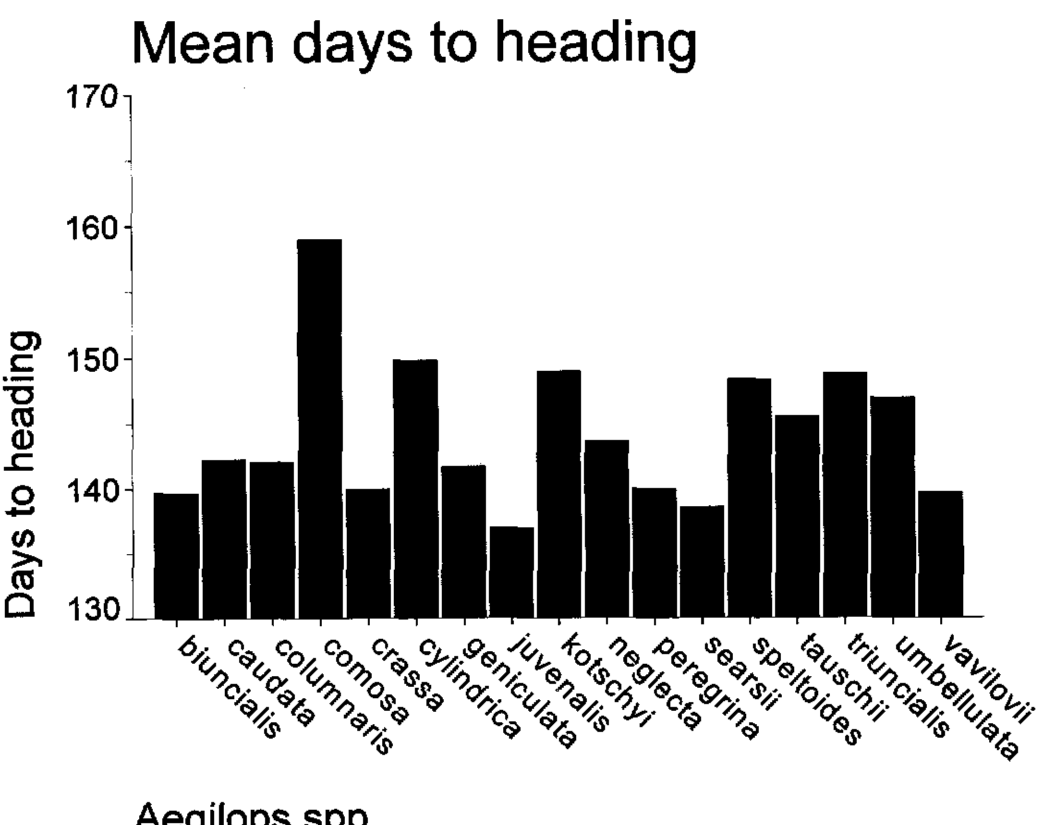

Fig. 17. Mean days to heading for 325 accs. of 17 *Aegilops* spp. from ten different countries

Table 26. Reaction of 606 single-plant progenies (SPP) derived from 21 natural populations of wild *Triticum* spp. to yellow rust of wheat at Tel Hadya during 1993–1994

Population	Yellow rust reaction						SPP
	Score	0	3	5	7	9	
	% Coverage	0	≤20	≤40	≤60	>60	
	Category	R	MR	M	MS	S	
TB_ALP1[a]		8	14	-	-	-	22
TU_TAF1		-	-	1	9	2	12
TU_TAF2		-	-	1	4	16	21
TU_SWD1		-	-	4	13	4	21
TU_SWD2		-	-	6	25		31
TU_SWD3[b]		-	-	5	21	6	32
TU_SWD4[c]			6	6	16	2	30
TU_ALP1		20	20	-	-	-	40
TU_ALP2[a]		8	11	-	-	-	19
TU_ALP3		-	32	-	-	-	32
TU_ALP4		-	16	-	-	-	16
TU_GAZ1		-	4	19	-	-	23
TU_URF1		-	9	7	9	-	25
TD_IRB1		-	2	17	-	-	19
TD_SWD1		-	52	16	6	4	78
TD_SWD2[b]		-		2	14	22	38
TD_SWD3		6	15	7	8	4	40
TD_SWD4		9	10	6	2	3	30
TD_SWD5[c]		-	-	-	6	23	29
TD_DAM1		-	6	12	6	2	26
TD_ALP1[a]		-	-	-	-	22	22
Total		**51**	**197**	**109**	**139**	**110**	**606**

R = resistant; MR = moderately resistant; M = intermediate;
MS = moderately susceptible; S = susceptible.

[a] Population acronyms were developed in the following way - the first two letters *refer to a species and the other three to a province.*

Identical superscripts indicate sympatric populations.

Table 27. Summary statistics for three important characters in 325 *Aegilops* spp. from ten countries evaluated during 1993–94

Species	No. of accs.	Plant height (cm)				Days to flowering				Spikelets/spike			
		Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD
Ae. biuncialis	21	47	32	59	7	140	133	149	3	3.12	2.67	5.0	0.42
Ae. caudata	4	49	41	54	6	142	140	143	2	6.58	6.0	7.0	0.50
Ae. columnaris	18	42	31	54	7	142	133	151	6	5.87	4.67	8.0	0.83
Ae. comosa	1	48	48	48	-	159	159	159	-	4.0	-	4.0	4.0
Ae. crassa	27	54	43	75	10	140	133	143	3	10.44	7.0	14.0	1.55
Ae. cylindrica	56	58	45	85	9	150	142	159	4	10.78	6.33	13.7	1.25
Ae. geniculata	11	40	31	49	5	142	137	151	4	3.70	3.33	4.0	0.23
Ae. juvenalis	2	48	47	48	1	137	137	137	-	6.84	6.67	7.0	0.23
Ae. kotschyi	1	30	30	30	-	149	149	149	-	4.33	4.33	4.3	-
Ae. neglect	11	39	38	40	1	144	131	157	13	5.0	0.58	4.3	5.33
Ae. peregrina	6	47	34	60	10	140	123	151	12	5.39	4.0	7.3	1.14
Ae. searsii	3	64	54	75	5	139	133	151	4	14.17	12.7	15.3	0.79
Ae. speltoides	7	63	48	75	7	148	140	157	5	14.49	11.3	17.3	2.03
Ae. tauschii	48	54	38	72	8	146	137	164	7	13.29	9.0	16.3	2.05
Ae. triuncialis	101	52	29	75	10	149	133	159	6	5.76	4.0	7.6	0.67
Ae. umbellulata	3	36	25	43	10	147	133	157	12	5.11	5.0	5.3	0.19
Ae. vavilovii	5	59	45	73	7	140	137	142	1	11.71	9.0	13.0	1.21
Total	**325**												
Checks													
Ae. vavilovii	12	65	55	73	7	138	137	140	1	11.71	9.0	13.0	1.22
Ae. triuncialis	12	60	50	74	8	143	142	149	2	6.36	5.67	7.0	0.44
Ae. searsii	12	67	60	75	5	137	133	140	2	14.28	12.7	15.3	0.72
Ae. biuncialis	12	52	43	59	5	138	137	140	1	2.83	2.67	3.0	0.13

Table 28. Summary statistics for 486 samples of *T. dicoccoides* from Syria (SYR) and Lebanon (LBN) for four important characters with checks Hourani (HOU) and Cham 1 (CH1)

Origin	Char.	Mean	Min.	Max.	SD
LBN	DHE	163	154	169	4
	PLH	90	57	132	11
	SPL	14.4	9.3	19.3	1.6
	SPS[a]	23.6	13.7	33.0	3.3
SYR	DHE	156	139	167	4
	PLH	99	63	145	14
	SPL	12.8	7.6	18.3	1.6
	SPS	24.5	11.0	31.0	2.7
Checks					
HOU	DHE	149	139	157	6
	PLH	102	88	115	9
	SPL	7.9	6.7	12.7	1.5
	SPS	22.7	20.3	25.0	1.6
CH1	DHE	144	139	149	4
	PLH	86	75	98	6
	SPL	8.6	7.7	11.0	1
	SPS	21.3	19.3	24.7	1.7

[a] SPS = No. of spikelets/spike

During the 1994–95 season a set of 751 entries of wild wheat relatives collected from Lebanon and Syria were planted in the post-quarantine area at Tel Hadya: *T. dicoccoides* 486, *T. baeoticum* 99, and *T. urartu* 166. This material was planted in single rows 2m long, with a distance of 0.45m between rows, and 1.35m between plots. Hourani, the local well-adapted durum wheat landrace and Cham 1, the improved durum cultivar for low rainfall areas, were used as checks in the experiment, 14 and 15 times, respectively. The following qualitative and quantitative characters were recorded: Growth habit, plant waxiness, number of days to heading, tillering capacity, leaf attitude, plant height, awn and spike length, number of spikelets per spike, glume color, awn color, glume hairiness, flag-leaf attitude, and leaf size and shape. The number of days to maturity was not recorded as the brittle spikes shatter and fall to the ground before maturity in wild *Triticum* spp.

The summary statistics for 486 samples of *T. dicoccoides* and the checks are given in Table 28. The bar-charts for days to heading, plant height (cm), spike length, and number of spikelets/spike are given in Fig. 18. The minimum days to heading for the Syrian

Table 29A. Summary statistics of 99 samples of *T. baeoticum* from Syria (SYR) and Lebanon (LBN) for four important characters with checks

Origin	Char.	Mean	Min.	Max.	SD
LBN	DHE	174	146	179	5
	PLH	125	108	150	10
	SPL	18.2	13.7	18.2	1.8
	SPS[a]	41	36	44	2
SYR	DHE	165	139	175	8
	PLH	121	75	159	15
	SPL	15.8	7	15.8	3.7
	SPS	38	19	47	8
Checks					
HOU	DHE	149	146	154	3
	PLH	114	108	123	6
	SPL	7.8	7.0	9.0	0.8
	SPS	24	20	26	2
CH1	DHE	144	139	146	4
	PLH	85	75	93	8
	SPL	9.5	8.7	10.3	0.8
	SPS	24	21	26	2

[a] = No. of spikelets/spike.

samples of *T. dicoccoides* was significantly lower than that for Lebanon. However, there is practically little difference in the maximum value for this character. The samples from Syria were, on the whole, shorter in plant height than those from Lebanon. Fifty-four single plant samples from Lebanon and 7 from Syria were found to be resistant to naturally occurring yellow rust (*Puccinia striiformis* West.f.sp. *tritici*) races at Tel Hadya, i.e., Lebanon

(601074, 601075, 601076, 601078, 601079, 601080, 601081), and Syria (601070, 601071, 601072). The summary statistics of 99 samples of *T. baeoticum* and 166 samples of *T. urartu* from Syria and Lebanon for four important characters are given in Table 29A and 29B, respectively.

Table 29B. Summary statistics of 166 samples of *T. urartu* from Syria (SYR) and Lebanon (LBN) for four important characters with checks

Origin	Char.	Mean	Min.	Max.	SD
LBN	DHE	159	149	189	5
	PLH	120	73	151	21
	SPL	15.2	10.3	15.2	1.7
	SPS[a]	37	23	43	7
SYR	DHE	161	139	169	4
	PLH	116	80	151	18
	SPL	16.2	7	24.7	3.8
	SPS	35	18	43.7	5
Checks					
HOU	DHE	145	142	149	4
	PLH	108	98	113	6
	SPL	7.6	7.0	9.0	0.8
	SPS	22.6	21.3	24.3	1.3
CH1	DHE	142	139	146	3
	PLH	90	80	95	6
	SPL	8.7	7.67	10.0	0.8
	SPS	20	18	22	1.5

[a] = No. of spikelets/spike.

Two single plant samples of *T. baeoticum* from Lebanon and 9 from Syria were found to be resistant to naturally occurring yellow rust races at Tel Hadya. Their acc. nos. are as follows: Lebanon (500549 and 500550), Syria (500546, 500547, and 500548). *T. urartu* bulk population samples were not resistant to yellow rust. However, 9 single plant lines were resistant and these came from two accs. (300157 and 300158). The bar-charts for the four characters scored ae given in Fig. 19.

J. Valkoun and B. Humeid

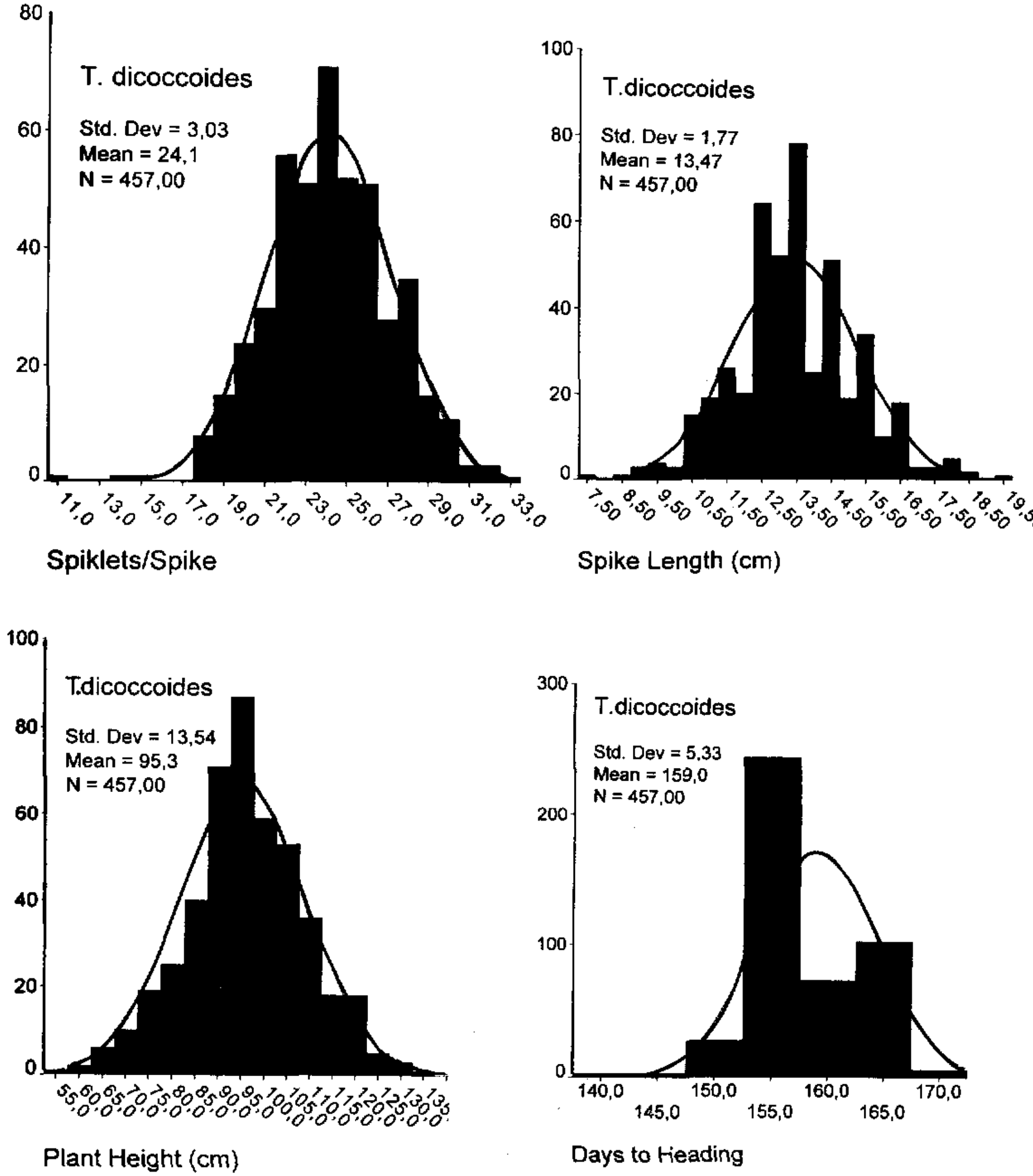

Fig. 18. Bar-charts for days to heading, plant height (cm), spike length (cm), and number of spikelets/spike for 486 samples of *Triticum dicoccoides* from Syria and Lebanon

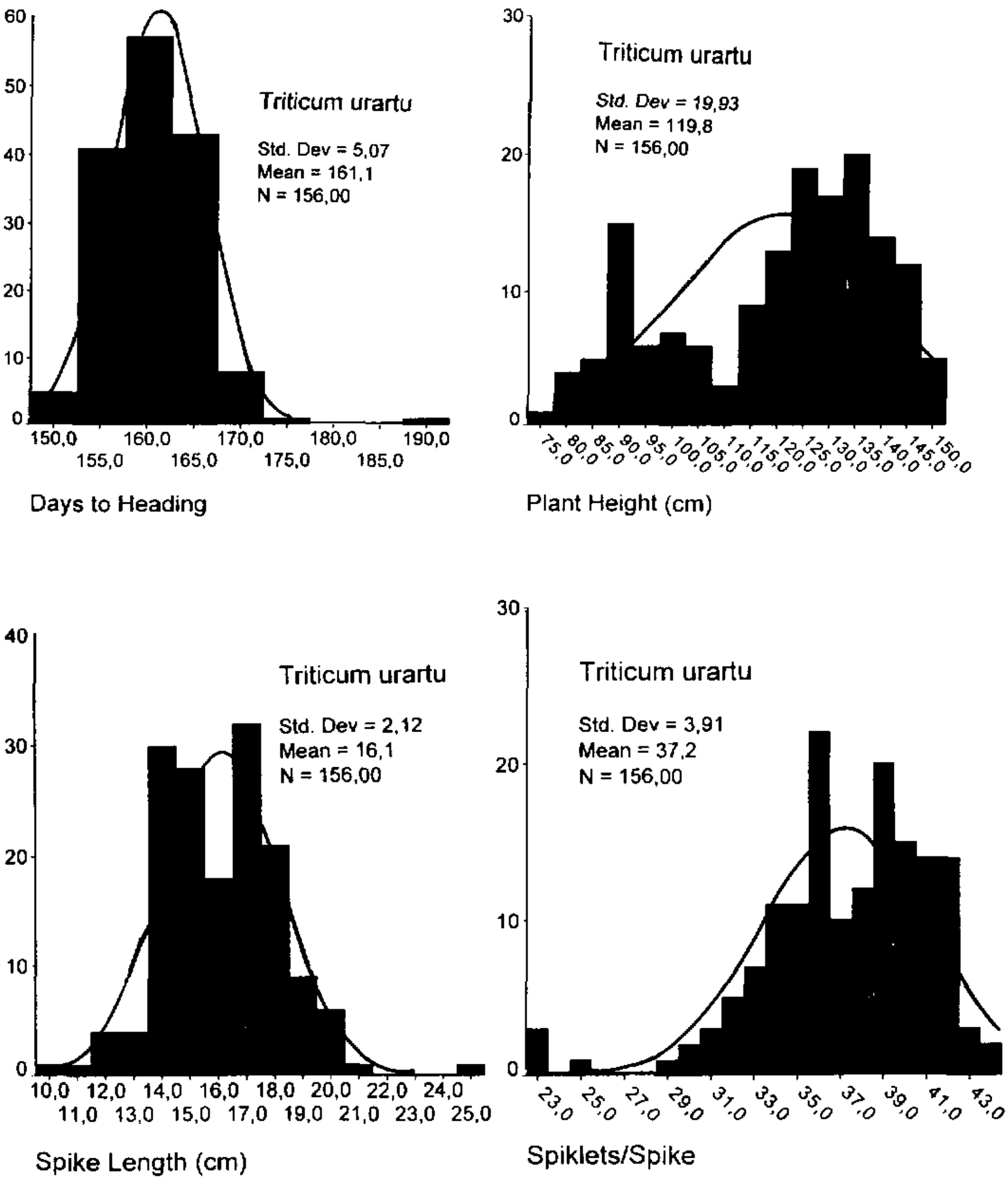

Fig. 19. Bar-charts for days to heading, plant height (cm), spike length (cm), and number of spikelets/spike for 166 accs. of *Triticum urartu* from Syria and Lebanon

1.3.8. Evaluation of the wild annual *Cicer* collection

The cultivated chickpea (*Cicer arietinum* L.) is thought to have originated in present-day southeastern Turkey and the adjoining area of Syria (van der Maesen 1987), where the International Center for Agricultural Research in the Dry Areas (ICARDA) headquarters is located. All eight annual wild *Cicer* species (*C. bijugum* K.H. Rech., *C. chorassanicum* (Bge) M. Pop., *C. cuneatum* Hochst. ex Rich, *C. echinospermum* P.H. Davis, C. *judaicum* Boiss., *C. pinnatifidum* Jaub. & Sp., *C. reticulatum* Lad., and *C. yamashitae* Kitamura) are found in the ICARDA regional mandate area (Morocco to Pakistan and Turkey to Ethiopia). The two most closely-related species to the cultigen (*C. reticulatum* and *C. echinospermum*) are endemic in the eastern Turkey-northern Iraq area (van der Maesen 1987).

Collections of annual wild *Cicer* are much smaller than for the cultigen. However, the collections at ICARDA are the largest in the world. ICARDA holds 268 accs. Nevertheless, there is an urgent need for more collection of *Cicer* species.

Two hundred twenty-eight accs. of eight annual wild *Cicer* species were characterized and evaluated for 43 characters. These characters were divided into four groups: (a) morphological; (b) phenological; (c) agronomic; and (d) seed and stresses. Observations of morphological, phenological, agronomic and seed descriptors were made partly in the field and partly in the laboratory during 1993−94. The evaluations for stress-response characters were carried out under artificially-created stress conditions between 1987 and 1994.

The accs. were sown on 29 November, 1993 at Tel Hadya, Syria, the main research station of ICARDA. Tel Hadya is located in northern Syria, near Aleppo, at 36^{0}35' E, 36^{0}51' N and 284 m asl, with an average annual rainfall of 330 mm. The rainfall during the 1993−94 season was 373 mm, 13% above the normal rainfall. Tel Hadya has a typical mediterranean climate characterized by cool, wet winters and hot, dry summers.

The 248 accs., consisting of 228 annual wild species accs. and 20 cultigen checks, were grown in two replicates, each 29m wide and 55m long. Each acc. was sown in a three−row plot, 2m long with spacing of 45 cm between and 15 cm within rows. Forty seeds of each acc. were sown in each plot. Overall precipitation in October, November and December was 77.7 mm. Most of the entries germinated between two and three weeks after sowing, due to sufficient moisture in the soil and favorable temperature.

The plots were fertilized with 50 kg P_2O_5 ha^{-1}. Hand weeding was done three times during the growing period. The crop was protected from ascochyta blight by periodic spraying of the fungicide chlorothalonil (tetrachloroisopenthalonitrite) at the rate of 0.8 kg a.i. per hectare.

Forty-three descriptors were chosen for evaluation. These descriptors were selected on the basis of their economic importance (e.g., seed size and color), of growers' requirements (e.g., resistance to stresses, plant height and growth habit), and of plant breeding considerations (e.g., seed yield and quality, suitability for winter sowing); and there were other descriptors. Descriptors evaluated were leaflet number per leaf (LFL), leaflet length (LFLL) (mm), leaflet width (LFLW) (mm), leaf area (LFA) (cm^2), rachis length (RL) (mm), rachis width (RW) (mm), branch number per plant (BRPL), plant pigmentation (PLPIG), pod pigmentation (PDPIG), growth habit (GRH), flower color (FLCOL), days to first flowering (DFFL), days to 50% flowering (DFTFL), flowering duration (FLD), uniformity to maturity (UMAT), days to first pod (DFPD), days to last pod (DLPD), plant height (HGT) (cm), canopy width (CAW) (cm), first pod height (FPDHGT) (cm), pod number per plant (PDPL), pod length (PDL) (mm), pod width (PDW) (mm), seed number per pod (SPD), pod dehiscence (PDD), biological yield (BYLD) (g/plant), seed yield (SYLD) (g/plant), harvest index (HI) (%), seed number per plant (SPL), hundred-seed weight (100SW) (g), protein content (PRO) (%), seed color (SCOL), black dots (BKDT), seed shape (SSH), testa texture (TTX), ascochyta blight resistance (AB), fusarium wilt resistance (FW), leaf miner resistance (LM), seed beetle (*Callosobruchus chinensis*) resistance (CC), cyst nematode resistance (CN), cold resistance (CO)

The screening for ascochyta blight resistance was carried out in an ascochyta blight nursery, where disease was created artificially through inoculation with diseased plant debris and with spore-suspension spray. The screening for fusarium wilt resistance was

Table 30. Average leaf area of 4 leaves/plant (from the median part of the plant) from 3 randomly-selected plants of *Cicer* spp. at mid-pod filling stage

State / *Cicer* spp.		*ari*	*ret* [*]	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
10	(1- 10 cm²)	3	17	2	40	34	5	5	-	3
9	(11- 20 cm²)	-	14	7	27	16	20	-	3	-
8	(21- 30 cm²)	1	18	2			10	-	-	1
7	(31- 40 cm²)	5	-	-	-	-	1	-	-	-
6	(41- 50 cm²)	4	-	-	-	-	-	-	-	-
5	(51- 60 cm²)	4	-	-	-	-	-	-	-	-
4	(61- 70 cm²)	-	-	-	-	-	-	-	-	-
3	(71- 80 cm²)	-	-	-	-	-	-	-	-	-
2	(81- 90 cm²)	1	-	-	-	-	-	-	-	-
1	(91-100 cm²)	1	-	-	-	-	-	-	-	-
No. of obs.		19	49	11	67	50	36	5	3	4
Mean		42.2	16.8	15.8	10.6	9.6	18.3	4.6	16.0	12.9
Minimum		8.1	4.4	5.4	5.2	4.1	6.0	2.3	11.9	8.4
Maximum		95.6	30.5	24.7	18.8	20.3	37.8	8.0	18.4	23.1
Range		87.5	26.1	19.3	13.6	16.2	31.8	5.7	6.5	14.6
Variance		489.34	62.76	37.09	5.32	11.53	49.26	4.84	12.73	47.28
C.V.		52.42	47.16	38.54	21.79	35.37	38.35	47.83	22.30	53.30
Kurtosis		1.14	-1.34	-0.76	1.92	0.62	0.72	1.36	–	3.70
Skewness		0.68	0.06	-0.30	0.66	0.68	0.35	1.06	-1.66	1.91
Accs. with large leaf area:		9564 (1)	124 (8)	238 (8)	175 (9)	263 (9)	67 (7)	23 (10)	214 (9)	232 (8)
		6455 (2)	105 (8)	180 (8)	103 (9)	261 (9)	72 (8)	15 (10)	53 (9)	40 (10)
		1929 (5)	135 (8)	39 (9)	168 (9)	92 (9)	66 (8)	222 (10)	215 (9)	185 (10)
		9428 (5)	111 (8)	235 (9)	174 (9)	250 (9)	83 (8)	147 (10)	-	187 (10)
		6929 (5)	-	179 (9)	101 (9)	248 (9)	-	146 (10)	-	-

[*] *ari* = *arietinum* (check); *ret* = *reticulatum*; *ech* = *echinospermum*; *jud* = *judaicum*; *pin* = *pinnatifidum*; *bij* = *bijugum*; *cho* = *chorassanicum*; *yam* = *yamashitae*; *cun* = *cuneatum*.

Table 31. Average height of 3 randomly-selected plants at the end of flowering from ground level to the highest point in the plant

State / *Cicer* spp.		*ari*	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
9	(1- 5 cm)	-	9	7	1	6	15	5	1	-
8	(6-10 cm)	-	27	4	44	36	21	-	2	3
7	(11-15 cm)	-	14	-	22	7	1	-	-	1
6	(16-20 cm)	1	1	-	-	1	-	-	-	-
5	(21-25 cm)	1	-	-	-	-	-	-	-	-
4	(26-30 cm)	7	-	-	-	-	-	-	-	-
3	(31-35 cm)	5	-	-	-	-	-	-	-	-
2	(36-40 cm)	5	-	-	-	-	-	-	-	-
1	(41-45 cm)	1	-	-	-	-	-	-	-	-
No. of obs.		20	51	11	67	50	37	5	3	4
Mean		32.1	8.5	5.2	9.6	8.5	6.6	2.9	5.8	10.2
Minimum		20.0	2.0	2.5	5.5	4.0	3.5	2.0	5.5	8.5
Maximum		42.5	15.5	9.5	15.5	16.0	12.0	3.5	6.0	12.0
Range		22.5	13.5	7.0	10.0	12.0	8.5	1.5	0.5	3.5
Variance		36.31	11.43	4.77	5.98	5.71	4.03	0.30	0.08	2.08
C.V.		18.77	40.00	42.00	25.53	28.11	30.42	18.89	4.95	14.14
Kurtosis		-0.21	-0.73	-0.37	-0.51	0.75	-0.10	2.92	–	0.91
Skewness		-0.24	0.08	0.64	0.54	0.41	0.55	-1.29	-1.73	0.00
Tall accs.:										
		7480 (1)	122 (7)	180 (8)	168 (7)	151 (6)	241 (7)	147 (9)	215 (8)	185 (7)
		2639 (2)	231 (7)	246 (8)	189 (7)	248 (7)	228 (8)	15 (9)	214 (8)	187 (8)
		9564 (2)	120 (7)	238 (8)	102 (7)	225 (7)	42 (8)	222 (9)	53 (9)	232 (8)
		6933 (2)	216 (7)	181 (8)	174 (7)	169 (7)	71 (8)	146 (9)	-	40 (8)
		5801 (2)	-	-	-	-	-	23 (9)	-	-

carried out in a greenhouse at the Istituto Sperimentale per la Patologia Vegetale, Rome, Italy. The screening for leaf miner resistance was carried out by growing the accs. during spring under natural insect infestation. Scoring was done twice; the first time during the late vegetative stage, and the second time during the podding stage. The screening for *C. chinensis* infestation was carried out by artificially releasing the seed beetle in the Entomology Laboratory of ICARDA to seed samples. Cyst nematode screening was conducted in the greenhouse by growing accs. in plastic pots containing cyst nematode infested soils. The screening for cold tolerance was ensured at the Tel Hadya farm by advancing sowing date to early October.

The performance of the wild annual *Cicer* species for desirable morphological traits was modest to poor compared to that of the cultigen, particularly for characters like leaf area, growth habit, plant height, first pod height, pod dehiscence and 100-seed weight. Average leaf area per plant in the wild accs. was never greater than 30 cm^2 (except for one *C. bijugum* acc. where leaf area was almost 38 cm^2), whereas most cultigen accs. showed leaf areas larger than this figure (Table 30). The tallest wild accs. were shorter than the shortest *C. arietinum* accs. (Table 31). The 100-seed weight of wild accs. was below 16 g (except for one *C. reticulatum* acc. which had 20 g), whereas most *C. arietinum* accs. showed seeds heavier than this value (Table 32).

Table 32. Angle of primary branches recorded at mid-pod filling stage

State / *Cicer* spp.	*ari*	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
1 (2= semi-erect)	20	-	-	-	-	-	-	-	-
2 (3= semi-spread)	-	34	2	20	41	36	-	2	4
3 (4= spreading)	-	17	9	47	9	1	5	1	-
No. of obs.	20	51	11	67	50	37	5	3	4
Mean	2.0	3.2	3.7	3.6	3.1	3.0	4.0	3.2	3.0
Minimum	2.0	3.0	3.0	3.0	3.0	3.0	4.0	3.0	3.0
Maximum	2.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.0
Range	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0.5	0.0

Table 33. Whether pods split open or not

State / *Cicer* spp.	*ari*	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
0 (no dehiscence)	20	-	-	-	-	-	-	-	-
1 (dehiscence)	-	51	11	67	50	37	4	3	4
No. of obs.	20	51	11	67	50	37	4	3	4

Table 34. Protein expressed as a percentage of the dry seed weight (Kjeldahl method)

State / *Cicer* spp.	*ari*	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
11 (16.1-17.0%)	1	-	-	-	-	-	-	-	1
10 (17.1-18.0%)	4	-	1	-	-	-	-	1	-
9 (18.1-19.0%)	7	4	3	1	-	-	1	-	-
8 (19.1-20.0%)	6	18	6	13	13	1	-	-	-
7 (20.1-21.0%)	2	26	1	23	16	18	1	-	1
6 (21.1-22.0%)	-	3	-	19	11	11	-	-	2
5 (22.1-23.0%)	-	-	-	9	3	5	-	1	-
4 (23.1-24.0%)	-	-	-	1	2	-	-	-	-
3 (24.1-25.0%)	-	-	-	-	1	-	-	-	-
2 (25.1-26.0%)	-	-	-	-	-	-	-	-	-
1 (26.1-27.0%)	-	-	-	-	1	-	1	-	-
No. of obs.	20	51	11	66	47	35	2	3	4
Mean	18.8	20.1	19.2	21.0	21.1	21.1	19.6	21.6	20.5
Minimum	17.0	18.8	17.4	19.0	19.4	20.0	18.7	17.4	16.8
Maximum	20.3	21.5	21.0	23.1	26.8	22.6	20.1	24.7	22.0
Range	3.3	2.7	3.6	4.1	7.4	2.6	1.4	7.3	5.2
Variance	0.78	0.49	0.70	1.08	2.01	0.43	0.56	9.68	6.04
C.V.	4.71	3.47	4.37	4.95	6.73	3.11	3.82	14.43	12.00
Kurtosis	-0.62	-0.76	3.26	-0.82	5.05	-0.56	-	-	-
Skewness	0.08	-0.11	-0.02	0.06	1.92	0.53	-	-	-
Accs. with high seed protein content:									
	2639 (7)	182 (6)	179 (7)	193 (4)	226 (1)	178 (5)	146 (7)	215 (3)	232(6)
	2758 (7)	229 (6)	239 (8)	173 (5)	251 (3)	80 (5)	23 (9)	214 (6)	185(6)
	6455 (8)	233 (6)	180 (8)	207 (5)	221 (4)	83 (5)	-	53 (10)	187(7)
	1376 (8)	124 (7)	230 (8)	206 (5)	249 (4)	177 (5)	-	-	40(11)
	6933 (8)	258 (7)	-	176 (5)	-	220 (5)	-	-	-
	-	257 (7)	-	-	-	-	-	-	-

Table 35. Reaction distribution of annual wild *Cicer* species collection to biotic and abiotic stresses

State / *Cicer* spp.		*ari*[a]	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
ascochyta blight										
1	(free from damage)	-	-	-	-	-	-	-	-	-
2	(highly resistant)	-	-	-	1	2	4	2	-	-
3	(resistant)	-	-	-	-	1	5	-	-	-
4	(moderately resistant)	-	-	-	-	2	12	2	-	-
5	(tolerant)	3	-	1	5	9	7	-	-	-
6	(moderately susceptible)	1	2	3	6	6	13	-	-	-
7	(susceptible)	3	5	2	7	7	5	-	-	1
8	(highly susceptible)	-	3	15	1	5	6	1	-	-
9	(all plants killed)	-	-	9	27	3	30	-	2	133
fusarium wilt										
1	(free from damage)	1	11	4	25	6	27	-	-	-
2	(highly resistant)	-	-	6	1	3	2	2	-	2
3	(resistant)	1	5	-	1	-	1	-	-	1
4	(moderately resistant)	-	1	15	2	15	5	1	-	-
5	(tolerant)	-	3	1	7	2	-	-	-	-
6	(moderately susceptible)	1	6	1	5	3	2	-	-	-
7	(susceptible)	1	-	-	-	5	-	-	-	-
8	(highly susceptible)	-	1	1	-	-	4	-	-	-
9	(all plants killed)	-	-	4	-	-	1	5	-	-
leaf miner										
1	(free from damage)	-	-	-	-	-	-			
2	(highly resistant)	-	-	-	1	18	4	1	1	4
3	(resistant)	-	4	3	22	4	2	-	-	-
4	(moderately resistant)	-	2	7	3	7	9	6	-	-
5	(tolerant)	2	17	-	11	18	12	-	1	-
6	(moderately susceptible)	1	10	3	2	8	2	-	-	-
7	(susceptible)	3	10	1	2	4	11	-	1	-
8	(highly susceptible)	-	1	-	-	-	-	-	-	-
9	(very highly susceptible)	7	-	-	-	-	2	-	1	-

Table 35. (Cont'd.)

State / *Cicer* spp.	*ari*[a]	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
seed beetle									
1 (free from damage)	-	1	3	6	-	9	-	-	1
2 (highly resistant)	-	-	1	-	4	2	5	-	-
3 (resistant)	-	1	-	-	-	3	-	-	-
4 (moderately resistant)	-	-	1	-	-	1	1	-	1
5 (tolerant)	-	1	-	1	-	-	-	-	-
6 (moderately susceptible)	-	3	-	2	-	3	-	-	-
7 (susceptible)	1	9	-	6	-	-	1	-	1
8 (highly susceptible)	-	3	3	-	24	21	-	2	1
9 (very highly susceptible)	6	-	-	4	5	-	-	-	-
cyst nematode									
1 (free from damage)	-	-	-	-	1	-	-	-	-
2 (highly resistant)	-	-	1	-	-	3	14	-	-
3 (resistant)	-	6	-	-	-	19	-	1	-
4 (moderately resistant)	-	-	7	1	21	4	4	2	2
5 (tolerant)	-	37	10	41	36	-	3	-	4
6 (moderately susceptible)	-	-	-	-	-	-	-	-	-
7 (susceptible)	-	-	-	-	-	-	-	-	-
8 (highly susceptible)	-	4	-	-	-	-	-	-	-
9 (all plants killed)	-	-	11	-	-	-	-	-	-
cold									
1 (free from damage)	-	-	-	-	-	-	-	-	-
2 (highly resistant)	-	-	2	-	-	-	21	-	-
3 (resistant)	-	26	-	-	-	10	-	-	-
4 (moderately resistant)	-	-	13	8	-	8	2	-	-
5 (tolerant)	1	2	-	-	11	-	-	-	-
6 (moderately susceptible)	1	-	-	-	7	-	-	-	-
7 (susceptible)	4	-	-	1	8	-	-	-	-
8 (highly susceptible)	-	2	-	-	3	4	-	-	1
9 (all plants killed)	-	-	7	-	-	48	1	-	324

[a] *ari*= *arietinum* (check); *ret*= *reticulatum*; *ech*= *echinospermum*; *jud*= *judaicum*; *pin*= *pinnatifidum*; *bij*= *bijugum*; *cho*= *chorassanicum*; *yam*= *yamashitae*; and *cun*= *cuneatum*.

Table 36. Means, ranges, standard deviations and coefficients of variation of biotic and abiotic stresses descriptors in the ICARDA annual wild *Cicer* species collection

State / *Cicer* spp.	*ari*[a]	*ret*	*ech*	*jud*	*pin*	*bij*	*cho*	*yam*	*cun*
ascochyta blight									
Mean	7.7	8.4	6.7	7.6	6.2	5.4	9.0	9.0	8.5
Range	5-9	6-9	2-9	2-9	2-9	2-9	9-9	9-9	7-9
S.D.	1.52	0.84	2.10	1.89	1.98	1.72	0.00	0.00	1.00
C.V.	19.67	9.97	31.25	24.92	32.11	31.76	0.00	0.00	11.76
fusarium wilt									
Mean	6.4	3.3	2.8	2.9	5.3	1.5	-	-	2.3
Range	1-9	1-8	1-6	1-9	1-9	1-6	-	-	2-3
S.D.	2.94	1.81	1.98	2.01	2.87	1.33	-	-	0.58
C.V.	44.85	54.16	71.49	68.31	53.96	87.52	-	-	24.73
leaf miner									
Mean	7.25	5.3	4.4	3.4	4.7	5.5	2.0	7.0	2.0
Range	4-9	3-7	2-7	2-7	2-7	2-9	2-2	5-9	2-2
S.D.	2.00	1.20	1.63	1.34	1.33	1.61	0.00	2.00	0.00
C.V.	26.41	22.70	37.33	39.26	28.16	29.16	0.00	28.57	0.00
seed beetle									
Mean	8.6	6.0	1.0	6.4	7.6	2.4	7.7	8.0	4.3
Range	7-9	1-8	1-1	1-9	2-9	1-6	7-8	8-8	1-7
S.D.	0.71	2.00	0.00	2.74	1.78	1.75	0.58	0.00	3.06
C.V.	8.32	33.33	0.00	42.78	23.37	73.33	7.52	0.00	70.50
cyst nematode									
Mean	8.6	4.6	4.9	4.7	4.6	2.7	4.6	3.7	5.0
Range	8-9	2-5	4-5	4-5	1-5	2-4	4-5	3-4	5-5
S.D.	0.83	0.78	0.30	0.48	0.97	0.65	0.55	0.57	0.00
C.V.	5.24	17.09	6.15	10.23	21.02	23.88	11.91	15.73	0.00
cold									
Mean	7.9	3.3	4.0	8.9	5.8	2.4	9.0	8.7	9.0
Range	5-9	2-5	4-4	7-9	4-9	2-4	9-9	8-9	9-9
S.D.	1.30	0.65	0.00	0.36	1.40	0.61	0.00	0.58	0.00
C.V.	16.55	19.41	0.00	4.02	24.14	25.33	0.00	6.66	0.00

[a] *ar=arietinum* (check); *ret=reticulatum*; *ech=echinospermum*; *jud=judaicum*; *pin=pinnatifidum*; *bij=bijugum*; *cho=chorassanicum*; *yam=yamashitae*; and *cun=cuneatum*.

Moreover, *C. arietinum* was the only species which showed accs. with a semi-erect growth habit and no pod dehiscence (Table 33 and 34). The differences between the cultigen and the wild annual taxa for the above descriptors are a clear indication that they are among the most antropic chickpea traits, that is, those which have been deliberately or undeliberately modified by man during domestication of chickpea.

Protein content (Table 34) of the wild species was generally higher than with the cultigen. However, with the species in the primary genepool of the cultigen there was not a significantly higher protein content.

Distribution of reactions of the annual *Cicer* species to the six stresses (ascochyta blight, fusarium wilt, leaf miner, seed beetle, cyst nematode and cold) are given in Table 35. The six stresses differed in their patterns of distribution and amount of variation. For instance, distribution for ascochyta blight and seed beetle were skewed towards susceptibility; that of fusarium wilt and cyst nematode were nearly skewed towards resistance; whereas distributions for leaf miner and cold were nearly normal. But while distribution of score reactions among species were consistent for ascochyta blight, seed beetle and cyst nematode, moderate variation was present in fusarium wilt and leaf miner, and strong in cold.

The highest levels of resistance within this collection were found to fusarium wilt, followed far-off to seed beetle and leaf miner. The least number of resistance sources was associated to ascochyta blight. The highest frequencies of accs. resistant to ascochyta blight were found in *C. echinospermum* and *C. pinnatifidum*; to fusarium wilt in *C. bijugum*; to leaf miner in *C. chorassanicum* and *C. cuneatum*; to seed beetle in *C. echinospermum*; to cyst nematode in *C. bijugum*; and, finely, to cold in *C. bijugum*.

All annual wild *Cicer* species, excluded *C. chorassanicum* and *C. pinnatifidum*, showed accs. with at least one source of stress resistance/tolerance, i.e. with 1 to 4 score reaction (Table 35). *C. bijugum* was the only annual wild *Cicer* species which showed accs. in the desirable resistance categories 1 and 2 for responses to all the six stresses. Next in performance come *C. pinnatifidum* found resistant to all six stresses but cold. Followed found resistant to four stresses. Moreover, *C. reticulatum* had rate three to an additional stress, *C. echinospermum* rate four to two stresses, and *C. judaicum* rate four to one stress. *C. yamashitae* and *C. chorassanicum* showed the least number of accs. with desirable ratings.

Overall, *C. bijugum* was the annual wild *Cicer* species which showed the highest relative frequencies and the highest absolute number of resistant accs. (Table 35). Ninety per cent of its accs. were found resistant to fusarium wilt, 94% to cold, 89% to cyst nematode and 81% to seed beetle.

Overall, *C. bijugum* showed the highest means for the highest categories of resistance followed by *C. judaicum*, *C. reticulatum*, and *C. pinnatifidum* (Table 36).

C. bijugum had the highest number of accs. with multiple resistance to the six stresses, followed far-off by *C. reticulatum* and *C. judaicum* (Table 37). Two *C. bijugum* accs. were resistant to five stresses and 16 to four; among these, three accs. showed rating 4 to an additional stress. Moderate negative association, but very highly significant, was found between cold and leaf miner stresses, while moderate positive association was observed between cold and cyst nematode stresses (Table 38).

Table 37. Accs. of annual wild *Cicer* species with overall best reactions to six biotic and abiotic stresses

Species	Accession (ILWC)	Origin	AB[a]	FW	LM	CC	CN	CO
C. bijugum	73	TUR[b]	3[c]	1	7	1	2	2
C. bijugum	65	TUR	5	1	5	1	2	2
C. bijugum	74	TUR	5	1	5	1	2	2
C. bijugum	79	TUR	6	1	4	2	2	2
C. bijugum	62	TUR	4	1	7	2	2	2
C. bijugum	66	TUR	5	2	3	-	3	2
C. bijugum	72	TUR	5	1	3	3	3	-
C. bijugum	76	TUR	5	1	5	2	3	2
C. bijugum	69	TUR	3	4	5	2	3	2
C. bijugum	70	TUR	3	1	9	1	2	3
C. cuneatum	187	ETH	9	2	2	1	5	9
C. cuneatum	232	ETH	7	3	2	-	5	9
C. echinospermum	39	TUR	7	1	4	1	5	4
C. echinospermum	245	TUR	2	5	3	-	5	-
C. judaicum	255	JOR	2	2	3	-	4	-
C. judaicum	256	JOR	2	-	3	-	4	-
C. judaicum	46	SYR	9	1	2	1	5	9
C. judaicum	189	LBN	9	1	3	1	4	9
C. pinnatifidum	250	TUR	2	2	3	-	2	-
C. pinnatifidum	251	TUR	2	1	4	-	5	-
C. pinnatifidum	171	TUR	5	1	5	2	5	5
C. reticulatum	113	TUR	2	6	5	3	-	-
C. reticulatum	112	TUR	9	1	6	2	4	3
C. reticulatum	117	TUR	9	1	5	3	4	3
C. reticulatum	141	TUR	8	1	6	6	2	3
C. reticulatum	81	TUR	8	3	3	7	3	3
C. reticulatum	139	TUR	8	1	5	8	3	3
C. reticulatum	140	TUR	8	3	5	6	3	3

[a] AB=ascochyta blight, FW=fusarium wilt, LM=leaf miner, CC=seed beetle, CN=cyst nematode, CO=cold.
[b] TUR=Turkey, ETH=Ethiopia, JOR=Jordan, SYR=Syria, LBN=Lebanon.
[c] Score.

Table 38. Linear correlation coefficients[a] for six biotic and abiotic stresses in annual wild *Cicer* species.

Character	FW[b]	LM	CC	CN	CO
AB	59	-288*	174	392**	374**
FW		-85	303**	360**	104
LM			-237*	-345**	-636**
SB				427**	354**
CN					572**

[a] Correlation coefficient × 1000. Degrees of freedom = 108.
[b] AB = ascochyta blight, FW = fusarium wilt, LM = leaf miner, SB = seed beetle, CN = cyst nematode, CO = cold.
*, ** Significant association at the 1% and 1‰ level, resp.

Low, but very highly significant positive associations were observed between the following stresses: ascochyta blight and cold, ascochyta blight and cyst nematode, fusarium wilt and cyst nematode, seed beetle and cyst nematode and seed beetle and cold (Table 38).
L.D. Robertson (GRU), and K.B. Singh and B. Ocampo (GP)

1.3.9. Evaluation of the *Vicia sativa* ssp. *sativa* germplasm collection

The entire *Vicia sativa* ssp. *sativa* germplasm (common vetch, 1466 accs.) collection was evaluated in an augmented nursery during 1993–94 using one systematic check (IVFI 2541), and two random checks (IFVI 2627 and IFVI 1416). The largest number of accs. were from Turkey (522 accs.), Italy (415 accs.) and Syria (143 accs.).

The 23 descriptors observed were: Growth habit (GRH), anthocyanin (ANTH), vigor (VIG), leaf shape (LFSH), leaflet shape (LFTSH), days to 50% flowering (DFLR), days to 90% maturity (DMAT), days to 90% podding (DPOD), plant height in cm (PTHT), height to the first flower in cm (HTFF), number of leafs per plant (NOLF), number of leaflets per leaf (NOLFL), leaf length in cm (LFL), leaf width in cm (LFW), pods per peduncle (PODPD), pods per plant (PODPP), seeds per plant (SEEDPP), seeds per pod (SPD), 1000 seed weight in g (W1000), hay yield (HYLD) in kg/ha dry matter, seed yield in kg/ha (SYLD), biomass in kg/ha (BYLD), straw yield in kg/ha (STYLD), and harvest index in % (HI).

Table 39. Frequency distributions for GRH, FLCO, ANTH, and LFSH for *Vicia sativa* ssp. *sativa* (n=1466), *V. narbonensis* (n=165) and *V. ervilia* (n=245) germplasm evaluated at Tel Hadya, during 1992–93

Descriptor/score[a]	V. sativa	V. narbonensis ssp. sativa	V. ervilia
VIG			
Very strong	1.8	15.8	11.0
Good	11.6	29.7	31.0
Intermediate	61.7	29.7	38.8
Poor	17.7	15.2	14.3
Very poor	7.3	9.7	4.9
GRH			
Prostrate	5.2	49.1	30.6
Semi-erect	94.0	19.4	64.1
Erect	0.8	31.5	5.3
ANTH			
Very weak	19.5	-	-
Weak	0.1	-	-
Fair	54.6	-	-
Strong	24.2	-	-
Very strong	1.6	-	-
PDSH			
Very high	-	45.4	5.7
High	-	3.7	0.8
Medium	-	5.5	9.4
Low	-	11.0	34.3
Very low	-	34.4	49.8

a: Descriptor abbreviations as per text.

Most accs. of *V. sativa* ssp. *sativa* were of semi-erect GRH (Table 39). The VIG of most accs. was intermediate or less with only 13.4% with good or strong vigor. Approximately 75% of all accs. were with weak ANTH.

The accs. of common vetch were slightly later in phenology than the check common vetch accs. (Table 40), though the earliest accs. were approximately 8 days earlier than the checks. The yield components SEEDPP, PODPP and SDP were lower for the tested accs. The W1000 was also smaller for the tested accs., though the maximum seed size in the tested accs. was double the checks (Fig. 20). The mean HYLD of the accs. was higher than the test entries,

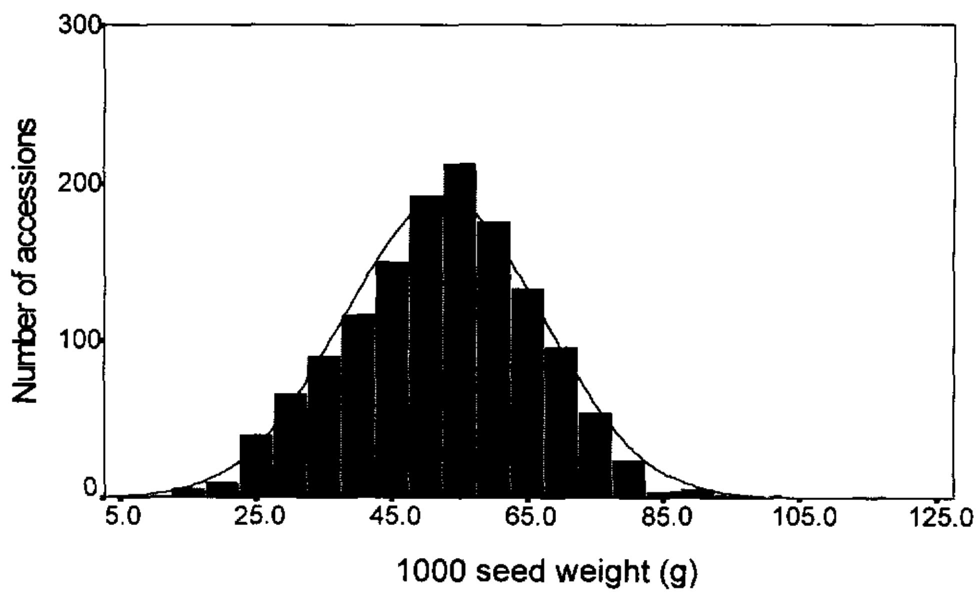

Fig. 20. Distribution of 1000-seed weight (W1000) for tested *Vicia sativa* ssp. *sativa* accs.

however, the mean SYLD, STYLD and HI were significantly lower than the checks. Again, there were large variations for these descriptors with the range of the tested accs. showing accs. with potential for use for these descriptors. Accs. have been selected for further testing in the breeding program at ICARDA.

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1.3.10. Evaluation of the *Vicia narbonensis* germplasm collection

The entire *Vicia narbonensis* (including all subtaxa) germplasm (narbon vetch, 165 accs.) was evaluated during 1994–95 in an augmented nursery using one systematic check (IVFI 67), and two random checks (IFVI 564 and IFVI 2541, *V. sativa* ssp. *sativa*). The largest number of accs. were from Syria (56), Lebanon (34 accs.) and Turkey (33 accs.).

The 23 descriptors observed were: Growth habit (GRH), pod shattering (PDSH), vigor (VIG), leaf shape (LFSH), days to 50% flowering (DFLR), days to 90% maturity (DMAT), days to 90% podding (DPOD), plant height in cm (PTHT), height to the first flower in cm (HTFF), number of leafs per plant (NOLF), number of leaflets per leaf (NOLFL), leaf length in cm (LFL), leaf width in cm (LFW), pods per peduncle (PODPD), pods per plant (PODPP), seeds per plant (SEEDPP), seeds per pod (SPD), 1000 seed weight in g (W1000), hay yield (HYLD) in kg/ha dry matter, seed yield in kg/ha (SYLD), biomass in kg/ha (BYLD), straw yield in kg/ha (STYLD), and harvest index in % (HI).

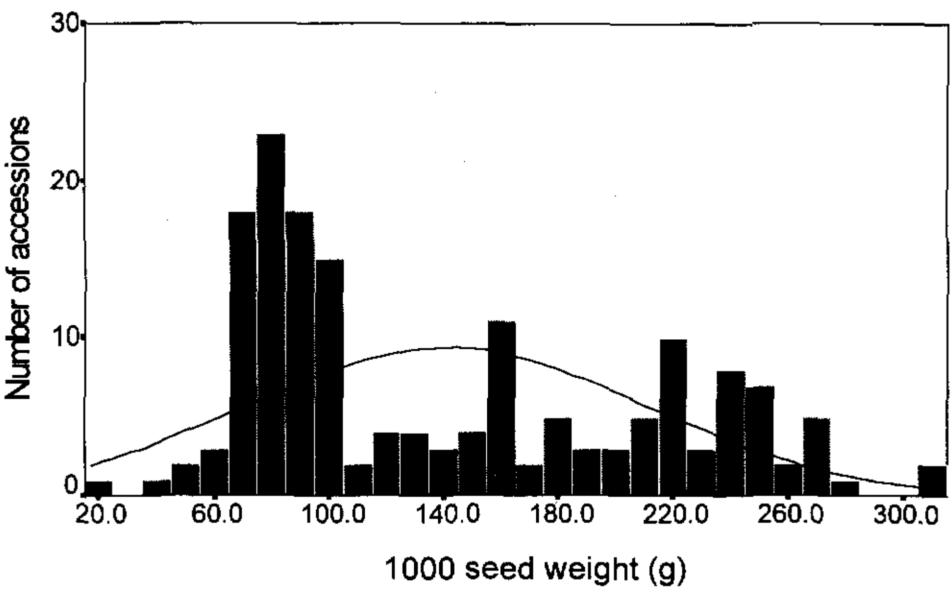

Fig. 21. Distribution of 1000-seed weight (W1000) for tested *Vicia narbonensis* accs.

Table 40. Summary statistics for 1466 *Vicia sativa* ssp. *sativa* germplasm accs. evaluated at Tel Hadya, Syria during 1993–94

Descriptor		Check mean[a]	Mean	Min.	Max.	CV(%)
DFLR[b]	(days)	139.3	147.1	131	187	6.8
DPOD	(days)	153.1	162.2	147	199	6.9
DMAT	(days)	182.3	190.6	105	229	6.0
HTFF	(cm)	26.3	27.3	13	57	26.1
PTHT	(cm)	49.9	52.5	24	91	20.1
PODPP	-	35.8	29.1	2.7	105.0	45.8
SEEDPP	-	162.3	104.8	0.3	381.3	63.4
SPD	-	4.57	3.56	0.01	12.37	39.3
HYLD	(kg/ha)	1742.6	1839.1	407	7520	40.5
SYLD	(kg/ha)	1629.4	765.3	5	2413	59.8
STYLD	(kg/ha)	2587.6	2470.5	304	6586	34.2
HI	(%)	39.6	22.7	0.2	67.6	47.2
W1000	(g)	58.1	52.6	4.0	122.8	28.0

a : IFVI 2541 and IFVI 2627, *V. sativa* ssp. *sativa.*
b : Descriptor abbreviations as per text.

Table 41. Summary statistics for 165 *Vicia narbonensis* germplasm accs. evaluated at Tel Hadya, Syria during 1994–95

Descriptor		Check mean[a]	Mean	Min.	Max.	CV(%)
DFLR[b]	(days)	108.1	109.9	100	125	5.8
DPOD	(days)	133.9	135.4	129	144	2.4
DMAT	(days)	164.1	166.5	161	179	2.4
HTFF	(cm)	37.1	25.5	7.2	59.7	47.7
PTHT	(cm)	59.6	41.8	17.2	75.3	36.0
PODPP	-	12.6	14.4	3.7	46.7	54.7
SEEDPP	-	45.1	43.7	10.0	173.3	50.2
SPD	-	3.58	3.06	0.59	4.93	23.9
HYLD	(kg/ha)	2376.0	1528.0	173.3	3573.3	43.1
SYLD	(kg/ha)	3554.4	2079.8	1142.2	5234.4	56.9
STYLD	(kg/ha)	5332.3	3934.5	29.3	7047.4	34.2
HI	(%)	39.6	32.4	1.23	54.2	28.4
W1000	(g)	164.6	141.1	22.0	310.3	49.5

a : IFVI 67 and IFVI 564, *V. narbonensis.*
b : Descriptor abbreviations as per text.

A large proportion (32%) of the accs. of *V. narbonensis* were with erect GRH, though almost half were prostrate GRH (Table 39). The VIG of half of the accs. was good or very strong with only 25% with poor vigor. Although one-third of the accs. had very low PDSH, approximately half had very high PDSH.

The accs. of narbon vetch were of approximately the same phenology as the check narbon vetch accs. (Table 41), though the earliest accs. were approximately 8 days earlier than the checks. Although the W1000 was lower for the tested accs., the range was very large, offering potential for selection for larger seed size (Fig. 21). The mean performance of the accs. for yield traits was lower than the checks, though the ranges offer chance for selection of superior germplasm (Fig. 22). Accs. have been selected for further testing in the breeding program at ICARDA.

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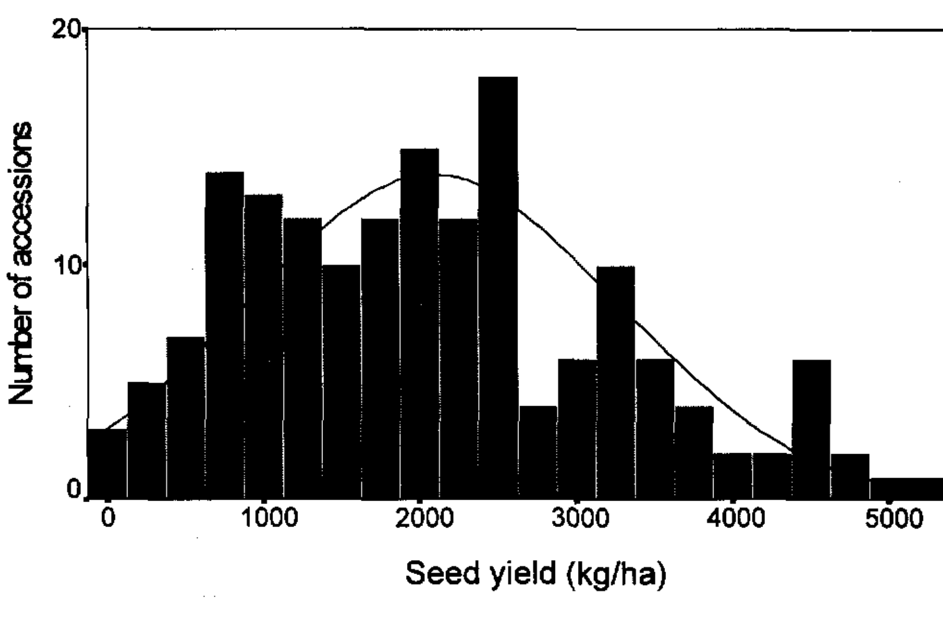

Fig. 22. Distribution of seed yield for *Vicia narbonensis* accs.

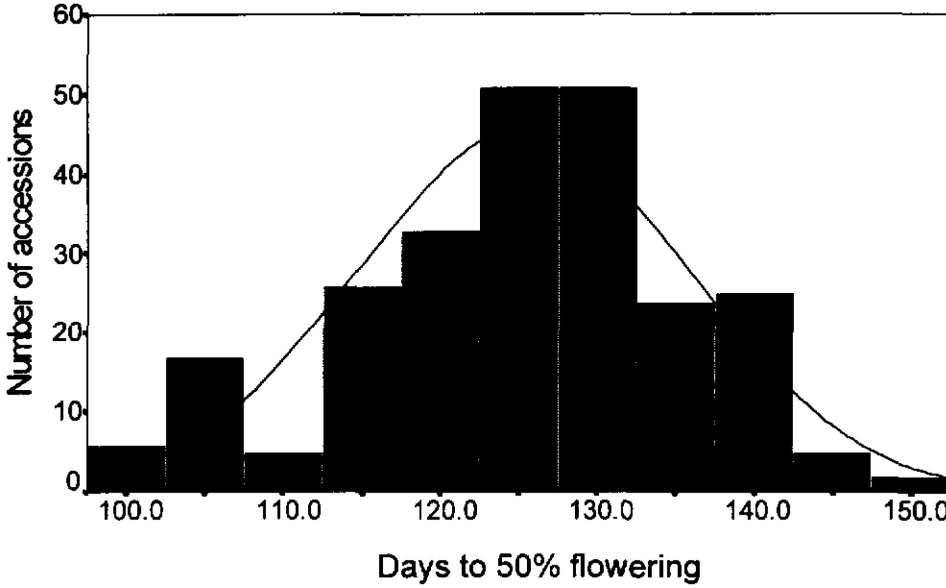

Fig. 23. Distribution of days to 50% flowering of *Vicia ervilia*

1.3.11. Evaluation of the *Vicia ervilia* germplasm collection

The entire *Vicia ervilia* germplasm (bitter vetch, 245 accs.) was evaluated during 1994–95 in an augmented nursery using one systematic check (IVFI 2542), and two random checks (IFVI 3030 and IFVI 2541, *V. sativa* ssp. *sativa*). The largest number of accs. were from Turkey (56 accs.), Greece (39 accs.) and Syria (35 accs.).

The 23 descriptors observed were: Growth habit (GRH), pod shattering (PDSH), vigor (VIG), leaf shape (LFSH), days to 50% flowering (DFLR), days to 90% maturity (DMAT), days to 90% podding (DPOD), plant height in cm (PTHT), height to the first flower in cm (HTFF), number of leafs per plant (NOLF), number of leaflets per leaf (NOLFL), leaf length in cm (LFL), leaf width in cm (LFW), pods per peduncle (PODPD), pods per plant (PODPP), seeds per plant (SEEDPP), seeds per pod (SPD), 1000 seed weight in g (W1000), hay yield (HYLD) in kg/ha dry matter, seed yield in kg/ha (SYLD), biomass in kg/ha (BYLD), straw yield in kg/ha (STYLD), and harvest index in % (HI).

Most (69%) of the accs. of *V. ervilia* were with semi-erect or erect GRH (Table 39). The VIG of 42% of the accs. was good or very strong with only 29% with poor vigor. Half of the accs. had very low PDSH, with most of the rest (34%) with low PDSH.

Table 42. Summary statistics for 245 *Vicia ervilia* germplasm accs. evaluated at Tel Hadya, Syria during 1994–95

Descriptor		Check mean[a]	Mean	Min.	Max.	CV(%)
DFLR[b]	(days)	116.9	129.2	104	153	7.9
DPOD	(days)	139.5	146.3	134	160	4.4
DMAT	(days)	180.3	180.3	147	201	4.2
HTFF	(cm)	19.3	24.1	6.2	44.0	29.9
PTHT	(cm)	43.4	43.0	20.7	75.0	17.7
PODPP	-	64.6	64.6	14.3	358.3	55.4
SEEDPP	-	156.7	158.0	23.3	702.7	51.3
SPD	-	2.41	2.47	1.23	4.47	15.0
HYLD	(kg/ha)	2056.4	2271.0	293.3	4320	32.4
SYLD	(kg/ha)	4313.0	3061.8	95.7	6818.4	44.0
STYLD	(kg/ha)	4955.0	4978.5	903.0	10899.0	31.1
HI	(%)	46.7	37.0	3.3	67.2	27.9
W1000	(g)	49.9	40.6	13.1	65.8	26.2

a : IFVI 2541 and IFVI 2627, *V. ervilia*.
b : Descriptor abbreviations as per text.

Table 43. Summary statistics for 933 *Medicago rigidula* germplasm accs. evaluated at Tel Hadya, Syria during 1994–95

Descriptor		Check mean[a]	Mean	Min.	Max.	CV(%)
DFLR[b]	(days)	120.6	119.0	97	143	6.9
DPOD	(days)	128.1	126.2	104	150	6.4
DMAT	(days)	168.6	166.7	151	185	2.9
PTHT	(cm)	23.1	22.2	2.0	47.0	38.4
CANOPY	(cm)	122.3	114.0	46	150	16.2
PODPP	-	13.3	11.2	0.68	40.3	44.6
SEEDPP	-	83.0	84.5	4.06	314.9	44.9
SPD	-	6.26	7.62	3.16	17.4	19.3
BYLD	(kg/ha)	4701.5	4330.8	386.7	10053.3	42.8
W1000	(g)	4.10	4.43	1.91	11.89	36.1

a : IFMA 811, *M. rigidula*.
b : Descriptor abbreviations as per text.

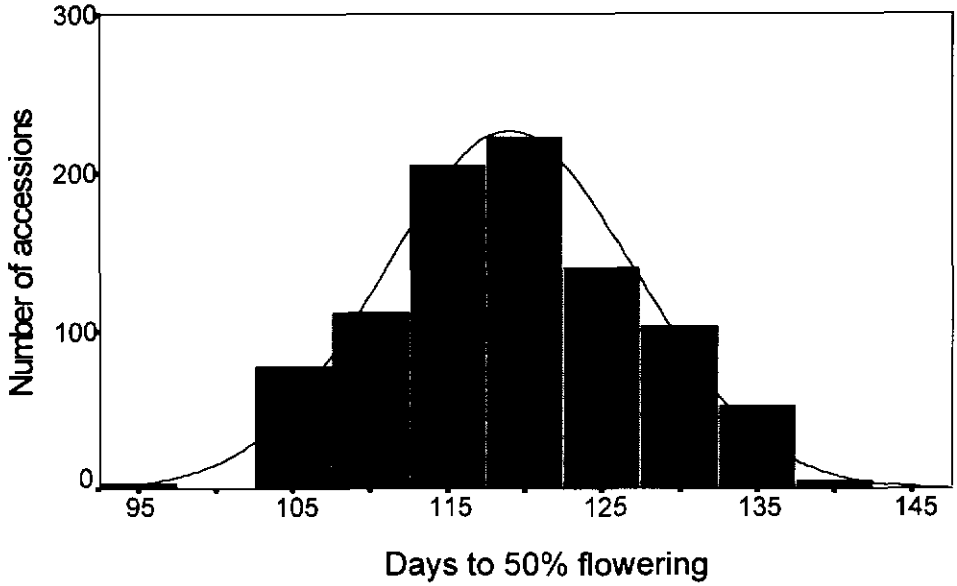

Fig. 24. Distribution of days to 50% flowering for *Medicago rigidula* germplasm accs.

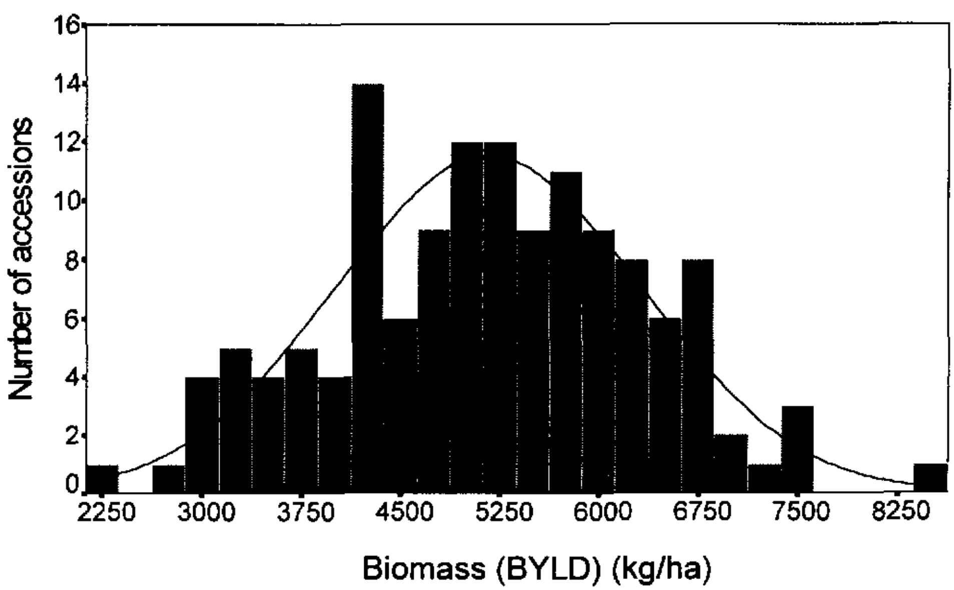

Fig. 25. Distribution of biomass (BYLD, kg/ha) for *Medicago radiata* germplasm accs.

The accs. of bitter vetch had a mean DFLR significantly later than the check bitter vetch accs. (Table 42), though there was a large range for DFLR with a number of accs. earlier than the checks (Fig. 23). Although the W1000 was lower for the tested accs., the range was large, offering potential for selection for larger seed size. The mean performance of the accs. for yield traits was lower than the checks, mainly through lower HI, though the ranges offer chance for selection of superior germplasm. Accs. have been selected for further testing in the breeding program at ICARDA.

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Table 44. Summary statistics for 135 *Medicago radiata* germplasm accs. evaluated at Tel Hadya, Syria during 1994–95

Descriptor		Check mean[a]	Mean	Min.	Max.	CV(%)
DFLR	(days)	119.2	119.9	109	140	6.0
DPOD	(days)	125.7	127.0	115	149	5.6
DMAT	(days)	168.8	168.6	163	178	1.5
PLHT	(cm)	23.0	18.0	7	32	36.2
CANOPY	(cm)	125.6	97.7	60	130	16.2
SEEDPP	-	126.9	224.6	70.6	782.1	47.4
PODPP	-	27.7	43.0	11.1	139.0	46.1
SDP	-	5.02	5.27	3.28	8.14	14.6
BYLD	(kg/ha)	4666.7	5164.5	2200	8480	21.4
W1000	(g)	4.26	3.75	1.52	7.97	39.7

a : Mean of IFMA 811, 2600 and 7585; *M. rigidula, M. rotata,* and *M. polymorpha* var. *vulgaris*, respectively.
b : Descriptor abbreviations as per text.

1.3.12. Evaluation of the *Medicago rigidula* and *M. radiata* germplasm collections

The entire *Medicago rigidula* (933 accs.) and *M. radiata* (135 accs.) germplasm collections were evaluated in augmented nurseries during 1994–95 using one systematic check (IFMA 7858 *M. polymorpha* var. *polymorpha*), and two random checks (IFMA 811, *M. rigidula* and IFMA 2600, *M. rotata*). The largest number of *M. rigidula* accs. were from Syria (437 accs.), Turkey (221 accs.) and Jordan (64 accs.). The largest number of *M. radiata* accs. were from Syria (65 accs.), Jordan (27 accs.) and Turkey (22 accs.).

The 14 descriptors observed were: Growth habit (GRH), days to 50% flowering (DFLR), days to 90% maturity (DMAT), days to 90% podding (DPOD), plant height in cm (PTHT), canopy width in cm (CANOPY), pods per plant (PODPP), seeds per plant (SEEDPP), seeds per pod (SPD), 1000 seed weight in g (W1000), seed yield in kg/ha (SYLD), biomass in kg/ha (BYLD), straw yield in kg/ha (STYLD), and harvest index in % (HI).

The majority of both *M. rigidula* and *M. radiata* accs. were with prostrate GRH (73.1% and 82.2%, respectively).

The remainder were with semi-erect GRH. The mean phenology of the tested medics were the same as the checks (Tables 43 and 44), though there were a significant number of accs. of *M. rigidula* with much earlier flowering than the *M. rigidula* checks (Fig. 24). The mean biomass production of *M. radiata* was higher than the mean of the checks (three species), with a large range (Table 44 and Fig. 25). The yield components SPD, SEEDPP, PODPP, and W1000 for *M. rigidula* were comparable to the *M. rigidula* checks, with large ranges which offer the possibility of selection. Selected accs. of *M. radiata* are being further tested by PFLP.

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1.4. GENETIC RESOURCES SUPPORT RESEARCH

1.4.1. Enhancing wheat productivity in stress environments utilizing wild progenitors and primitive forms

In continuation of the research activity carried out under the above collaborative project at the University of Tuscia, Viterbo, Italy, reported in the GRU Annual Report 1993 the following progress was made during 1994–95.

New developments in two alien gene transfer projects are herein described. This work was carried out using cytogenetic techniques of chromosome engineering. The first one concerns the transfer into common and durum wheat of a powdery mildew resistance gene (Pm13) derived from *Agropyron elongatum* chromosomal segment. This segment contains both the Lr19 leaf rust resistance gene and Yp, a gene for yellow flour pigmentation, particularly in *Triticum urartu*, through the use of molecular markers.

Transfer of Pm 13 *into durum wheat*

Several common wheat *T. aestivum* cv. Chinese Spring - *Ae. longissima* mildew resistant recombinants had been obtained by ph1b mediated homologous recombination. As a result of cytogenetic (metaphase 1 pairing), genetic (telocentric mapping) and RFLP analyses, recombinant R1B, carrying the *Ae. longissima* segment on chromosome 3B, was chosen as donor to introduce the Pm13 gene into durum wheat. Recombinant line R1B has been crossed and backcrossed to high-yielding and good quality durum cultivars; either fully susceptible to powdery mildew (cv. Duilio) or bearing Pm4a as the only source of resistance (cv. Simento). In the latter case the aim was to pyramid the highly effective Pm13 gene to the widely used Pm4a, whose efficacy appears to be progressively declining.

Screening for resistance and somatic chromosome number was carried out in the backcross progenies. The average percentage of resistant euploid plants in the BC1 generation was about 10%. The recombinant chromosome did not apparently suffer any adverse selection when competing with a normal one as seen from the correspondence of the observed resistant-to-susceptible ratios with the expected. Meiotic analyses showed a regular behavior of the 3B pair present in BC1 heterozygote as well. Preliminary data also indicated normal fertility in Pm13/pm13 heterozygote and Pm13/pm13 + Pm4a/pm4a double heterozygote as compared to control lines. Such plants are currently being selfed for the recovery of homozygous carriers of Pm13 alone and in combination with Pm4a.

Transfer of Lr19 + Yp into durum wheat

Chinese Spring-*Agropyron elongatum* transfer No. 12, one of the transfer lines produced by the late Professor E.R. Sears to incorporate into common wheat the *Agropyron* Lr19 leaf rust resistance gene, has been used as donor of the alien chromosome segment to durum wheat. The translocated segment, carried on the long arm of chromosome 7A, which allowed it to be transferred by homologous recombination, contains a Yp gene for yellow endospore pigmentation as well. The effect of Yp could be valuable for enhancing the yellow index of semolina, a recently requested attribute by the consumers. 'Transfer No. 12' was thus crossed and backcrossed to several durum wheat cultivars. Selection for leaf rust resistance and a check of the somatic chromosome numbers was carried out in each generation. Also, *in situ* hybridization tests showed that the translocated segment was much longer than previously expected, spanning the whole long arm of chromosome 7A and approximately half of the short one.

Euploid ($2n$=28) heterozygous resistant individuals obtained from one of the BC1 progenies have been selfed in order to obtain individual homozygous for the translocation. However, the selfed BC1 progenies did not show a regular segregation of the transfer chromosome. Whereas transmission of the agropyron segment appeared to be regular through the female gamete in the different durum backgrounds, pollen grains carrying the 7A/7Ag chromosome seemed to suffer an almost complete adverse selection when in competition with those bearing a normal 7A. Screening of such progenies was carried out simultaneously by *in situ* hybridization and leaf rust infection of plantlets. The results of the two tests always concurred, and ISH allowed to assess a very low percentage (1.6%) of homozygous resistant plants.

A general explanation for this behavior could be based on the irrefutably proven lower tolerance to chromosomal and genic unbalance of tetraploid wheat as compared to hexaploid wheat. This would be in spite of the claimed presence, within the same agropyron segment, of a Sd-1 gene, causing segregation distortion of variable plants with $2n$=28 which are now being crossed to a ph1c/ph1c durum mutant. This is being done to shorten the alien segment by homoeologous recombination and thus to hopefully improve its 'tolerance' at the tetraploid level. Derivatives of such crosses are being probed by means of ISH with total *Agropyron* DNA to check the presence and amount of *Agropyron* chromatic, and with the pSc 119.2 probe, which gives an intercalary signal in the Ph1 region on chromosome arm 5BL to detect ph1c/ph1c individuals. The simultaneous use of a genomic and a repeated probe, an original development of the ISH technique made by our research group, will make selection for desired individual more rapid and unequivocal than conventional screening methods.

Molecular markers-assayed genetic variability

Genetic variability of *Triticum urartu* accs. has been assessed using RFLP (Restriction Fragment Length Polymorphism) and PCR (Polymerase Chain Reaction) analysis. Both tests showed a high degree of polymorphism among the accs. In particular, PCR analysis of high molecular weight (HMW) glutenin genes showed a very high degree of length variation for the 1Ay gene. Detailed PCR analysis by using oligonucleotide primers specific for each domain of the HMW1 Ay glutenin gene demonstrated that in all *T. urartu* accs. tested the central repetitive domain is responsible for the observed length variation. The PCR analysis also showed that all *T. urartu* accs. that do not express the subunit contain the corresponding 1A gene. This result demonstrates that the absence of the Ay subunit in those accs. is due suppression of its encoding gene and not to its deletion.

In addition to this research, in order to increase the number of RFLP clones useful to detect genetic variability, 250 additional Pstl recombinant clones from the *T. urartu* library have been analyzed. Thirty of these were able to detect polymorphism among different *Triticum* species, i.e., *T. urartu*, *T. dicoccoides*, *T. dicoccum*, *T. durum* and *T. aestivum*. The hybridizing bands obtained with the polymorphic clones were subsequently assigned to specific

chromosomes and chromosome arms by using genomic DNA from nulli-tetrasomic lines of *T. aestivum* cv. Chinese Spring.
C. Ceoloni, M. Biagetti, E. Iacono and E. Porceddu (University of Tuscia, Italy) and J. Valkoun (GRU).

1.4.2. Genetic diversity and taxonomic relationships within the genus *Lens* as revealed by allozyme polymorphism

Introduction

An understanding of the genetic variation which exits both in the cultivated species and its wild relatives is required for effective genetic conservation. Two fundamental aspects of this are the amount of intra-specific genetic variation and the taxonomic relationships. Debate still exists over the classification within the genus *Lens*, particularly relating to the position of *L. odemensis* and *L. ervoides*, and the status of two differentiated cytotypes of *L. nigricans*. A study was undertaken to determine intra-specific genetic diversity, and phylogenetic and phenetic relationships within the genus *Lens* by measuring allozyme polymorphism in 439 accs.

Materials and methods

All original bulk accs., which had undergone one or more multiplications, from the ICARDA wild lentil collection were included in the study. This comprised 154 accs. of *L. culinaris* ssp. *orientalis*, 35 accs. of *L. odemensis*, 118 accs. of *L. ervoides*, 32 accs. of *L. nigricans* and 2 accs. of the differentiated cytotype of *L. nigricans*. In addition, 100 landrace accs. of the cultivated lentil (*L. culinaris* ssp. *culinaris*), from 10 different countries were included. Starch gel electrophoresis was used to resolve the enzyme bands. One plant per acc. was analyzed for allozymes in seven enzyme systems; these were, aspartate aminotransferase (Aat), phosphoglucose isomerase (Pgi), malic enzyme (Me), shikimic acid dehydrogenase (Skdh), acid phosphatase (Aps), leucine aminopeptidase (Lap) and glucose 6-phosphate dehydrogenase (Pgd).

Results and discussion

Genetic diversity

The percentage of polymorphic loci, the number of allozymes per locus and mean genetic diversity are given in Table 45. The percentage of polymorphic loci provides a rough guide to the level

Table 45. Percentage of polymorphic loci, the number of alleles per locus and mean genetic diversity in *Lens* taxa

Taxon	Percentage of polymorphic loci	Mean number of alleles/ locus	Mean genetic diversity
L. culinaris ssp. *culinaris*	45.5	1.64	0.161
L. culinaris ssp. *orientalis*	90.9	3.55	0.234
L. odemensis	72.7	2.36	0.183
L. ervoides	72.7	2.55	0.107
L. nigricans	72.7	2.25	0.232

of genetic variation. The mean number of alleles per locus emphasizes allelic richness, one component of diversity. Nei's mean genetic diversity, which is independent of sample size, provides an estimate of allelic evenness. In contrast to other diversity studies of the genus *Lens*, our study showed the level of diversity in the cultivated species was lowest for percentage of polymorphic loci and the mean number of alleles per locus, and only had a greater mean genetic diversity than *L. ervoides*. The discrepancy between our study and that of previous authors can be explained by the use of a larger sample size, particularly for the wild species and in the use of Nei's mean genetic diversity as a measure of genetic variation. Even though Nei's genetic diversity is independent of sample size, a larger sample allows more variants to be detected.

In addition, genetic diversity measures in the wild species indicated that different genetic structures exist within the different taxa. *L. culinaris* ssp. *orientalis* possessed the greatest diversity according to all three measures. It possessed both allelic richness and evenness. The high mean genetic diversity relative to the mean number of alleles per locus of *L. nigricans* indicated an evenness of genetic variation distribution, as opposed to allelic richness. This is in contrast to *L. ervoides* and *L. odemensis* which harbored more alleles of lower frequency. This suggests that the situation regarding taxon delimitation and diversity within *L. nigricans* appears more complex than is presently recognized, particularly in view of the existence of the differentiated cytotype, its existence in contrasting ecological niches and the possibility of being a relic of ancient cultivation.

Phylogenetic and phenetic analysis

Nei's genetic distance was computed for phenetic analysis and cluster analysis performed by the unweighted pair group method (UPGMA) using NTSYS-pc. The dendrogram drawn according to the mean genetic distances between *Lens* taxa and the cytotype, and are given in Fig. 26. *L. odemensis* was closer to *L. culinaris* ssp. *orientalis* (0.11) than to *L. ervoides* (0.323), but more distantly related to *L. culinaris* ssp. *culinaris* and *L. culinaris* ssp. *orientalis* than they are related to each other. The cytotype appeared more closely related to *L. odemensis* and *L. ervoides* than to *L. nigricans*,

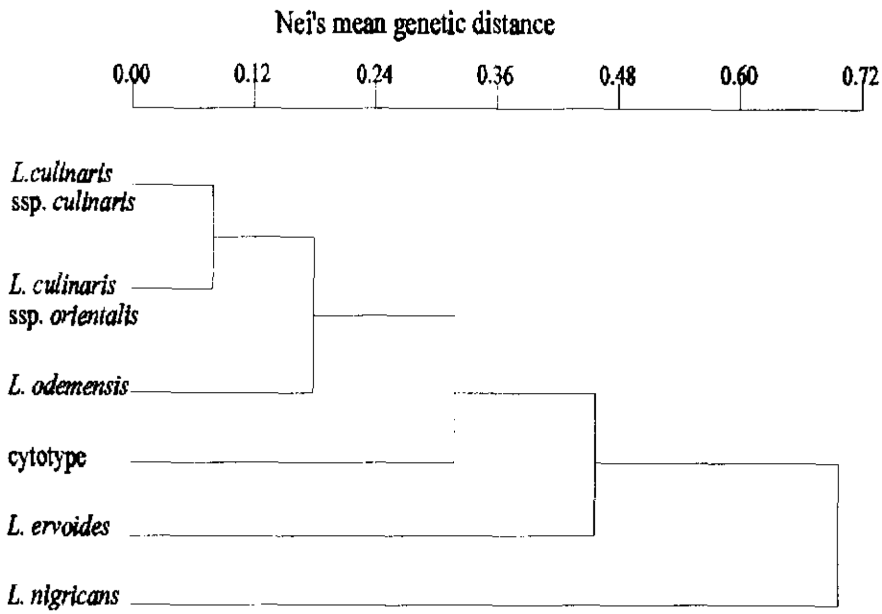

Fig. 26. Phenetic relationship of taxa within the genus *Lens* and a cytotype derived from allozyme polymorphism

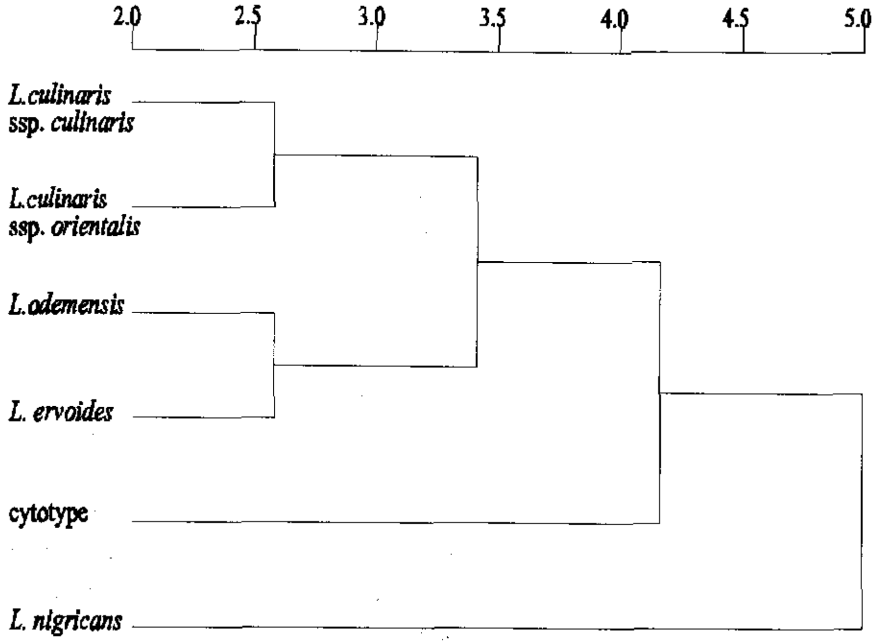

Fig. 27. Phylogenetic relationships of *Lens* taxa and a cytotype based on allozyme polymorphism (levels represent branching order of the tree)

the taxon to which they currently belong (Fig. 27). Phylogenetic relations were estimated by the neighbor-joining method, again using NTSYS-pc. The analysis suggested that *L. odemensis* originated from *L. ervoides* (or *vice versa*) rather than from the cultigen group.

Although not conclusive, the combination of phylogenetic and phenetic evidence suggests that *L. odemensis* should retain its specific status; however, further crossability studies should be carried out on a range of genotypes to assess the potential for gene flow. The evidence presented here shows the cytotype to be quite distinct from *L. nigricans*, both phenetically (Fig. 26) and phylogenetically (Fig. 27). They are more closely related to all the other taxa. This indicates that the cytotype should be raised to the specific status; however, further investigation of *L. nigricans* is required in order to fully separate and define a new taxon.

Predicted group membership

The predicted group membership from discriminant function analysis

Table 46. Predicted group membership from discriminant analysis of individuals within the genus *Lens*

	Predicted group membership %					
Taxon /Group	L. culinaris ssp. culinaris	L. culinaris ssp. orientalis	L. odemensis	L. ervoides	L. nigricans	cytotype
L. culinaris ssp. *culinaris*	65.0	35.0	0.0	0.0	0.0	0.0
L. culinaris ssp. *orientalis*	0.7	93.5	4.6	0.7	0.7	0.0
L. odemensis	0.0	11.4	85.7	2.9	0.0	0.0
L. ervoides	0.0	1.7	0.9	97.4	0.0	0.0
L. nigricans	0.0	3.1	0.0	0.0	96.9	0.0
cytotype	0.0	0.0	0.0	0.0	0.0	100

showed that overall 87.7% of accs. were classified correctly (Table 46) and suggests that isozymes may be of some use in validating species classification initially determined by morphological characters. Indeed, five accs. were found, on re-examination of morphological characters, to be mis-classified in the ICARDA collection as a result of isozyme evidence produced in this study. In particular, this technique may be useful in discriminating between *L. culinaris* ssp. *orientalis, L. odemensis* and *L. nigricans* where morphological differences are small and the predicted group membership percentages are high, 93.5, 85.7 and 96.9, respectively. Each of these three taxa possess unique alleles.

Conclusion

In conclusion, genetic diversity in the cultivated lentil appears to be low, relative to the wild species. The structure of genetic variation in *L. nigricans* suggests a complex situation and the differentiated cytotype appears more closely related to all the other taxa than to its conspecific. In order to understand and classify this variation, further germplasm collection, particularly in France and Spain, is required, followed by an investigation of the genetic variation, possibly at the molecular level, supported by crossability studies. The combination of phylogenetic and phenetic evidence suggests that *L. odemensis* should retain its specific status. This however is not conclusive. The uncertainty could be resolved by crossability studies, carried out on a range of genotypes, from *L. culinaris* ssp. *orientalis*, *L. culinaris* ssp. *culinaris* and *L. ervoides*.

M. Ferguson and L.D. Robertson

1.4.3. Genetic diversity and phylogenetic relationships among the annual *Cicer* species as revealed by isozyme polymorphism

Isozyme analysis has been used widely to estimate genetic variability of crop populations. This method has been useful in addressing questions on population genetic structure and genetic conservation. Knowledge of the genetic diversity of species is particularly important, since modern breeding practices have narrowed the genetic diversity of cultivated crops. This reduction in genetic diversity could severely limit future breeding programs for adaptive traits such as resistance to biotic and abiotic stresses and reduce stability of crop yields. Although considerable data are available for other species, few studies have been conducted with cultivated chickpea and its wild relatives.

The present study was undertaken to investigate the genetic variation within and among the annual *Cicer* species by use of isozyme polymorphism, and to establish allelic frequencies within species. This data on variation for isozyme loci was used to determine phylogenetic relationships among the annual *Cicer* species, to determine the genetic diversity within the genus, and to ascertain whether any correlation exists among isozyme variation and geographical origin of accs.

Materials and methods

Plant materials

A total of 139 accs. of *Cicer* from the germplasm collection held at ICARDA, Aleppo, Syria, representing 36 *Cicer arietinum*, 20 *C. bijugum* Rech., 5 *C. chorassanicum* (Bge.)M.Pop., 5 *C. cuneatum* Rech., 11 *C. echinospermum* Bav., 18 *C. judaicum* Bioss., 19 *C. pinnatifidum* J. & S., 20 *C. reticulatum* Lad., and 5 *C. yamashitae* Kit., were used for this study.

<u>Electrophoresis analysis</u>

Allozyme variation of 10 enzymes encoded by 14 loci was studied by horizontal starch gel electrophoresis using a 12% starch gel. The enzyme systems assayed included: aconitase (ACO), alcohol dehydrogenase (ADH), aspartate aminotransferase (AAT), diaphorase (DIA), esterase cathodal (EST), glucosephosphate isomerase (PGI), leucine aminopeptidase (LAP), malic enzyme (ME), phosphoglucomutase (PGM) and 6-phosphogluconate dehydrogenase (PGD).

Three different gel systems were used: (1) a tris-citrate/lithium borate, pH 8.1 system for AAT, PGI and EST, (2) a histidine, pH 6.1 system for PGM, ME, PGD and ACO and (3) a Trizma base, pH 7.0 system for LAP, DIA and ADH. PGI and ME were also assayed with the Trizma-base system.

<u>Statistical analysis</u>

Four statistical genetic parameters were calculated to analyze the data:

- Proportion of polymorphic loci, was calculated by dividing the number of polymorphic loci by the number of total loci analyzed.
- The mean number of alleles per locus was determined by summing the alleles observed over all loci and dividing them by the number of loci.
- Genetic diversity was computed as the gene diversity measure of diversity index according to Nei (1973).
- Nei's genetic distances between populations were calculated according to Nei (1972) for all possible pair-wise combinations of species using allelic frequencies. A phenogram based on these genetic distances was constructed using the unweighted pair group method (UWPGMA) to illustrate the genetic relationships among species using the computer software package NTSYS-pc (Rohlf 1993). A phylogenetic tree or evolutionary history of the annual wild *Cicer* species was determined using the neighbor-joining method of phylogenetic tree estimation of Saitou and Nei (1987) with the program provided in NTSYS-pc (Rohlf 1993).

Table 47. (Cont'd.)

Isozyme allele		Cicer species (Number of alleles)								
		ari[a]	ret	ech	jud	pin	bij	chor	yam	cun
	(No. accs.)	36	20	11	18	19	20	5	5	5
	(No. plants)	166	139	77	118	123	127	30	24	29
ME	a	1	0.8878	0.8800	0	0	0.0800	0.9286	1	0.7222
	b	0	0.1122	0.1200	1	1	0.9200	0.0714	0	0.2778
PGD1	a	0	0.5760	0.6984	0.7387	0.8850	0.0560	1	0.6500	0.2500
	b	0	0.1840	0.2063	0.1793	0.0531	0.0841	0	0.2000	0.5417
	c	1	0.1120	0.0952	0.0849	0.0619	0.7944	0	0.1500	0.1667
	d	0	0.1280	0	0	0	0.0561	0	0	0.0417
	e	0	0	0	0	0	0.0093	0	0	0
PGD2	a	0.3761	0	0	0	0	0.0960	0.8947	0.9000	1
	b	0.1743	1	1	0	0	0.0192	0	0	0
	c	0.4495	0	0	0	0	0.0096	0	0	0
	d	0	0	0	1	1	0.8750	0.1053	0.1000	0
PGI1	a	1	1	1	0.7059	1	1	0.6667	0.3529	0.5652
	b	0	0	0	0.2921	0	0	0.3333	0.6471	0.4348
PGI2	a	0	0	0.0893	0	0	0	0	0	0.6087
	b	1	0.8374	0.9107	1	1	1	0.1905	0.3529	0.3913
	c	0	0.1626	0	0	0	0	0	0.6471	0
	d	0	0	0	0	0	0	0.8095	0	0
PGM1	a	0	0.0615	0.1500	0.6885	0.8261	0.8906	0.8182	0	0.2941
	b	0	0.3951	0.7000	0.2459	0.1304	0.0625	0.1818	0.7780	0.4706
	c	1	0.5432	0.1500	0.0656	0.0435	0.0469	0	0.1111	0.2353
	d	0	0	0	0	0	0	0	0.1111	0
PGM2	a	0	0.0375	0.0750	0.7541	0.2059	0.4688	0.8182	0.6667	0.0588
	b	1	0.7125	0.800	0.2459	0.7500	0.5313	0.0909	0.1111	0.2946
	c	0	0.2500	0.1250	0	0.0441	0	0.0901	0.2222	0.5882
	d	0	0	0	0	0	0	0	0	0.0588

[a]: ari = *Cicer arietinum*, bij = *C. bijugum*, cho = *C. chorassanicum*, cun = *C. cuneatum*, ech = *C. echinospermum*, jud = *C. judaicum*, pin = *C. pinnatifidum*, ret = *C. reticulatum*, yam = *C. yamashitae*. [b]: No allele, or no activity.

Table 47. Allelic frequencies per locus in nine annual *Cicer* species

Isozyme	allele	ari[a]	ret	ech	jud	pin	bij	chor	yam	cun
		Cicer species (Number of alleles)								
	(No. accs.)	36	20	11	18	19	20	5	5	5
	(No. plants)	166	139	77	118	123	127	30	24	29
AAT	a	0	0	0	0	0	0	0	1	0
	b	0	0	0	0	0	0	0.6550	0	0
	c	0	0.3621	1	1	1	1	0.3448	0	0
	d	1	0.6379	0	0	0	0	0	0	1
ACO1	a	0	0.1972	0	0	0	0	0	0.5833	0
	b	1	0.5600	1	0.1563	0.1579	0	1	0.4167	0
	c	0	0.2394	0	0.1875	0.6184	1	0	0	0
	d	0	0	0	0.6562	0.1974	0	0	0	0
	n[b]	0	0	0	0	0.0263	0	0	0	1
ACO2	a	0	0.3467	0	0.0462	1	1	0	0	0
	b	0	0	0	0.0769	0	0	1	1	0
	c	0	0.1067	0	0.5692	0	0	0	0	0
	d	0	0.4933	1	0.1254	0	0	0	0	1
	e	1	0.0533	0	0.0923	0	0	0	0	0
ADH	a	0.9237	0.8704	0.8627	0	0	0.0660	0	0	1
	b	0	0.0556	0	0	0	0	0	1	0
	c	0.0763	0.0741	0.1373	1	1	0.9340	1	0	0
DIA	a	1	1	1	0.2812	1	1	0	0	0
	b	0	0	0	0.5469	0	0	0	0	0
	c	0	0	0	0.1719	0	0	0	0	1
	d	0	0	0	0	0	0	1	1	0
EST	a	0	0	0	0	0	0	1	0.3333	1
	b	1	1	1	0.2162	0.1778	1	0	0.3333	0
	c	0	0	0	0.7838	0.8222	0	0	0.3333	0
LAP	a	0	0.1237	0.0851	0	0.0119	0	0.6923	0	0.0556
	b	0	0	0	0	0	0	0.1538	0	0.1111
	c	0	0	0.0638	0	0.0238	0	0.0769	1	0.7222
	d	1	0.7629	0.8511	0	0.9048	1	0.0769	0	0.0556
	e	0	0.1134	0	1	0.0595	0	0	0	0.0556

Results

Genetic diversity among species

Fourteen loci were assayed from the 10 enzyme systems analyzed (Table 47). All loci were polymorphic across the nine *Cicer* species using the 99% criterion. The proportion of polymorphic loci differed within each species from the least polymorphic *C. arietinum* (0.14) to the most polymorphic *C. reticulatum* (0.71, Table 48).

Table 48. Proportion of polymorphic loci and the number of alleles per locus in annual *Cicer* species

Cicer	Proportion of polymorphic loci	Average no. alleles/locus
arietinum	0.14	1.21
reticulatum	0.71	2.35
echinospermum	0.50	1.78
judaicum	0.57	2.10
pinnatifidum	0.42	1.92
bijugum	0.42	1.85
chorassanicum	0.57	1.78
yamashitae	0.57	1.85
cuneatum	0.50	2.00

Polymorphism was detected in *C. arietinum* only for ADH and PGD2 (Table 47). All other species had nearly 0.50 of their loci polymorphic. All of the accs. of *C. cuneatum* and some of *C. pinnatifidum* were monomorphic for ACO1.

Among 14 loci over all species, 53 alleles, or an average of 3 to 4 alleles per locus, were detected. Per species there was a mean of 1.9 alleles per locus (Table 48).

The mean genetic diversity (He) over 14 loci showed a large variation across species (Table 49). The mean diversity varied from 0.0547 for *C. arietinum* to 0.3105 for *C. reticulatum*. The genetic diversity index (He) within each species showed considerable variation for diversity among loci, from 0 to 0.6667. In *C. cuneatum*,

Table 49. Mean genetic diversity or mean heterozygosity index (He) in nine annual *Cicer* species

Locus	ari	ret	ech	jud	pin	bij	cho	yam	cun	Mean[a]
AAT	0	0.4619	0	0	0	0	0.4520	0	0	0.1015
ACO1	0	0.5901	0	0.5000	0.5529	0	0	0.4861	0	0.2365
ACO2	0	0.6222	0	0.4017	0	0	0	0	0	0.1137
ADH	0.1409	0.2338	0.2368	0	0	0.1232	0	0	0	0.0816
DIA	0	0	0	0.5922	0	0	0	0	0	0.0658
EST	0	0	0	0.3389	0.3239	0	0	0.6667	0	0.1477
LAP	0	0.3898	0.2643	0	0.1770	0	0.4852	0	0.4598	0.1973
ME	0	0.1992	0.2112	0	0	0.1472	0.1326	0	0.4012	0.1212
PGD1	0	0.6054	0.4606	0.4149	0.2101	0.3554	0.6145	0.5150	0	0.3528
PGD2	0.6261	0	0	0	0	0.2155	0.1884	0.1800	0	0.1736
PGI1	0	0	0	0.4163	0	0	0.4440	0.4567	0.4914	0.2009
PGI2	0	0.2723	0.1626	0	0	0	0.3084	0.4567	0.4763	0.1862
PGM1	0	0.5450	0.4660	0.4611	0.2986	0.2007	0.2974	0.3700	0.6366	0.3639
PGM2	0	0.42840	0.3387	0.3708	0.3931	0.4979	0.3141	0.4937	0.5603	0.3774
He	0.0547	0.3105	0.1528	0.2497	0.1396	0.1099	0.1873	0.2589	0.2600	------

[a] *Arithmetic mean*

three loci were polymorphic (He>0.5): PGD1, PGM1 and PGM2; two loci were polymorphic in *C. yamashitae*: PGD1 and EST (cathodal); one in *C. pinnatifidum*: ACO1; two in *C. judaicum*: ACO1 and DIA; four in *C. reticulatum*: ACO1, ACO2, PGD1 and PGM1; and one in *C. arietinum*: PGD2.

Relationships among species

Nei's identities and distances were calculated to compare the genetic affinities of the nine species (Table 50). The genetic distances observed between *C. arietinum*, *C. reticulatum* and *C. echinospermum* were much smaller than any other distances. The phenogram drawn from these values displays four different groups of annual *Cicer* species (Fig. 28). *C. arietinum*, *C. reticulatum* and *C. echinospermum* are clustered in the first group, *C. judaicum*, *C. pinnatifidum* and *C. bijugum* in the second, *C. chorassanicum* and *C. yamashitae* in the third, and *C. cuneatum* formed a fourth group. *C. cuneatum* had the largest genetic distances from the three species of the second group (1.466 to 1.697). The two species of the third group had large genetic distances with all other species.
The phylogenetic tree for the wild annual species and cultigen was determined using the neighbor-joining method of Saitou and Nei (1987). Only one tree was produced, evidence that the set of clusters produced are unique. The phylogenetic tree developed (Fig. 29) shows the four major groups of wild annual *Cicer* illustrated in the phenogram mentioned in the preceding paragraph (Fig. 28). Early in the evolution of the annual wild *Cicer* species there was a bifurcation to one group that formed the groups 1 and 2 mentioned above and one that formed the groups 3 and 4 mentioned above (Fig. 29). This phylogenetic tree supports the theory that *C. reticulatum* is the expected progenitor of *C. arietinum*; and that *C. echinospermum* split off at an earlier stage in evolution. Similarly, *C. bijugum* split off from *C. judaicum* and *C. pinnatifidum*; and *C. cuneatum* split off from *C. chorassanicum* and *C. yamashitae*.

Geographical variation of genetic diversity

Among the nine *Cicer* species, only accs. of four species had different countries of origin. All accs. of *C. arietinum*, regardless of their origin, were less polymorphic (polymorphic loci = 0.14) with low genetic diversity indices (He < 0.06, Table 51). The populations of *C. arietinum* from Syria and Iraq showed slightly higher values than those from Jordan and Turkey. In contrast, most populations from the other three species were more diverse and He varied from 0.0757 to 0.2611.

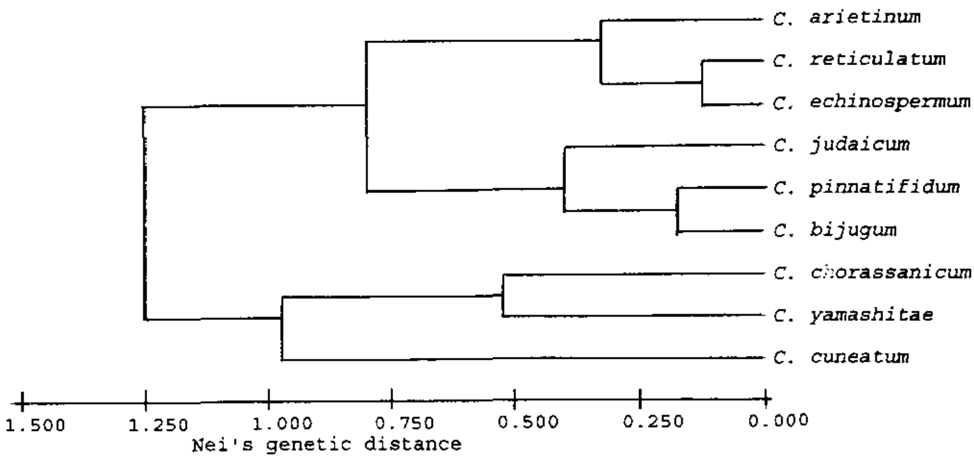

Fig. 28. Dendrogram of relationships among annual *Cicer* spp.

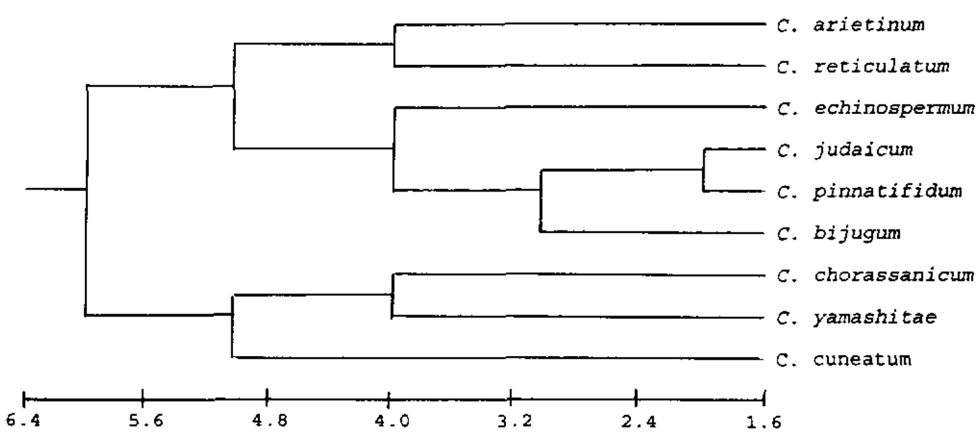

Fig. 29. Midpoint-rooted neighbor-joining annual *Cicer* phylogenetic tree computed using Nei's genetic distances (levels represent branching order of the tree)

Table 50. Genetic affinities of nine species calculated following Nei's distances

Species	ari	ret	ech	jud	pin	bij	cho	yam	cun
ari	0.000								
ret	0.217	0.000							
ech	0.368	0.086	0.000						
jud	1.383	0.946	0.825	0.000					
pin	0.894	0.579	0.572	0.252	0.000				
bij	0.660	0.521	0.563	0.424	0.130	0.000			
cho	1.304	1.142	0.985	0.882	0.978	1.184	0.000		
yam	1.308	1.099	1.124	1.371	1.645	1.836	0.520	0.000	
cun	0.906	0.781	0.873	1.466	1.642	1.697	1.002	0.907	0.000

Table 51. Estimates of mean genetic diversity indices (He) in four wild species of *Cicer* by country

	arietinum				bijugum		judaicum				pinnatifidum		
	JOR	LBN	SYR	IRQ	SYR	TUR	JOR	LBN	SYR	TUR	LBN	SYR	TUR
No. accs.	9	10	9	8	3	17	5	4	5	4	1	7	11
No. plt.	32	46	43	45	12	115	38	26	30	24	8	37	78
Isozyme													
AAT	0	0	0	0	0	0	0	0	0	0	0	0	0
ACO1	0	0	0	0	0	0	0	0.4857	0.5446	0.4710	0.5600	0.5648	0.5418
ACO2	0	0	0	0	0	0	0.2906	0.6146	0.4262	0.3898	0	0	0
ADH	0.0859	0.0468	0.2379	0.1847	0.4630	0.0619	0	0	0	0	0	0	0
DIA	0	0	0	0	0	0	0.4032	0.6027	0.4857	0.5000	0	0	0
EST	0	0	0	0	0	0	0.0804	0.4735	0.4687	0	0	0	0.4167
LAP	0	0	0	0	0	0	0	0	0	0	0	0.1215	0.2332
ME	0	0	0	0	0.3969	0.1057	0	0	0	0	0	0	0
PGD1	0	0	0	0	0.1973	0.3679	0.4481	0.4062	0.5203	0.1696	0	0.1551	0.2549
PDG2	0.3821	0.3799	0.5100	0.5635	0.4937	0.1764	0	0	0	0	0	0	0.0276
PGI1	0	0	0	0	0	0	0.4978	0.3329	0.0859	0.4753	0	0	0
PGI2	0	0	0	0	0	0	0	0	0	0	0	0	0
PGM1	0	0	0	0	0.3700	0.1693	0.4095	0.5600	0.4950	0.1522	0	0.3025	0.3221
PGM2	0	0	0	0	0.3454	0.5000	0.3329	0.1800	0.4200	0.4442	0.5000	0.3624	0.3794
He	0.0334	0.0304	0.0534	0.0534	0.1618	0.0986	0.1758	0.2611	0.2461	0.1858	0.0757	0.1075	0.1554

IRQ = Iraq; JOR = Jordan; LBN = Lebanon; SYR = Syria; TUR = Turkey

For *C. bijugum*, accs. from Syria and Turkey had diversity for the same loci, with differences in the degree of diversity. For *C. judaicum*, accs. from Lebanon had the highest values (He = 0.2611) followed by accs. from Syria (He = 0.2461). Accs. from these two countries were similar but the accs. from Turkey had two more rare alleles for the loci PGD1 and PGD2. The accs. from Turkey and Jordan had almost the same diversity indices but each of them differed from the others by one locus being monomorphic: EST for the accs. from Turkey and ACO1 for the accs. from Jordan. For *C. pinnatifidum*, the accs. from the three countries were distinct, considering the number of monomorphic loci and diversity indices. Accs. from Turkey were more diverse (He = 0.1554). The accs. from Syria had two less monomorphic loci than the one from Turkey: EST and PGD2 with He = 0.1075. However, the data for *C. pinnatifidum* from Lebanon are questionable since only one acc. was available.

Discussion

Polymorphism was found for the eight wild annual species at much higher levels than reported previously. Previous researchers found *C. echinospermum, C. judaicum, C chorassanicum*, and *C. yamashitae* with no polymorphic loci and *C. bijugum* and *C. cuneatum* with only 0.05 polymorphic loci, whereas these ranged from 0.42 to 0.57 in our study. For *C. reticulatum,* they found the value for polymorphic loci as 0.59 vs. the 0.71 that we found. These results are reflected in the genetic diversity indices calculated for each species.

With the exception of *C. reticulatum*, the greater the distance of a species from the cultigen, the greater was it's genetic diversity.

For the wild annual *Cicer* species, the average number of alleles per locus varied from 1.78 for *C. chorassanicum* and *C. echinospermum* to 2.10 for *C. judaicum*. The numbers reported by others for average number of alleles per locus are much lower (1.00 to 1.68).

Cicer arietinum had low isozyme polymorphism: only two loci (ADH and PGD2) out of 14 analyzed were polymorphic. These results are supported by the research of others who also found few isozyme loci polymorphic for the cultigen.

With the exception of *C. pinnatifidum*, there were no major differences in countries of origin for genetic diversity indices (Table 51).

We used only a subset of the isozyme systems used by the authors cited above. Therefore, the major difference for number of alleles per locus and higher levels of polymorphism and genetic diversity should be the greater number of accs. per species used in our study compared to earlier studies. Even though a large number of plants per acc. were used by these researchers for the wild annual species, little polymorphism was observed by them.

The phylogenetic tree developed by the neighbor-joining method supports the theory that *C. reticulatum* is the probable progenitor of *C. arietinum* (Fig. 29). Though *C. echinospermum* is also closely related to *C. arietinum*, it split off from an earlier common ancestor to form the secondary gene pool. This was not discernable from our phenogram and those of earlier researchers.

Phenetic and phylogenetic analysis both support the grouping of annual *Cicer* into four major similarity groups: (1) the primary and secondary gene pool (*C. arietinum, C. reticulatum, and C. echinospermum*); (2) *C. judaicum, C. pinnatifidum, and C. bijugum*; (3) *C. chorassanicum* and *C. yamashitae*; and (4) *C. cuneatum*.

The phylogenetic evolutionary tree developed from our analysis supports crossability studies and karyotype analysis that led to the theory that the primary gene pool of the cultivated chickpea consists of the cultigen and its progenitor, *C. reticulatum*, with *C. echinospermum* in the secondary gene pool. The seed protein data and isozyme profiles of these three species are similar, indicating that they have probably diverged recently, which is indicated in the phylogenetic tree we have produced using isozyme frequencies.

The reduced variability found in the isozyme profiles of *C. arietinum* compared to the other two species found in the primary and secondary gene pool is probably a reflection of the 'founder effect'. The genetic diversity value for *C. arietinum* was only 0.0547 compared to 0.3105 for the wild progenitor, *C. reticulatum* (Table 49).

M. Labdi (ITGC, Algeria), L.D. Robertson (GRU), K.B. Singh (GP) and A. Charrier (INRA, Montpellier)

Table 52. Number of clusters of *L. culinaris* ssp. *orientalis* accs. based on RAPD data calculated according to Nei's genetic distance, and the number of accs. found in each of nine geographic regions

Region	No. clusters per region	No. accs.
Uzbekistan, Tajikistan, Turkmenistan	2	12
Iran	1	2
Northern Turkey	4	5
Central eastern Turkey	3	5
South western Turkey	4	7
Cyprus	2	3
South eastern Turkey and northern Syria	11	65
Lebanon	5	22
Southern Syria, Palestine and Jordan	5	10

Table 53. GEC (mg/g) content of *V. narbonensis* and its relatives

Vicia species	Number	Mean	SE
hyaeniscyamaus	5	13.91	1.04
johannis	20	14.80	0.43
serratifolia	2	14.35	4.71
narbonensis	88	17.97	0.40

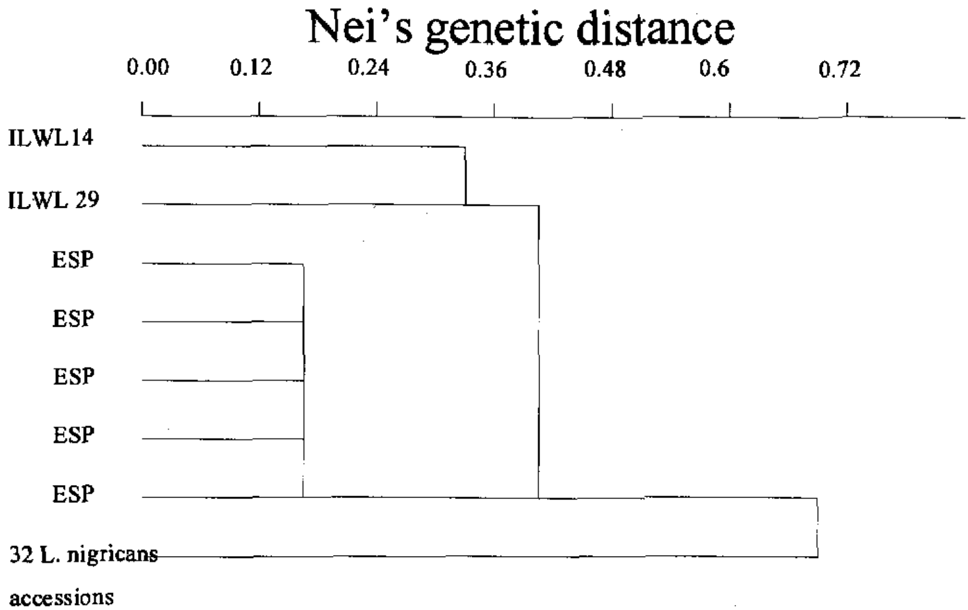

Fig. 30. Dendrogram resulting from cluster analysis of Nei's distance values for two *Lens nigricans* cytotypes (ILWL 14 & 29), five accs. of *L. nigricans* collected in Spain and 32 *L. nigricans* accs.

1.4.4. Isozyme phenetic studies with *Lens nigricans* newly collected from Spain.

Isozyme studies carried out to date using seven enzyme systems (AAT, ACP, LAP, ME, PGI, PGD and SKDH), providing a total of eleven scorable loci, have shown no variation either between populations or within population. Interestingly, as part of a larger study on the relationship between *Lens* taxa based on isozyme electrophoresis, the new accs. do not cluster with *Lens nigricans*, but with two "cytotypes" from Toulon, France (ILWL 14) and Jativa, Spain (ILWL 29). Ladizinsky (1984) identified these two cytotypes as a result of crossability studies. They were found to be cross incompatible with their conspecific *Lens nigricans*. Fig. 30 shows a section of a dendrogram resulting from the clustering of 32 *Lens* *nigricans* accs., the cytotypes (ILWL 14 and 29), and the five new accs. from Spain, based on Nei's measure of genetic distance (1972). In addition, the shape of the first bifoliate leaflet, which is characteristically round in the case of *L. nigricans*, was found to be more elongated, as was evident in the cytotypes, ILWL 14 and 29. **M. Ferguson and L.D. Robertson (GRU) and B. Ford-Lloyd and J. Newbury (University of Birmingham)**

1.4.5. Genetic variation within *Lens culinaris* ssp. *orientalis*, the wild progenitor of the cultivated lentil, using RAPD

L. culinaris ssp. *orientalis* is recognized as a wild progenitor of the cultivated lentil, *L. culinaris* ssp. *culinaris.* It is fully inter-fertile with the cultivated lentil and therefore has potential to provide useful genetic resources for future plant breeding efforts. The very existence of *L. culinaris* ssp. *orientalis* is however under threat due to habitat destruction. It is therefore important and logical that these genetic resources are conserved *ex-situ.*

The primary objective of the wild *Lens* collection at ICARDA is to conserve as wide a representation as possible of the spectrum of genetic variation which still exist, irrespective of the relative frequency or rarity of any genes or linked gene complexes. Unfortunately, to date most collections are measured only quantitatively, by the number of accs. they contain, rather than qualitatively, by the genetic diversity those accs. represent. Most species exhibit extensive geographical variation with a pattern of within population variation superimposed upon it. An understanding of the geographical patterns of genetic variation or genetic structure of a species is required in order to meet conservation objectives. This necessarily involves the measurement of genetic variation.

An accurate measure of genetic variation has been sought for many years. Traditionally, the measurement of agro-morphological characters is used to assess diversity, but the susceptibility of these characters to environmental influence renders this measure relatively insensitive. Isozyme and seed protein analyses are widely used techniques which operate at the gene product level. Their major drawback appears to be the limited number of polymorphic units which are available. In 1990 Williams et al. described a new technique, Random Amplified Polymorphic DNA (RAPD) to detect polymorphism at the DNA level. The RAPD procedure is simple, rapid, requires only small amounts of DNA which need not be of high quality, involves no radioactivity and can be used over a wide range of species. It currently provides a quick method for the study of population genetics.

A study is underway at ICARDA to identify geographical clines of genotypes of *L. culinaris* ssp. *orientalis* to enable appropriate collection strategies to be devised so that genotypes may be equally sampled and with distinct or high variation identified.

One plant per acc. from 131 accs. of *L. culinaris* ssp. *orientalis* from the ICARDA wild lentil collection were screened for RAPD variation using two different primers, 1 and 4 of the F kit from Operon Technologies Inc., Alemeda, California, USA. The accs. were distributed throughout the geographical range of the species. DNA extraction was based on a method for *Musa* spp. by Gawel and Jarret (1991). Amplification was an adaptation of the protocol described by Williams et al. (1990) and products visualized on a 1.2% agarose gel.

Amplification products were scored as present or absent. Nei's genetic distance was calculated (Nei 1972) and cluster analysis performed using NTSYS (Rohlf 1993). An arbitrary minimum genetic distance of 0.8 was used to define different clusters. In this way a total of eleven different groups each containing similar genotypes were defined. The frequency of bands was calculated for each group and Nei's genetic distance calculated once more. Using cluster analysis the relationship between groups could be visualized in the form of a dendrogram (see Fig. 31). The number of accs. representing each cluster are also given. From this figure it can be seen that clusters 1, 3 and 11, the most distant clusters to the bulk of accs., consist of one (clusters 3 and 11) and two (cluster 1) accs. only. They thus represent rare variation in the collection. If these four accs. are removed from the analysis four major groups emerge from the remaining seven clusters (see Fig. 32). Clusters 2 and 9 are fairly similar, clusters 4, 10 and 7 are closely related and clusters 5 and 8 come together at 0.012, however cluster 6, represented by only 10 accs., appears to be most distantly related.

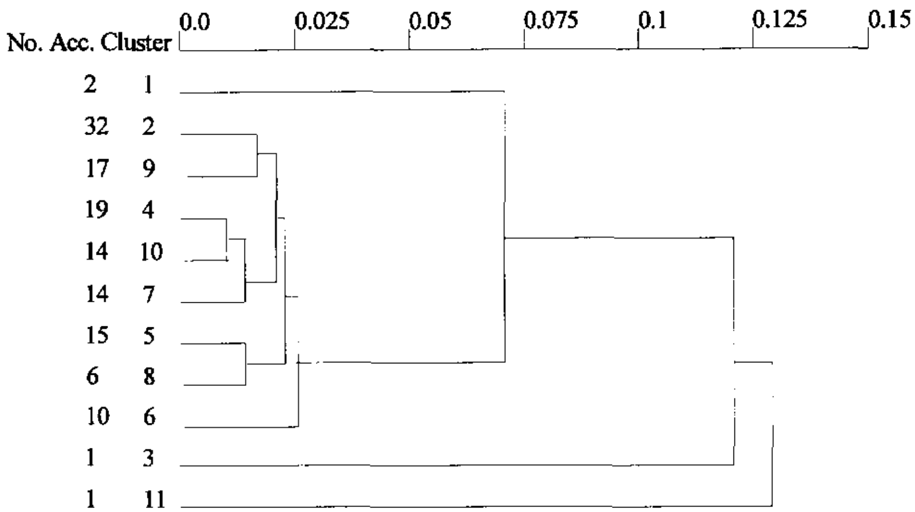

Fig. 31. Relationships between eleven genotype clusters of *Lens culinaris* ssp. *orientalis* based on RAPD data

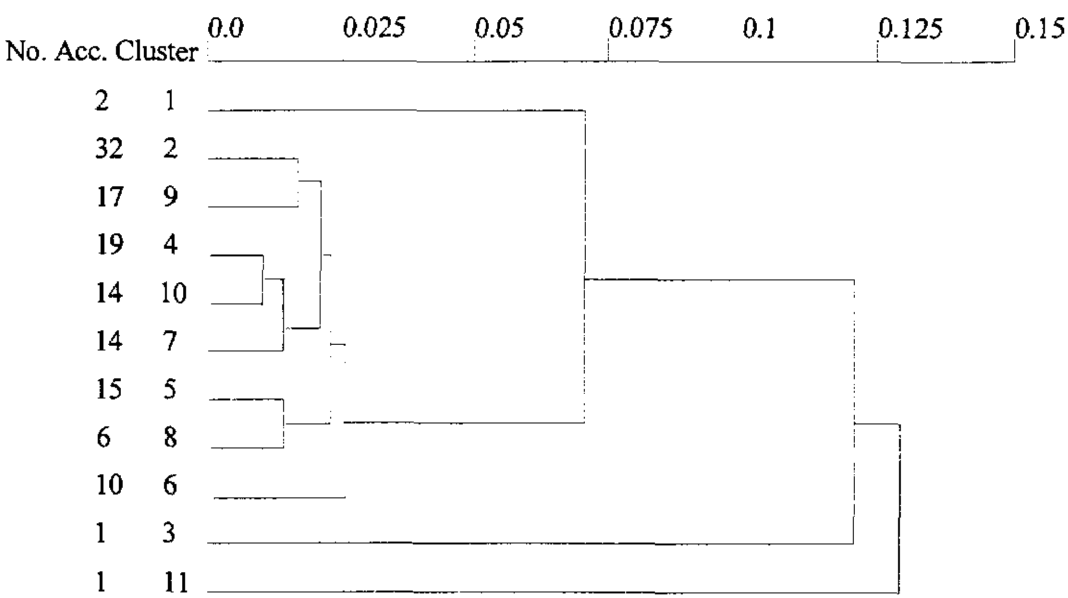

Fig. 32. Relationships of eight major clusters within *Lens culinaris* ssp. *orientalis* based on RAPD data

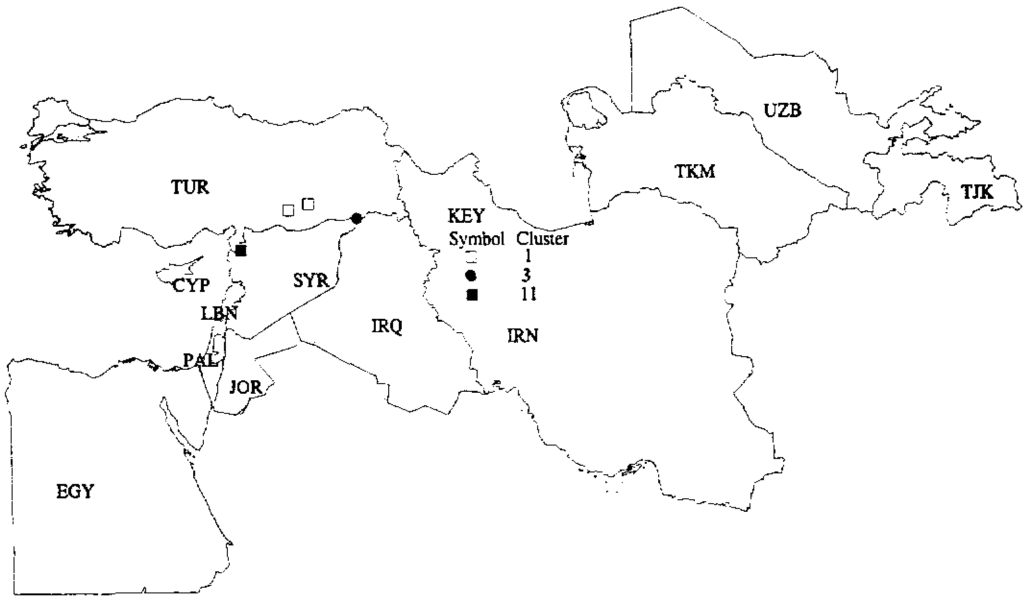

Fig. 33. Geographical distribution of clusters 1, 3, and 11 of *Lens culinaris* ssp. *orientalis*

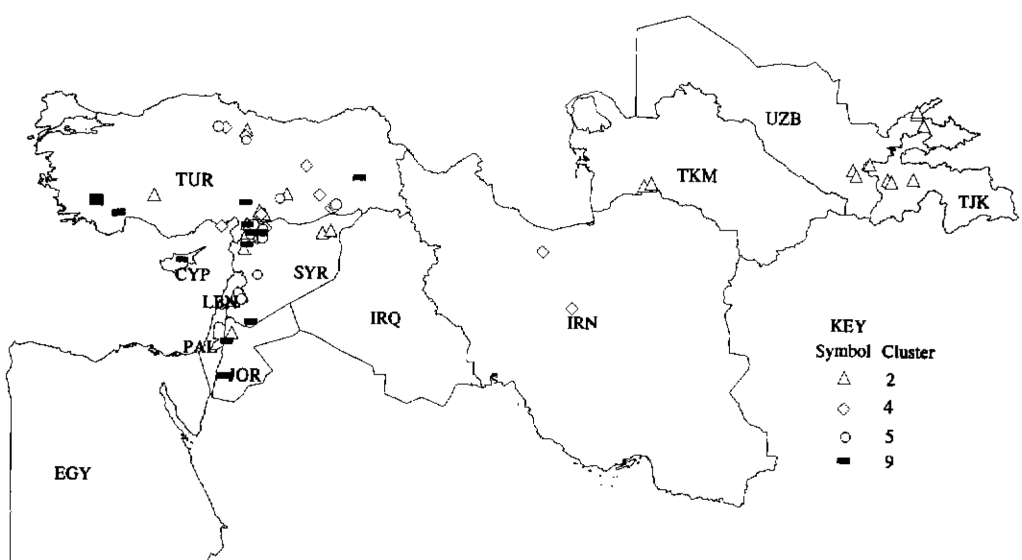

Fig. 34. Geographical distribution of clusters 2, 4, 5 and 9 of *Lens culinaris* ssp. *orientalis*

The geographical location of clusters 1, 3 and 11 can be seen in Fig. 33. The geographical location of the four clusters containing the greatest number of accs., clusters 2, 4, 5 and 9 based on Nei's measure of RAPD data are also shown in Fig. 34. It is interesting to note from Fig. 34 that *L. culinaris* ssp. *orientalis* from Turkmenistan, Uzbekistan and Tajikistan all fall into the same cluster. They are, therefore, relatively similar. This cluster stretches to south eastern Turkey, northern Turkey and south to Jordan. Cluster 2 appears in Iran, northern Turkey and north western Syria. Cluster 5 has more of a longitudinal distribution from northern Turkey to southern Syria. Cluster 9 is distributed more along the Mediterranean with an outlier population in eastern Turkey. All four of these major clusters overlap in south eastern Turkey and northern Syria. Similarly, Fig. 33 shows three rare groups are also found in this region suggesting this region is a center of diversity. This is also the region from where lentil is thought to have been domesticated. Caution should however be taken before drawing conclusions from the above results as the number of accs. representing this region is far higher than in other regions as can be seen from Table 52. The data also suggests that collection missions should be target to increase the number of accs. from genotype cluster 6 and more accs. should be obtained from both northern Turkey and south western Turkey as these appear to have a relatively high degree of diversity. Accs. from Iran are also under represented.

M. Ferguson and L.D. Robertson (GRU), and B. Ford-Lloyd (University of Birmingham)

1.4.6. Screening *Vicia narbonensis* for anti-nutritional factors

Legumes contain a wide array of secondary metabolites which reduce the nutritional value of the whole plant and seeds for both man and ruminant animals. An important non-protein amino acid in *V. narbonensis* is γ-Glutamyl-S-ethenyl cysteine (GEC). This compound reduces the palatability of narbon bean because of the 'sulfur' taste it gives the seed.

A program was started in 1994 to screen *V. narbonensis* and it's relatives for the concentration of GEC. The mean of *V. narbonensis* was higher for GEC than the relatives in its section (Table 53) .

However, there was a large range in GEC content found (Fig. 35).
M. Ferguson and L.D. Robertson (GRU)

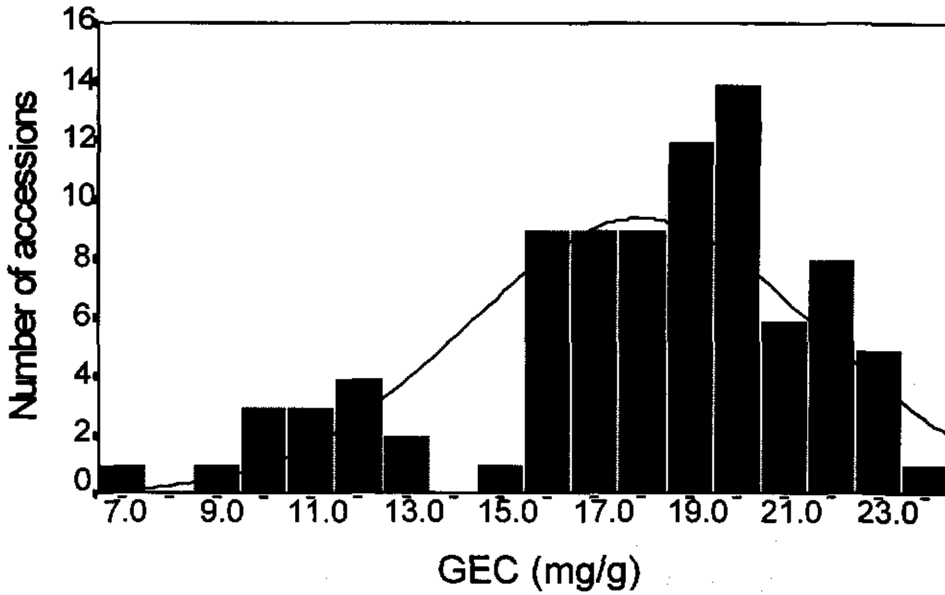

Fig. 35. Distribution of GEC (mg/g) for *Vicia narbonensis*

1.4.7. Effect of environment and genotype on barley seed infection with *Pyrenophora graminea* in northern Syria

Pyrenophera graminea, the casual agent of leaf stripe disease of barley, is strictly seed-borne pathogen. The disease can provoke reduction in yield and grain quality in barley growing areas. Under favorable conditions the pathogen produces profuse sporulation from lesions developed on leaves. Disseminated conidia, secured by rain splashing, contaminate emerged heads and infect seeds during different stages of its development. Under artificial infection, barley genotypes differ in their reaction towards *P. graminea*. The genotype tendency for seed infection under natural conditions is however unknown well. Therefore the objective of this research subject was to study influence of natural conditions on seed infection by *P. graminea*, and to have better information on the effect of genotype x environment interaction on seed infection.

Fifteen barley genotypes (Table 54) were tested during the 1992-93 and 1993-94 seasons for reaction to *P. graminea* under natural conditions prevailing at three sites in Northern Syria: Jindirees (high rainfall), Tel Hadya (moderate rainfall), and Breda (low rainfall). Barley lines were each planted in 1m x 2 rows with 3 replications in a RCB design. Genotypes were separated by 1 row of a susceptible spreader and the whole experiment was surrounded by the spreader as well. Spreader seeds were artificially inoculated with the pathogen (isolate PYG 8710), prior planting. Tested lines were harvested in June, and a randomized sample of 150 seed/line were germinated under 8$\pm$1 c° for 10 days with continuous dark. Each five germinated seeds were transferred to a conical plastic tube containing a mixture of soil-sand-pythmous and incubated at 20 $\pm$ 1C° with continuous light. The number of seedlings showing leaf stripe symptoms were recorded after 4 weeks.

Table 54. Percentage of barley seedlings infected with *P. graminea* at 3 sites in Northern Syria. Average of 1992–93 and 1993–94 growing seasons, resp.

Variety	Tel Hadya			Jinderees			Breda			Across sites		
CI06944	37.67	a*	a**	47.67	a*	a**	39.67	a*	a**	41.67	a*	a**
Arta	18.50	b	b	26.00	b	b	24.99	ab	b	12.17	ab	b
Beecher	4.34	bc	c	16.67	bc	c	6.995	bc	c	12.67	b	bc
Roumi	12.00	cd	c	9.995	cd	cd	11.99	bc	c	11.33	b	bc
Faiz	7.665	de	d	4.330	cd	d	4.330	bc	c	5.44	b	c
ACSAD 176	4.330	efg	efg	4.665	cd	d	6.995	bc	c	5.33	b	c
WI2291	7.330	def	de	2.000	cd	d	2.995	bc	c	4.11	b	c
D. Alla 106	5.330	efg	def	4.330	cd	d	2.330	bc	c	4.00	b	c
Harmal	4.330	efg	efg	4.665	cd	d	2.330	bc	c	3.78	b	c
Rihan 03	2.995	efg	fgh	6.330	cd	d	1.995	bc	c	3.77	b	c
Salmas	2.165	fg	fgh	3.000	cd	d	4.665	bc	c	3.277	b	c
Tadmor	4.665	efg	defg	3.330	cd	d	0.660	c	c	2.89	b	c
Zanbaka	5.000	efg	def	0.665	d	d	1.665	bc	c	2.44	b	c
Betzes	1.665	g	gh	1.665	cd	d	3.000	bc	c	2.11	b	c
Vada	1.000	g	gh	2.660	cd	d	0.995	bc	c	1.55	b	c

* Figures with similar letters do not differ significantly (P>0.05) according to the Tukey's Test.

** Figures with similar letters do not differ significantly (P>0.05) according to the Duncan's Test.

In terms of percentage of infected seedlings during the two seasons, results reveal significant differences between genotypes within and across three sites (Table 54). It shows also a genotype x location interaction in both seasons (Table 55). Differences between sites were however insignificant in the first season due to rainfall occurred during spring of 1993, across three sites, but it was significant in 1993-94.

Table 55. Analysis of variance for infected barley seedlings in two seasons (1992–93 and 1993–94)

Source	D.F.	S.S.	M.S.	F	Prob
Locations	2	33.784	16.89	0.0439	
Error	3	1153.820	384.607	-	
Varieties	14	9772.876	698.063	13.311	0.0000
Loc. x Var.	28	393.546	14.055	0.268	
Error	42	2202.582	52.442		
Total	**89**	**13556.607**			

LSD: 14.61 at P>0.050

Turkey's and Duncan's tests permit us to classify genotypes reaction under natural conditions into two groups; susceptible to moderately susceptible (CI 06944, Arta, Beecher, Roumi) and resistant to moderately resistant. Vada, Betzes and Zanbaka proved to be the most resistant cultivars.

It is evident that the most resistant to susceptible genotypes are consistent in their reaction towards this pathogen within and across locations, compared to moderately resistant to moderately susceptible genotypes.

A. El-Ahmed, S. Asaad (GRU) and J. van Leur (GP)

1.4.8. Development of new blotter method for detection of *Pyrenophora graminea* in barley seed.

The routine test for detecting any pathogen should be reliable, simple in application, not costly, and results can be reproduced for any seed sample in a shot time.

Detection of *P. graminea* in barley seed has been longtime recommended by the use of conventional blotter/freezing blotter (B/FB) and growing-on methods. Both techniques reveal satisfactory results but the latter method is costly, required more space, and time consuming. Therefore the B/FB method being widely adopted as a routine test at seed health laboratories, although detection of infected seed by this technique depends entirely on mycelium characteristics where species determination is always in doubt because of absence or scarcity of conidia development.

The Seed Health Laboratory (SHL) at ICARDA has developed in 1995 a new technique named Cold Blotter (CB) method, where seeds are incubated at 8°C instead of 20°C used in the B/FB method. Results obtained from the CB method proved its performance over other methods, with the following advantages:

- CB Technique reveals higher number of infected seeds within a very short time (3 to 4 days) compared to 8 to 10 days and 30 days needed in the B/FB and growing-on methods, respectively.
- The CB method allowed development of conidiophores and conidia of *P. graminea* on infected seed starting from the 2nd day of incubation at 8°C. Mycelium development at this degree was very limited during the first 5 days of incubation.
- Development of common saprophytes associated with barley seed was also very limited. This makes seed examination very easy.
- There is no need to kill the embryo. Therefore the CB method is considered a non-destructive technique, suitable even for the very limited number of seed sample. The non-infected seed could be then retained for direct growing.

Because of the above advantages, the SHL at ICARDA has adopted this method as a routine test for *P. graminea* in barley seeds. CB method results a quick and reliable detection of the pathogen, thus it is also recommended for use in other seed health laboratories dealing with barley seeds, either for quarantine or for seed certification, seed treatment, cultivar resistance, and genebank conservation.

A. El-Ahmed and S. Asaad

1.5. DOCUMENTATION OF GENETIC RESOURCES

1.5.1. Hunting evaluation data

Genetic resources database resides on ICARDA's center-wide network and thus provides all scientists with information on seed samples conserved in the GRU. The data obtained during characterization and evaluation of samples by curators are regularly fed to the database and kept up-to-date. However, there is significant volume of data generated in experiments which are carried out by scientists other than those at GRU and capturing of such data is a challenging task. To stimulate such feedback of information the database model and software were modified to handle more complex data structures and to accept 'external' data files. The strength of the revised system lies in its flexibility; the user can add his/her own 'personal' data files to the database. 'Personal' status means that the system will not make the data available to other users. The change of datafile status from 'personal' to 'public' is, of course, possible and results in making the data available to all other users of the database.

The above approach brought encouraging results. For example, the data on screening of *Aegilops* germplasm (1890 accs.) for a number of diseases, the results of work carried out by Germplasm Program since 1991, were successfully incorporated into the germplasm database by GRU.

1.5.2. Survey of ICARDA collecting missions

During 1994 and 1995 the GRU reviewed the results of collecting missions carried out by ICARDA (and also by its predecessor ALAD) in collaboration with NRS and other international organizations, e.g., IPGRI and ICRISAT. All available documents (mission reports, collecting forms, correspondence with cooperators, etc.) were assembled, systematically catalogued and filed. The database records were checked against the original information found in the above documents. A great deal of time and effort was expended in tracing or estimating missing data, such as, latitude and longitude coordinates of collection sites. A standard of coding of missions was also introduced.

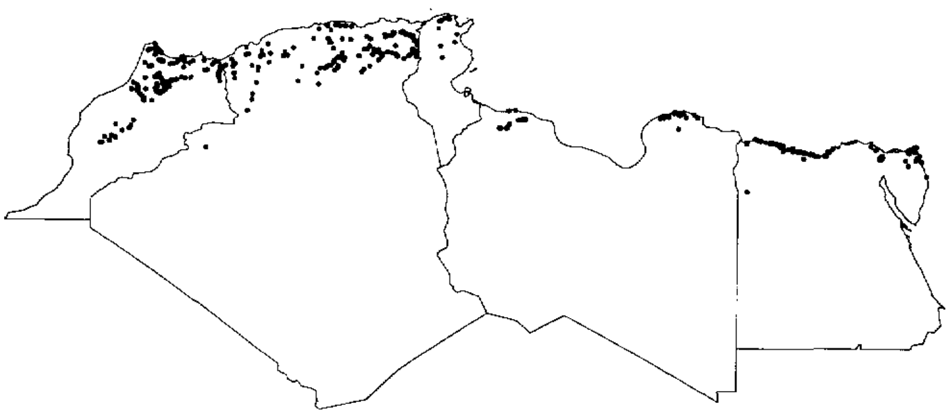

Fig. 36. Collection sites of cereal genetic resources collected by GRU/ICARDA in North Africa

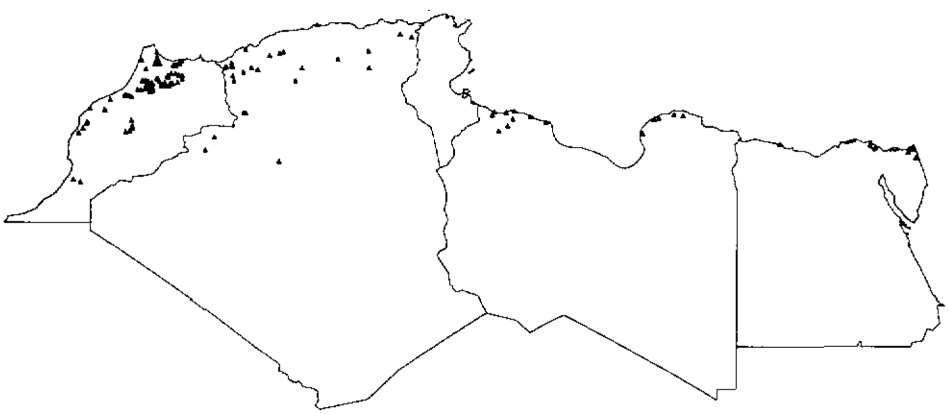

Fig. 37. Collection sites of food legume genetic resources collected by GRU/ICARDA in North Africa

Fig. 38. Collection sites of forage legume genetic resources collected by GRU/ICARDA in North Africa

The site description data in the database was augmented with results of analysis of soil samples taken during collecting missions in the last 3 years.

Table A11 in the Appendix provides a summary of genetic resources collection missions carried out since 1977, the inception of ICARDA. The missions yielded 21,683 accessions from over 6000 sites sampled. Over 64% of accessions are forage legumes, 23% are cereals, and the remaining are food legume samples. Fig. 36, 37 and 38 show the distribution of collection sites of ICARDA's mandate crops and their wild relatives in North Africa while Fig. 39, 40 and 41 illustrate the distribution of collected germplasm in countries of West Asia.

1.5.3. Seed stock control system

For efficient maintenance of germplasm collection, and to assure its availability to users, the genebank manager has to consider current conservation status of accessions, determine the needs for regeneration and multiplication, take into account the demand from users for samples, and subsequently balance such needs with available resources. Accurate determination of work required to be carried out each season could be a formidable task for the curator, especially for large collections, unless reliable information on the quantity and quality of each seed sample and adequate tools to process this information is available. Seed stock control module has, therefore, been regarded as an essential component of GRU germplasm documentation system. In 1993−94 the data structures were determined, a software package was developed and work begun on 'populating' the database with up-to-date information. At the end of 1995 the information gathering process was nearly completed; stock data is now available to curators on collections of cereals, legumes and majority of forage species. It includes information on weight and number of seeds in the active and base collection; seed viability; location of the material in cold room; safety duplication in other collections; designation for conservation in the FAO network; need for testing for 'pathogen-free' and 'virus-free' status.

In addition, in 1994−95 emphasis was put on registration of seed distribution records. Thanks to computerization of seed requests, the

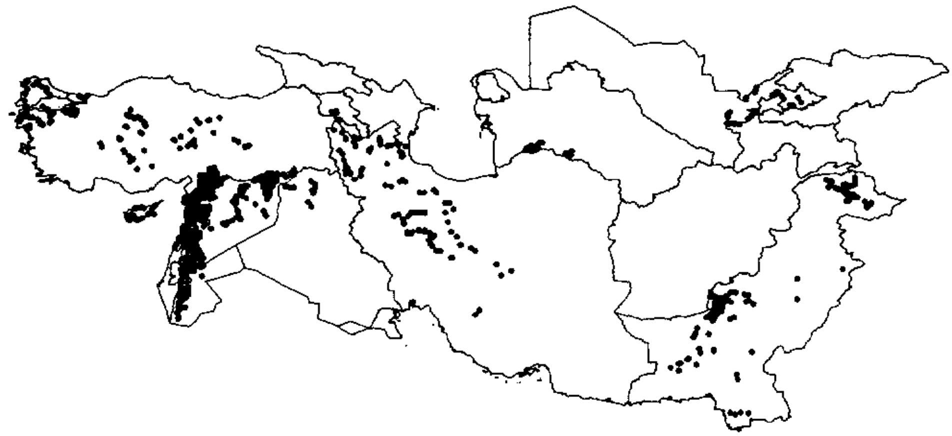

Fig. 39. Collection sites of cereal genetic resources collected by GRU/ICARDA in West Asia

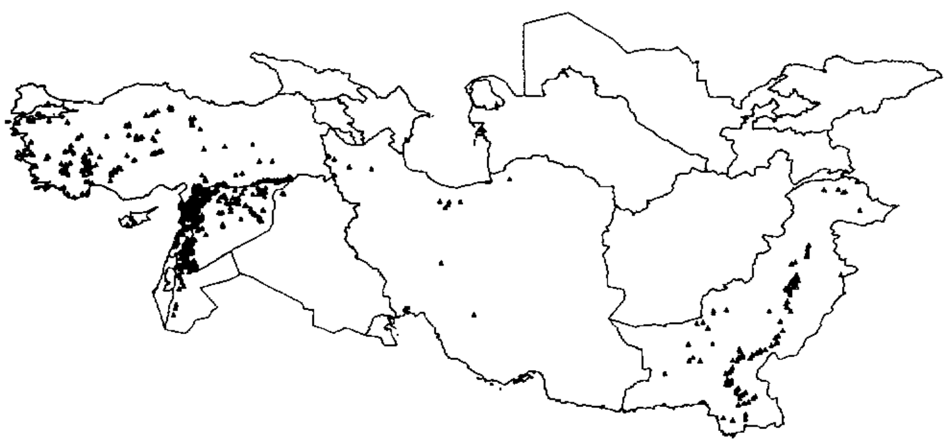

Fig. 40. Collection sites of food legume genetic resources collected by GRU/ICARDA in West Asia

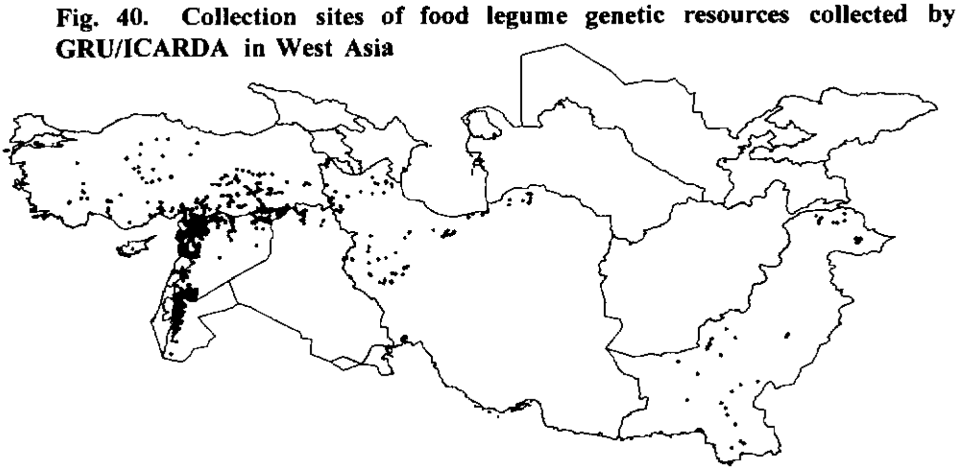

Fig. 41. Collection sites of forage legume genetic resources collected by GRU/ICARDA in West Asia

germplasm database is able to respond to queries on when and where each accession was sent. Table A12 in the Appendix provides a breakdown of seed dispatched by crops from 1990 to 1995 by GRU. It is worth noting that since 1989 the genebank manager had to withdraw an average of 25,000 samples a year from the active collection (excluding those accessions which were sent for safety duplication to other genetic resources centers).

1.5.4. Database for rhizobial genetic resources

Approximately half of the ICARDA genebank accessions are legumes which may require inoculation with compatible and adapted rhizobial strains, especially if they are introduced to new environments. Collecting rhizobial biodiversity associated with host plants is frequently a parallel activity in legume germplasm collection trips of ICARDA. Over the years ICARDA has assembled a total of 1512 *Rhizobium* accs.: *Rhizobium ciceri* (99), *R. leguminosarum* (481), *R. meliloti* (700) and *R. trifolii* (232) maintained by Germplasm Program (GP) and the Pasture, Forage and Livestock Program (PFLP). In 1995, the collaborative efforts of GP, PFLP and GRU resulted in the establishment of ICARDA *Rhizobium* database, which includes both the passport and evaluation data. The important feature of the *Rhizobium* database is its full integration with plant germplasm database. Table 56. lists the origin of rhizobial strains in the ICARDA collection and Figs. 42 and 43 show the provenance of *Rhizobium* species. The best geographical coverage is of *R. meliloti* in WANA countries; the major gaps in all species are for Algeria, Iraq, Iran and Libya. Seventy per cent of accessions were collected by ICARDA in collaboration with NARS.

1.5.5. Global database on wheat wild relatives

The database was initially established during 1989–90 through a joint project with IPGRI. Major genebanks known to hold collections of *Aegilops* and wild *Triticum* spp. were surveyed and data on over 14,000 accessions from 52 genebanks were assembled. Since then ICARDA/GRU has assumed responsibilities for the database. Following the development of GRU's database system the assembled data files of were also subjected to certain developed standards. Better cross referencing of accessions held in different genebanks became possible; similarly we were able to clarify and fill major gaps in collection site data. The database is linked to ICARDA germplasm system and, therefore, it is regularly updated with information on ICARDA's holdings. Currently the system covers 13,100 accessions of *Aegilops* and 2,900 samples of wild *Triticum* species. In 1996 it is planned to obtain fresh information on collections from several NARS through the Cereal Working Group of WANANET. Although the database is not entirely complete, it has proved to be valuable, e.g., as a guide to the geographical distribution of species. Fig. 44 to 46 show distribution of selected wild *Triticum* spp.

J. Konopka and A. Antypas

Table 56. Geographic origin of ICARDA rhizobial collection

			Rhizobium		
Country	**ciceri**	**legum.**	**melil.**	**trif.**	**Total**
Syria	19	105	221	55	400
Morocco	9	17	210	83	319
Jordan	2	86	94	56	238
Turkey	8	65	117	-	190
Egypt	-	80	-	-	80
Lebanon	2	8	30	31	71
USA	10	32	-	-	42
Tunisia	3	13	14	-	30
Cyprus	2	9	6	-	17
India	12	4	-	-	16
Sudan	-	12	-	-	12
Ethiopia	-	10	-	-	10
Other countries	30	30	5	-	65
Unknown	2	10	3	7	22
Total	**99**	**481**	**700**	**232**	**1512**

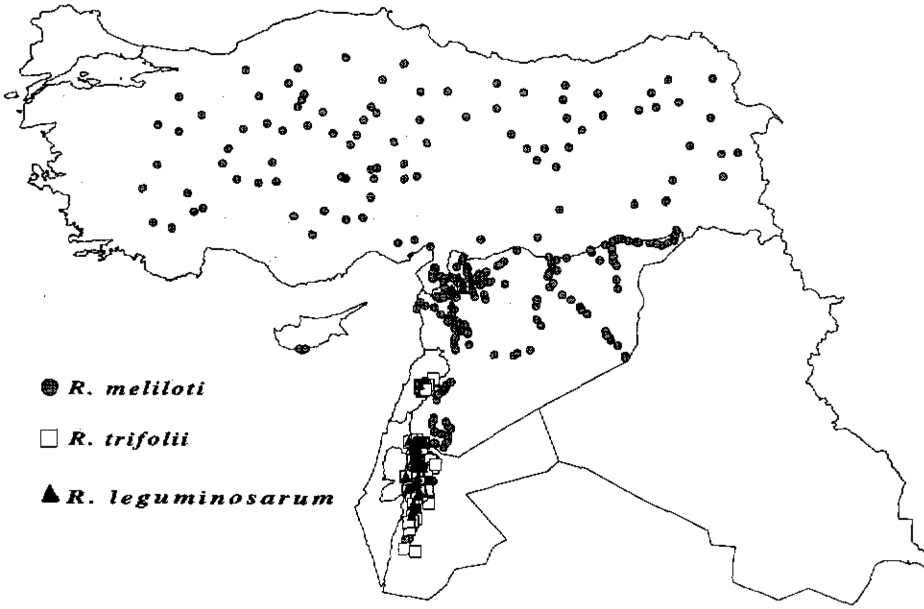

Fig. 42. Provenance of *Rhizobium* strains from West Asia

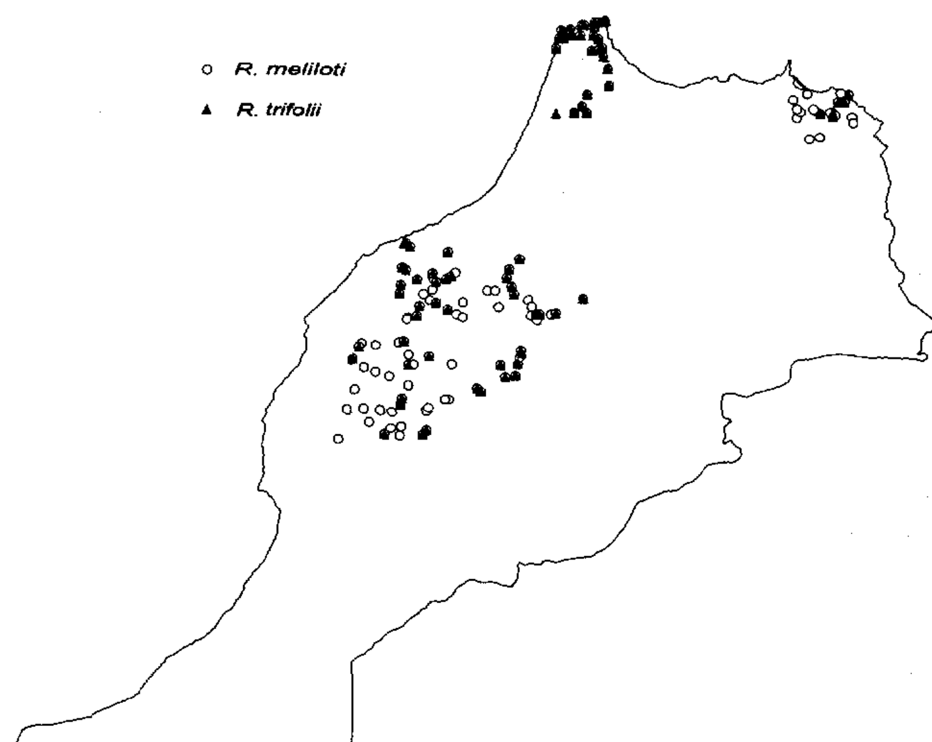

Fig. 43. Provenance of *Rhizobium* strains from Morocco

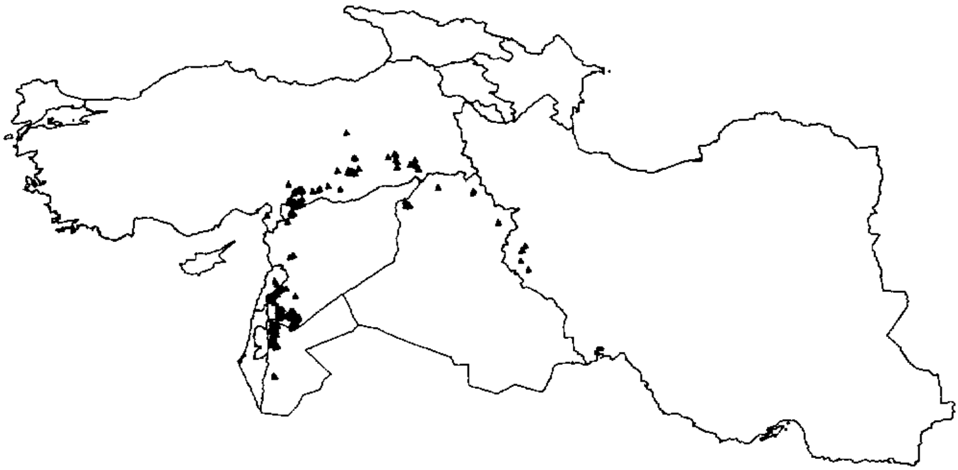

Fig. 44. Distribution of *Triticum dicoccoides* from the wheat wild relatives database at GRU/ICARDA)

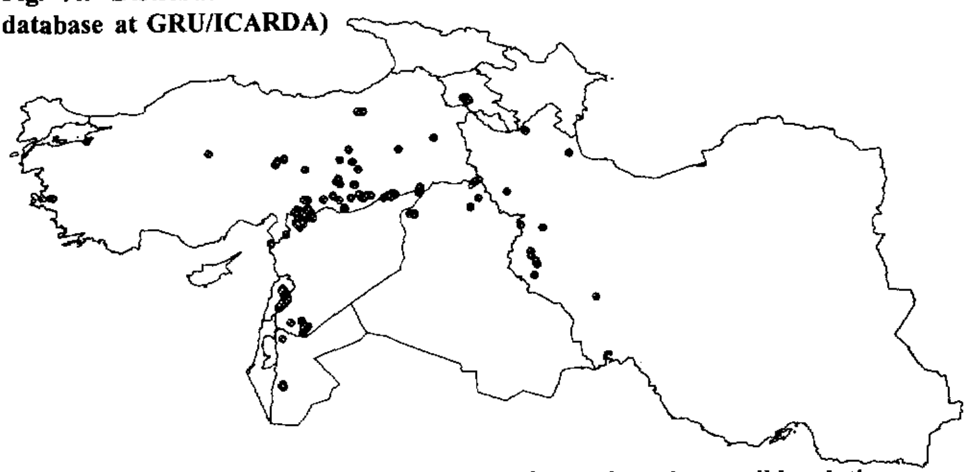

Fig. 45. Distribution of *Triticum urartu* from the wheat wild relatives database at GRU/ICARDA)

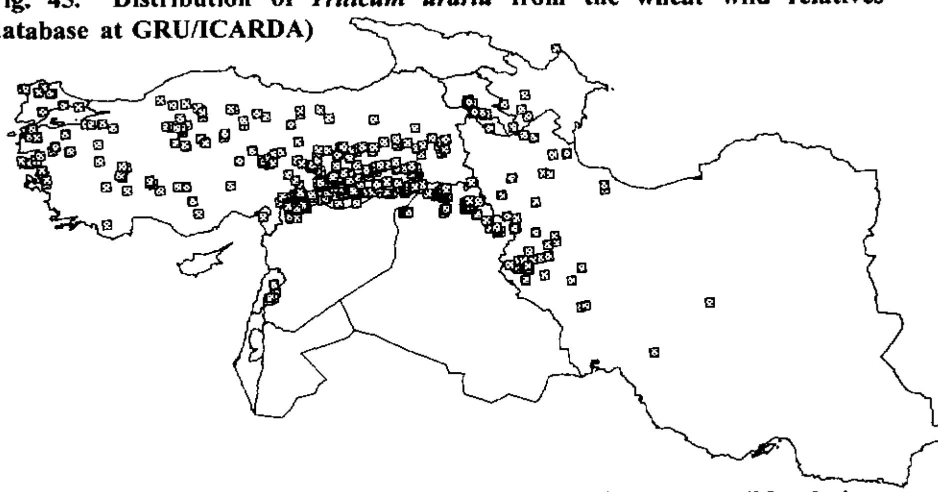

Fig. 46. Distribution of *Triticum baeoticum* from the wheat wild relatives database at GRU/ICARDA)

1.6. GERMPLASM MANAGEMENT

1.6.1. Cereal multiplication and rejuvenation

Whenever seed stock monitoring shows that the quantity of seed for distribution is below 50g and/or viability falls below 85% the acc. is multiplied and rejuvenated. During the 1993–94 season a total of 2281 cereal accs. from the genebank were multiplied and rejuvenated as follows: Barley (cultivated) 1037, barley (wild) 73, durum wheat 665, bread wheat 167, and wild wheat relatives 339. *After harvest and cleaning the seed stock was replenished and excess* seeds added stored for distribution. The material was planted in two rows one meter in length with a distance of 0.45m maintained between rows and 1.35m between plots. In the 1994–95 season a total of 4604 cereals from the ICARDA'S genebank were multiplied and rejuvenated. The material was planted in the same manner as above and characterization and evaluation observations were also recorded for a number of traits (Table 57).

Table 57. Germplasm multiplication and characterization during 1994–95 growing season

Crop	Multi. (accs.)	Charact. (accs.)	Traits
Barley	1157	3954	15-20
Wild barley	113	307+125(SH)	10
Durum wheat	2254	205	12
Bread wheat	491	451	12
Wild wheat	589	278+865(SH)	15
Total	4604	5195+990(SH)	-

SH = Samples evaluated by Seed Health Laboratory (GRU)

1.6.2. Viability testing

Viability testing of seed genetic resources of ICARDA's mandate crops is an on-going activity. Up to December 1995, 47% of ICARDA's total collection (approx. 111,000) has been tested for viability. The work done so far is summarized in Table 58.

During 1994, 1258 durum wheat accs. and 6754 lentil accs., making a total of 8012 accs. were tested for seed viability in the germination room of GRU. Typically forty seeds were placed on four petri dishes and incubated at 25°C for a maximum of seven days. Germination was recorded in each dish after the second day.

Results of the viability testing on durum wheat accs. showed that 97% had a high viability of equal to or more than 90%. Results of tests on the lentils revealed that 98% of the accs. had a viability percentage of equal to or more than 90%. The accs. which showed lower germination percentage were planted for rejuvenation in 1995–96 season.

In addition to testing viability, all barley and durum wheat germplasm which showed low viability in the last two successive years (1993 and 1994) and which were planted for rejuvenation were retested for viability after harvest and subsequently stored in the medium term store (active collection).

During 1995, 4857 barley accs., 4045 durum wheat accs., and 441 chickpea accs. were tested for viability. The results showed that 93% of barley accs. had viability equal to or exceeding 90%. Only 84% of the durum wheat accs. showed viability equal to or exceeding 90%. And, 94% of chickpea accs. showed viability equal to or exceeding 90%. The accs. which showed germination lower than 90% were set aside for planting in the next season for rejuvenation. These samples were retested for viability after harvest and subsequently stored in the medium term store (active collection).

B. Humeid & GRU staff

1.6.3. Long-term Preservation

Base collection build up of the ICARDA collection is also an on-going activity. In two successive years (1994 and 1995) a total of 15,260 accession of ICARDA mandated crops, were dried, sealed under vacuum in laminated aluminum foil packets, and deposited in long-term cold room which is maintained at a temperature of −20°C to −22°C. The current status of ICARDA's base collection is given in Table 59.

B. Humeid & GRU staff

Table 58. Germplasm tested for viability as of December 1995

Crop	Accs. with adequate stocks	Accs. tested Dec.95	Percentage
Barley	22613	22541	99.7
Durum	8029	12226	67.8
Lentil	7658	7272	95.0
Chickpea	8798	8700	98.9
Total	57098	50739	88.9

Table 59. Status of ICARDA base collection (as of Dec. 1995)

Crop	Total held	In base collection	%
Barley	22613	21886	96.8
Wild barley	1638	419	25.6
Durum wheat	18029	15918	88.3
Bread wheat	7764	6839	88.1
Wild wheat	4671	3346	71.6
Total Cereals	54715	48408	88.5
Chickpea	8798	8066	91.7
Lentil	7658	6846	89.4
Total Food Legumes	16456	14912	90.6
Vicia spp.	5414	3478	64.2
Medicago spp.	7305	4444	60.8
Total Forages	**12719**	**7922**	-
Total	**83890**	**71242**	**84.9**

2. SEED HEALTH ACTIVITIES

During the period 1986 to 1992 incidence of flag smut (*Urocystis agropyri*) had increased gradually in wheat plots at Tel Hadya station. It appeared in one field/season during 1986, 1987 and 1989, two fields in 1990, three fields in 1991, and 6 fields in 1992. Consequently, some fields were banned for wheat cultivation for 4 years. Subsequently precautionary measures have been taken starting from the 1992–93 season in order to minimize its incidence through rotation, catch crop, field inspection and rouging, laboratory seed health testing, and seed treatment. As a result of these measures, only one plant infected with flag smut was detected in Tel Hadya fields during the last three seasons (1992–93, 1993–94, and 1994–95), compared to 154 plants in the 1991–92 season alone (Table 60).

Table 60. Flag smut (*Urocystis agropyri*) occurrence in wheat fields at Tel Hadya from 1990 to 1995.

Season	No. of infected fields	No. of plants detected
1989-90	2	2
1990-91	3	36*
1991-92	6	145
1992-93	0	0
1993-94	1	1
1994-95	0	0

* Detected plants in borders are not included.

The Seed Health Laboratory (SHL) continues testing incoming and outgoing seed lots to ensure that they ate free from seed-borne pathogens and pests, particularly those of quarantine significance. The slide Agglutination Test (Antisera Test) has been introduced, for the first time, in the SHL routine work for detection of *Pseudomonas syringae* pv. *pisi* in imported and exported pea seeds. The SHL was also active in training and research.

Table 61. Seed health tests conducted on cereal seeds newly introduced to ICARDA in 1993–94[a] and 1994-95[b] seasons

Crop	Number of lines: Tested	Number of lines: *Found* Infected	Tests carried out	Pathogens observed*
Durum wheat	1493[a]/398[b]	358[a]/398[b]	Karnal bunt test or centrifuge wash test	*Tilletia caries* and/or *T. foetida* (358[a]/96[b]), *Urocystis agropyri* (0/2)
Bread wheat	3424/3135	799/387	Karnal bunt test, Centrifuge wash test, and Embroy test *tritici* (535/0).	*Tilletia caries* and/or *T. foetida* (238/380), *Urocystis agropyri* (6/1); *T. contraversa* (20/0), *Ustilago*
Barley	2720/511	480/2	Centrifuge wash test, Freezing blotter test, and Embryo test	*Helminthosporium* spp. (76/0), *Fusarium* spp (75/0). *Fusarium* & *Helminthosporium* (0/1). *Ustilago nuda* (320/0), *Tilletia* spp. (9/0).
Triticale	288/98	0/0	Centrifuge wash test	----
Wild wheat	5/106	5/28	Centrifuge wash test *U. agropyri* (0/9).	*Tilletia caries* and/or *T. foetida* (5/19),
Wild barley	5/101	0/32	Centrifuge wash test *U. agropyri* (0/7).	*T. caries* and/or *T. foetida* (0/25),
Total	7935/4389	1642/547		

* Numbers in parenthesis refer to infested entries.

Table 62. Seed health tests conducted on food and forage legumes newly introduced to ICARDA in 1993-94[a] and 1994-95[b] seasons

	Number of lines			
Crop	Tested	Found Infected	Tests carried out	Pathogens observed*
Lentil	11[a]/61[b]	0[a]/4[b]	Freezing blotter test, Agar media test	*Fusarium* spp. (0[a]/4[b])
Faba bean	7/32	0/2	Agar media test, for stem nematode	*Fusarium* spp. (0/2)
Chickpea	44/90	0/10	Agar media test	*Fusarium* spp. (0/10)
Pea	20/101	4/0	Slide agglutination test	*Pseudomonas pisi* (4/0)
Vetch	3/26	1/0	Freezing blotter test, Agar media test	*Fusarium* spp. (1/0)
Medic	1/6	0/0	Test for stem nematode, Freezing blotter test	—
Lathyrus	0/40	0/11	Freezing blotter test	*Fusarium* spp. (0/11)
Total	86/365	5/27		

* : Numbers in paranthesis refer to infested entries.

2.1. ACTIVITIES ON INCOMING SEEDS

During the 1993–94 and 1994–95 seasons, 48 and 34 seed consignments were received from 20 and 16 countries, respectively, compared to 65 consignments in the previous year (1992–93). All incoming seeds were immediately either fumigated or treated to temperatures of $-18^{o}C$ for seven days.

2.1.1. Laboratory Testing

After visual inspection, several techniques were used to detect seed-borne pathogens in seeds. During the 1993–94 and 1994–95 seasons, 8021 and 4754 seed samples, respectively, were tested for seed-borne pathogens in cereals (Table 61) and food and forage legumes (Table 62). The percentage of samples found contaminated with seed-borne pathogens was 20.5% and 12.1%, respectively, compared to only 7.5% in 1992–93. The most frequent pathogens associated with the incoming seed material in both seasons were *Tilletia caries/T. foetida* in wheat, and *Helminthosporium* spp. and *Fusarium* spp. in barley seed lots. *Ustilago triticii*, *U. nuda* and *T. contraversa* were detected only in the 1993–94 seed consignments. *Urocystis agropyri* was found in six (1993–94) and nineteen (1994–95) seed samples. The contaminated samples with the latter two quarantine pathogens were kept for cleaning and regeneration in the post-quarantine plastic house.

During 1993–94 imported seeds of lentil, chickpea, faba bean and medics were free from seed-borne pathogens and pests. However, some seed samples of the first three crops imported in 1994–95 were found to be contaminated with *Fusarium* spp. Four out of 20 pea seed samples had positive reaction to the specific antisera for bacteria *Pseudomonas pisi* in the 1993–94 season.

2.1.2. Field Inspection

All incoming seeds which were free from quarantine pathogens were grown for one generation at the post quarantine area at Tel Hadya. This seed material usually covers approximately 14 ha/season. A single field inspection carried out during the 1993–94 season in this area showed the absence of exotic pathogens in cereal and legume plots, except one plant of *Aegilops crassa* which was infected with

U. agropyri. In fact very few plants of cereal and legumes were found to be infected with one of the following pathogens: *Pyrenophora graminea*, *Ustilago nuda*, *U. tritici*, *Tilletia caries/T. foetida*, *Ascochyta rabiei*, *A. fabae*, *Botrytis fabae*, *Orobanche* spp., *Cuscuta* spp. and virus-like symptoms. All infected plants were rouged and burned as per normal quarantine regulations.

2.2 ACTIVITIES ON SEED DISPATCHED

During the 1993–94 and 1994–95 seasons, 415 and 392 consignments, accompanied by a phytosanitary certificate, were dispatched internationally and distributed to cooperators in 69 and 70 countries, respectively.

2.2.1 Laboratory Testing

The total number of seed samples tested at the SHL by the different techniques rose from 2460, in 1993–94 to 6481 in 1994–95, with about 23% found to be contaminated in each season. Table 63 shows that *T. caries/T. foetida* (wheat) and *Fusarium* spp. and *Helminthosporium* spp. (barley) were the most common pathogens detected in seed lots of these two crops. A high contamination by teliospores of common hunt was detected in some wheat seed samples although field inspection revealed low incidence of this disease in respective fields, and such samples were discarded.

Results of laboratory tests confirm absence of flag smut teliospores from all tested seed samples in 1993–94, and only 6 samples were found contaminated in 1994–95. *Fusarium* spp. were detected in 19% and 32% of tested seed samples of lentil, but less frequently (2% and 9%) in chickpea seed lots. In 1993–94 *P. pisi* bacteria had contaminated 19% of pea seed samples.

2.2.2. Field Inspection

The field inspection was carried out once only during each of the two seasons. However, this is not sufficient for efficient detection of infected plants. Flag smut disease was absent in all inspected wheat plots. Some seed-borne diseases such as common bunt of wheat, covered smut of barley, scald of barley, barley stripe disease, loose smut, barley stripe mosaic virus, wilt/root rot of chickpea and lentil, and *Ascochyta* blight of chickpea and faba bean were infrequent in seed multiplication fields. *Orobanche* and *Cuscuta* were also detected in some food and forage legumes plots. All infected plants were rouged and burned. In 1994–95 the cereal gall nematode (*Anguina tritici*) was detected in one of the fields and was destroyed immediately before maturity.

A. El-Ahmed and S. Asaad

Table 63. Seed health tests conducted on seeds dispatched internationally from ICARDA in 1993/94[a] and 1994-95[b] seasons

Crop	Number of lines		Tests carried out	Pathogens observed*
	Tested	Found Infected		
Durum wheat	266[a]/2006[b]	93[a]/177[b]	Centrifuge wash test	*Tilletia caries* and/or *T. foetida* (93[a]/175[b]), *Urocystis agropyri* (0/2).
Bread wheat	264/1571	68/920	Centrifuge wash test	*Tilletia caries* and/or *T. foetida* (68/329), *Urocystis agropyri* (0/4).
Barley	1403/2172	356/920	Freezing blotter test	*Helminthosporium* spp. (54/74), *Fusarium* spp. (282/846), *Fusarium* spp. and *Helminthosporium* spp. (20/0).
Lentil	78/142	15/46	Freezing blotter test	*Fusarium* spp. (15/46)
Chickpea	286/355	6/32	Freezing blotter test	*Fusarium* spp. (6/32)
Pea	79/74	15/0	Slide agglut. test	*Pseudomonas pisi* (15/0)
Lathyrus	26/45	4/5	Freezing blotter test	*Ascochyta* spp.(4/1), *Fusarium* spp. (0/4)
Vetch	22/61	0/1	Freezing blotter test	*Fusarium* spp. (0/1)
Medic	36/11	0/0	Stem nematode test, Freezing blotter test	— —
Safflower	0/25	0/0	Freezing blotter test	—
Rape	0/19	0/0	Freezing blotter test	—
Total	2460/6481	557/1514		

* : Numbers in parenthesis refer to infested entries.

3. TRAINING

3.1. Training in Genetic Resource Activities

A. Short Courses

1. An "Advanced Training Course in Plant Genetic Resources" was jointly organized by IPGRI and Genetic Resources Unit of ICARDA for two weeks in May 1994, and attended by 10 participants representing 10 WANA Countries.
2. A specialized training course on "Pasture Forage Legumes Identification" was organized jointly by the Center for Legumes in Mediterranean Agriculture (CLIMA) and ICARDA in April, 1995. The training program covered a range of topics relevant to taxonomy and identification techniques for pasture and forage legumes, mainly vicia, lathyrus, medicago and others. The course was attended by fifteen participants from four North African countries: Morocco (8), Algeria (3), Tunisia (3), and Libya (1).
3. A training course on "Collection and Conservation of Dry Land Genetic Resources" was organized jointly by UNEP, IPGRI and ICARDA in November 1995. The program focused on the major concepts of conservation, both *in-situ* and *ex-situ*, biodiversity documentation of germplasm, and other related topics. The course was attended by fourteen participants: Syria (3), Palestine (2), Turkey (2), Jordan (3), Lebanon (1), Iran (1) and Iraq (2).

B. Individual training

On request of NARSs in WANA, a number of trainees received individual training in various aspects of genetic resources at the Genetic Resources Unit located at ICARDA's main research station at Tel Hadya, in activities relating to germplasm collection, evaluation, identification, and documentation. A Summary of the training activities is presented in Table 64.

GRU staff

3.2. Training in seed health activities

During the 1993–94, three scientists from the Syrian Quarantine Department were trained at SHL for six months on seed health testing and field inspection. The SHL personnel covered, in lectures and practicals, the seed health component of seed production training courses carried out in Pakistan and Egypt as well as in residential and short training courses of ICARDA.

In 1994−95, two in-country training courses on seed health testing were carried out in Pakistan and Egypt. In addition, two scientists from DASR (Syria) and two scientists from CAS (Egypt) were trained at SHL for one month on seed health testing and field inspection techniques.

A. El-Ahmed and S. Asaad

Table 64. Number of trainees and courses conducted in genetic resources activities in 1994−95

Topic	Type of training	No.of trainees	Country	Course duration
Genetic Resources Utilization and Enhancement	Individual	1	Syria	2 weeks
Wild forage evaluation	Individual	2	Syria	2 weeks
Germplasm Documentation and Data Management	Individual	1	Morocco	2 weeks
		2	Syria	
		1	Jordan	
		2	Turkey	
		1	Yemen	
Germplasm Conservation	Individual	1	Jordan	2 weeks
		1	Oman	
Germplasm Collection	Individual	1	Lebanon	1 week
Wild Cereals Evaluation	Individual	1	Syria	1 week
Advanced Course in Plant Genetic Resources	Short course	10	Lebanon Jordan, Pakistan, Iran, Morocco, Tunisia, Egypt Oman, Yemen, Syria	2 weeks
Pasture and Forage Legumes Identification (Rabat - Morocco)	Short course	8	Morocco	1 week
		3	Algeria	
		3	Tunisia	
		1	Libya	
Collection and Conservation of Dry-land Genetic Resources (Amman - Jordan)	Short course	3	Syria	2 weeks
		2	Palestine	
		2	Turkey	
		3	Jordan	
		1	Lebanon	
		1	Iran	
		1	Iraq	
Total trainees		52		

PUBLICATIONS

(includes also a few papers not captured in the 1993 GRU Annual Report)

Books

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GRU STAFF LIST FOR 1994 & 1995 (as of Dec. 1995)

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Dr Larry D. Robertson	Legume Germplasm Curator
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Mr Ali Abdullah Ismail	Research Assistant II
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Table A1. Monthly precipitation (mm) for the 1993−94 season at Tel Hadya

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Total
1993−94 season	0.0	13.1	45.7	18.9	112.6	139.8	14.6	13.0	15.6	0.0	0.0	0.0	373.3
Long term aver. (13 seasons)	0.4	25.4	47.0	52.7	64.1	56.8	40.2	24.0	16.3	2.7	0.0	0.6	330.2
%of long term average	0	52	97	36	176	246	36	54	96	0	-	0	113

Table A2. Monthly air temperature (°C) for the 1993−94 season at Tel Hadya

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Mean maximum	34.8	30.7	16.1	14.1	13.3	13.8	18.9	26.9	31.6	34.7	35.6	37.6
Mean minimum	16.0	12.8	4.1	4.9	3.7	2.8	4.0	8.3	11.8	17.7	22.7	21.1
Average	25.4	21.8	10.1	9.5	8.5	8.3	11.5	17.6	21.7	26.2	29.2	29.4
Absolute maximum	39.8	33.4	24.5	18.1	16.5	18.8	24.3	34.6	39.6	38.2	39.5	43.5
Absolute minimum	9.3	8.7	-4.6	0.2	-1.5	-2.6	-1.6	1.1	5.1	11.8	16.8	18.0

Table A3. Frost events during 1993−94 season at Tel Hadya

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
Number of frost days	6	-	4	9	1	-	-	20
Absolute minimum (°C)	-4.6	-	-1.5	-2.6	-1.6	-	-	-4.6
No. of frost events at 5 cm above ground	6	1	5	11	3	1	-	27
Absolute minimum (°) at 5 cm above ground	-5.6	-0.6	-2.4	-5.6	-2.9	0	-	-5.6

Table A4. Monthly precipitation (mm) for the 1994–95 season at Tel Hadya

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Total
1994–95 season	1.3	15.7	98.1	45.1	42.4	16.5	24.5	48.3	19.5	1.5	0.0	0.0	312.9
Long term aver. (17 seasons)	0.5	24.8	50.0	52.2	62.8	57.3	39.3	25.6	16.5	2.7	0.0	0.8	332.4
%of long term average	260	63	196	86	68	29	63	189	118	56	-	0	94

Table A5. Monthly air temperature (°C) for the 1994–95 season at Tel Hadya

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Mean maximum	37.3	30.3	17.8	9.6	12.2	16.5	18.9	23.1	31.6	35.7	35.9	37.3
Mean minimum	19.9	14.8	7.4	1.6	3.7	2.7	3.4	6.9	11.5	18.6	21.4	22.6
Average	28.6	22.6	12.6	5.6	8.0	9.6	11.1	15.0	21.5	27.1	28.7	29.9
Absolute maximum	41.8	36.3	28.5	12.4	17.0	21.8	23.9	30.4	41.8	41.2	38.8	40.5
Absolute minimum	14.9	8.0	-2.0	-6.6	-1.2	-2.9	-2.1	0.7	4.7	11.8	17.0	19.2

Table A6. Frost events during 1994–95 season at Tel Hadya

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
Number of frost days	2	9	5	4	3	-	-	23
Absolute minimum (°C)	-2.0	-6.6	-1.2	-2.9	-2.1	-	-	-6.6
No. of frost events at 5 cm above ground	2	12	8	9	6	1	-	38
Absolute minimum (°) at 5 cm above ground	-3.0	-7.0	-3.0	-4.0	-3.3	0	-	-7

Table A7. Status of ICARDA germplasm collections by species (June 1994)

Crop	AC	(%)	BL	(%)	LR&OC	(%)	WS	(%)	GS	(%)	TOTALS
Barley	290	1	2397	11	19735	88	-	-	-	-	22422
Wild *Hordeum*	-	-	-	-	-	-	1670	100	-	-	1670
Bread wheat	1476	19	433	5	5925	76	1	<1	-	-	7835
Durum wheat	21	<1	307	2	17718	98			-	-	18046
Wild/primitive Triticum	-	-	15	1	21	1	1767	98	-	-	1803
Aegilops							2841	100	14	<1	2855
											54631
Faba bean	28	<1	68	2	4359	98	-	-	-	-	4455
Faba bean BPL	-	-	-	-	-	-	-	-	5248	100	5248
Chickpea	8	<1	2475	26	7198	74	1	<1	-	-	9682
Wild *Cicer*	-	-	-	-	-	-	292	100	-	-	292
Lentil	3	<1	1211	16	6263	84	-	-	-	-	7477
Wild Lens	-	-	-	-	-	-	434	100	-	-	434
											27588
Medicago (annual)	73	1	-	-	8	<1	7724	99	-	-	7805
Vicia	-	-	-	-	110	2	5243	98	-	-	5353
Trifolium	-	-	-	-	1	<1	3400	100	-	-	3401
Lathyrus	1	<1	-	-	9	1	1672	99	-	-	1682
Pisum	6	<1	-	-	3502	99	45	1	-	-	3553
Medicago (perennial)	-	-	-	-	84	13	597	87	-	-	651
Other forages	-	-	-	-	26	1	4339	99	-	-	4365
											26810
TOTALS	**1906**	**2**	**6906**	**6**	**64959**	**60**	**29996**	**27**	**5362**		
											109029

Legend: AC = Advanced Cultivars; BL = Breeding Lines; LR = Landraces or primitive; OC = Old Cultivars; GS = Genetic Stocks; WS = Wild/Weedy Species; Figures in **bold** are totals.

Table A8. Status of ICARDA germplasm collections by origin (December 1994)

Crop	W A N A		Other Countries		Unknown origin		Total
	No.	(%)	No.	(%)	No.	(%)	
Barley	10216	45.5	11970	53.3	284	1.3	22470
Wild Hordeum	1495	92.1	101	6.2	27	1.7	1623
Durum wheat	13148	72.9	4197	23.3	691	3.8	18036
Bread wheat	7104	90.7	691	8.8	41	0.5	7836
Other cult. wheat	171	36.8	56	12.0	238	51.2	465
Wild Triticum	1282	95.7	18	1.3	40	3.0	1340
Aegilops	2275	79.7	551	19.3	28	1.0	2854
Total Cereals	**35691**	**65.3**	**17584**	**32.2**	**1349**	**2.5**	**54624**
Chickpea	7509	78.3	1911	19.9	166	1.7	9586
Wild Cicer	283	97.3	7	2.4	1	0.3	291
Lentil	4133	55.8	3242	43.8	32	0.4	7407
Wild Lens	382	88.2	51	11.8	--	--	433
Faba bean	2319	52.3	1574	35.5	541	12.2	4434
Faba bean BPL	2182	41.6	2115	40.3	951	18.1	5248
Total Food Legumes	**16808**	**61.3**	**8900**	**32.5**	**1691**	**6.2**	**27399**
Medicago	6366	81.1	1125	14.3	354	4.5	7845
Vicia	3018	56.4	1122	21.0	1209	22.6	5349
Pisum	628	17.7	1820	51.2	1105	31.1	3553
Lathyrus	1349	84.8	233	14.7	8	0.5	1590
Trifolium	3265	96.1	63	1.9	68	2.0	3396
Alfafa	490	51.0	408	42.5	65	6.5	960
Other genera	3944	76.9	1142	22.3	43	0.8	5129
Total Forages	**19060**	**68.5**	**5913**	**21.3**	**2849**	**10.2**	**27822**
GRAND TOTAL	**71559**	**65.1**	**32397**	**29.5**	**5889**	**5.4**	**109845**

Table A9. Status of ICARDA germplasm collections by origin (December 1995)

Crop	W A N A No.	(%)	Other countries No.	(%)	Unknown origin No.	(%)	Total No.
Barley	10343	45.7	12001	53.0	283	1.3	22627
Wild *Hordeum*	1565	92.7	97	5.7	26	1.6	1688
Durum wheat	13245	73.5	4320	24.0	463	2.5	18028
Bread wheat	7094	90.8	686	8.8	31	0.4	7811
Other cultivated wheat	217	46.4	142	30.3	109	23.3	468
Wild *Triticum*	1382	96.8	18	1.3	27	1.9	1427
Aegilops	2321	80.0	551	19.0	29	1.0	2901
Cereals	**36167**	**65.8**	**17815**	**32.4**	**968**	**1.8**	**54950**
Chickpea	7550	77.4	1969	20.2	241	2.4	9760
Wild *Cicer*	284	96.9	8	2.7	1	0.4	293
Lentil	4220	55.1	3401	44.4	36	0.5	7657
Wild *Lens*	430	89.6	50	10.4	0	0.0	480
Faba bean	2392	52.0	1673	36.4	536	11.6	4601
Faba bean BPL	2182	41.6	2117	40.3	952	18.1	5251
Food legumes	**17058**	**60.8**	**9218**	**32.9**	**1766**	**6.3**	**28042**
Medicago	6370	82.7	1182	15.4	146	1.9	7698
Vicia	3778	70.0	1604	29.7	19	0.3	5401
Pisum	638	17.6	1966	54.3	1014	28.1	3618
Lathyrus	1438	49.6	1455	50.2	7	0.2	2900
Trifolium	3294	96.0	68	2.0	68	2.0	3430
Medicago perennial	322	49.5	278	42.7	51	7.8	651
Other forages	3431	85.7	534	13.3	39	1.0	4004
Forages	**19286**	**68.3**	**7603**	**26.9**	**1344**	**4.8**	**28233**
Grand total	**72511**	**65.2**	**34636**	**31.1**	**4078**	**3.7**	**111225**

Table A10. Germplasm collected by GRU/ICARDA-sponsored missions in 1994

Mission	CB	WB	WT	AEG	DW	BW	CL	WL	CH	MED	VET	LAT	OFL	Total
Syria 94-1							4		1	3	73	20	3	104
Syria 94-2		4	6	2										12
Syria 94-2		12	11	48			1							72
Lebanon 94	12	5	17	7	30	23	3							97
Tunisia 94										280	74	31	510	895
Morocco 94							15		1	10	98	23	65	212
Spain 94								6						6
Total	12	21	34	57	30	23	23	6	2	293	245	74	578	1398

Legend: CB=Cultivated barley; WB=Wild barley; WT=Wild *Triticum*; AEG= *Aegilops*; DW= Durum wheat; BW= Bread wheat; CL= Cultivated lentils; WL= Wild lentil; MED=Medics; VET= Vetches; LAT= Lathyrus; OFL= Other forages.

Table A11. Germplasm collected on GRU/ICARDA missions since 1977

Year	Mission code	Sites	No. of samples	Crop group
1977	EGY77	7	12	Forage legumes
	IRQ77	25	168	Forage legumes
			1	Cereals
	JOR77	50	241	Forage legumes
	SYR77	88	459	Forage legumes
			2	Food legumes
	TUR77	24	108	Forage legumes
1978	IRN78-1	55	240	Forage legumes
			1	Food legumes
	IRN78-2	38	98	Forage legumes
	SYR78	4	28	Forage legumes
	TUR78	123	478	Forage legumes
	SYR79-1	13	30	Forage legumes
	SYR79-2	3	5	Forage legumes
	SYR79-3	54	105	Food legumes
	TUR79	10	17	Forage legumes
1980	DZA80	3	13	Forage legumes
	LBN80	6	32	Forage legumes
	SYR80-1	135	623	Forage legumes
			2	Cereals
			1	Food legumes
	SYR80-2	78	134	Cereals
	SYR80-3	26	73	Forage legumes
1981	JOR81	23	60	Forage legumes
	JOR81-2	43	47	Cereals
			12	Food legumes
	JOR81-3	8	10	Cereals
	SYR81-1	40	72	Cereals
	SYR81-2	2	2	Cereals
1982	SYR82	36	89	Forage legumes
1983	ESP83	27	27	Food legumes
	JOR83-1	5	57	Forage legumes
	MAR83	93	288	Forage legumes
			1	Food legumes

	SYR83-1	53	227	Forage legumes
	SYR83-2	106	109	Food legumes
	SYR83-3	132	132	Cereals
1984	CYP84	38	46	Food legumes
			14	Forage legumes
	MAR84	329	329	Cereals
	SYR84-1	35	532	Forage legumes
			1	Food legumes
	SYR84-2	54	730	Forage legumes
			1	Food legumes
	SYR84-3	5	38	Forage legumes
1985	EGY85	28	97	Forage legumes
			2	Food legumes
	JOR85	36	408	Cereals
	PAK85	104	244	Food legumes
			14	Forage legumes
			10	Cereals
	SYR85	112	776	Forage legumes
	TUR85	120	180	Food legumes
			49	Forage legumes
1986	PAK86-1	53	91	Cereals
	PAK86-2	59	116	Cereals
			24	Forage legumes
			4	Food legumes
	SYR86	146	1271	Forage legumes
			115	Food legumes
	SYR86-2	17	76	Forage legumes
	TUR86	74	368	Forage legumes
1987	EGY87	94	189	Cereals
			8	Food legumes
			1	Forage legumes
	MAR87-1	102	173	Cereals
			1	Food legumes
	MAR87-2	114	171	Food legumes
			7	Forage legumes
	SYR87-1	144	196	Cereals
			31	Food legumes
			6	Forage legumes
	SYR87-2	238	475	Food legumes
			2	Forage legumes

1988	JOR88-1	49	85	Cereals
	JOR88-2	42	79	Cereals
			6	Forage legumes
	JOR88-3	49	91	Food legumes
	LBN88	4	106	Cereals
	MAR88	135	493	Forage legumes
	SYR88-1	56	104	Cereals
	SYR88-2	47	101	Cereals
			4	Food legumes
	SYR88-3	110	134	Food legumes
			36	Cereals
			17	Forage legumes
	SYR88-4	52	113	Cereals
			43	Forage legumes
			9	Food legumes
1989	BGR89	38	72	Cereals
			2	Forage legumes
	CYP89	32	55	Cereals
	DZA89-A	44	86	Cereals
			12	Food legumes
			12	Forage legumes
	DZA89-B	75	120	Cereals
			15	Food legumes
			1	Forage legumes
	EGY89	32	47	Cereals
			17	Forage legumes
	JOR89	61	616	Forage legumes
			5	Food legumes
	NPL89	83	119	Food legumes
	SYR89-1	5	13	Cereals
	SYR89-2	15	118	Forage legumes
			2	Food legumes
	SYR89-3	17	29	Food legumes
			8	Cereals
			1	Forage legumes
	SYR89-4	14	21	Cereals
	TUR89-1	68	144	Cereals
	TUR89-2	50	118	Cereals
1990	BGR90	42	74	Cereals
			1	Forage legumes
	DZA90	34	48	Cereals
			17	Food legumes
			5	Forage legumes

	JOR90	52	1031	Forage legumes
			13	Food legumes
	LBY90	18	34	Cereals
	MAR90	45	68	Cereals
			4	Forage legumes
			1	Food legumes
	SUN90	9	37	Cereals
	SYR90-1	17	29	Cereals
	SYR90-2	17	41	Cereals
	SYR90-3	3	4	Cereals
	TUN90	11	12	Cereals
			7	Forage legumes
1991	DZA91	108	1266	Forage legumes
			11	Cereals
	JOR91	107	172	Cereals
	LBY91	14	15	Cereals
	PRT91-A	96	90	Food legumes
			69	Forage legumes
	PRT91-B	55	69	Food legumes
	SUN91	56	118	Cereals
			2	Forage legumes
	SYR91-1	9	14	Cereals
	SYR91-2	28	31	Food legumes
	SYR91-3	25	48	Cereals
1992	ARM92	10	35	Cereals
	JOR92	18	19	Cereals
	LBN92-1	17	21	Food legumes
	LBN92-2	18	33	Cereals
			1	Forage legumes
	LBY92	14	14	Food legumes
	SYR92-1	4	9	Cereals
	SYR92-2	23	149	Forage legumes
			6	Cereals
			3	Food legumes
	SYR92-3	22	59	Cereals
	SYR92-4	10	22	Cereals
	TUN92	40	394	Forage legumes
1993	IRN93-1	56	153	Cereals
	IRN93-2	51	113	Cereals
			1	Food legumes
			1	Forage legumes
	IRQ93	12	39	Cereals

	LBN93	27	108	Cereals
	MAR93	171	443	Forage legumes
			6	Food legumes
	PAK93	40	43	Food legumes
			36	Cereals
			21	Forage legumes
	SYR93-1	8	16	Cereals
	SYR93-2	6	11	Cereals
	SYR93-3	3	10	Cereals
	SYR93-4	17	20	Food legumes
1994	ESP94	6	6	Food legumes
	LBN94-1	13	28	Cereals
			3	Food legumes
	LBN94-2	36	67	Cereals
	MAR94	62	181	Forage legumes
			30	Food legumes
	SYR94-1	37	99	Forage legumes
			5	Food legumes
	SYR94-2	7	12	Cereals
	SYR94-3	24	69	Cereals
			1	Food legumes
	TUN94	91	905	Forage legumes
1995	BGD95	75	74	Forage legumes
			48	Food legumes
	IRQ95	7	13	Forage legumes
			1	Food legumes
	JOR95	27	63	Cereals
			1	Food legumes
	MAR95	38	250	Forage legumes
			3	Food legumes
	NPL95E	69	125	Food legumes
			92	Forage legumes
	NPL95W	95	209	Forage legumes
			182	Food legumes
	SYR95	10	10	Food legumes
	TUN95	42	44	Forage legumes
	TUR95-1	37	37	Food legumes
	TUR95-2	44	154	Cereals
	Totals	**6323**	**13938**	**Forage legumes**
			5007	**Cereals**
			2738	**Food legumes**
	Grand total		**21683**	

Table A12. Distribution of germplasm to users from 1990 to 1995 (excluding safety duplication)

Crop	1990	1991	1992	1993	1994	1995	Total
Barley	3651	3171	2002	3358	1523	3288	16993
Wild barley	121	42	-	-	9	164	336
Bread wheat	58	56	59	99	401	495	1168
Durum wheat	7801	3651	4636	1613	4583	849	23133
Other cult. wheat	-	55	3	6	66	266	396
Wild Triticum	170	29	74	161	501	315	1250
Aegilops	405	1741	5526	3083	2930	526	14211
Cereals	**12206**	**8745**	**12300**	**8320**	**10013**	**5903**	**57487**
Chickpea	1103	220	1584	1239	3028	4047	11221
Wild Cicer	273	181	613	385	748	568	2768
Lentil	1098	1620	2663	1890	2880	1908	12059
Wild Lens	103	340	464	33	70	228	1238
Faba bean	495	60	547	2394	273	249	4018
Faba bean BPL	-	-	731	311	140	565	1747
Food legumes	**3072**	**2421**	**6602**	**6252**	**7139**	**7565**	**33051**
Medicago	313	-	145	987	1694	571	3710
Vicia	422	660	701	3292	1761	3311	10147
Lathyrus	228	12	769	854	877	265	3005
Trifolium	96	74	39	101	534	284	1128
Other	21	10	74	270	525	824	1724
Forages	**1080**	**756**	**1728**	**5504**	**5391**	**5255**	**19714**
Total	**16358**	**11922**	**20630**	**20076**	**22543**	**18723**	**110252**
GRU's own work	2206	5188	8149	4368	10213	11718	41842
Grand total	**18564**	**17110**	**28779**	**24444**	**32756**	**30441**	**152094**

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