GENETIC RESOURCES UNIT

Annual Report for 1992

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 18 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 focuses its research efforts on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. 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, and pasture and forage crops and the associated farming systems.

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 are offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and by specialized information services.

GENETIC RESOURCES UNIT

Annual Report for 1992

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. Due to the tight production deadlines, editing of the report was kept to a minimum.

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1. GENETIC RESOURCES ACTIVITIES

1.1. Introduction

In 1992 the Genetic Resources Unit at ICARDA continued its effort to acquire, characterize, document, conserve, and distribute germplasm of the Center mandate crops for the benefit of crop improvement programs, both at ICARDA and for countries of the West Asia and North Africa (WANA) region.

Collecting missions to countries of West Asia and North Africa (Figures 1 and 2) conducted by ICARDA in cooperation with national programs yielded more than 1000 new accessions of mandated crops and/or their wild relatives (Table 1).

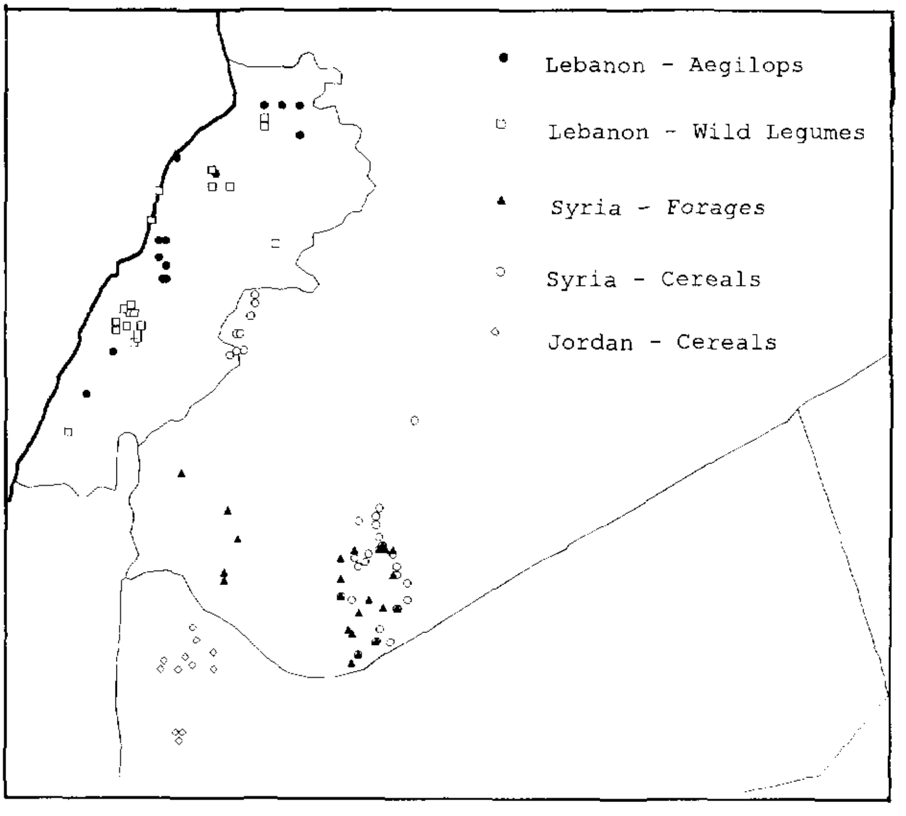

Figure 1. Sites of collection missions for cereals, food legumes, pasture and forage legumes, and their wild relatives in West Asia for 1992

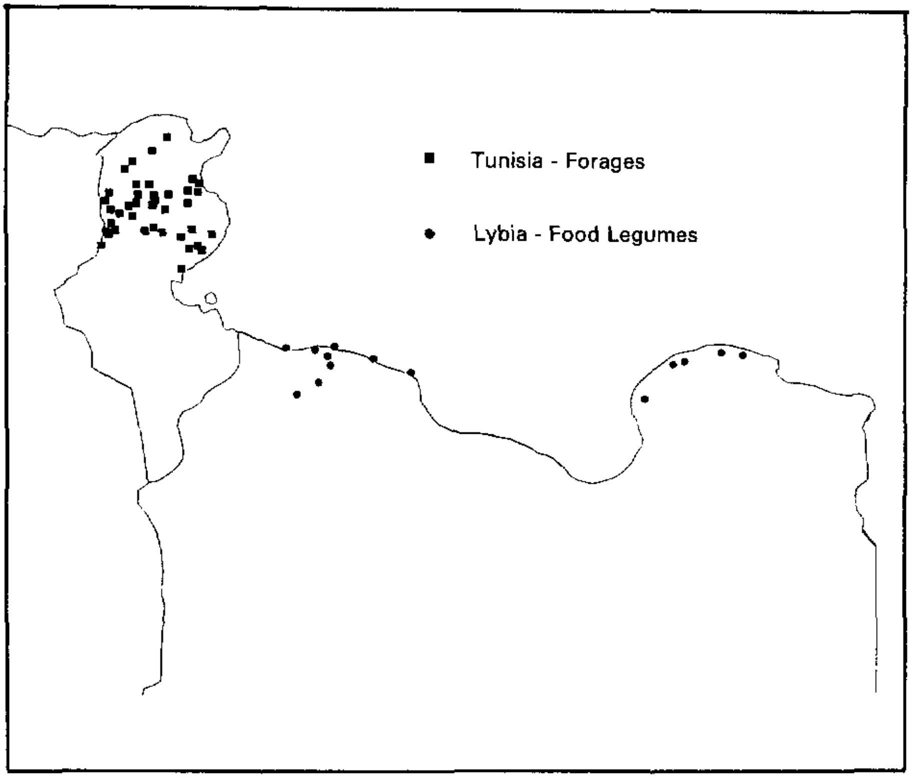

Figure 2. Sites of collection missions for pasture, forage, and food legumes in North Africa for 1992

Germplasm exchange with other institutions resulted in 5000 new entries in ICARDA's collections (Table 1).

In June, a collection mission for wild wheat relatives was held for the first time by ICARDA in Armenia. It included collecting in the Erebuni Nature Reserve northeast of Yerevan, which is a classic example of in situ conservation.

In germplasm collection trips to Syria and Jordan, 68 bulk and 1500 single-head samples of wild relatives of cereals were collected. Existence of T. boeoticum in Syria, as well as in Jordan, was confirmed. However, the other diploid wheat, T. urartu was more frequent in Syria, where 14 populations were collected from diverse habitats, ranging from the dry eastern

Table 1. Germplasm introduction at ICARDA in 1991/92

Crop	Collected by GRU	From other institutions	New acquisitions (total)
Barley	68	2442	2510
Wild barley	125	75	200
Durum wheat	7	156	163
Bread wheat	17	160	177
Wild wheat	83	240	323
Cereals	300	3073	3373
Chickpea	64	364	428
Wild *Cicer*	3	9	12
Lentil	-	2	2
Wild *Lens*	28	15	43
Faba bean	96	80	176
Food legumes	191	470	661
Medicago	157	-	157
Vicia	36	-	36
Lathyrus	18	-	18
Trifolium	54	1500	1554
Others	248	-	248
Forage legumes	516	1500	2016
Grand total	**1007**	**5043**	**6050**

slopes of the basaltic Jebel Al-Arab mountains in the province of Sweida, through the more fertile, low-land sites in northern Syria, to high elevation limestone slopes in the Anti-Lebanon mountains in the province of Damascus. The highest site was found at 1840 m a.s.l., which is a record altitude for this species. Seed storage protein electrophoresis revealed significant differences in genetic diversity among these wheat populations collected from southern Syria.

In Lebanon, 37 accessions of wild Lens and Cicer were collected from the coastal region and in Libya, 14 accessions of food legumes were collected (faba bean and chickpea).

An ecogeographical survey of pasture and forage legumes was conducted in Tunisia, with 375 ecotypes collected from the central region and data was taken on the relative frequencies of various species. One-hundred-fifty ecotypes of pasture and forage legumes were collected from southern Syria to fill the gap for this area in the collections.

A total of 6500 accessions of cereals and legumes were evaluated for the IBPGR/ICARDA descriptor list (Table 2). Multivariate statistical procedures were applied to the data of lentil and barley to study the relationships of landraces from different countries and sub-regions.

Jordanian ecotypes of Vicia and Lathyrus from recent collections were characterized in collaboration with NARS Jordan.

Photothermal characterization of barley landraces from China, Algeria, Egypt, and Syria revealed very high diversity for basic parameters of the photothermal response (earliness per se, vernalization, and photoperiod reaction) among the Chinese germplasm. Some Algerian and Syrian landraces were heterogeneous in their response.

The wild Lens collection was evaluated for agro-morphological traits and eight isozyme loci. This data has been used to draw phylogeny trees for the genus which show that L. orientalis and L. odemensis are the closest related wild Lens species. Genetic diversity for the wild Lens species were calculated using isozyme analyses data and L. orientalis was found to have the highest genetic diversity, followed by L. ervoides.

New introductions in 1992 increased the total number of accessions held in the genebank to more than 92000 (Table 3). Details on the status of ICARDA collections by country of origin

Table 2. Germplasm multiplication, characterization and evaluation in 1991/92

	Multiplied	Characterized and/or evaluated	
Crop	**(accessions)**	**(accessions)**	**(traits)**
Barley	1401	2340	18
Wild barley	67	133	18
Durum wheat	705	163	14
Bread wheat	616	177	14
Wild wheat	339	159	16
Cereals	3128	2972	-
Chickpea	729	1123	29
Wild Cicer	57	-	-
Lentil	432	1860	30
Wild Lens	55	323	41
Faba bean	1005	-	-
Food legumes	2278	3306	-
Medicago	810	-	-
Vicia	1281	195	19
Lathyrus	104	23	19
Trifolium	515	-	-
Others	2341	-	-
Forage legumes	5051	218	-
Grand total	**10457**	**6496**	**-**

are presented in Tables A4-7 of the Appendix.

Utilization of the GRU/ICARDA germplasm collection was high in 1992; more than 24000 seed samples were distributed to users worldwide. Two thirds of this number were used in West Asia and North Africa - the region mandated to ICARDA - either directly by

Table 3. Status of ICARDA collections by origin (December 1992)

	Number of accessions originated from						
	WANA		Other countries		Unknown		Total
Crop	no.	(%)	no.	(%)	no.	(%)	no.
Barley	9233	44.0	11545	55.1	190	0.9	20968
Wild *Hordeum*	1391	90.3	129	8.4	20	1.3	1540
Durum wheat	12222	68.9	4288	24.2	1241	7.0	17751
Bread wheat	6665	93.2	438	6.1	48	0.7	7151
Other *Triticum*	1248	87.3	42	2.9	140	9.8	1430
Aegilops	1786	77.2	472	20.4	56	2.4	2314
Cereals	32545	63.6	16914	33.1	1695	3.3	51154
Chickpea	6700	78.9	1659	19.5	136	1.6	8495
Wild *Cicer*	263	97.0	8	3.0	-	0.0	271
Lentil	3988	55.2	3205	44.3	35	0.5	7228
Wild *Lens*	315	81.6	64	16.6	7	1.8	386
Faba bean	1628	46.2	1354	38.4	541	15.4	3523
Food legumes	12894	64.8	6290	31.6	719	3.6	19903
Medicago	5791	79.9	1107	15.3	353	4.9	7251
Vicia	2247	48.8	1147	24.9	1210	26.3	4604
Pisum	467	13.7	1791	52.4	1160	33.9	3418
Lathyrus	1180	83.3	228	16.1	9	0.6	1417
Trifolium	2741	95.4	63	2.2	68	2.4	2872
Other genera	2218	81.1	516	18.9	-	0.0	2734
Forages	14644	65.7	4852	21.8	2800	12.6	22296
Grand total	**60083**	**64.4**	**28056**	**30.1**	**5214**	**5.6**	**93353**

NARS or indirectly through crop improvement programs at ICARDA (Table 4).

Table 4. Distribution of ICARDA germplasm to users in 1991/92

	Cereals		Food legumes		Forage legumes		Total 1991/92	
User	**no.**	**%**	**no.**	**%**	**no**	**%**	**no.**	**%[a]**
WANA	4525	67.2	1855	27.5	357	5.3	6737	27.9
ICARDA	7147	77.6	1543	16.8	517	5.6	9207	38.2
Total WANA	11672	73.2	3398	21.3	874	5.5	15944	66.1
Others	5069	62.0	2361	28.9	742	9.1	8172	33.9
Total	**16741**	**69.4[a]**	**5759**	**23.9[a]**	**1616**	**6.7[a]**	**24116[b]**	**100.0**

a : Percent of the grand total.
b : Grand total.

An "Agreement on Safety Duplication of ICARDA's Genetic Resources Data at IBPGR" has been signed and a data duplicate was deposited in IBPGR, Rome. The data sets will be replaced annually.

In the 1991/92 season, the Genetic Resources Unit started using "PSION Organizer II" dataloggers to speed up and facilitate computerization of genetic resources data.

In 1992, ICARDA participated in various global and regional genetic resources activities. The Center organized and hosted, in collaboration with IBPGR and other institutions, four international events relating to genetic resources as follows:

- Barley Core Collection meeting of a working group of the International Barley Genetic Resources Network (IBGRN);

- West Asia and North Africa Plant Genetic Resources Workshop, organized jointly with IBPGR and FAO, in which a collaborative network on plant genetic resources in WANA was established;

- IBPGR/IDRC/ICARDA training workshop dedicated to a self-teaching approach to the understanding, analysis, and development of genetic resources documentation systems;

- International workshop on "Evaluation and Utilization of Biodiversity in Wild Relatives and Primitive Forms for Wheat Improvement." This workshop, which was attended by 60 scientists from 26 countries, reviewed the progress achieved and identified areas of research where emphasis should be placed.

Collaboration with IBPGR has been strengthened with the transfer of the IBPGR regional office for West Asia and North Africa from Rome to ICARDA headquarters in Aleppo, Syria.

This Annual Report presents the activities as a unit, irrespective of the diverse funding of several staff members and their projects. In order to facilitate the donors of these special projects to take notice of the achievements during 1992 the respective projects and their sections are listed below:

- "Enhancing wheat productivity in stress environments utilizing wild progenitors and primitive forms", funded by Italy, principal scientist Dr A.B. Damania, is reported in Sections 1.2.3, 1.3.4, 1.3.8, 1.4.1, 1.4.2, 1.4.3, and 1.4.4.

- "Collection and characterization of germplasm of wild relatives of wheat", funded by the Netherlands, principal scientist Dr M.W. Van Slageren, is reported in Sections 1.2.1, 1.2.3, 1.2.4, 1.3.5, 1.3.6, and 1.4.6.

- "Measurement of biodiversity within the Genus Lens" funded by ODA, U.K., Dr L.D. Robertson and Ms M. Ferguson, is reported in sections 1.3.12 and 1.4.7.

Two laboratories are associated with the GRU: (1) the Seed Health Laboratory, and (2) The Virology Laboratory.

The Seed Health Laboratory has conducted testing for seed-borne pathogens/pests in all seed shipments coming into ICARDA or going abroad. The total number of lines tested from the received and dispatched shipments were 11868 and 3319, respectively.

The field inspection of plots from the newly introduced germplasm grown at the post-entry quarantine area revealed no exotic seed-borne pathogen/pest during the season.

In the Virology laboratory, the surveys for virus diseases focussed on faba bean necrotic yellow virus, luteoviruses, and lentil seed-borne viruses. The effect of resistance to barley yellow dwarf virus (BYDV) in barley was studied in relation to BYDV movement. Seed samples from the ICARDA international nurseries were tested for the presence of seed-borne viruses. The cleaning of the GRU/ICARDA barley germplasm collection from seed-borne viruses continued.

New ELISA kits for detection of plant viruses were developed and distributed to the laboratories of national programs in the WANA region.

J. Valkoun and GRU staff

1.2. New germplasm collected or introduced in 1991/92

1.2.1 Collection of wild wheat relatives in Lebanon

A germplasm collection/herbarium study mission was jointly conducted in Lebanon with the Agricultural Research Institute (ARI), Beirut, Lebanon. Based mainly on an extensive survey in the Beka'a valley by Nicolas Rebeiz in 1988, it was known that Lebanon is a rich country for wild relatives of wheat. A total of 39 germplasm accessions and two herbarium samples were collected in this mission. The germplasm collection breaks down as follows: Aegilops biuncialis (2), Ae. ovata (9), Ae. peregrina var. peregrina (11), Ae. speltoides var. speltoides (2), Ae. speltoides var. ligustica (1), Ae. triuncialis (4), Hordeum bulbosum (bulbs from 1 population), H. spontaneum (1), and, in addition, Medicago sp. (6), and Onobrychis sp. (1). Nicolas Rebeiz from the ICARDA-Terbol station supplied germplasm samples from Aegilops cylindrica (1) and Ae. vavilovii (1) while visiting the station on the way back to Damascus. The accessions collected of Aegilops spp. and wild Triticum species in this and other GRU missions (Sections 1.2.2, 1.2.3 and 1.2.4) this year are given in Tables 5 and 6, respectively.

The regions visited within Lebanon were as follows: (1) the Chouf mountains and the coastal region south to Sidon (Saïda) and Tyrus (Sour); (2) the northern mountain area, east of Tripoli: Halba, Zgharta, Bcharre, and (3) the mountains east and northeast of Beirut: Brummana and the Jounié-Jbail area. In general, rainfall in the regions visited varies between 700-1000 mm annually, which is rather high for Aegilops species. The results of the mission may, therefore, be somewhat disappointing, but is probably the maximum that could be expected. Nicolas Rebeiz's earlier survey in the much drier Beka'a valley, however, serves as a very good complementation, so most parts of Lebanon can now be considered well covered for wheat wild relatives. Triticum urartu, reported from the Mt. Hermon region in Lebanon, was, unfortunately, not found elsewhere. Hordeum bulbosum was collected only once, but this species is a weed in Leb-

Table 5. New accessions of Aegilops and Amblyopyrum resulting from 1992 collection missions

Species	Armenia[a]	Lebanon	Syria[b]	Total[c]
Aegilops				
biuncialis	1/-	3/-	5/1	9
caudata	-	-	2/2	2
columnaris	5/2	-	1/1	6
crassa	2/-	-	1/-	3
cylindrica	6/2	1/-	-	7
ovata	-	9/-	3/-	12
peregrina peregrina	-	11/1	1/-	12
peregrina brachyathera	-	-	-/1	-
searsii	-	-	4/1	4
speltoides ligustica	-	1/-	-	1
speltoides speltoides	-	2/-	-	2
tauschii[d]	3/2	-	-	3
triuncialis	5/1	4/-	3/-	12
vavilovii	-	1/1	3/-	4
Amblyopyrum				
muticum	1/1	-	-	1
Total	**23/8**	**32/2**	**23/6**	**78**

a : Reported in Section 1.2.4. For all countries listed: left number = germplasm; right number = herbarium sample.
b : Reported in Section 1.2.3.
c : Numbers refer only to germplasm accessions.
d : Also known as squarrosa.

anon and can be found everywhere. On the other hand, H. spontaneum proved to be very rare and was found only once at the sites visited on this mission.

M. van Slageren and N. Suleiman (ARI, Lebanon)

Table 6. New accessions of Triticum resulting from 1992 collection missions

Species	Armenia[a]	Jordan[b,c]	Syria[d]	Total[c]
aestivum[e]	5/-	5	-	5
timopheevii				
araraticum	2/3	-	-	2
monococcum				
boeoticum	4/4	2	3/2	7
turgidum				
dicoccoides	-	5	23/8	23
urartu	1/1	-	14/3	15
Total	**12/8**	**12**	**40/13**	**52**

a : Reported in Section 1.2.4. For all countries listed: left number = germplasm; right number = herbarium sample.
b : Reported in Section 1.2.2.
c : Numbers refer only to germplasm accessions.
d : Reported in Section 1.2.3.
e : Includes cultivars and landraces.

1.2.2. Collection of wild wheat relatives in Jordan

Jordan belongs to the center of genetic diversity for wild emmer wheat (T. dicoccoides). Therefore, collection and conservation of native populations of this species receives high priority.

A collection mission to previously collected sites was conducted jointly with the Jordanian national program in June, 1992, to attempt to study population dynamics of T. dicoccoides over years and locations. In total, 18 sites were revisited and and the mission resulted in collecting 5 populations and 1059 single head samples of T. dicoccoides and 2 populations and 35 single head samples of T. boeoticum. The collected materials will be planted in the 1992/93 season in the ICARDA post-quarantine field as a joint activity between GRU/ICARDA and the Jordan University for Science and Technology (JUST).

B. Humeid, M. Hamran, A. Jaradat (JUST, Irbid), and Z. Thopsun (NCARTT, Amman).

1.2.3. Collection of wild wheat relatives in Syria

West Asia is the primary center of diversity and origin of cultivated wheat (Triticum species). A number of wild progenitors and relatives, primitive forms, and old varieties of this crop are indigenous to this area of the world. Syria forms part of the 'Fertile Crescent', which is particularly rich in diversity of wild relatives and progenitors of modern wheats. In order to collect this valuable germplasm, missions were mounted in the last week of June 1992, to areas around the town of Afrin in northwest Syria and in the provinces of Damascus and Suweida in southern Syria. The latter areas had received a record amount of snowfall in February this year and the observation of the effects of this form of stress was also interesting. The explorations were carried out jointly with the Agricultural Research Center at Douma near Damascus.

In the areas before Afrin, in the province of Aleppo, collections of T. boeoticum, T. urartu, T. dicoccoides, and H. spontaneum were taken near the village of Deir Al Jamal. These were mostly found growing on roadsides or on dividers between cultivated fields of cereals, legumes or occasionally in fig and/or olive groves.

During the last week of June, the provinces of Suweida and Damascus were explored and population samples, as well as single spike samples, were collected as follows: T. boeoticum (3), T. urartu (14), T. dicoccoides (23), Ae. biuncialis (5), Ae. caudata (2), Ae. columnaris (1), Ae. crassa (1), Ae. ovata (3), Ae. peregrina (1), Ae. searsii (4), Ae. triuncialis (3), and Ae. vavilovii (3). All boeoticum samples were collected in Damascus province, the team did not come across this species in Suweida. In addition, 19 herbarium samples were made, mainly of the wild Triticum species. These samples were collected from or near the following villages: Salkhad, Rashida, Sha'af, Salih, Shaba, Shaka'a, Abu Dubeib, and Bithiana in the Suweida area, and Tukeya, Rawda, Wadi El Hanoun, Ain Hawar, and Abu Zaad in the Bloudan-Zabadani area in Damascus province. A hybrid between T. durum and T. dicoccoides was also observed near Om Dubeib village in the Suweida area, providing evidence of gene exchange and evolution in nature. Also, sympatric samples of Ae. searsii, T. urartu, and T. dicoccoides were found in these areas.

A sample of T. urartu was observed in the mountains above Bloudan at an elevation of 1840 m a.s.l. At this height, it was not surprising that it was still green, with maturity at least a month or so later than samples at lower altitudes. This has been the highest reported altitude for this species in the 'Fertile Crescent' or elsewhere, to the best of our knowledge.

It was concluded that there is some danger of genetic erosion of the wild species of Triticum and Aegilops due to overgrazing, disturbance, and rapid urbanization as a result of an upsurge in the economy. For example, near Bloudan the team found an area where Aegilops species were growing naturally in great abundance. However, a part of this area was encroached upon by a horticulturist who had cleared the field to grow peaches, cherries, plums, and vegetables.

Another problem was overgrazing. Also, in the Suweida region a considerable number of fields left as fallow were grazed by small ruminants.

It is fortunate that there had been good rains in 1992 in the region, thus providing enough green cover for the small ruminants to graze. But in years of drought, it is conceivable that several hectares of fields supporting wild wheat relatives would be grazed by a succession of flocks of small ruminants, as was observed by the team this year. More such destruction of the natural habitat of these species may be expected in the future.

Conservation of wild plants is most effective in their natural habitat. If this is threatened, selected sites may require protection. Hence, the Genetic Resources Unit is taking steps to develop projects, with external funding, in collaboration with the national programs of Jordan, Lebanon, and Syria to conserve this genetic diversity in situ. One such area which merits attention is located just outside Salkhad village in Suweida province.

J. Valkoun, A.B. Damania, M. van Slageren, P.A. Gandilyan (AAI, Armenia), M. Hamran, and Kh. Obari and Y. Waghani (ARC, Douma)

1.2.4. Collection of wild wheat relatives in Armenia

From 11-18 June, 1992, a joint collection mission was held in Armenia with the Armenian Agricultural Institute (AAI), Yerevan, Armenia. Due to the difficult situation in the country, trips could only be made in the larger vicinity of the capital Yerevan. The expert knowledge of the Armenian counterpart, Dr P.A. Gandilian, greatly contributed to the success of the mission. All known Aegilops and wild Triticum species for Armenia were found, as well as Amblyopyrum muticum. In all, 35 accessions and 20 herbarium specimens were collected. The germplasm collection breaks down as follows: Aegilops biuncialis (1), Ae. columnaris (5), Ae. crassa (2), Ae. cylindrica (6), Ae. tauschii (also known as Ae. squarrosa) (3), Ae. triuncialis (5), Amblyopyrum muticum (1), Triticum timopheevii ssp. araraticum (2), T. monococcum ssp. boeoticum (4), T. urartu (1), and the cultivated T. aestivum (5). Except for Ae. biuncialis and crassa, and the cultivated bread wheat, herbarium material was also collected of all species. In addition, herbarium material was made from natural hybrids occurring among their parents (citation of female parent x male parent): Ae. crassa x cylindrica (1), Ae. cylindrica x columnaris (1), and Ae. cylindrica x T. aestivum (2). The bread wheat material included a released cultivar, "Armeniaca 60", the old Armenian cultivar "Kangun", and three landraces growing as mixtures within these cultivars.

A large grassland adjacent to and including the Erebuni Nature Reserve northeast of Yerevan yielded most of the wild species mentioned above. The dominant cover consisted of Aegilops triuncialis, representing the largest population ever encountered and estimated to exceed 50 hectares. Amblyopyrum muticum has been considered a species of Aegilops (as Ae. mutica and occupying the monospecific subgenus Amblyopyrum, according to Hammer, 1980). From its creation by Boissier in 1844 on, however, it has been considered to be taxonomically intermediate between Aegilops and Agropyron. Davis (1985), in his Flora of Turkey, cites Amblyopyrum as a separate genus that is intersterile with Aegilops. It has long been considered an uncommon species of the Anatolian highlands in Turkey. The Armenian location is thus far the only one known from outside that country, ending its status as an endemic for Turkey. Revisiting the site, discovered earlier by Dr Gandilian, a large population, including both known varieties, muticum and loliaceum, was found just outside the protected area of the Erebuni Reserve, and duly collected as germplasm and herbarium material. The Reserve also yielded the rare subspecies araraticum of Triticum timopheevii, as well as various Triticum boeoticum populations, whereby black- and white-spiked plants were collected separately. Also interesting, in this now protected area, T. urartu was discovered and published for the first time in 1935 by the Armenian botanist Thumanian. This "locus classicus" was also revisited, providing a confusing mixture of urartu and black- and white-spiked boeoticum.

At places where the grassland next to the Erebuni Reserve bordered a field of bread wheat, the natural hybrid of Ae cylindrica with T. aestivum was found. This hybrid has been described by Gandilian as x Aegilotriticum cylindroaesivum Gandil. in 1976, but the earlier name x Aegilotriticum sancti-andreae (Degen) Soó from 1951, based on Aegilops sancti-andreae Soó 1917, must have preference according to the rules of botanical nomenclature. In the experimental garden of the Botanical Institute in Yerevan the hybrid Ae. cylindrica x columnaris was found among the parental species. In the canyon of the Rasdan river, flowing through Yerevan, the rare hybrid Ae. crassa x bread wheat was found on a ruderal site.

M. van Slageren and P.A. Gandilyan (AAI)

1.2.5. Collection of wild relatives of food legumes in Lebanon

To enrich the ICARDA collection of wild food legume relatives, a joint collection mission in Lebanon with the Agricultural Research Instituite, Beirut, Lebanon (ARI) was conducted in May, 1992. This seven day collection mission visited 17 sites and resulted in 16 germplasm samples of Lens (15 accessions of L. ervoides and 1 accession of L. orientalis) and 5 accessions Cicer (all C. judaicum).

The areas covered by the mission included the provinces of Beirut, Saida, Sour, Junie, Jubeil, Bitron, and Tripoli and were all coastal sites.

N. Suleiman (ARI) and A. Ismail

1.2.6. Collection of food legumes in Libya

A joint collection mission with the ARC, Libya was conducted 24 May to 6 June, 1992, to collect food legumes and their wild relatives. This 14 day mission visited 14 locations and resulted in 11 accessions of faba bean (Vicia faba), 2 accessions of chickpea (Cicer arientum) and one accession of wild Lens (L. odemensis). The provinces visited included Benghazi, Al-Marj, Al Beyda, Darna, Musrata, Al Kums, Tripoli, Azzawiyah, Gharyan, Tarhooneh, Yafren, and Nalut. These accessions, with what already exists in the ICARDA germplasm collection from Libya, now well represent the diversity that exists in Libya for food legumes.

M. Al Shareif, Y. Om. Shoaeb and F. Sumeida (ARC, Tripoli) and A. Ismail

1.2.7. Collection of pasture and forage legumes in Syria

During the period 14 to 20 June, 1992, a joint seven day mission to collect pasture and forage legumes was conducted with the Agricultural Research Center, Douma (ARCD) in the southern provinces of Dera'a, Qunaitra, and Sweida. The objective of the mission was to collect the pasture and forage legumes from these provinces which had not been previously collected in.

Twenty-three sites were collected and 150 accessions were collected. The accessions were from 14 genera (Table 7) with the greatest number from Trifolium (56), Medicago, and Vicia (20 each). Soil samples were taken at each site to evaluate to evaluate soil characteristics to relate to distribution of the species collected.

Kh. Obari, G. M. Ali and H. Hariri (ARCD), and A. Shehadeh and F. Sweid

Table 7. Frequency of pasture and forage legume genera collected in Syria in 1992

Genera	No. of accessions	Frequency (%)
Medicago	20	13.33
Trifolium	56	37.33
Astragalus	15	10.00
Scorpiurus	3	2.00
Hymenocarpus	5	3.33
Trigonella	3	2.00
Pisum	3	2.00
Vicia	20	13.33
Lathyrus	14	9.33
Onobrychis	4	2.66
Coronilla	2	1.33
Hippocrepis	2	1.33
Biserrula	2	1.33
Cicer	1	0.66
TOTAL	**150**	**100.00**

1.2.8. Ecogeographic survey of pasture and forage legumes in Tunisia

The objective of this mission was to collect useful pasture and forage legume genetic resources from south central Tunisia in the range of 200 to 400 mm rainfall in a joint collection mission with the Pasture, Forage and Livestock Program, ICARDA (PFLP), and the Tunisian national program (Institute National de la Recherche de Agronomiqe Tunisie, INRAT). Ecotypes of forage legumes were collected and divided with INRAT and plans established for multiplication, characterization, and evaluation of populations collected.

The mission was conducted 26 June to 5 July, 1992, and covered the following locations: Sfax; Kasserine; Sbeitala; Kairouan; Thugga; Tbboursouk; and Tunis. Locations for all sites are given in Figure 2 in Section 1.1 of this Report.

During this mission, 375 accessions from 16 genera and 49 species were collected of pasture and forage legumes (Table 8). The largest number of accessions were of Medicago, with 12 species, and of Astragalus, with 7 species. Importantly, 30 accessions of 3 Hippocrepis species and 21 accessions of 5 Hedysarum species were added to the ICARDA collection.

A. Zoghlami and H. Hamai (INRAT) and L.D. Robertson and A. Khatib (PFLP)

Table 8. Distribution of genera and number of samples collected of each species of pasture and forage legumes in Tunisia in 1992

Genera	Number of species	Number of samples	Frequency (%)
Astragalus	7	51	13.60
Coronilla	2	22	5.87
Hedysarum	5	21	5.60
Hippocrepis	3	30	8.00
Hordeum	1	1	.27
Hymenocarpus	1	1	.27
Lathyrus	2	3	.80
Lolium	1	3	.80
Lotus	3	17	4.53
Medicago	12	131	35.20
Melilotus	2	19	5.06
Ononis	1	2	.53
Scorpiurus	1	29	7.47
Trifolium	1	1	.27
Trigonella	4	24	6.40
Vicia	3	20	5.33
TOTAL	**49**	**375**	**100.00**

1.3 Germplasm multiplication, characterization and evaluation

1.3.1. Evaluation of barley from the USDA collection

A large number of new accessions received from the USDA collection (1603 accessions from 30 countries) were multiplied and evaluated in the field using a non-replicated design with repeated checks. Accessions were planted November 17, 1991, in plots of two rows, 1 m long, with 0.35 m between rows and 0.70 m between plots.

The main objective of the study was to characterize the germplasm in the eco-geographical conditions of northern Syria using the following set of 17 descriptors: growth habit (GHA), frost damage (FRD), leaf color (LFC), growth class (GCL), days to heading (DHE), days to maturity (DMA), flag leaf width (FLW), kernel row number (RNO), hoodedness/awnedness (H/A), awn roughness (ARG), spike density (SDE), resistance to lodging (LOD), awn color (ACO), kernel covering (KCO), powdery mildew reaction (PMR), plant height (PLH), and 1000-kernel weight (KWT).

This characterization data was used for computation of descriptive statistics and multivariate statistical analysis to assess the discriminative power of the descriptors used and to determine relationships among germplasm groups based on origin. Countries with less than 10 accessions (Argentina, Bolivia, Egypt, Ethiopia, Iraq, Libya, Morocco, Romania, Tunisia, and USA) were excluded from the multivariate analyses.

Most accessions were classified in the intermediate growth habit category, but there was considerable variation in relation to country of origin. Short plant stature was typical for Iran, Yemen, and Pakistan, while germplasm from Finland was the tallest (Table 9). Yugoslavia and Australia had a high proportion of prostrate types (69.8 and 68.2%, respectively), while Japan and Nepal displayed more erect types (72.2 and 38.6%, respectively).

Light-green leaf color was typical for barley from Pakistan (71.7%) and this category was also frequent in Indian germplasm (40.7%).

Table 9. Country means for FRD, DHE, DMA, PHT, and KWT for barley accessions from 20 countries

Origin	Code	No.acc.	FRD[a]	DHE	DMA	PHT	KWT
Australia	AUS	22	7.3	140.1	170.4	78.3	44.6
China	CHN	74	7.0	142.7	176.3	76.0	36.6
Czechoslovakia	CSK	51	7.2	146.6	179.1	79.9	40.5
Spain	ESP	196	7.3	153.3	185.9	75.7	40.1
Finland	FIN	25	6.8	145.5	176.1	88.4	35.4
Germany	FRG	127	6.7	147.9	181.6	82.9	42.3
Greece	GRC	13	7.3	147.1	181.2	84.2	35.4
Hungary	HUN	11	6.8	150.9	183.5	71.4	42.2
India	IND	145	5.9	140.0	175.2	73.5	39.3
Iran	IRN	16	7.1	143.8	175.8	63.1	44.5
Japan	JPN	18	6.1	143.0	178.4	70.8	32.0
Nepal	NPL	176	6.0	140.5	173.6	83.3	33.5
Pakistan	PAK	92	5.6	143.5	176.7	66.5	34.8
Peru	PER	93	6.4	146.0	179.9	79.1	40.0
Poland	POL	38	6.8	147.6	183.5	72.3	40.7
Portugal	PRT	10	7.4	148.4	183.2	80.3	42.8
USSR	SUN	29	7.5	149.3	182.0	76.1	40.3
Turkey	TUR	86	7.0	152.1	185.0	72.5	35.5
Yemen	YEM	13	6.2	139.0	171.8	64.6	50.2
Yugoslavia	YUG	199	8.0	154.1	185.3	74.2	36.2
Total/mean		**1434**	**6.8**	**147.0**	**180.1**	**76.4**	**38.1**

a : For descriptor abbreviations, see text.

Approximately half of the accessions were classified in the spring growth class. All barley accessions from Bolivia (7 accs.), Egypt (5 accs.), and USA (6 accs.) belonged to that category. The high proportion of the spring category was also found in germplasm from India, Nepal, and Yemen (> 90%), Australia and China (> 80%) and India, Japan, Pakistan, and Finland (>70%). The winter growth class category prevailed in barley from Yugoslavia and Romania (>70%), and Spain and Turkey (>50%).

Six-row accessions were more frequent than two-row ones (70.6 vs 28.7%). All entries from Pakistan, Portugal, and Romania were six-row barley. The high proportion of this row type was found as well in Indian, Japanese, Nepalese, Peruvian, and Yugoslavian germplasm (>90%). However, two-row barley was typical for Czechoslovakia, Finland, Germany, Hungary, Poland (>90%), and Australia (86.4%).

Dense-spike types prevailed among the Japanese accessions (61.1%) and were common in the Portuguese germplasm (50.0%). Most of the barley accessions had covered grains (81.0%), however, naked barley prevailed in barley originating from Peru (76.3%), Pakistan (73.9%), and Japan (61.1%) and was also common among Chinese accessions. Germplasm from Yemen and Australia (mostly two-row barley) had the largest and that from Japan the smallest grains (Table 9).

Mean values in Table 9, as well as frequency distributions, indicate a high level of frost tolerance in germplasm from Yugoslavia, Romania, and USSR (52.3, 50.0, and 31.0%, respectively).

Earliness was characteristic for Yemen, India, Australia, and Nepal, whereas barley from Yugoslavia, Spain, and Turkey was late in heading and also in maturity (Table 9). Australian germplasm had the earliest maturity, due to its short grain filling period.

Phenotypic correlations among the descriptors revealed that plant height was not strongly associated with the other traits. Row type was correlated with flag leaf width (-0.54^{**}) and kernel weight (0.42^{**}). Surprisingly, frost damage was more strongly correlated with growth habit (-0.45^{**}) than with growth class (-0.40^{**}). This might indicate that the classification into growth class categories was more related to photoperiod than to vernalization response. This assumption is further supported by the high correlation between growth class and days to heading (-0.89^{**}) and the multiple regression equations in Section 1.4.5 of this Annual Report, which show a high effect of photoperiod sensitivity on heading time in the field.

One-way analysis of variance revealed that with DHE, DMA, and GCL, most of the variation was due to differences between countries, while with the other descriptors, the within-country variation was more important (Table 10). Descriptors, either related directly to adaptation (days to heading and days to maturity) or correlated with these traits (growth class), had a high proportion of between country variation (Table 10). For other descriptors, the between country variation was lower than 50%.

Table 10. Partitioning of variance for different descriptors to between and within countries variation (in % of total) for barley accessions from 20 countries

		Source of variation	
Descriptor	**Abbrev.**	**Between countries**	**Within countries**
Growth habit	GHA	42.5	57.5
Frost damage	FRD	39.3	60.7
Growth class	GCL	61.6	38.4
Days to heading	DHE	64.2	35.8
Days to maturity	DMA	58.4	41.6
Spike density	SPD	15.3	84.7
Lodging	LOD	44.0	56.0
1000-kernel weight	KWT	30.8	69.6
Plant height	PHT	34.8	65.2
Degrees of freedom		29	1601

Plant phenology was also associated with the average latitude of the country of the germplasm origin, as shown by the simple correlation between the average country latitudes and days to heading of $r=0.57^*$.

Discriminant analysis was applied to 17 descriptors to estimate the importance of the descriptors for classification, assessing the similarity of germplasm from the different geographical origins by use of misclassification data, and obtaining group centroid values which were used in a subsequent hierarchical cluster analysis.

The first four canonical discriminant functions contained 49.5, 18.4, 9.1, and 6.3%, respectively, of the total between-group variance. The variables days to heading, growth class, days to maturity, lodging, and frost damage were strongly correlated with the first canonical discriminant function (0.62*, -0.59*, 0.50*, -0.43*, and 0.40*, respectively). Row type was correlated with the second (r=0.82*) and kernel cover with the fourth function (r=-0.59*).

Large countries (China, USSR, and Turkey), which included regions with different agro-ecological conditions and different

Table 11. Summary of the classification by discriminant analysis for barley accessons from 20 countries

Country	**No. acc.**	**Correct class.(%)**	**Misclassifications in % (for frequencies >7.0%)**
Australia	22	72.7	CSK-9.1
China	74	21.6	PER-16.2, IND-12.2, AUS-12.2, JPN-9.5
Czechoslovakia	51	49.0	POL-15.7, FRG-11.8, HUN-7.8
Spain	196	44.9	YUG-12.8, TUR-12.8
Finland	25	84.0	-
Germany	127	51.2	CSK-12.6, HUN-10.2, POL-7.1
Greece	13	46.2	ESP-15.4, PRT-15.4, HUN-15.4
Hungary	11	54.5	FRG-18.2, POL-18.2, GRC-9.1
India	145	50.3	NPL-17.2, PAK-13.8
Iran	16	62.5	YEM-12.5
Japan	18	61.1	CHN-11.1, NPL-11.1
Nepal	176	54.5	IND-11.4, CHN-8.5, JPN-8.5
Pakistan	92	76.1	IRN-7.6
Peru	93	73.1	PRT-7.5
Poland	38	68.4	CSK-13.2, HUN-7.9
Portugal	10	90.0	TUR-10.0
USSR	29	31.0	ESP-13.8, CSK-10.3, YUG-10.3
Turkey	86	40.7	YUG-15.1, POL-9.3
Yemen	13	69.2	IND-15.4, IRN-7.7, FRG-7.7
Yugoslavia	199	73.4	ESP-10.6, TUR-7.0
Total	**1434**	**56.1**	

types of germplasm, displayed a higher proportion of misclassifications (Table 11). The incorrectly classified cases indicated the type of within-country heterogeneity involved and the misclassifications in Table 11 usually follow the clustering patterns resulting from the hierarchical cluster analysis (Figure 3).

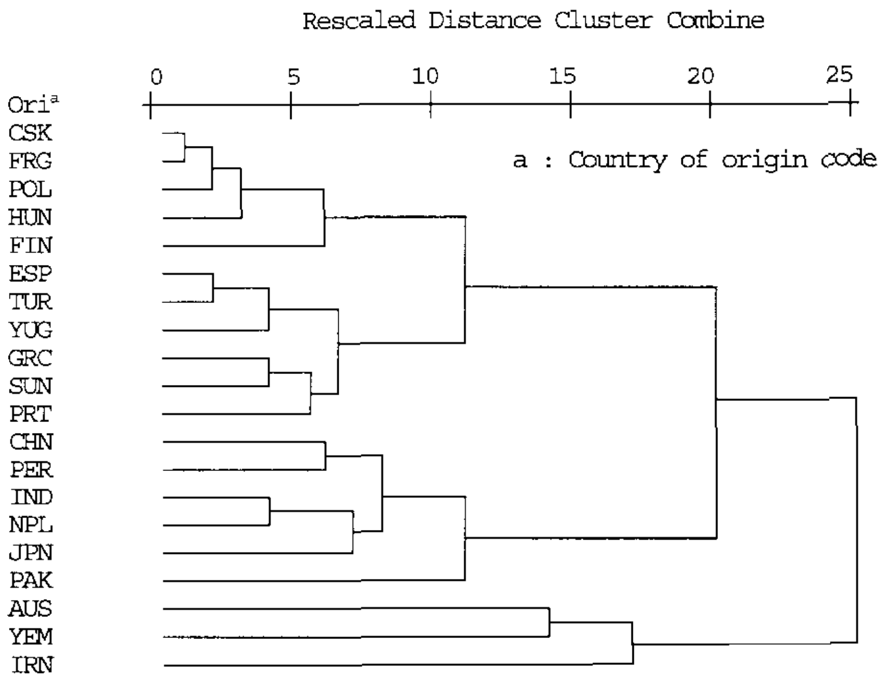

Figure 3. Cluster analysis for barley accessions from 20 countries of origin based on group centroids of 12 significant canonical discriminate functions

The first twelve canonical discriminant functions, i.e., the significant ones, evaluated at group means (group centroids) in the discriminant analysis were used for hierarchical clustering.

The dendrogram (Figure 3) computed by using the average linkage method (between groups) shows a high similarity within the Central European germplasm (Czechoslovakia, Germany, Poland, and Hungary).

This cluster is also associated with Finland. Another large cluster involves the Mediterranean countries (Spain, Turkey, Yugoslavia, Greece, and Portugal) and the former USSR. The two clusters are well separated from the Asian group (China, India, Nepal, and Japan), which also included Peru. Australia, Yemen, and Iran formed a very loose association, somewhat apart from the other clusters.

The hierarchical cluster analysis revealed that the countries of origin may be grouped into larger groups which are mutually different in several aspects. For example, the central European group consists mostly of two-row, malting spring barley; the Mediterranean germplasm includes six-row, winter or facultative types; and the Asian group has a high proportion of the naked, mostly spring barley.

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1.3.2. Multiplication and characterization of new barley germplasm

A total of 877 seed samples of barley received from or collected in different countries (Czechoslovakia - 25, Hungary - 140, Libya - 76, Yemen - 75, Japan - 40, Jordan - 54, Russia - 41, Tunisia - 115, and Nepal - 311) were planted during the 1991/92 season in the ICARDA post-quarantine area. The accessions were planted with six ICARDA checks (Harmal, Arar, Tadmor, Roho, Radical, and Steptoe) in mid-November, 1991, and in late December for Nepal accessions.

The germplasm was planted in non-replicated plots of 1-2 rows of 1.0 m length and 0.45 m between rows and 0.9 m between plots, except for germplasm from Nepal, where the plots were 1.0 m long, with 0.3 m between rows and 0.6 m between plots.

The germplasm was scored for the following descriptors: growth habit (GHA), frost damage (FRD), leaf color (LFC), growth class (GCL), days to heading (DHE), days to maturity (DMA), flag leaf width (FLW), kernel row number (RNO), hoodedness/awnedness (H/A), awn roughness (ARG), plant height (PLH) in cm, spike density (SDE), resistance to lodging (LOD), awn color (ACO), kernel covering (KCO), 1000-kernel weight (KWT) in g, powdery mildew reaction (PMR), and grain yield/plot (PGY) in g.

A large diversity was found for most descriptors. All accessions from Libya and all but one from Nepal were six-row barley. This row type was also most prevalent in Tunesian barley landraces. Yemeni barley landraces were the earliest, while those from Tunisia were the latest (Table 12).

Table 12. Descriptor means for countries of origin for new accessions of barley and the checks

Origin	No.acces.[a]	DHE[b]	DMA	PLH	KWT	PGY
Country						
Libya	76	140.0	173.4	68.7	40.0	322.8
Yemen	75	134.9	167.1	61.2	46.1	228.0
Japan	40	141.3	176.3	65.8	36.3	239.1
Jordan	54	141.8	173.7	67.1	47.3	370.4
Tunisia	115	151.3	188.3	74.0	48.6	263.7
Checks						
Harmal	18	129.0	162.5	62.8	48.4	280.2
Arar	17	131.6	166.9	68.2	34.1	243.0
Tadmor	14	130.8	162.5	63.0	44.8	323.4
Roho	14	133.7	167.2	56.6	52.8	260.6
Radical	13	146.8	178.7	53.3	34.9	241.9
Steptoe	12	145.1	179.3	80.4	44.5	495.0

a : No. of plots for checks.
b : For abbreviations, see text.

Germplasm from Jordan and Libya showed the best adaptation to the semi-arid agroecological conditions of northern Syria and a number of accessions from both countries exceeded the mean plot yield of the best check (Table 13). The characterization data is to be published in a catalog.

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Table 13. Characterization of new high-yielding accessions of barley (plot yield higher than mean of the best check)

ICB[a]	Origin	RNO[b]	LOD	PMR	DHE	DMA	PLH	KWT	PGW
118696	Algeria	1	1	3	152	182	86	41	691
118699	Afghanistan	1	5	3	152	182	65	40	666
119152	Jordan	2	3	7	139	171	70	45	608
119135	Jordan	2	3	7	149	170	72	41	599
120672	Libya	1	3	3	141	182	88	47	587
120679	Libya	1	3	3	141	174	84	46	582
120673	Libya	1	3	3	141	182	77	48	581
120674	Libya	1	3	3	143	182	84	51	566
119171	Jordan	2	5	7	140	171	78	40	565
119162	Jordan	2	3	3	140	171	70	52	562
118698	Afghanistan	1	3	5	152	182	83	41	556
119164	Jordan	2	3	3	141	171	68	48	551
119172	Jordan	2	5	3	139	171	75	49	540
119153	Jordan	2	5	5	139	171	71	54	536
120947	Tunisia	1	3	5	149	193	86	51	536
120671	Libya	1	3	3	135	182	82	47	534
118684	Iran	1	3	5	155	182	78	36	530
120670	Libya	1	3	3	145	182	79	47	528
119131	Jordan	2	3	5	140	171	68	50	526
118687	USSR	1	3	3	147	179	88	38	524
120710	Libya	1	5	3	138	171	68	42	521
119157	Jordan	2	3	3	138	167	62	45	518
118682	Iran	1	5	3	147	182	74	40	516
119128	Jordan	2	5	3	140	171	72	53	515
120680	Libya	1	3	3	145	182	76	48	511
118691	Tunisia	1	3	3	149	185	88	46	509
119193	Tadzhikistan	2	1	3	147	179	83	56	508
120782	Yemen	2	3	3	135	171	68	51	504
118695	Tunisia	1	5	3	157	190	85	42	501
119173	Jordan	2	5	5	141	171	76	55	501
120676	Libya	1	3	3	145	179	73	47	499
119166	Jordan	2	3	3	141	171	70	45	496

a : ICB=ICARDA accession number.
b : RNO=row number, 1=six-row, 2=two-row; LOD=lodging resistance, 1=excellent, 9=very poor; PMR=powdery mildew resistance, 0=resistant, 9=very susceptible; for other abbreviations, see text.

1.3.3. Multiplication and characterization of wild barley

A total of 122 bulk population samples of wild barley H. spontaneum, collected from Jordan (89), Syria (22), Turkestan (8), Uzbekistan (2), and Tadzhikistan (1) were planted in the post-quarantine area for multiplication and characterization. The germplasm was planted in mid-November, 1991, in a non-replicated nursery with two types of ICARDA checks: wild type checks (41-1, 41-5) and cultivated type checks (Harmal, Arar, Tadmor, Roho, Radical, and Steptoe).

The plots were 2 rows, 1 m long, with a distance of 0.45 m between rows and 0.90 m between plots.

The accessions were evaluated for 18 descriptors: growth habit, frost damage, leaf color, growth class, days to heading, days to maturity, flag leaf width, row type, hoodedness/awnedness, awn roughness, canopy architecture, node pigmentation, plant height, spike length, awn length, peduncle length, peduncle extrusion, and powdery mildew reaction.

An extensive diversity was found in most of the characters evaluated. The characterization data will be analyzed jointly with the collection site information, to established associations between the two types of data.

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1.3.4. Characterization and multiplication of new wheat germplasm

Durum wheat

A total of 163 seed samples of durum wheat landraces originating from Tunisia (100), Yemen (56), and Jordan (7) were planted during in 1991/92 season in the post quarantine area in the same way as the wild barley germplasm (see Section 1.3.3). Haurani and Om Rabi were used as checks.

The following characters were scored: Growth habit, frost damage, growth class, days to heading, days to maturity, plant waxiness, awnedness, spike length, plant height, spike density, lodging, 1000-kernel weight, grain color, and kernels per spike.

Bread wheat

In the 1991/92 season, a total of 162 seed samples of bread wheat originating from Czechoslovakia (23), Turkey (38), Russia (5), Japan (129), Jordan (12), and Tunisia (84) were planted in the post-quarantine area for multiplication and characterization using the same experimental design and descriptors as in durum wheat above.

Primitive forms and wild Triticum

A set of 26 seed samples of *T. compactum*, *T. dicoccoides*, and *T. urartu* collected from Uzbekistan (2) and Syria (24) were planted in mid-November, 1991, with three ICARDA checks: Mexipak, Cham-4 and Sonalika. Another set of 112 samples was received from CIMMYT, comprising *Triticum dicoccum*, *T. monococcum*, *T. polonicum*, *T. carthlicum*, *T. compactum*, and *T. sphaerococcum*. The materials were planted in 2 row plots of 0.45 m row width and 0.9 m apart.

The following characters were scored: Growth habit, frost damage, growth class, days to heading, days to maturity, plant waxiness, maturity time, plant height, spike length, awn length, peduncle length, and peduncle extrusion.

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1.3.5 Characterization of *Aegilops* germplasm

A set of 159 entries from Algeria, Armenia, Azerbaijan, Bulgaria, Libya, Syria, Tadzhikistan, Tunisia, Turkmenia, and Uzbekistan were planted in an unreplicated nursery with three systematically repeated checks (*Aegilops searsii*, Acc. no. 400061; *Ae. triuncialis*, Acc. no. 400021; *Ae. vavilovii*, Acc. no. 400067) and, in addition, a fourth randomized check (*Ae. biuncialis*, Acc. no. 400831).

Table 14. Minimum, maximum, mean and standard deviation for 3 descriptors for Aegilops germplasm (1992 evaluation)

Aegilops species	No. of tested acc.	Plant Height (cm)				Number of days to heading				Number of spikelets per spike			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
biuncialis	3	17	49	34.6	13.21	150	184	165.3	17.24	3	3	3.0	0.00
columnaris	3	33	39	36.0	0.87	157	166	163.0	5.20	4	6	5.2	0.76
crassa	18	32	76	50.2	7.64	150	155	151.1	2.14	7	12	9.3	0.84
cylindrica	21	35	67	50.1	6.71	155	170	162.0	4.68	7	11	9.4	0.87
ovata	18	13	40	25.8	5.50	150	166	151.7	4.04	2	7	3.4	0.87
peregrina	4	21	39	30.3	5.53	162	170	167.0	3.83	3	5	4.1	0.75
speltoides	3	44	82	59.9	9.81	150	157	152.3	4.04	11	14	12.7	1.04
squarrosa	39	20	58	38.5	6.54	150	170	157.0	5.41	5	13	9.4	1.36
triaristata	3	24	32	26.9	1.40	170	175	171.7	2.89	4	5	4.5	0.50
triuncialis	34	29	54	41.2	5.35	150	181	161.2	9.62	3	7	5.1	0.61
umbellulata	4	17	38	24.5	6.49	157	162	160.8	2.50	4	5	4.5	0.41
ventricosa	5	33	60	43.4	7.14	155	162	156.4	3.13	5	9	7.6	1.19
vavilovii	(I)[a]	42	74	51.6	7.73	150	150	150.0	0.00	7	11	9.4	0.92
triuncialis	(II)	26	55	42.4	6.76	150	162	155.7	3.88	4	6	5.5	0.45
searsii	(III)	32	57	47.0	6.06	150	155	150.8	2.04	8	14	12.2	1.47
biuncialis	(IV)	23	44	34.5	5.24	150	150	150.0	0.00	2	3	2.8	0.41

a : I-IV = Check.

Qualitative and quantitative descriptors were evaluated on a plot basis using the IBPGR wheat descriptor list. Qualitative descriptors included early vigor, juvenile growth habit, growth class, leaf shape, leaf attitude, flag leaf attitude, and waxiness of the plants. The Aegilops trial was not protected against yellow rust. Nine quantitative descriptors were evaluated on three single plants randomly selected from each plot. They included: number of tillers per plant, number of productive tillers per plant, plant height (average of 3 readings per individual plants), spike length (average of 3 readings per individual plants), number of spikelets per spike, and flag leaf length and width. In addition, the number of days to heading and days to maturity were calculated starting from the day of the first effective rain after planting (11 December 1991). Data on three quantitative traits are presented in Table 14.

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1.3.6. Screening for resistance to important wheat diseases in a selection of the ICARDA Aegilops collection

During the 1991/1992 season, a second part of the Aegilops collection was tested for important fungal wheat diseases, viz. yellow rust [Puccinia striiformis Westend. f.sp. tritici], septoria tritici blotch [Mycosphaerella graminicola (Fuckel) Schr.; anamorph Septoria tritici Rob.], and common bunt [Tilletia foetida (Wallr.) Liro and T. caries (DC.) Tul.]. We attempted to screen for leaf rust and stem rust using summer planting and produced preliminary results. In total, 660 accessions were selected for screening. Eighteen out of the 23 recognised species (Ae. mutica is for the moment regarded as belonging to Aegilops rather than to the monospecific genus Amblyopyrum) were involved. Only material of Ae. sharonensis has not been tested, so far, for the above diseases. Results for the testing for resistance to septoria blotch and common bunt are presented under "Durum Wheat Pathology: studies on the host-pathogen system" in the Cereal

Program Annual Report for 1992.

For yellow rust screening, a set of 660 accessions was planted on 16 December, 1991, in an unreplicated trial, using 8 seeds planted in 2 rows of 1 m each and 30 cm apart as the test plot. Randomization was not performed but instead the selected accessions were planted following their accession number. This, in general, prevented outcrossing species from being planted next to each other, while providing for a certain amount of randomization.

Seventy five entries did not germinate. Also included in the initial 660, were 178 retested entries that scored 15 MR, a CI of 6.0, or less during the 1990/1991 screening (GRU Annual Report for 1991: Table 17; 177 are listed there). Of those 178, 18 did not germinate. Thus, a total of 660 - (178 + 75) = 407 new entries were tested, results of which are presented in Table 15.

Scoring of severity of the infection was again done with the modified COBB's scale, with trace infection scored as 1%. Field response, or reaction type, was classified with the categories R, MR, M, MS, and S. Severity and response were converted to a Coefficient of Infection, or CI (= severity x response), using a constant value for the field response: R = 0.2, MR = 0.4, M = 0.6, MS = 0.8, and S = 1 (Stubbs et al., 1986). For each species the Average Coefficient of Infection, or ACI, was calculated as the sum of individual CI's divided by the number of entries.

The results are varied for the new entries, tested for yellow rust both at the individual accession and at the species level, (Table 15). An ACI of 15 MR (CI = 6.0) or less was shown by only seven species: overall in Ae. biuncialis, ovata, neglecta, speltoides, and triuncialis, as well as in a limited number of accessions of Ae. kotschyi, umbellulata, and uniaristata. The widespread Ae. neglecta, Ae. ovata, and Ae. triuncialis may provide a rich source of resistance to yellow rust. From these three species, and over two years and from many different countries, a total of 64, 197, and 152 accessions, respectively,

Table 15. Performance of 18 *Aegilops* spp., resulting from the yellow rust screening, Tel Hadya, Syria; 1991/1992

Species	Severity/Reaction range	ACI species	ACI country	No. pop.	Country
biuncialis	1-30/R-S	3.4	1.6	20	Bulgaria
			0.2	3	Cyprus
			5.1	14	Lebanon
			5.45	4	AZB, RUS[b]
			30.0[a]	1	Tunisia
			1.5	7	Turkey
caudata	1-90/R-S	60.9	0.2	2	Bulgaria
			74.4	9	Lebanon
columnaris	1-40/R-S	13.8	13.2	9	Lebanon
			60.0[a]	1	AZB[b]
			1.6	3	Syria
			10.0[a]	1	Turkey
crassa	1-50/R-S	15.0	45.0	2	TRM, UZB[b]
			0.2[a]	1	Syria
cylindrica	1-40/R-S	6.8	6.8	5	AZB, GEO, RUS, UZB[b]
juvenalis	20-80/MS-S	48.0	48.0	2	RUS, UZB[b]
kotschyi	1/S	0.6[a]	0.6[a]	1	AZB[b]
neglecta[c]	1-15/R-MS	0.8	0.9	9	Bulgaria
			0.2[a]	1	Iraq
			1.7	3	Morocco
			0.6	5	ARM, AZB, RUS[b]
			0.5	3	Syria
			0.7	20	Turkey
ovata	1-60/R-S	3.9	0.6	10	Bulgaria
			40.0[a]	1	Cyprus
			3.6	19	Algeria
			3.5	22	Lebanon
			30.4	8	Libya
			1.3	37	Morocco
			1.4	13	Syria
			1.0	5	Tunisia
			0.6	15	Turkey
peregrina	1-60/R-S	8.3	1.4	3	Lebanon
			9.0	29	Syria
searsii	85/S	85.0	85.0[a]	1	Jordan
speltoides	1-70/R-S	7.1	0.2[a]	1	Bulgaria
			5.6	18	Syria
			40.0[a]	1	Turkey
tauschii[c]	1-30/R-S	10.4	20.0[a]	1	India
			8.5	5	AZB, RUS[b]

Table 15. (continued)

Species	Severity/Reaction range	ACI species	ACI country	No. pop.	Country
triuncialis	1-20/R-S	1.3	1.4	25	Bulgaria
			2.4	2	Cyprus
			0.2[a]	1	Algeria
			0.6	17	Lebanon
			2.6	15	Morocco
			0.2[a]	1	Pakistan
			1.3	8	AZB, RUS, TUR, UZB[b]
			2.1	2	Syria
			0.85	24	Turkey
umbellulata	1-5/M-MS	1.9	3.0[a]	1	AZB[b]
			0.8[a]	1	Turkey
uniaristata	1/R	0.2[a]	0.2[a]	1	RUS[d]
vavilovii	80/S	80.0	80.0[a]	1	Lebanon
			80.0[a]	1	Syria
ventricosa	10-90/MS-S	67.0	80.7	7	Libya
			19.0	2	Morocco
Total				**407**	

a : Data of one accession; only CI calculated.
b : USSR now defunct. Material originating from Armenia (ARM), Azerbaijan (AZB), Georgia (GEO), Daghestan, Russia (RUS), Turkmenia (TRM), Uzbekistan (UZB).
c : Synonym of neglecta: triaristata; synonym of tauschii: squarrosa.
d : Material from Daghestan, Russia, station of the Vavilov Institute. Origin unclear but probably Croatia of Greece.

have consistently shown good resistance to yellow rust. The lesser widespread Ae. biuncialis also scored well with ACI's of 7.1 in the first year and now 3.4, but some accessions (from Jordan and Syria in 1990/1991, and now from Tunisia) were more susceptible. Emphasis for collection may thus be on other countries where this species is represented. The ACI by species may obscure promising regions (here: countries), present in species with a higher overall ACI. An example of this are the 18

Syrian accessions of Ae. speltoides with an ACI by country of 5.6. When excluding from this species, the susceptible Turkish accession (CI of 40), and one from Syria with a CI of 70, the overall species ACI would have been as low as 1.75, and thus similar to the 1990/1991 results (then an ACI of 2.1).

Material with good resistance was again defined as showing a severity of infection between trace (1%) and 15%, and a response of R-MR, which is a CI range of 0.2 to 6.0. Out of the 407 new entries tested in this season, a total of 275 accessions (67.5%) fell in this range, while the remaining 132 (32.5%) had a CI of over 6.0 (Table 16).

Table 16. Number of resistant accessions to yellow rust in the Aegilops collection, screened in 1991/1992

Severity and reaction type[a]	**No. Accessions**
1 R	242
5 R	7
10 R	10
15 R	5
1 MR	10
5 MR	-
10 MR	1
15 MR	-
Total	**275**

a : Trace severity put at 1%.

Retesting of the 178 resistent accessions of the 1990/1991 screening gave the following results (referring to 160 entries, as 18 accessions did not germinate) in 1991/1992. Out of the 160, 72 (45%) gave the same CI score, 33 (20.5%) a lower CI score than the previous year, and 55 (34%) a higher CI score, of which 32 scored a CI of 6 or lower, and 23 a CI higher than 6. Thus, most of the entries maintained their resistance to yellow rust during the second year. As a result of the retesting of 160 accessions, a total of 105 are identified as having a good resistance to yellow rust, maintained during the two years.

That repeated testing is necessary, is illustrated by the 23 accessions (nearly 13%) that showed a sometimes dramatic sensitivity to the disease. Examples of striking differences between the years are Jordanian and Syrian accessions of Aegilops biuncialis, and all accessions of Ae. kotschyi and Ae. peregrina. The resistance of two Ae. searsii accessions from the 1990/1991 screening also proved to be misleading. Their score (ACI of 65) is now more similar to the ACI calculated for 22 accessions in the first year (then a susceptible 27.1; GRU Annual Report for 1991, Table 18).

The 1991/1992 season shows generally higher ACI scores than the first year, which may be due to a change in the pathogen virulence or the environment. Table 17 shows a comparison of the two years

Table 17. Resistance of 178 accessions of Aegilops species by regions, resulting from the 1991/1992 retesting as compared with the 1990/1991 screening, Tel Hadya, Syria

	1991/1992		1990/1991			
Species	ACI[b] species	ACI country	ACI species	ACI country	No. pop.	Country
bicornis	-	-	0.2	0.2	0-4	Cyprus
	-	-	0.2[a]	0.2[a]	0-1	Egypt
biuncialis	4.8	1.5	1.1	1.9	6	Bulgaria
		0.3		0.8	6	Cyprus
		11.8		0.9	5	Jordan
		0.2[a]		2.0[a]	1	Lebanon
		18.0		0.25	4	Syria
		1.0		1.1	9-10	Turkey
caudata	6.0	15.0	0.2	0.2	1-2	Syria
		1.6		0.2	2-3	Turkey

Table 17. (Continued)

Species	1991/1992 ACI[b] species	1991/1992 ACI country	1990/1991 ACI species	1990/1991 ACI country	No. pop.	Country
columnaris	3.3	-	1.8	4.0[a]	0-1	Lebanon
		3.3		1.0	5	Syria
		-		4.0[a]	0-1	Turkey
cylindrica	40.0	40.0[a]	0.2	0.2[a]	1	Turkey
kotschyi	45.0	40.0[a]	1.4	0.2[a]	1	Jordan
		47.5		2.0	2	Syria
mutica	-	-	2.0[a]	2.0[a]	0-1	Turkey
neglecta[c]	0.95	1.0	1.0	0.8	3	Bulgaria
		1.1		0.3	5	Syria
		0.9		1.3	13	Turkey
ovata	1.45	1.1	1.0	2.0	2-3	Bulgaria
		6.1		0.2	7	Cyprus
		0.3		2.5	5	Algeria
		3.0[a]		0.2	1-2	Jordan
		0.2		1.0	8-9	Syria
		0.3		0.9	15-16	Turkey
peregrina	16.2	21.25	0.8	0.7	4	Jordan
		11.1		1.0	4-5	Syria
searsii	65.0	65.0	3.0	3.0	2	Jordan
speltoides	1.1	0.2	0.75	0.2	4-6	Syria
		5.0[a]		4.0[a]	1	Turkey
triuncialis	1.4	1.4	0.9	0.8	6	Bulgaria
		2.3		0.7	7	Cyprus
		0.2[a]		0.2[a]	1	Algeria
		4.7		0.2	5	Syria
		0.3		1.1	20	Turkey
umbellulata	4.1	1.0[a]	0.7	0.2[a]	1	Syria
		5.1		1.7	3	Turkey
Total					**160-178**	

a : Data on one accession; only CI calculated.
b : ACI calculated for the retested entries only. A (-) in any of the columns indicates that the accession died in an early stage during retesting.
c : Common synonym: triaristata.

of testing of the 178 accessions initially scored as resistant. Table 15, together with the similar Table 18 from the GRU 1991

Table 18. Susceptibility of Aegilops species carrying the D- and S-genome to yellow rust, screenings 1990/1991 and 1991/1992, Tel Hadya, Syria

Species	Genome formula+	ACI 90-91	ACI 91-92
D-genome			
crassa	DM / DDM	18.6	15.0
cylindrica	CD	28.6	6.8
juvenalis	DMU	-	48.0
tauschii	D	31.8	10.4
vavilovii	DMS	44.8	80.0
ventricosa	DUn	25.1	67.0
S-genome++			
bicornis	S^b	10.8	-
longissima	S^l	7.7	-
searsii	S^s	27.1	85.0
speltoides	S	2.1	7.1

+ : Genomic formula according to Kimber & Sears, Proc. 6th International Wheat Genetics Symposium, Kyoto, Japan: 1195-1196 (1983). A (-) indicates that entries were either not tested or died during retesting.
++ : One species of this group, Ae. sharonensis, has not been tested.

Annual Report, furthermore shows the interesting feature that species with the D-genome show a consistent susceptibility for yellow rust (separately presented in Table 18). To a lesser extent, the S-genome species, one of which may have contributed the B-genome in wheat, are also susceptible. The exception here is Aegilops speltoides, which scored an ACI of 2.1 (for 9 accessions) in the first year and slightly above 6.0 (i.e. 7.1 with 19 accessions) in the 1991/1992 screening. Resistant accessions of this species maintained their performance over the two years (Table 18).

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1.3.7. Screening for barley yellow dwarf virus (BYDV) in cereals

Over 1000 new breeding lines were evaluated for their reaction to BYDV after artificial inoculation with a PAV isolate (non-specifically transmitted by Rhopalosiphum padi and Sitobion avenae), tolerant lines are listed in Table 19.

Table 19. Evaluation of new cereal breeding lines after artificial inoculation with BYDV during the 1991/92 growing season

Cereal nursery	Number of lines tested	Lines with tolerance to infection
Bread wheat		
WKL-1992	280	2[a],10,25,63,71,94,98, 105,114,124,141,147, 151,153,161,164,187, 201,216,222,225,232, 237,244,246,256,263, 272,273,279.
C-YD-BW-1992	157	6,12,57,67,119,120,121, 122,132,140,145,147, 149,151.
Durum wheat		
DKL-1992	260	42,46,49,58,81,95,115, 116,139,149,172,174, 197,198,213,252.
C-YD-DW-1992	52	2,3,4,27,28,31,33,48, 50,51.
Barley		
BKL-1992	200	17,24,25,30,57,59,63, 65,84,85,87,93,101,110, 170.
C-YD-BA-1992	71	11,14,17,18,19,23,24, 32,34,62,71.

a : Numbers refer to ICARDA nursery serial number, e.g. 2 is WKL-92-2.

The most promising lines of the previous two years were pooled and evaluated in 1.5 m long 4-row plots. A number of traits, including yield loss in comparison with a healthy control, were evaluated (Table 20). The best performing lines from this trial were used to constitute the BYDV nursery which is being distributed to national programs of the region.

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Table 20. Re-evaluation of cereal breeding lines which performed well over the last two years after artificial inoculation with BYDV during 1991/92

Cereal nursery	Lines with tolerance to infection
Bread wheat	
Canada-91	2[a],4,7,9,10,11,12,13,15,17,19,20,28
CIMMYT-YD-BW-91	3,4,27,28,31,32,36,45,104
WKL-91	11,16,28,37,43,46,62,63,64, 65,71,79,82,110,125,138,185
Chile-BW-91	2,3,8,9,10,14,16,18,21,23,25
Durum wheat	
DKL-91	17,19,37,41,43,69,162,164, 177,187,191,193,197,198,216
DCB-91	14,23,24,25,36,38
CIMMYT-YD-DW-91	2,4,7,14,22,37,47,49
Chile-DW-91	28,29,31,32,33

a : Numbers refer to ICARDA nursery serial number, e.g. 2 is WKL-92-2.

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

Wheat is one of the earliest crops to be brought under cultivation through domestication and has acquired a wide range of distribution throughout the world. To further realize advances in improvement and to address new demands being put on this crop in terms of improved yields and tolerance to stresses, it has become increasingly urgent to broaden its genetic base with the introduction of genes from non-conventional sources, such as wild relatives and previously cultivated species.

In view of the 'greenhouse phenomenon' and subsequent global warming, increasing genetic tolerance of crop species to environmental stresses such as drought and high temperature is of paramount importance. For any fruitful work in this area, it is important to have at hand a comprehensive collection of germplasm from the areas of high genetic diversity where these traits occur. For wheat, this has been partly accomplished through a series of expeditions since 1978 in the southwest Asian and Mediterranean regions, which are in the primary centers of diversity for wheat and its wild evolutionary progenitors, such as wild emmer (Triticum turgidum var. dicoccoides Koern.), as well as a number of other wild Triticum and Aegilops species.

Since the most realistic approach toward improving wheat production under drought stress is the genetic improvement of wheats for biotic and abiotic stress tolerance, we emphasize the genetic aspect of these stresses in our research. The 1991/92 season was considerably wetter than previous seasons. Tel Hadya received a total rainfall of 352.5 mm, which is 20 mm above the long-term average and hence, conditions were ideal for wheat growing. Breda received a total of 263.2 mm, which is identical to the long-term average. The season was noted for a relatively heavy snowfall in February, which was unprecedented in the last 50 years. This was, hence, an ideal opportunity to confirm the results of several years of testing for frost tolerance.

1.3.8.1. Evaluation of Triticum dicoccoides for abiotic stresses

Wild emmer, T. dicoccoides (AABB), is the progenitor of all cultivated wheats. Its distribution can be divided into two regions according to Zeven and de Wet (1982). The northern region is comprised of southern Turkey, Iran, Iraq, and the southern region consists of Palestine, southern Syria, and Jordan. This wild species seems to have been derived from a natural amphi-diploidization of an unknown diploid species, perhaps T. boeoticum. It is thought that this amphi-diploidization must have occurred in southern Syria or Palestine, or at several places within this region. Speculation as to the identification of this unknown diploid parent is a subject of continuing research.

One hundred and seventy selected samples from the T. dicoccoides collection have undergone continuing evaluation at Tel Hadya and Breda to identify suitable parents to be used in crosses with cultivated durum wheat in order to improve protein content and disease resistance. Variation was considerable for all characters, even for the checks, viz., Cham 1, Haurani, T. dicoccum (tetraploid); and Mexipak and Cham 4 (hexaploids).

Table 21. Simple statistics of 170 samples of T. dicoccoides evaluated at Tel Hadya and Breda

Trait	Mean	Max.	Min.	S.D.	Mean	Max.	Min.	S.D.
DHE[a]	156	164	150	1.98	162	172	150	3.69
	155	**159**	**152**	**3.24**	**157**	**164**	**152**	**4.41**
DMA	186	191	182	2.17	190	197	180	3.29
	191	**193**	**189**	**1.41**	**176**	**192**	**90**	**3.08**
PLH	84.5	105	65	8.24	53.6	84	35	8.63
	88.6	**100**	**66**	**11.5**	**56.5**	**76**	**39**	**14.7**
PED	36.8	52	26	4.50	24.6	47	14	5.14
	37.7	**50**	**30**	**6.50**	**22.4**	**32**	**12**	**8.82**
TOTIL	9.3	18	3	3.30	11.1	26	3	4.84
	4.0	**7**	**3**	**37.6**	**4.6**	**7**	**3**	**1.51**
FTIL	5.6	10	2	1.79	9.79	20	3	3.99
	3.8	**7**	**3**	**1.40**	**4.30**	**7**	**2**	**1.80**

a : DHE = Days to heading; DMA = Days to maturity; PLH = Plant Height; PED = Peduncle length; TOTIL = Total no. of tillers; FTIL = No. of fertile tillers. Figures in bold refer to the five checks.

All dicoccoides samples were tolerant to frost at both locations, although during this season there was relatively more days with low temperatures than in previous seasons. Simple statistics for the dicoccoides samples are given in Table 21.
A.B. Damania and H. Altunji

1.3.8.2. Characterization and taxonomic identification of wild Triticum

The wild diploid species of Triticum, which have contributed their genomes to polyploid wheats, are presumably monophyletic in origin, though they have diverged considerably from each other. This divergence is particularly evident in the morphologically well defined seed dispersal units of the species and their specific ecological requirements and geographical distributions. Cytogenetic data have corroborated the taxonomic classification by showing that each diploid contains a distinct genome. There is complete sterility and isolation of the diploid species from each other.

A collection of wild Triticum species was planted at Tel Hadya in order to correctly classify the plants according to their species. Of a total of 558 accessions, 175 were found to be diploid T. urartu and 24 were T. boeoticum, whereas the rest were T. dicoccoides (tetraploid). Several morphological features such as smoothness or hairiness of leaves, erect or prostrate habit, and hairiness of the stems were used to correctly identify the species. Final confirmation was made at the time of flowering when obvious differences in spike characteristics, such as the relative size of the adaxial and abaxial glume teeth, and anther size, left no doubts as to the species. The computerized documentation on these accessions have now been corrected.
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1.3.8.3. Evaluation of *Aegilops* spp. for drought and frost tolerance

Pure lines from two hundred and thirty-nine accessions of *Aegilops* spp. selected from the previous three seasons for drought stress tolerance were planted in a replicated experiment at Tel Hadya during the 1991/92 season. The incidence of severe frost at the beginning of February, 1992, provided an excellent screening opportunity.

In general, all species of *Aegilops* exhibited a moderate tolerance to frost and the accompanying low temperatures, however, it was observed that *Ae. vavilovii* was considerably more frost tolerant than the rest of the species (Table 22).

Table 22. Screening *Aegilops* spp. for tolerance to cold at Tel Hadya during 1991/92 season (two replicates)

Species	No. of lines	Frost[a] toler.	Genome	Ploidy
biuncialis	36	2.89	UM	4X
caudata	4	2.83	C	2X
columnaris	18	2.94	UM	4X
crassa	2	3.00	DM	4X
kotschyi	4	3.21	US	4X
longissima	1	5.00	S	2X
ovata	71	3.03	UM	4X
peregrina	30	2.95	US	4X
speltoides	7	3.00	S	2X
squarrosa	2	2.50	D	2X
triaristata	7	3.12	UMUn	6X
triuncialis	43	2.89	UC	4X
umbellulata	7	3.18	U	2X
vavilovii	7	2.54	DMS	6X
Checks				
Haurani	2	2.94	AABB	4X
T. dicoccum	2	2.50	AABB	4X
Cham 1	2	3.75	AABB	4X
Mexipak	2	2.00	AABBDD	6X
Cham 4	2	2.50	AABBDD	6X

a : Frost tolerance scored on 1-5 scale, i.e. 1 = tolerant; 5 = susceptible, based on mean of two observations.

Eighty of the best performing lines from this collection will be planted next season. This will also be the last season for testing these Aegilops species, which will then be recommended to breeders for possible use in wide-crossing.

Forty-four accessions of Aegilops spp. were sent in 1990 to the Biotechnology Center, Punjab Agricultural University (PAU) at Ludhiana, India, for screening for drought tolerance. After undergoing quarantine procedures at the National Bureau of Plant Genetic Resources (NBPGR) during 1990-91, the accessions were tested under field conditions at Ludhiana. In a particularly drought prone season, 15 lines showed a marked degree of tolerance to low soil moisture conditions by flowering almost normally. The lines are given in Table 23 and are available to interested scientists.

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Table 23. Lines of Aegilops spp. selected from ICARDA population samples tested at PAU and found to be highly tolerant to drought

ICARDA Acc.No. (popn.)	PAU No. (lines)	Species	Ploidy level	Genome[a] symbols
400023	13750	speltoides	2X	S
400044	13751	speltoides	2X	S
400047	13752	speltoides	2X	S
400048	13753	speltoides	2X	S
400072	13754	speltoides	2X	S
400073	13755	speltoides	2X	S
400081	13756	speltoides	2X	S
400090	13759	squarrosa	2X	D
400091	13760	squarrosa	2X	D
400017	13749	umbellulata	2X	U
400588	13773	umbellulata	2X	U
400010	13748	triuncialis	4X	UC
400590	13770	columnaris	4X	UM
400589	13771	columnaris	4X	UM
400586	13772	peregrina	4X	US

a : Genome symbols according to Kimber and Feldman (1987).

1.3.8.4. Evaluation of diversity in wheat landraces from Ethiopia

Wheat is the fifth most important crop in Ethiopia, generally grown exclusively by small holder peasant farmers and cooperatives run by the government of Ethiopia, at elevations ranging from 1600 to 3000 m a.s.l. under rainfed conditions. In recent years the broad genetic diversity of wheat is under great threat in Ethiopia due to the influx of newer varieties of wheat and clearing of forests for fire-wood and cultivation.

The more easily accessible areas in Ethiopia have already been explored and collected. A University of Kyoto 1967 expedition managed to explore less accessible areas and reported a very high degree of genetic diversity in wheat.

The continuing evaluation of the collection of 62 samples of bread and durum wheat landraces from Ethiopia forms part of a joint project between the Plant Genetic Resources Center - Ethiopia (PGRC/E), the University of Reading (UK), and the ICARDA Genetic Resources Unit.

Ten and fifty-two samples of bread wheat and durum wheat, respectively, were planted in two 2.5 m rows with 30 cm between rows and 1 m between plots. The long-term ICARDA checks, Haurani and Cham 2, were also included in the experiment as controls. Fertilizer was applied at the time of land preparation (no fertilizer or irrigation was subsequently supplied to the experiment).

A rare snowfall in February could have done considerable harm, but growth was somewhat retarded due to the cold weather in the two previous months and the plants were in the three-leaf stage. Hence, they were able to fully recover from any damage caused by exposure to subzero temperatures. This season most rain fell after flowering and hence, a high incidence of rust was avoided.

Table 24 gives the yield performance of durum and bread wheat samples as compared to the checks.

The highest 1000-kw of 37.7 g was recorded for a bread wheat,

Table 24. List of samples from Ethiopia with higher grain yield per plot than the checks Haurani and Cham 2

Sample No.[a]	1000-KW (g)	Yield g)	Pl. Hgt. (cm)	Protein content (%)	Fertile tillers (%)
T. aestivum					
5706	27.8	836	99	11.5	4
214344	31.7	945	94	10.7	4
214602	24.2	921	100	10.6	6
208871	29.8	873	95	10.1	4
204517	20.6	964	105	11.3	4
5891	31.4	897	96	10.4	4
203974	31.8	1122	107	14.6	4
208877	37.7	914	118	10.4	6
222782	18.2	942	121	13.6	7
227038	32.4	966	113	9.9	4
T. durum					
204520	26.6	893	96	12.2	7
Checks					
Haurani	34.6	921	101	10.4	5
Cham 2	36.1	822	93	9.6	5

a : Sample Nos.

PGRC/E sample No. 208877, but its grain yield was 914 g, which was lower than the checks. The highest yielder was sample No. 203974. This sample had a tall habit and a relatively high protein content of 14.6%. Its heading and maturity time was identical to the checks and hence, could be a valuable source of genes for high yield under moderately favorable conditions. The Ethiopian germplasm also exhibited considerable variability in gliadin banding patterns (Figure 4).

The *T. dicoccoides* samples mentioned in Table 21, as well as samples from this collection from Ethiopia, were given to the cereal breeders for further evaluation in yield trials and disease

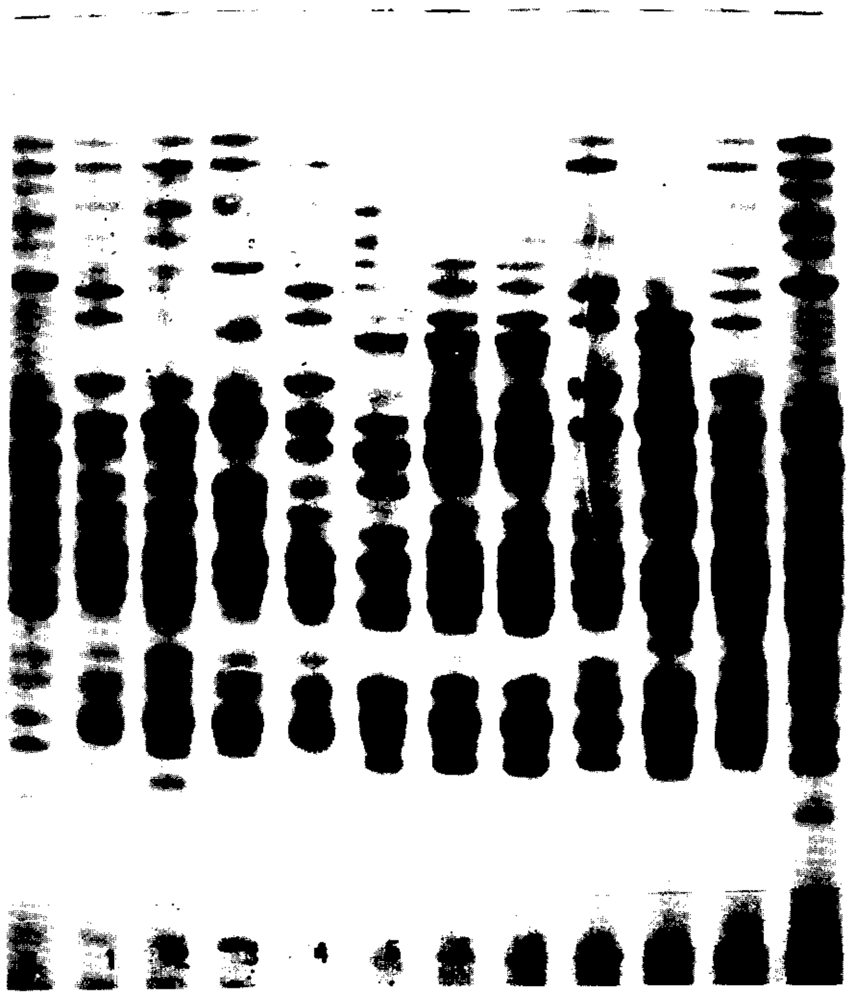

Figure 4. PAGE banding patterns of storage proteins (gliadins) in samples of old wheat landraces from Ethiopia. Samples in lanes 5, 6, 7, and 9 are tetraploid wheats. M = bread wheat cv. "Marquis" used for reference

nurseries. Selected samples will be tested at Breda and Tel Hadya for stress tolerance and for genotype x environment interaction.

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1.3.8.5. Evaluation of wild relatives and primitive forms of wheat for heat and cold tolerance

In the WANA region, wheat is mostly grown in areas receiving between 300-500 mm of rainfall. These moderate to low rainfall areas are characterized by large seasonal fluctuations in precipitation, temperatures, and other environmental factors, hence, cultivated wheat is at risk and poor yields or even crop failures are common. Yield loss in wheat occurs when day and night mean temperatures during grain-filling period rise above 15°C. Several methods have been reported to estimate the damage caused by heat and a number of approaches are available to develop heat-tolerant wheat varieties.

Forty-six samples of cultivated wheat and its wild and primitive forms originating from WANA, representing diverse ecological regions, were selected for this study. They ranged in collection site altitude from -10 meters a.s.l. for samples collected near the Dead Sea in Jordan, to 1900 meters above sea level in the highlands of Pakistan.

A modified method, using a growth chamber described by Saadalla (1990), was used for screening for heat tolerance and cold tolerance using the methods described by Tahir (1991). A heat tolerant winter wheat variety, Triticum aestivum cv. Tam 105, from Texas, USA, was used as a heat tolerant check.

The samples were screened for heat and cold tolerance in two sets of experiments, each comprising 23 genotypes plus the check in a randomized complete block (RCB) design with three replications. In the cold tolerance study, entries from the second experiment could not be evaluated due to malfunctioning of the freezing chamber, hence, the results from this study are not reported.

The check cultivar, TAM 105, proved to be tolerant to heat, as expected. However, there were several samples which were equally tolerant and a few were considerably more tolerant than the tolerant check, cv. TAM 105. These were as follows: T. aestivum

ICBW 206010 (Pakistan); T. durum ICDW 22417 (Algeria), ICDW 19543 and ICDW 22539 (Syria), ICDW 22421 (Morocco); Ae. squarrosa 400627 (Azerbaijan), 400623 (Armenia), 400709 (Syria), and 400359 (Iran). While studying a large number of T. aestivum and T. durum samples from different ecological regions for heat tolerance, Tahir (1991) reported higher numbers of tolerance genes in T. aestivum and attributed it to the D genome from the donor species Ae. squarrosa. The identification of highly tolerant lines of Ae. squarrosa in the present study appears to support this report.

The tetraploid cultivated wheat T. durum was found to be, on average, the most tolerant to heat. Three samples of T. compactum were also tolerant to heat, followed closely by Aegilops squarrosa. Bread wheat, T. aestivum, was only moderately tolerant and the rest of the species were susceptible. T. dicoccoides, the wild progenitor of durum wheat was, surprisingly, the most susceptible to heat. The single sample of T. timopheevi was also susceptible. These results are summarized in Table 25. The sam-

Table 25. Summary of heat tolerance tests of wild relatives and primitive forms of wheat based on genomic composition of the samples tested

Species	Genome	No. of samples	Mean heat damage (%)	Rank
T. aestivum	AABBDD	8	29.9	4
T. compactum	AABBDD	3	28.6	2
T. durum	AABB	8	28.5	1
T. dicoccoides	AABB	8	44.8	8
T. timopheevi	AAGG	1	42.0	7
T. boeoticum	AA	8	36.8	6
T. urartu	AA	3	32.3	5
Ae. squarrosa	DD	8	28.8	3

Table 26. List of samples of wild relatives and primitive forms of wheat with better heat tolerance than the check, T. aestivum cv. TAM 105

Species	Genome	IC NO.	Origin
T. aestivum	AABBDD	206010	Pakistan
T. durum	AABB	22417	Algeria
		22414	Algeria
		19543	Syria
		22539	Syria
		22421	Morocco
Ae. squarrosa	DD	400627	Azerbaijan
		400623	Armenia
		400709	Syria
		400359	Iran

ples which exceeded the performance of the check TAM 105 under heat stress are listed in Table 26.

The provenance of a sample and the ecology of the collection site is important in determining reaction to heat stress. For example, the three most tolerant samples were all Ae. squarrosa originating from low altitude areas in Central Asia. Similarly, the heat tolerant accessions of T. durum originated from heat prone sites in Algeria and Morocco, whereas the most susceptible samples of T. dicoccoides were collected from higher altitudes ranging from 760 to 1500 meters. Hence, it can be surmised that these samples were unadapted to heat stress, which mostly occurs at low altitudes. It has been reported that samples of T. durum collected from Afghanistan were among the most tolerant to the combined stresses of heat and soil salinity when tested at a site in Northern Syria (ICARDA Cereal Program Annual Report 1987).

This study of cultivated wheat and its wild progenitors for heat tolerance has shown that the AABB genomic composition seems to the most tolerant to heat, whereas no clear trend for cold tolerance emerged. Heat tolerance in cultivated T. durum is not unexpected. For centuries after its domestication durum wheat was grown mostly in the Mediterranean and the Near East, where terminal heat was one of the major stresses.

The check TAM 105 was also the most cold tolerant, with 75% of the plants surviving the screening test (Table 27). The next most

Table 27. Species, genomes, IC no., cold tolerance (CT) (percent surviving plants), and origin of wheat and its progenitors tested in 1991/92

Species	Genome	IC NO.	CT	Origin
Triticum aestivum (Check)	AABBDD	TAM 105	75	USA
		206418	7	Syria
		206414	3	Syria
		206408	0	Algeria
Triticum compactum	AABBDD	500024	3	Turkey
		500003	17	Turkey
Triticum durum	AABB	22546	0	Syria
		22539	19	Syria
		22426	0	Syria
		22421	0	Morocco
Triticum dicoccoides	AABB	600905	0	Syria
		600919	7	Jordan
		600908	0	Syria
		600894	10	Jordan
Triticum boeoticum	AA	300076	27	Turkey
		300049	18	Turkey
		300047	7	Bulgaria
Triticum urartu	AA	300020	5	Syria
		500253	57	Russia
		500254	40	Russia
Aegilops squarrosa	DD	400627	40	Azerbaijan
		400623	17	Armenia
		400709	7	Syria
		400359	0	Iran

tolerant group was T. urartu, whereas for T. boeoticum, Ae. squarrosa and everything else, including other bread wheats, the reaction to cold ranged from complete susceptibility to moderately susceptible.

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1.3.8.6. Evaluation of Triticum dicoccum (emmer wheat)

Emmer, Triticum dicoccum Schuebl. (2x=2n=28), is the oldest type of wheat grown in the 'Fertile Crescent', dating from ca. 10000 BP but has been widely replaced in recent times by modern forms of tetraploid (T. durum) and hexaploid (T. aestivum) wheats. Together with other older forms of wheats, emmer wheat possesses considerable morphological variation which can be useful for breeding for the dry areas, where abiotic stresses play a major role in reducing yield.

Further evaluation of sixteen lines selected from the original 41 accessions evaluated in previous seasons was carried out at Tel Hadya during 1991/92. Observations for the following traits were recorded: early growth vigor, frost tolerance, days to heading, total no. of tillers, fertile tillers, plant height, peduncle length, and days to maturity.

The results of this evaluation were as follows: eight lines were highly tolerant to frost, as they were not affected by the spell of very low temperatures, including snow fall, which occurred at the beginning of February, 1992, and seven lines were moderately tolerant. One line, however, selected from accession 600778, was killed by the frost and snow fall. The early growth vigor of the test lines was lower than the mean for the checks Haurani and Cham 1. Days to heading was not very different but maturity was a week earlier than the checks in the T. dicoccum lines tested. The high tillering in some genotypes of this primitive wheat has been reported by Hakim. There was large variability in plant height, which ranged from 81 to 104 cm. The peduncle length also varied between 23 to 42 cm. The evaluation data is given in Table 28.

Table 28. Evaluation data on fifteen lines of T. dicoccum selected at Tel Hadya in 1991/92

ACC.NO.	FRO[a]	EGV	DHE	TOTIL	FTIL	PLH	PED	DMA
600765	1	3	164	6	5	92	30	194
600767	1	3	162	6	6	81	23	193
600768	1	4	161	5	5	94	26	192
600769	1	3	158	3	3	100	33	191
600770	1	3	163	5	4	90	32	195
600771	1	2	167	7	7	104	42	199
600772	1	3	169	6	5	103	36	199
600774	2	3	164	6	5	103	34	196
600775	1	2	165	7	7	100	34	198
600776	2	3	167	4	4	99	34	198
600777	2	3	165	6	6	83	29	197
600780	2	4	165	9	9	107	35	197
600781	2	3	166	7	6	109	34	197
600782	2	2	168	6	6	104	31	198
600783	2	3	164	8	8	104	43	195
Check means	2	5	155	5	5	88	37	191

a : FRO; Frost tolerance 1=highly tolerant and 5=highly susceptible; EGV: Early growth vigor 1=low and 5=High. Other abbreviations as in Table 21.

Hence, it can be seen that the T. dicoccum lines harbor a large amount of useful morphological variation which could be exploited for durum wheat improvement in the dry areas.

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1.3.8.7. Multiplication and evaluation of primitive wheats from the CIMMYT collection

One hundred and twelve samples of primitive received from CIMMYT in 1989 and characterized during the 1990/91 season were planted at Tel Hadya for a second season for multiplication and further evaluation. The response of these samples to naturally occurring rusts and other diseases was reported in the GRU Annual Report

(1991). The agromorphological data on various species are reported below.

Triticum carthlicum

Persian wheat (T. carthlicum Nevski; syn. T. persicum Vav. ex Zhuk. 2n = 28, genome AABB) is said to have evolved by hybridization from T. dicoccoides and subsequent domestication of the progenies. The primary center of origin is in the Near East, with a secondary center in Ethiopia and the Mediterranean basin. Carthlicum wheat used to be widely cultivated in the past in Iraq, Iran, and Caucasia. Forty-three samples were evaluated in 1991/92 and the simple statistics of evaluation given in Table 29.

Table 29. Simple statistics of 43 samples of Triticum carthlicum from the CIMMYT collection

Trait[a]	Min.	Max.	Mean	Var.	S.D.
FRO	1.0	4.0	1.79	0.64	0.80
EGV	3.0	4.0	3.41	0.25	0.49
DHE	161	169	163	2.21	1.48
TOTIL	4.0	11.0	6.53	3.25	1.80
FTIL	3.0	9.0	5.97	2.07	1.44
PED	23.0	43.0	33.9	21.4	4.63
PLH	87.0	119.0	101.1	46.79	6.84
DMA	193	199	195	2.85	1.69

a : Abbreviations same as in Table 28.

Table 30 gives the correlation coefficients among FRO, EGV, DHE, TOTIL, FTIL, PED, DMA, and PLH. Only three correlations were statistically significant, as expected. A considerable number of samples of this species are late in comparison to the checks, Cham 1 Haurani, Mexipak, and T. diccocum (Acc. No. 600777), which matured 190 days after sowing. There was considerable variation in plant height, with most of the samples being between 92 and 106 cm. However, a lower plant height was found in one of the samples

Table 30. Correlation coefficients among descriptors for 43 samples of T. carthlicum from the CIMMYT collection

Descriptor	EGV[a]	DHE	TOTIL	FTIL	PED	DMA	PLH
FRO	-0.07	-0.13	0.09	0.07	-0.01	-0.26	-0.12
EGV		-0.05	-0.17	-0.18	-0.19	-0.06	-0.06
DHE			0.28	0.18	-0.17	0.50*	0.03
TOTIL				0.05	0.02	0.22	0.16
FTIL					0.03	0.10	0.07
PED						-0.11	0.56*
DMA							0.60*

* : Significant at P= 0.05.
a : Abbreviations same as Table 29.

and plant height was at least 107 cm in at least seven samples (Figure 5).

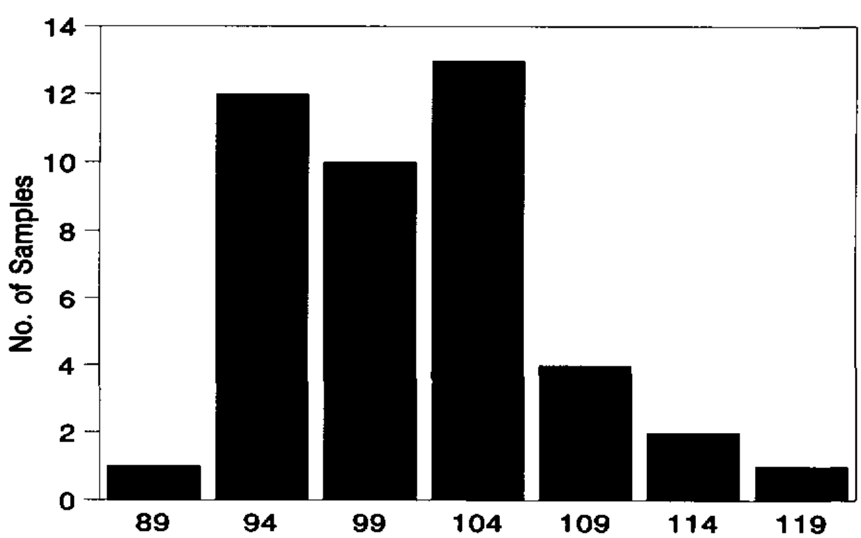

Figure 5. Distribution of plant height (cm) for samples of T. dicoccum evaluated at Tel Hadya during 1991/92

Triticum monococcum

Einkorn (Triticum monococcum L. 2n=14, genome AA) was domesticated in the 'Fertile Crescent' from its wild progenitor T. boeoticum Boiss., which has a brittle rachis. Its earliest appearance in archaeological records is from Ali Kosh in Iraq dating from ca. 8500 BP. This makes it later than T. dicoccum which, according to archaeological records, dates from ca 10000 BP, making it the oldest cultivated wheat. In the past, einkorn was spread over Europe, N. Africa, Asia Minor, Caucasia, Iraq, and Iran. In Europe it was mainly cultivated as a fodder crop and poultry feed.

Twenty-one samples of einkorn received from CIMMYT were evaluated at Tel Hadya. Three samples (CWI 2288, 2358 and 19537) were killed by frost. Apart from other useful variation in days to heading and maturity, and plant height (Table 31), one of the samples (Acc. no. 19469) headed in only 151 days and matured in 186 days.

Useful disease resistance genes have also been found in this species (see following Section).

Triticum compactum

Club wheat (T. compactum Host. 2n = 42, genome AABBDD) is reported to have developed in the Hindu Kush mountains and have a secondary center of diversity in Armenia. According to Simmonds, the earliest hexaploid wheat to be found was club wheat in the archaeological remains at Tell Ramad in Syria from ca. 9000 BP. While tetraploid wheats, in keeping with their center of origin in the Near East, are adapted to mild winters and rainless summers, the addition of the D genome introduced from Central Asia by Ae. tauschii must have contributed to greater adaptation of hexaploid wheats, resulting in the spread to Asia through the highlands of Iran to the Indus valley, where they seem to have arrived by 5000 BP. In Syria, remnants of past cultivation of club wheat can still be found in the form of two or three odd plants in cultivated

Table 31. Evaluation data on eighteen lines of T. monococcum from the CIMMYT collection at Tel Hadya in 1991/92

CWI.NO.	FRO[a]	EGV	DHE	TOTIL	FTIL	PLH	PED	DMA
2354	2	2	178	22	13	108	38	207
2355	3	2	177	16	9	108	41	209
2356	1	4	176	6	5	112	37	208
2357	1	3	178	9	5	110	32	209
2359	2	4	174	5	5	112	29	204
19457	2	2	170	8	6	108	35	199
19465	3	2	173	7	6	134	47	200
19468	2	3	170	6	5	130	45	199
19469	2	3	151	4	4	118	34	186
19490	1	3	172	22	18	138	44	203
19494	1	3	168	5	4	107	38	199
19502	1	3	162	8	6	115	42	199
19528	1	4	175	13	8	119	37	204
19532	1	3	178	9	7	108	36	203
19535	1	3	168	15	11	105	39	203
19536	1	4	178	12	9	118	43	205
19538	2	3	177	8	8	110	42	207
19539	2	4	176	8	7	125	45	205
Check mean	2	5	155	5	5	88	37	191

a : Abbreviations and scales same as in Table 28.

wheat fields in the El Hassakeh region, where they can be easily detected by their earliness in maturity and sometimes due to infection with rusts to which they are susceptible.

A collection of 18 samples of T. compactum received from CIMMYT was planted at Tel Hadya. All samples were tolerant to cold temperatures and resistant to frost damage. For other characters, such as days to heading and maturity, there was a high degree of uniformity. Only in the case of CWI No. 3162 was there a high number of total and fertile tillers. The evaluation data results are given in Table 32.

To conclude this section on primitive germplasm, we can say that there exists useful genetic variability for desirable traits in

Table 32. Evaluation data on eighteen lines of *T. compactum* from the CIMMYT collection at Tel Hadya in 1991/92

CWI.NO.	FRO[a]	EGV	DHE	TOTIL	FTIL	PLH	PED	DMA
3149	1	4	163	5	5	102	37	195
3150	2	4	162	7	7	95	39	194
3152	2	3	163	9	9	97	39	195
3153	1	4	163	7	7	101	28	195
3154	1	4	163	6	6	98	34	195
3155	1	3	163	5	5	100	31	194
3157	2	3	162	5	5	98	29	195
3158	2	2	164	8	7	101	28	195
3159	1	3	162	6	6	92	27	196
3160	2	3	162	6	6	94	29	195
3161	2	3	163	5	5	92	32	195
3162	2	2	165	10	8	101	34	197
3163	2	2	163	6	5	100	29	195
3164	1	3	161	7	6	100	30	193
3165	1	3	162	8	8	102	31	196
3166	1	2	167	6	6	98	26	199
3167	1	3	166	7	6	90	31	199
3168	1	3	165	8	7	103	29	204
Check mean	2	5	155	5	5	88	37	191

a : Abbreviations and scales same as in Table 28.

old forms of wheat. This variability can be readily exploited for crop improvement programs since, unlike certain wild relatives, genomic disharmony does not impede crossing with other forms of cultivated wheat.

In recent years, short strawed, solid stemmed, erect progeny lines of durum wheat, possessing resistance to lodging and relatively good grain yield under unfavorable conditions, have been obtained from crosses where one of the parents has been *T. dicoccum*.

Breeders seeking genes for biotic and abiotic stresses to broaden the genetic base of durum wheat targeted towards the low-rainfall areas could develop pure lines for greater stability from the accessions reported here. It is also suggested that older forms of wheat, such as _T. dicoccum_, can themselves be promoted as cultivars and hence, play a broader and more significant role in improving quality than merely correcting specific shortcomings of otherwise well-adapted modern varieties.

All the above collections of primitive wheats from CIMMYT have now been accessed into the ICARDA collection, which will also serve as a safety duplication of the CIMMYT germplasm, as per the Memorandum of Understanding between the two Centers.

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1.3.8.8. Further evaluation of genetic stocks from Czechoslovakia

Genetic stocks of bread and durum wheat lines were developed by utilizing disease resistance genes from _T. monococcum_ at the Research Institute of Crop Production in Prague, Czechoslovakia (GRU Annual Report 1991). Twenty of these lines were planted at Tel Hadya for evaluation against moderate drought and frost tolerance, as well as recording of agronomic traits, with results given in Table 33.

It was observed that all winter bread wheat, except one line, were highly tolerant to frost. Three of the lines which were highly tolerant possessed the Lr Tm_1 gene, which has resistance to leaf rust, whereas 206973 was the check cv. Yubileynaya from Russia, which is highly cold tolerant, photo-insensitive and as early as the other lines derived from crosses with _T. monococcum_. Therefore, this germplasm material could be extremely useful for breeding for the WANA highlands where cold tolerance is an important requirement. Further tests at a cold site in Turkey are in progress in collaboration with the Cereal Improvement Program.

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Table 33. Results of agronomical and frost tolerance evaluation on 20 wheat lines derived from crosses with T. monococcum

S.No.	Acc.No.	Habit	FRO[a]	DHE	DMA	TIL	PLH	PED
T. durum (Durum wheat)								
1.	22708	Spring	2	160	199	9	98	45
2.	22709	Spring	2	161	199	4	111	46
3.	22710	Spring	2	163	194	9	100	34
4.	22712	Spring	2	163	195	5	118	49
5.	22713	Spring	2	167	199	3	125	48
6.	22714	Spring	2	162	196	5	113	41
7.	22715	Spring	2	162	196	7	113	43
8.	22716	Spring	2	166	195	5	114	38
9.	22717	Spring	2	163	198	9	114	46
T. aestivum (Bread wheat)								
10.	206969	Winter	2	164	195	5	103	37
11.	206970	Winter	1	163	193	5	94	35
12.	206971	Winter	1	162	192	6	107	34
13.	206972	Winter	1	163	193	8	106	37
14.	206973	Winter	1	164	193	3	105	37
15.	206974	Spring	2	167	202	3	103	36
16.	206975	Spring	3	167	201	5	108	33
17.	206976	Spring	2	166	202	3	115	38
18.	206977	Spring	2	168	202	4	115	39
19.	206978	Spring	2	167	200	3	97	36
20.	206979	Spring	2	169	203	6	105	31

a : Abbreviations as in Table 28.

1.3.8.9. Pre-breeding and development of genetic stocks with genes from wild and primitive forms

Germplasm of wild and primitive forms is also being utilized for a pre-breeding program which seeks to infuse desirable genes from the wild or primitive parent into the cultivated form through crossing and selection. This work will create stable lines which can be utilized by breeders without fear of non-desirable characteristics becoming linked to those which are sought from the wild or primitive parent.

The wild progenitors of wheat are commonly sympatric with their cultivated forms. They differ, however, in phenotype and adaptation but remain sufficiently related genetically to cross and produce fertile hybrids with exchange of genes particularly in the direction of the cultivated forms. Breeders are adverse to use germplasm which may retard their improved lines or those which require years of back crossing to eliminate undesirable traits, which are very often inherited when wild or primitive material has been used in the pedigree.

Selections from twenty-five crosses between wild species (T. dicoccoides with good agronomic performance at Breda as the male parent) and durum wheat, and between durum wheat and primitive forms with disease resistance (T. dicoccum and T. carthlicum), which were initially made in 1989, were re-tested in in order to observe stability in two important traits of interest to breeders, viz. days to heading and maturity.

It was observed that there was no difference for days to heading and maturity in the two previous seasons, although they were both quite different in the amount and distribution of rainfall, as well as in the presence of cold stress. Small quantities of seed samples from the above mentioned lines are available.

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1.3.9. Characterization of Jordanian vetch and Lathyrus and Algerian vetch

Twenty accessions of Jordanian Lathyrus and fourty-eight accessions of vetch were characterized for twelve descriptors at Tel Hadya, Syria. One hundred twenty-three accessions of Algerian vetch were evaluated. The plot size varied from one row 4 m to 4 rows 3 m long, with 37.5 cm between rows. The seeding rate was 50 seeds per row. Checks used for Lathyrus were IFLA 101 (L. sativus) and IFLA 347 (L. ochrus) and for vetch were IFVI 67 (Vicia narbonensis) and IFVI 2541 (V. sativa).

The descriptors evaluated were growth habit (GRH), frost tolerance (FROST), vigor (VIG), flower color (FCO), days to 50% flowering (DFLR), days to 90% podding (DAP), days to 90% maturity (DMAT), pod length in cm (PLEN), pod width in cm (PWID), seeds per pod (SPD), and hundred seed weight in g (HSW).

Most Lathyrus and Jordanian vetch accessions evaluated were semi-erect or erect and had strong or intermediate levels of vigor (Table 34). Algerian vetch accessions were mostly semi-spreading

Table 34. Frequency distributions for GRH, FROST, VIG, and FCO for 20 accessions of Lathyrus and 48 accessions of Jordanian vetch and 123 accessions of Algerian vetch evaluated at Tel Hadya, Syria in 1991/92

Descriptor/Score[a]	Jordanian Lathyrus	Jordanian vetch	Algerian vetch
GRH			
Spreading	0.0	22.4	13.2
Semi-spreading	23.8	16.3	72.9
Semi-erect	61.9	32.7	12.4
Erect	14.3	28.6	1.6
FROST			
Highly tolerant	0.0	10.2	0.8
Tolerant	71.4	59.2	13.2
Moderately tolerant	14.3	26.5	51.2
Susceptible	9.5	2.0	34.9
Highly susceptible	4.8	2.0	0.0
VIG			
Very strong	0.0	4.1	0.8
Strong	52.4	34.7	6.2
Intermediate	33.3	55.1	45.0
Poor	9.5	4.1	48.1
Very poor	4.8	2.0	0.0
FCO			
White	0.0	14.6	2.4
Blue	5.0	45.8	8.1
Dark pink	60.0	2.1	7.3
Pink	0.0	22.9	2.4
Violet	0.0	10.4	75.6
Yellow	35.0	4.2	4.1

a : For descriptor abbreviations, see text.

and with poor or intermediate VIG. Most accessions evaluated were also tolerant or moderately tolerant to frost, however, the Algerian accessions had a high proportion of susceptibility (34.9%). Lathyrus accessions were with dark pink and yellow flowers and the Algerian vetch accessions had mostly violet flow-

Table 35. Summary statistics for DFLR, DAP, DMAT, PDPI, PLEN, PWID, SPD, and HSW for 20 accessions of Lathyrus and 48 accessions of vetch from Jordan and 123 accessions of Algerian vetch evaluated at Tel Hadya, Syria in 1991/92

Crop/ Descriptor[a]	Check mean	Mean	Min.	Max.	C.V. (%)
Lathyrus					
DFLR (days)	114.5	112.4	104	120	2.9
DAP (days)	129.0	126.9	110	132	3.7
DMAT (days)	155.0	156.6	151	170	3.9
PDPI	1.20	1.10	1.0	1.8	20.9
PLEN (cm)	3.53	2.91	1.9	4.7	28.3
PWID (cm)	1.03	0.63	0.3	1.4	52.2
SPD	2.84	3.93	2.4	5.8	24.9
HSW (g)	12.35	3.83	1.3	7.6	45.8
Vetch (Jordan)					
DFLR (days)	111.1	109.8	99	122	5.1
DAP (days)	123.3	120.9	108	133	6.7
DMAT (days)	154.0	153.4	149	169	2.2
PDPI	1.08	1.36	1.0	2.6	33.8
PLEN (cm)	4.75	3.18	1.8	5.4	34.4
PWID (cm)	0.90	0.61	0.4	1.7	33.4
SPD	4.81	3.67	1.0	6.3	38.8
HSW (g)	7.18	3.21	0.4	7.9	71.2
Vetch (Algeria)					
DFLR (days)	114.0	129.0	117	162	6.5
DAP (days)	122.2	140.4	120	167	7.2
DMAT (days)	162.3	171.6	160	184	3.4
PDPI	1.00	1.22	1.0	3.0	38.7
PLEN (cm)	3.93	3.73	0.7	7.0	27.8
PWID (cm)	0.63	0.62	0.1	1.3	30.6
SPD	4.82	4.34	1.6	7.7	25.6
HSW (g)	11.73	6.03	1.2	16.8	46.2

a : For descriptor abbreviations, see text.

ers. However, flower colors of the Jordanian vetch accessions were distributed over the full range of flower colors.

Summary statistics for the Lathyrus and vetch accessions of Jordanian origin and Algerian vetch are given in Table 35. The Lathyrus accessions were smaller seeded than the checks because of the species evaluated (which were mostly aphaca and hierosolymitanus). These also had more SPD and were with smaller pods (PLEN and PWID). The Lathyrus accessions were similar to the checks phenologically. The Jordanian vetch accessions were also similar phenologically to the checks, although the Algerian vetch was later than the checks. The Jordanian vetch had smaller seeds (HSW), less SPD, and smaller pods (PLEN and PWID) than the checks. The Algerian vetch, while with less values for these descriptors than the checks, was much closer to the check values. Again, this was due to the species evaluated (mostly palaestina, peregrina, monantha, and sativa nigra) from Jordan, while the Algerian vetch included a much higher proportion of V. sativa sativa.

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1.3.10. Evaluation of Iranian chickpea accessions

A joint evaluation trial was conducted at ICARDA, Tel Hadya, Syria, together with the Seed and Plant Improvement Institute (SPII) of Iran with the objective to evaluate Iranian chickpea germplasm accessions.

The 495 chickpea accessions were evaluated at Tel Hadya, Syria in an unreplicated augmented design with one systematic (ILC 482) and two random (ILC 2379 and ILC 5104) checks, with a block size of 23 plots. The plot size was 4 rows, 45 cm between rows, 5 m long (9.0 m^2). The seeding rate was 240 seeds per plot. The center two rows, 4 m length (3.6 m^2), were used for yield determinations.

There were 27 descriptors observed: days to 50% flowering (DFLR), days to 90% maturity (DMAT), plant height (PTHT) in cm, first pod height (HTFP) in cm, canopy width (CAW) in cm, growth

Table 36. Frequency distributions for LFS, FCO, GRH, PLP, PLH, PDDH, and PDSH for 495 Iranian chickpea accessions evaluated at Tel Hadya, Syria during 1991/92

Descriptor/Score[a]		Frequency (%)	Number of Accessions
LFS			495
Small	(<10 mm long)	2.2	
Medium	(10-15 mm long)	96.4	
Large	(>15 mm long)	1.4	
FCO			495
White		98.2	
Pink		1.8	
GRH			495
Semi-erect		0.6	
Semi-spreading		90.9	
Spreading		8.5	
PLH			495
Hairs almost absent		0.2	
Pubescent		0.2	
Densely pubescent		99.6	
SCO			495
Beige		70.1	
Yellow		0.4	
Beige mixed		27.9	
Other mixed		1.4	
SSH			495
Kabuli		98.2	
Intermediate		0.2	
Desi		0.2	
Mixed		1.4	
SRO			495
Rough		97.0	
Smooth		0.2	
Mixed		2.8	
PLP			495
No anthocyanin, pale green		10.3	
No anthocyanin, green		89.5	
Weak anthocyanin, partly purple		0.2	
PDDH			488
No dehiscence		65.0	
<10% dehiscence		31.1	
10% dehiscence		3.9	
PDSH			488
Low		36.5	
Medium		62.9	
High		0.6	

a : For descriptor abbreviations, see text.

habit (GRH), iron deficiency chlorosis (IDC), pod dehiscence (PDDH), pod shedding (PDSH), leaflet type (LFT), leaflet size (LFS), flower color (FCO), plant pigmentation (PLP), plant hairiness (PLH), leaflets/leaf (LFL), seed shape (SSH), seed surface roughness (SRO), seed color (SCO), pods per plant (POD), seeds per plant (SPP), seeds per pod (SPD), pods per peduncle (PPPD), hundred seed weight (HSW) in g, seed yield (SYLD) in kg/ha, biomass (BYLD) in kg/ha, straw yield (STYLD) in kg/ha, and harvest index in % (HI).

There was no variation of LFT, all accessions had compound leaves. There was very little variation for LFS, FCO, GRH, and PLH, most accessions showed the values of the regularly cultivated chickpea for the near east (Table 36). Most accessions were kabuli type chickpea with a ram's shaped head (98.2%) and a rough seed texture (97.0%). Seed color was mostly beige (70.1%) or mixed with beige (27.9%). Pod dehiscence for these accessions was mostly none (65.0%) or less than 10% (31.1%) and pod shedding was none (36.5%) or low (62.9%).

Evaluation of summary statistics (Table 37) reveals that the

Table 37. Summary statistics for 495 Iranian chickpea germplasm accessions evaluated at Tel Hadya, Syria during 1991/92

Descriptor		Check mean	Mean	Min.	Max.	C.V. (%)
DFLR[a]	(days)	128.6	130.7	122	147	4.0
DMAT	(days)	170.3	171.6	165	186	2.5
PTHT	(days)	43.1	39.4	26	54	19.6
HTFP	(cm)	19.0	17.8	9	35	22.9
LFL		13.5	14.0	10.3	18.0	7.1
CAW	(cm)	35.4	34.0	15	52	16.8
POD		39.8	42.9	21.1	97.2	25.6
SPD		0.88	0.89	0.54	1.24	14.9
PPPD		0.63	0.67	0.42	0.87	11.6
HI	(%)	54.1	51.2	29.0	72.1	12.3
HSW	(g)	29.0	24.0	14.1	52.7	24.4
SYLD	(kg/ha)	1921	1777	739	2967	22.8
BYLD	(kg/ha)	3577	3482	1556	5544	16.2
STYLD	(kg/ha)	1656	1704	639	3247	22.8

a : For descriptor abbreviations, see text.

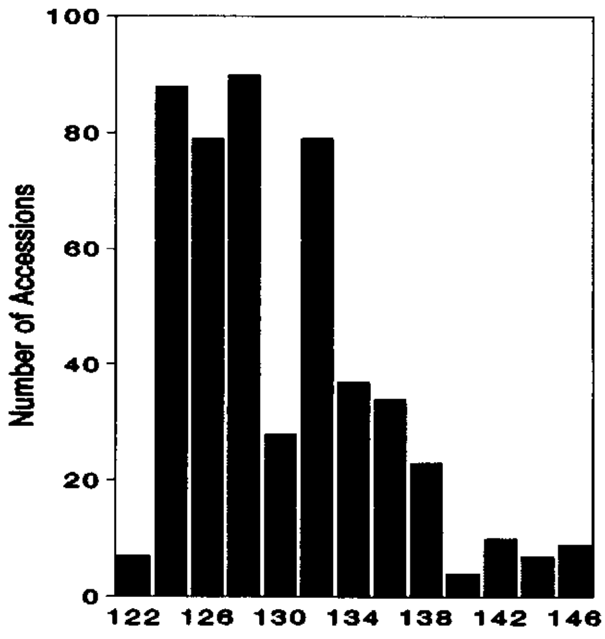


Figure 6. Distribution of DFLR (days) for 495 Iranian chickpea germplasm Iranian chickpea accessions evaluated at Tel Hadya, Syria

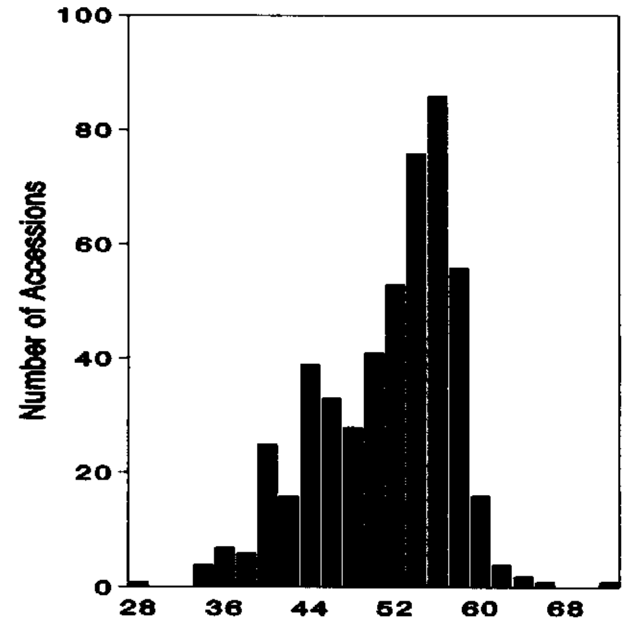


Figure 7. Distribution of HI (%) for 495 Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

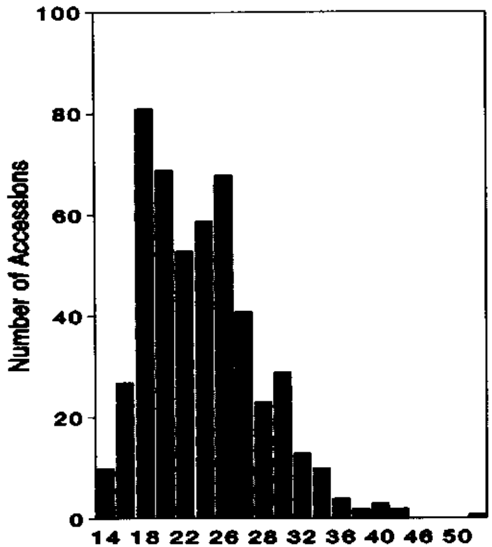


Figure 8. Distribution of HSW (g) for 495 Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

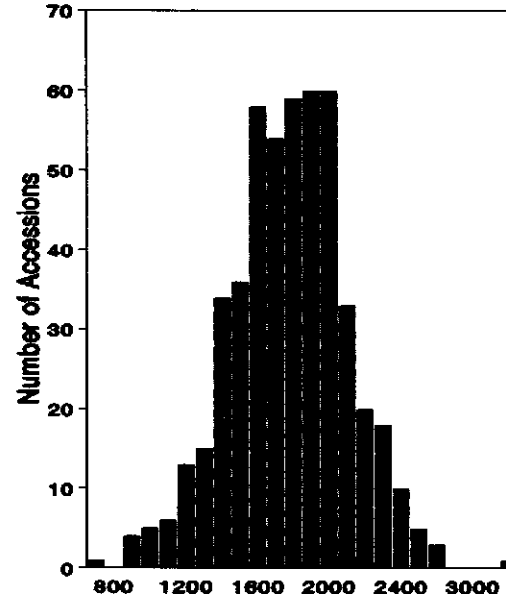
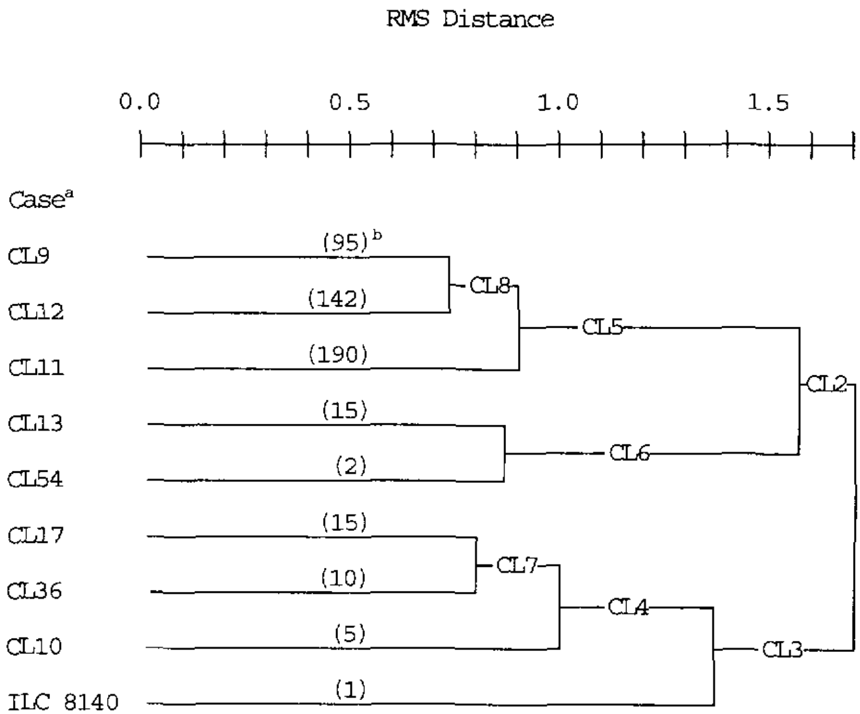


Figure 9. Distribution of SYLD (kg/ha) for 495 Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

largest variation for quantitatively scored descriptors was for POD, HSW, and HTFP, and the yield descriptors SYLD and STYLD. The mean values of Iranian chickpea accessions were similar to the check lines for most of these descriptors but had a lower HI, HSW, and SYLD.

The distributions for DFLR, HI, and HSW (Figures 6, 7, and 8) do not show normal distributions. They suggest that there are two to three different groups in the Iranian chickpea germplasm evaluated. The distribution for SYLD was more or less normal (Figure 9).



a : Case refers to original cluster number assigned, CL=cluster.
b : Numbers in parenthesis are number of accessions in cluster.

Figure 10. Dendrogram of 475 Iranian chickpea accessions evaluated in 1991/92 at Tel Hadya, Syria at the nine cluster level extraction. Original analysis cluster membership and normalized root mean square distances used

Unfortunately, data on the collection sites within Iran is not available at this time, however, heirarchical cluster analysis was run to try to separate out the major groups within this germplasm (475 accessions with no missing data) using the quantitatively scored discriptors DFLR, LFL, PTHT, HTFP, CAW, DMAT, PPPD, POD, SPD, HSW, SYLD, BYLD, STYLD, and HI. The results of hierarchical cluster analysis suggest three major clusters and six minor clusters, which will be explained below (Figure 10).

Cluster 6 (cluster numbers in this discussion refer to the original cluster analysis cluster numbers assigned) and cluster 3 are relatively small clusters (17 and 31 accessions, respectively) and most likely represent germplasm in the Iranian collection from outside the country, breeding lines or unique cases (Figure 10). The three major clusters (cluster 9, cluster 12 and cluster 11) represent the majority of the accessions (427 accessions), this is in agreement with Figures 6-9, which suggest three groups in this germplasm set.

Examination of summary statistics for the individual clusters (Table 38) reveals the characteristics of the three major clust-

Table 38. Summary statistics for nine clusters developed from hierarchical cluster analysis of 475 Iranian chickpea germplasm accessions evaluated at Tel Hadya, Syria in 1991/92

Cluster	Freq.	DFLR[a] (days)	DMAT (days)	SYLD (kg/ha)	HI (%)	HSW (g)	PTHT (cm)
CL11	190	128.7	169.8	1722	54.9	23.2	37.9
CL12	142	129.0	170.5	2062	53.2	26.2	40.4
CL9	95	135.7	175.2	1550	44.3	22.2	40.8
CL13	15	131.3	171.0	1192	51.7	19.2	36.3
CL17	15	133.5	174.9	1879	41.7	27.2	40.6
CL36	10	127.7	168.6	2463	53.4	27.2	40.0
CL10	5	134.8	175.6	2063	40.5	25.4	40.4
CL54	2	128.0	169.0	918	56.3	20.4	33.0
ILC 8140	1	125.0	167.0	2578	53.5	24.3	40.0

a : For descriptor abbreviations, see text.

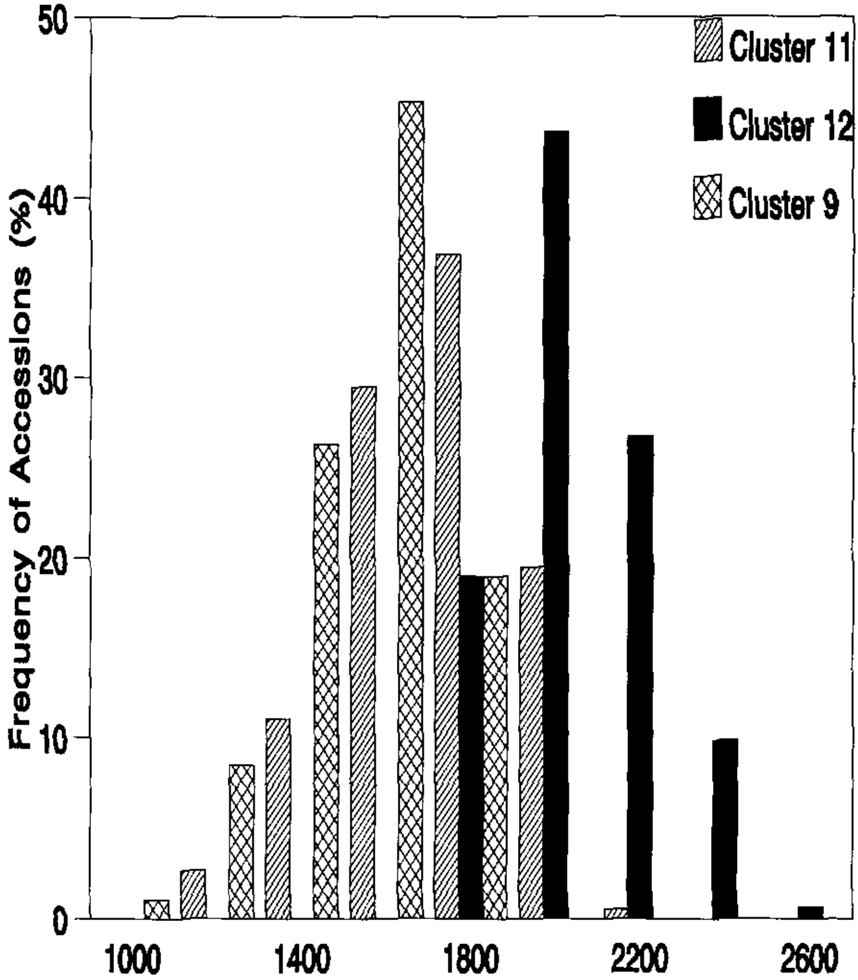


Figure 11. Distributions for SYLD (kg/ha) for the three major clusters from hierarchical analysis for Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

ers. Cluster 12 had the highest SYLD (Figure 11) and largest HSW of these clusters, with a high HI early DFLR (Figures 12 and 13). Cluster 9 had the latest DFLR, lowest SYLD, and lowest HI. Cluster 11 was similar to cluster 12 for DFLR and HI but had a smaller HSW and slightly higher HI and lower SYLD. The clusters

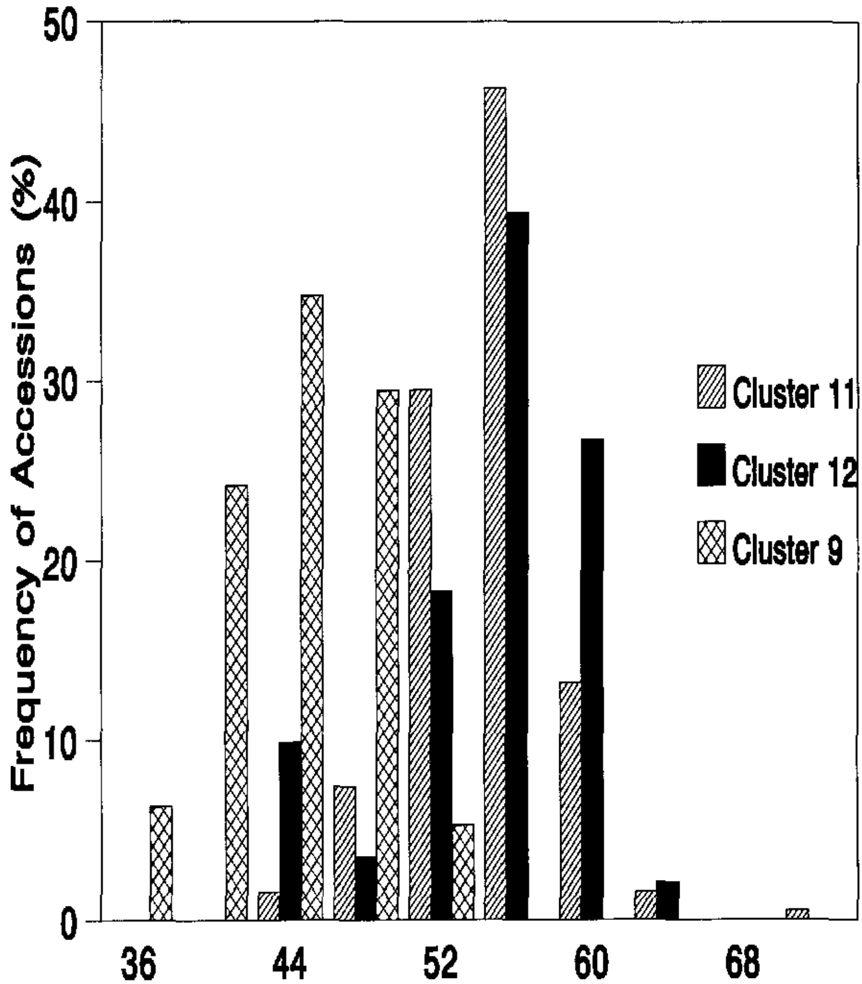


Figure 12. Distributions for HI (%) for the three major clusters from hierarchical analysis for Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

36 and ILC 8140 are interesting minor clusters with very early DFLR and very high SYLD and HI. Also, cluster 10 is interesting, in that although DFLR was late and HI was low, the SYLD was high.

Figures 6, 7, and 8 suggested that there were three major groups of germplasm when DFLR and HI were examined and therefore, hierarchical

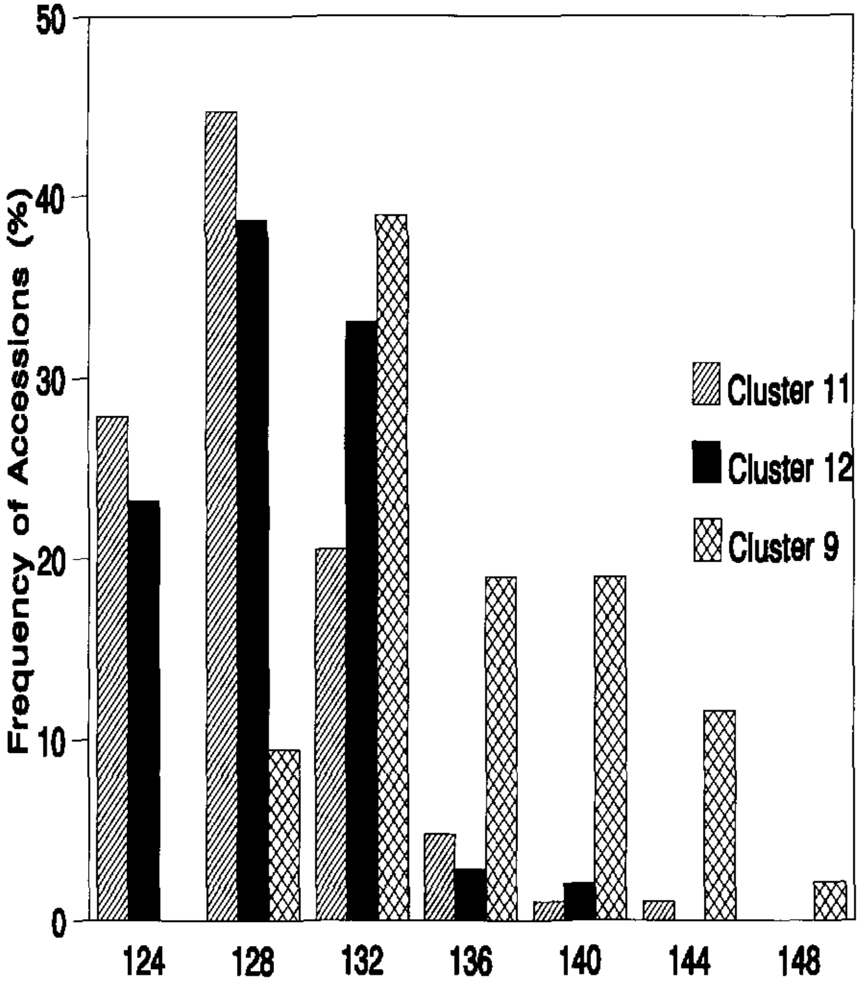


Figure 13. Distributions for DFLR (days) for the three major clusters from hierarchical analyses for Iranian chickpea accessions evaluated at Tel Hadya, Syria in 1991/92

cluster analysis was performed. The three major clusters from this hierarchical analysis had different means for DFLR and their distributions confirm one very late cluster and two clusters that are early (Figure 13). Similarly, distributions for the three clusters for HI are distinct and separate (Figure 12) and follow what was expected from Figure 7. The distribution for SYLD (Figure 9) did not suggest the three clusters that DFLR, HI, and HSW did. However, when the three major clusters are plotted separately (Figure 11), their distinct distributions can be seen.

The descriptors for the three major clusters show three distinct groups, each with their set of distinctive distributions for a set of quantitative descriptors. When data is obtained on the distribution of the Iranian chickpea accessions within the country, these accessions will be plotted and the geographical regions will be related to these clusters. The minor clusters will be studied to determine any unique information from the passport data that would explain their divergence from the majority of the accessions as found by hierarchical cluster analysis.

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1.3.11. Evaluation of lentil landraces

A total of 1859 lentil landraces and ICARDA breeding lines were evaluated in an unreplicated augmented design with one systematic (ILL 4400) and two random (ILL 4401 and ILL 5582) checks, with a block size of 23 plots. The plot size was 4 rows, 37.5 cm between rows, 5 m long (7.5 m^2). The seeding rate was 1200 seeds per plot. The center two rows, 4 m length (3 m^2), were used for yield determinations.

There were 20 descriptors observed: days to 50% flowering (DFLR), biomass in kg/ha (BYLD), seed yield in kg/ha (SYLD), straw yield in kg/ha (STYLD), 100 seed weight in g (HSW), days to 90% maturity (DMAT), plant height in cm (PTHT), height to first pod in cm (HTFP), pod shedding (PDSH), pod dehiscence (PDDH), lodging susceptibility (LOD), harvest index in % (HI), testa color (TCO), testa pattern (TPA), cotyledon color (COC), testa pattern color (TPC), leaflet size (LFS), tendril length (TLN), leaf pubescence (LFP), and pod pigmentation (PDP).

There was little variation for TLN, LFP, and PDP, with 94.6% of accessions with prominent TLN, 94.2% with dense LFP, and 99.7% of accessions with no PDP, respectively (Table 39). LFS was mostly large or medium. Seed testa traits were highly mixed and COC was yellow (49.8%) or orange/red (23.5%). LOD was mostly low or none (65.4%) with medium LOD of 30.2%. PDDH and PDSH were mostly none or low (66.6% and 44.3%, respectively) or medium (22.9% and 37.1%, respectively).

Table 39. Frequency distributions for LFS, TLN, LFP, LOD, PDP, TCO, TPA, TPC, COC, PDDH, and PDSH for 1859 lentil accessions evaluated at Tel Hadya, Syria in 1991/92

Descriptor/Score[a]	Frequency (%)	Number of accessions
LFS		1859
Small	7.0	
Medium	43.1	
Large	49.9	
TLN		1859
Rudimentary	5.4	
Prominent	94.6	
Mixed	0.1	
LFP		1859
Slight	5.8	
Dense	94.2	
LOD		1859
None	2.9	
Low	62.5	
Medium	30.2	
High	4.4	
PDP		1859
Absent	99.7	
Present	0.3	
TCO		1852
Green	0.5	
Grey	6.6	
Brown	1.8	
Black	15.3	
Pink	0.4	
Mixed	75.3	

Table 39. (continued) Frequency distributions for LFS, TLN, LFP, LOD, PDP, TCO, TPA, TPC, COC, PDDH, and PDSH for 1859 lentil accessions evaluated at Tel Hadya, Syria in 1991/92

Descriptor/Score[a]	Frequency (%)	Number of accessions
TPA		1852
Absent	15.1	
Dotted	1.4	
Spotted	0.7	
Marbled	0.5	
Complex	0.7	
Mixed	81.6	
TPC		1852
Absent	15.1	
Olive	5.9	
Grey	0.1	
Black	7.0	
Mixed	72.0	
COC		1852
Yellow	49.8	
Orange/red	23.5	
Mixed	26.7	
PDDH		1356
None	27.9	
Low	38.7	
Medium	22.9	
High	10.3	
PDSH		1356
None	3.1	
Low	41.2	
Medium	37.1	
High	18.6	

a : For descriptor abbreviations, see text.

Summary statistics (Table 40) reveal that the largest variation for quantitatively scored descriptors was for the yield descriptors SYLD, BYLD and STYLD, and HSW, all with C.V.s over 40%. The means of the accessions for SYLD and STYLD were lower by 25% and 17%, respectively, than the three checks. Except for HSW, the other descriptors had similar means for the germplasm accessions as the checks. Distributions for DFLR, PTHT, SYLD, and

Table 40. Summary statistics for 1859 lentil germplasm accessions evaluated at Tel Hadya, Syria during 1991/92

Descriptor		Check mean	Mean	Min.	Max.	C.V. (%)
DFLR[a]	(days)	122.4	122.8	106	147	4.8
DMAT	(days)	162.2	162.5	142	184	4.4
PTHT	(days)	23.8	22.8	6	41	19.6
HTFP	(cm)	12.4	11.1	1	26	33.7
HI	(%)	44.3	42.0	2.0	75.8	18.8
HSW	(g)	5.5	4.3	1.6	10.1	40.9
SYLD	(kg/ha)	1302	976	23	3453	43.8
BYLD	(kg/ha)	2924	2325	360	7293	40.3
STYLD	(kg/ha)	1623	1349	207	4667	43.2

a : For descriptor abbreviations see text.

STYLD are shown in Figures 14 to 17 and show normal distributions.

Stepwise discriminate analyses was performed with accessions from those countries represented by at least 10 accessions (20 countries) and for ICARDA breeding lines developed at Tel Hadya, Syria, which were treated as a separate category for discriminate and hierarchical cluster analyses. Sixteen descriptors (DFLR, LFS, TLN, LFP, DMAT, PTHT, HTFP, LOD, TPC, COC, PDP, HSW, SYLD, BYLD, STYLD, and HI) were chosen for further analyses.

Discriminate analysis was performed using canonical functions of the 16 descriptors selected, with 11 canonical functions found significant by Wilks lamda.

Overall, there was a 46.5% correct classification rate using the fifteen possible canonical functions (Table 41). For most countries of origin, the majority of misclassifications were with countries from similar ecologies and latitudes, for example, Ethiopian lines misclassified as Yemeni or Pakistani or Indian lines misclassified as Yemeni or Pakistani. The poor classification of some countries, such as Bulgaria and Algeria, may be because of the relatively small number of accessions, which may not be representative of the country. Algerian accessions classified

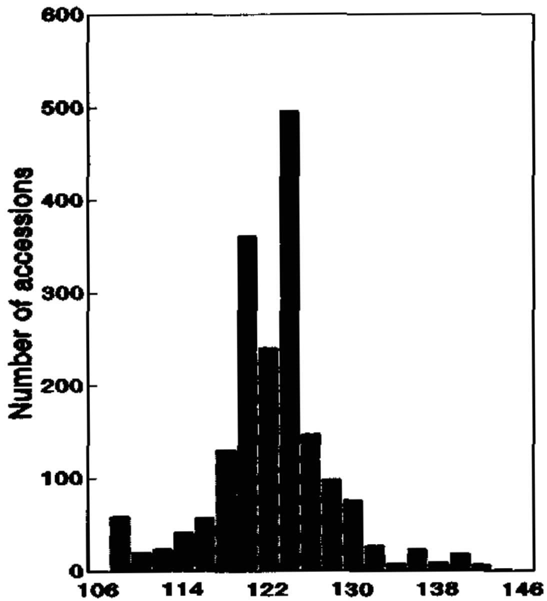

Figure 14. Distribution of DFLR (days) for 1859 lentil germplasm accessions evaluated at Tel Hadya, Syria in 1991/92

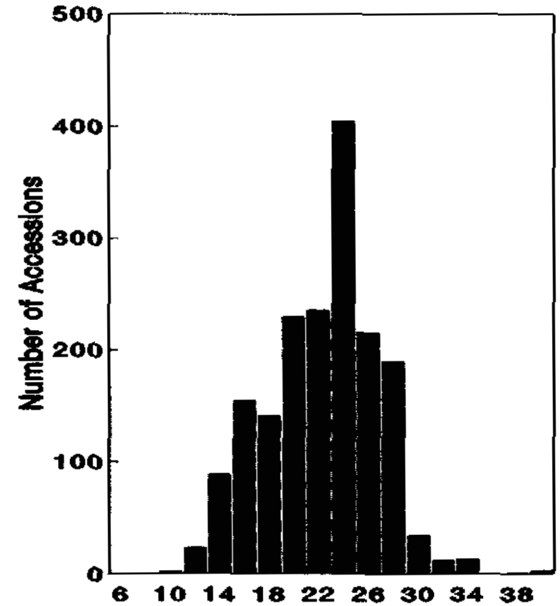

Figure 15. Distribution of PTHT (cm) for 1859 lentil germplasm acceccsions evaluated at Tel Hadya, Syria in 1991/92

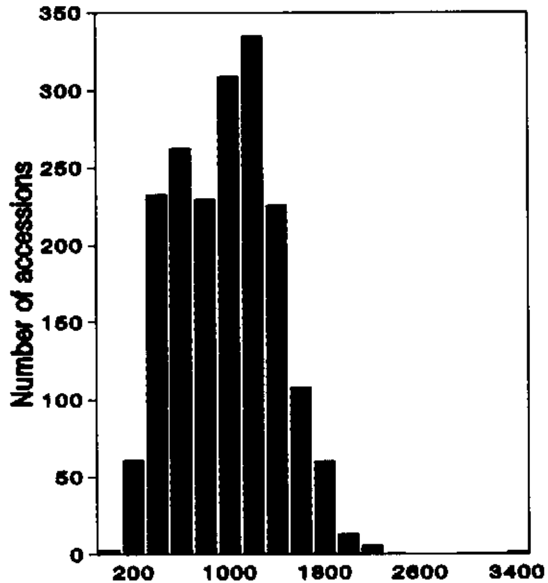

Figure 16. Distribution of SYLD (kg/ha) for 1859 lentil germplasm accessions germplasm accessions evaluated at Tel Hadya, Syria

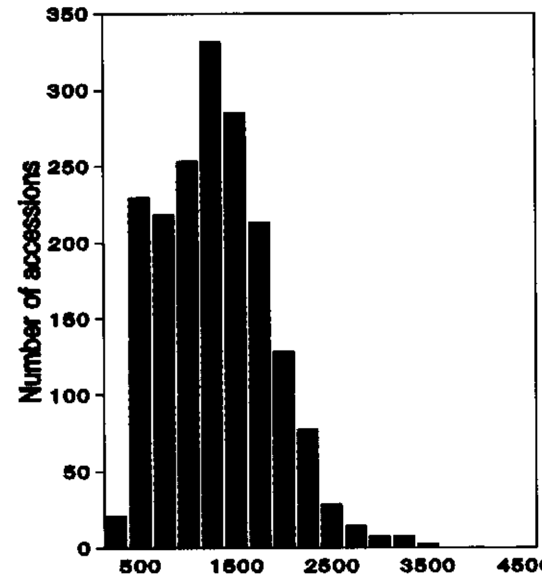

Figure 17. Distribution of Styld (kg/ha) for 1859 lentil germplasm accessions evaluated at Tel Hadya, Syria in 1991/92

Table 41. Classification by country of origin for lentil germplasm accessions evaluated at Tel Hadya, Syria in 1991/92 using canonical discriminate functions. Number of cases, percent correct classification, and first three misclassifications (% and country in parenthesis)

		Classification percentage (ORI[a])			
Ori[a]	No. Cases	Corr.	Miss. 1	Miss. 2	Miss. 3
BGR	17	5.9	23.5 (PRT)	17.6 (IRN)	11.8 (ICA, SYR)
CHL	26	34.6	15.4 (ESP)	11.5 (DZA)	11.5 (TUR)
DZA	12	0.0	25.0 (ESP)	16.7 (IND)	16.7 (SUN)
EGY	13	46.2	15.4 (JOR)	7.7[c]	---
ESP	59	54.2	8.5 (PRT)	8.5 (TUR)	5.1 (MEX)
ETH	35	45.7	20.0 (YEM)	11.4 (SYR)	5.7 (PAK)
GRC	13	23.1	15.4 (ESP)	15.4 (MAR)	15.4 (PRT)
ICA[b]	564	40.1	12.6 (SYR)	10.3 (JOR)	8.5 (MAR)
IND	81	17.3	21.0 (YEM)	17.3 (PAK)	8.6 (ICA, NPL)
IRN	18	33.3	11.1 (CHL)	11.1 (ICA)	11.1 (PRT)
JOR	90	40.0	21.1 (ICA)	15.6 (MAR)	8.9 (SYR)
MAR	39	56.4	10.3 (ICA)	7.7 (MEX)	5.1[d]
MEX	20	30.0	15.0 (DZA)	15.0 (MAR)	10.0 (SYR)
NPL	248	80.6	8.5 (PAK)	4.8 (IND)	1.2 (EGY)
PAK	89	50.6	16.9 (NPL)	14.6 (IND)	5.6 (SYR)
PRT	11	54.5	27.3 (BGR)	18.2 (ESP)	---
SUN	46	45.7	13.0 (BGR)	8.7 (ESP)	6.5 (MEX, PRT)
SYR	313	49.8	18.2 (ICA)	7.3 (JOR)	5.4 (DZA)
TUR	82	18.3	12.2 (SYR)	11.0 (PRT)	9.8 (ESP)
YEM	21	71.4	19.0 (ETH)	4.8 (DZA)	4.8 (SYR)
Total	1797	46.5	---	---	---

a : Country origin abbreviations are as per IBPGR country codes.
b : ICARDA lines developed at Tel Hadya, Syria.
c : ETH, ICA, IND, MEX, PRT.
d : BRG, DZA, ESP, MEX.

accessions classified as 25% from Spain, which probably represents the movement of seed to Algeria in the recent past. The highest correct classification rate was with Nepal (81%) with 13% misclassifications as Pakistan and India. The Turkish accessions were poorly classified, with only 18.3% correctly classified and Syria (12.2%) being the only closely related country being represented in the misclassifications.

ICARDA breeding lines represented 564 of the accessions tested and were treated as a separate origin. These represented mostly selections of crosses from the breeding program at ICARDA and also a few selections from within WANA landraces. These classified fairly distinctly (40.1% correct classification) as a separate group (Table 41). This would be expected with breeding pressure applied for a specific high yielding broadly adapted genotype. The misclassifications were from WANA with Syria (12.6%), Jordan (10.3%), and Morocco (8.5%) the highest. Also, seven of the 19 country of origins had misclassifications as ICARDA in their highest three misclassifications, an indication of the diversity of the ICARDA group.

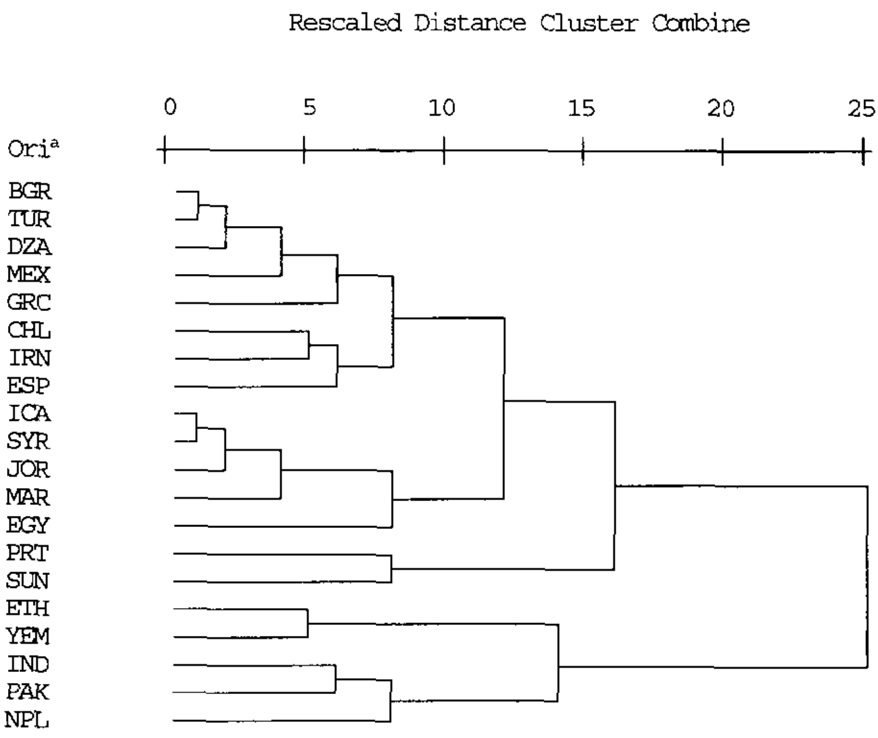

Figure 18. Dendrogram of lentil accessions evaluated in 1991/92 by country of origin for countries with at least 10 accessions evaluated. Rescaled cluster combines used

The centroid values for the 20 country of origins for the 11 significant canonical functions were used for hierarchical cluster analyses for the countries (Figure 18). As expected from latitude, the accessions from India, Pakistan and Nepal formed one group, accessions from Yemen and Ethiopia formed another and these two groups formed a section that was quite distinct from all the other countries. The ICARDA lines grouped very closely with the Syrian accessions, as would be expected from lines which were all developed at Tel Hadya. These also formed a group with accessions from Jordan, Morocco, and Egypt. The other groups formed predictable groups, though with some members which do not fit in well. Chile and Spain formed one group which can be explained by movement of landraces, but Iran is in the same group. Likewise Bulgaria, Turkey and Greece form a "Balkan" group, however, Mexico and Algeria are also in this group. However, in general, these groups fit the predicted response, considering latitude and eco-geographical region.

L.D. Robertson and A. Ismail

1.3.12. Evaluation of wild Lens

The wild Lens collection was evaluated for morphological, agronomic, and isozyme descriptors. A total of 316 accessions from L. orientalis, L. odemensis, L. nigricans, and L. ervoides were evaluated in nine randomized complete block trials, each with two replications and two L. culinaris checks (ILL 4401 and ILL 5582). Plot size was one row, 1 m long, with 37.5 cm between rows. The seeding rate was 40 seeds per plot.

There were 21 descriptors evaluated: days to 50 % flowering (DFLR), days to 90% podding (DAP), flower color (FLC), pod pigmentation (PDP), plant height in mm (PTHT), plant width between rows in mm (PWX), plant width within rows in mm (PWY), growth habit (GRH), cotyledon color (COC), flowers per plant (FPP), internode length (INL), leaflets per leaf (LPL), leaflet length in mm (LFTL), leaflet width in mm (LFTW), leaf length in mm

(LFL), leaves per plant (LPP), total leaf area per plant in cm^2 (LAP), tendril (TEN), arista (ARS), flowering duration (DDFLR), and podding duration (DDAP).

Table 42. Frequency distributions for FLC, PDP, GRH, COC, TEN, and ARS for 316 accessions of wild *Lens* evaluated at Tel Hadya, Syria in 1991/92

Descriptor/ score[a]	*Lens* species (%)			
	orientalis	odemensis	nigricans	ervoides
FLC				
White	0.6	0.0	0.0	0.0
White, blue veins	2.6	0.0	0.0	0.0
Blue	1.3	0.0	0.0	0.0
Violet	91.0	100.0	60.0	93.5
Pink	0.6	0.0	40.0	0.0
Other	3.9	0.0	0.0	6.5
PDP				
Absent	64.5	26.5	88.6	93.2
Slight, some pods	27.1	14.7	11.4	5.7
Slight, most pods	7.7	14.7	0.0	1.1
Deep purple	0.6	44.1	0.0	0.0
GRH				
Erect	3.4	5.3	3.0	0.0
Semi-erect	45.6	47.3	30.3	72.0
Semi-spreading	38.8	36.8	48.5	26.3
Spreading	12.3	10.5	18.2	1.8
COC				
Yellow	29.7	0.0	14.3	46.7
Orange/red	55.5	8.8	65.7	47.8
Olive-green	14.2	20.6	17.1	4.3
Mixed	0.6	70.6	2.9	1.1
TEN				
Rudimentary	55.5	55.9	77.1	92.4
Prominent	44.5	44.1	22.9	7.6
ARS				
Present	5.8	11.8	8.6	80.2
Absent	94.2	88.2	91.4	19.8
Number of accessions	155	34	35	92

a : For descriptor abbreviations, see text.

The *Lens* species had more than 90% of accessions with violet

FLC, except for L. nigricans, which had 40% pink and only 60% violet FLC (Table 42). L. nigricans and L. ervoides had mostly accessions with no PDP, while L. odemensis had 44.1% of accessions with deep purple PDP. All species had mostly accessions with semi-erect or semi-spreading GRH but L. ervoides had a higher proportion of semi-erect accessions. The wild species had mostly orange/red or yellow COC, except for L. odemensis, with mostly mixed (70.6%) and olive-green (20.6%) accessions. L. orientalis and L. odemensis had similar proportions of rudimentary/prominent TEN (55% vs 45%) accessions and L. nigricans and L. ervoides had similar, but different proportions, with a higher proportion of rudimentary TEN. L. ervoides had mostly present ARS, while the other species had mostly absent ARS.

Mean values for the quantitatively scored descriptors for each species are given in Table 43. In general, the wild species of

Table 43. Means for DFLR, DAP, DDFLR, DDAP, PTHT, PWX, PWY, FPP, INL, LPL, LFTL, LFTW, LFL, LPP, and LAP for 316 accessions of wild Lens species evaluated at Tel Hadya, Syria in 1991/92

Descriptor/ score[a]		Lens species				
		check	orien.[b]	odem.	nigr.	ervo.
DFLR	(days)	103.1	106.3	106.2	120.0	112.3
DAP	(days)	110.7	120.8	120.8	131.3	121.5
DDFLR	(days)	43.2	47.2	47.1	43.1	41.1
DDAP	(days)	2.9	5.8	7.1	6.5	5.9
PTHT	(mm)	241.7	136.8	102.7	99.3	86.3
PWX	(mm)	224.4	215.3	143.6	178.4	108.6
PWY	(mm)	187.9	209.3	132.2	165.1	101.5
FPP		17.1	11.8	12.1	12.0	10.2
INL	(mm)	21.9	15.5	10.9	12.6	13.1
LPL		9.4	7.7	7.0	7.0	4.9
LFTL	(mm)	11.6	8.0	6.0	7.5	8.8
LFTW	(mm)	3.5	2.7	2.0	2.6	1.8
LFL	(mm)	25.0	14.0	10.9	11.7	4.9
LPP		188.3	99.9	46.5	73.4	41.3
LAP	(cm^2)	338.0	104.7	23.7	58.1	18.4

a : For descriptor abbreviations, see text.
b : Orien.=orientalis, odem.=odemensis, nigr.=nigricans, and ervo.=ervoides.

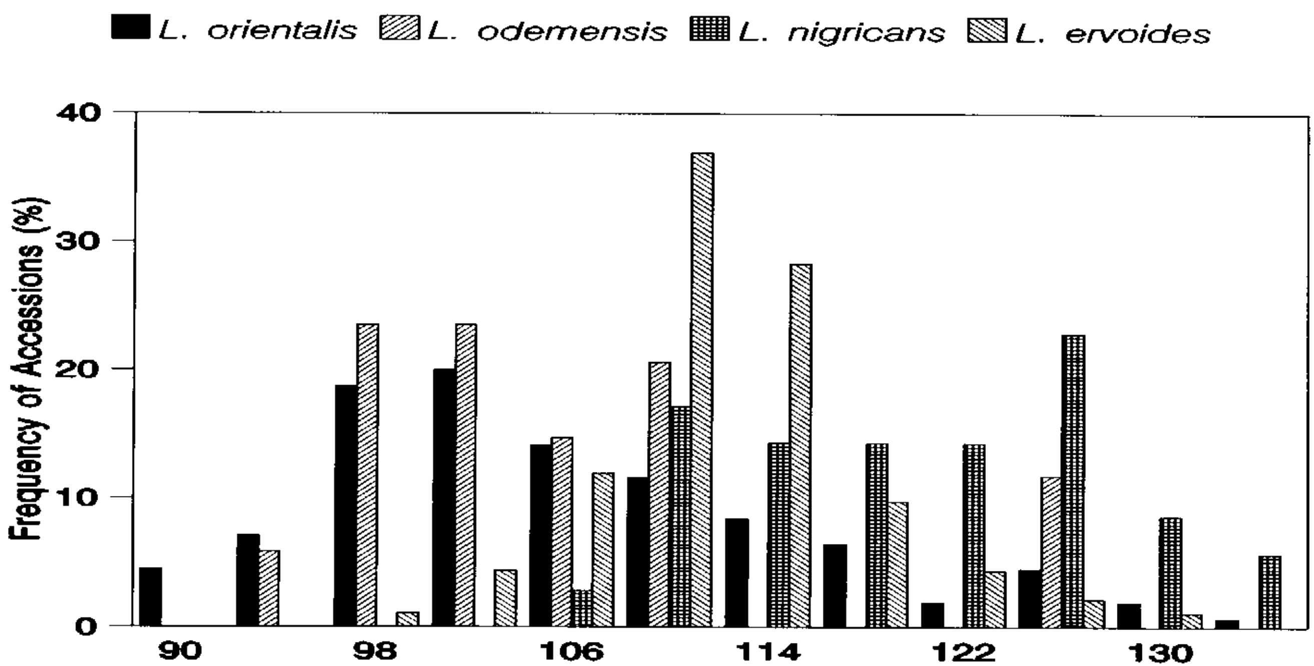

Figure 19. Distribution of DFLR (days) for the four wild Lens species evaluated at Tel Hadya, Syria in 1991/92

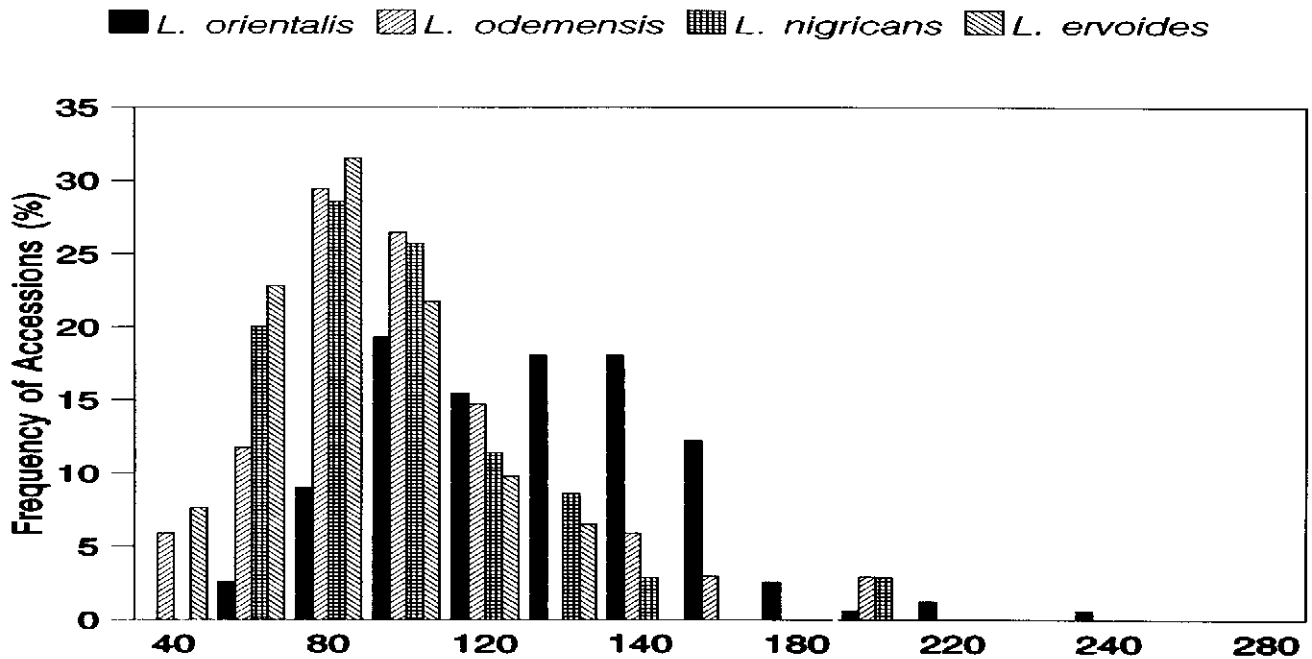

Figure 20. Distribution of PTHT (cm) for the four wild Lens species evaluated at Tel Hadya, Syria in 1991/92

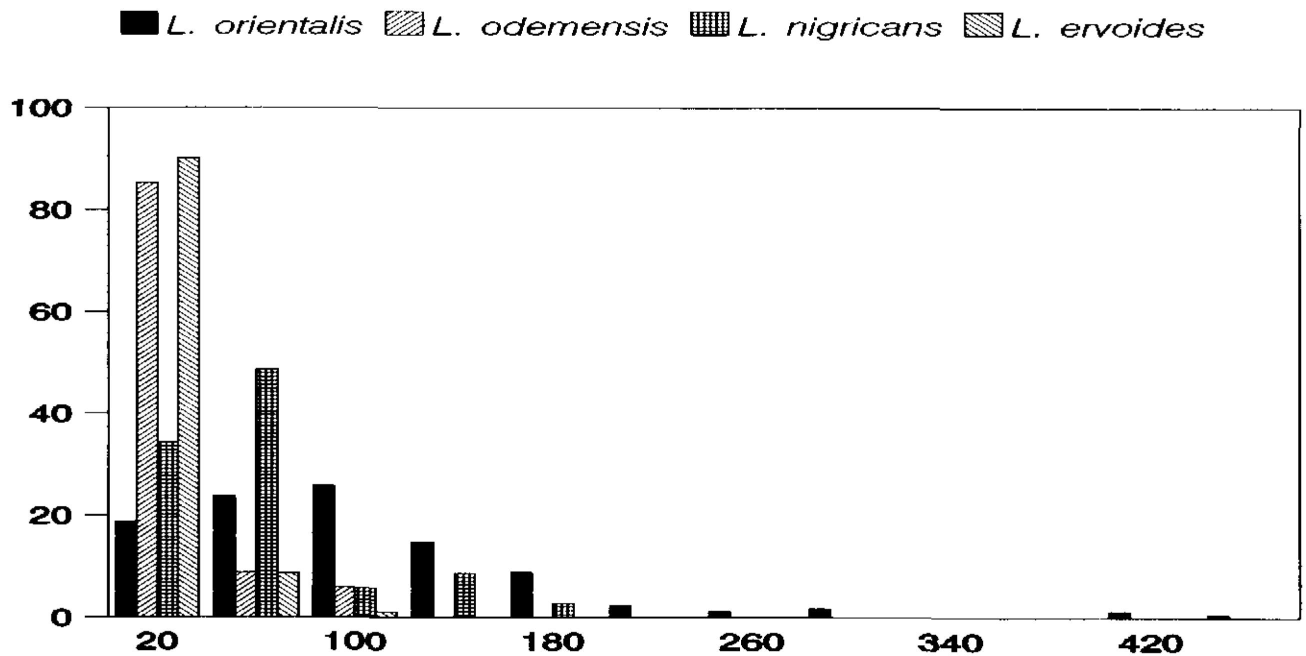

Figure 21. Distribution of LAP (cm^2) for the four wild Lens species evaluated at Tel Hadya, Syria in 1991/92

Lens were later (Figure 19) with L. orientalis and L. odemensis closest to the cultigen. The wild species had much smaller plants (Figure 20), again with L. orientalis closest to the cultigen. Smaller and fewer leaves were produced by the wild species than the cultigen (Figure 21). Even though L. orientalis was closest to the cultigen, its means were still only one-third of the cultigen (Table 43). L. orientalis is the closest of the wild species to the cultigen in general morphological appearance and size, as would be expected because it is the direct progenitor of L. culinaris. L. ervoides had the smallest plant size of the wild species and was the most divergent from the cultigen.

Results for relationships among wild Lens species, genetic diversity, and geographical distribution are presented in Section 1.4.7.

L.D. Robertson, M. Ferguson, and A. Ismail

1.4. Genetic resources support research

1.4.1. Variation for storage proteins in Triticum dicoccum

Emmer wheat has been grown in some countries on a limited scale for use as an animal or poultry feed. Recently, qualitative tests led to the discovery that its consumption reduces risk of colon cancer and heart diseases. It is now being actively promoted as a health food in Italy and elsewhere and its area under cultivation has increased due to its high market price. The efficacy of emmer wheat in reducing risks of these two major human diseases may be due to the high fiber content in its flour compared with other modern wheats.

Single seed protein electrophoresis is an efficient tool for screening genetic variability for seed storage proteins (gliadins) in wheats since the banding patterns are independent of the environment in which the material has been grown.

Samples from 21 accessions of T. dicoccum collected from diverse ecological and geographic areas within its center of origin in the 'Fertile Crescent' were subjected to polyacrylamide gel electrophoresis (PAGE) using the method described by Tkachuk and Mellish. The Canadian hexaploid wheat "Marquis" was used as a reference in all gels. Extensive variation in banding patterns was found in two accessions. Relative mobilities and intensities of the bands were calculated based on electrophoregrams of four seeds per sample, according to the procedure proposed by Bushuk and Zillman.

The following four observations, based on electrophoretic analysis, were made:

1) There were ten samples having the same banding profile for all four seeds selected at random (Figure 22). This indicates a high degree of purity within these samples. It is probable that these are single spike progenies.
2) For five samples there was a dominant profile and another

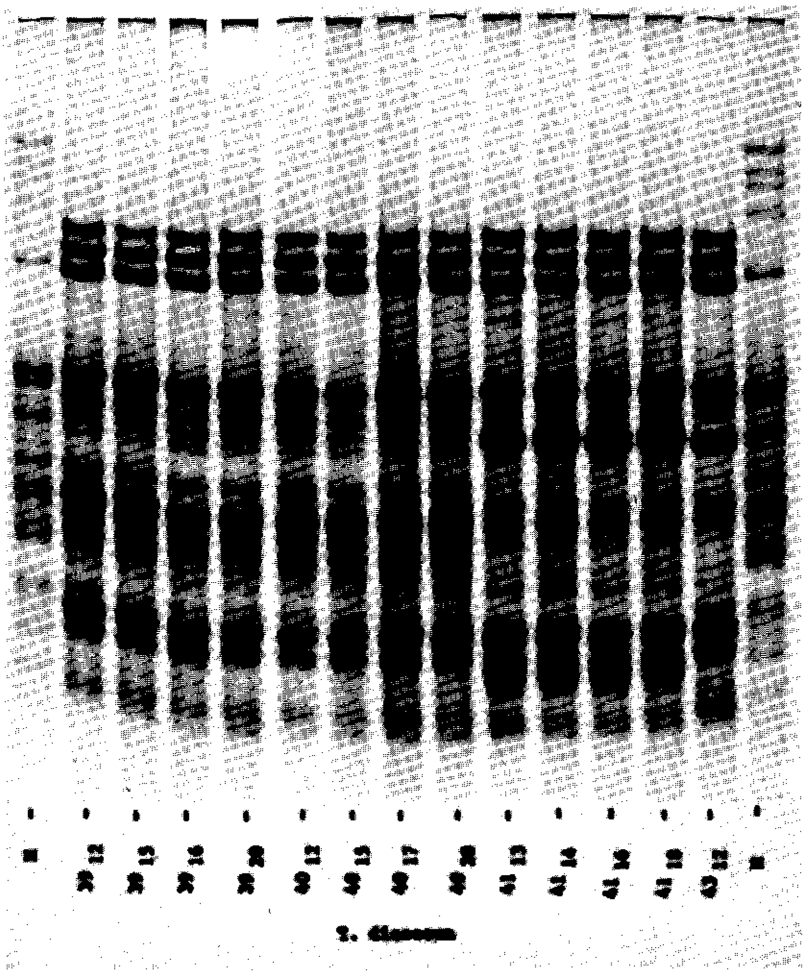

Figure 22. PAGE banding patterns of storage proteins (gliadins) in three samples of *T. dicoccum*. Top row of numbers indicate the plot no., whereas the bottom row indicates the sample no. M = Canadian bread wheat cv. "Marquis" used as a reference

profile which was different. This indicates that the samples may have been under cultivation as varieties rather than as landraces.

3) The remaining 6 samples exhibited considerable variability. The chemotypes indicate that the accessions were probably

highly variable populations.

4) Some of the 21 samples possessed the band with relative mobility (Rm) 45, which is indicative of good cooking quality of pasta. Hence, when lines from such samples are crossed with durum wheat it is presumed that the good cooking quality of the durum parent in the progenies will not be disturbed.

The variability found in these accessions of emmer wheat can be exploited in breeding programs aimed at improving drought tolerance and disease resistance for the dry areas. Other economically useful traits, such as earliness and frost tolerance, were also found in some accessions. This can be exploited in breeding for escaping terminal heat stress and cold tolerance, respectively.

S. Hakim and M.Y. Moualla (Tishreen University, Lattakia), and A.B. Damania and H. Altunji

1.4.2. Fingerprinting ICARDA Wheat Varieties using PAGE

Descriptive names given to varieties by plant breeders illustrate the practical necessity for farmers, for whom they are intended, to identify sources of seed of proved performance. Breeders need to describe cultivated varieties because they represent the end product of the investment of their time, effort and financial resources. Descriptions based upon traits that reflect genetic variation can be used to measure genetic diversity and can, therefore, be utilized to monitor and promote efficient conservation and utilization.

Storage proteins, such as gliadins, can be used to provide accurate varietal banding profiles through polyacrylamide gel electrophoresis (PAGE). There is abundant evidence that protein profiles can be obtained for all cereals of major importance and that these profiles are independent of environmental or storage conditions.

Ten varieties of wheat provided by ICARDA breeders were subjected to polyacrylamide gel electrophoresis (PAGE) using the

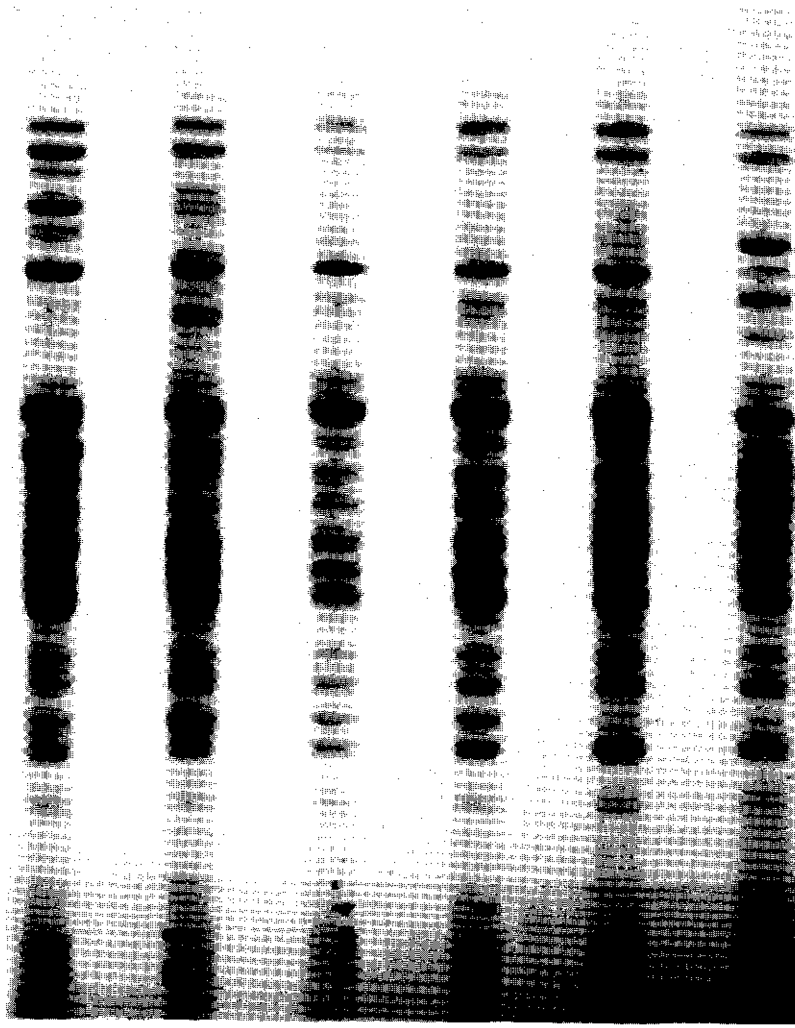

Figure 23. Fingerprints or typical gliadin banding patterns for bread wheat varieties (from left to right) "Marquis", "FL-A", "Cham 4", Cham 6", "Roomy", and "Memof"

method described by Tkachuk and Mellish. This method is rapid and gives excellent results in a relatively short period of time. The Canadian hexaploid wheat "Marquis" was used as a reference in all the gels. Relative mobilities and intensities of the bands were calculated according to the procedure proposed by Bushuk and

Zillman. The gliadin profiles of some bread wheat varieties (Figure 23) were obtained from a small sample of flour taken after crushing more than ten seeds so that a highly representative profile was obtained.

A.B. Damania and H. Altunji

1.4.3. Alien gene transfer and assessment of alien genetic polymorphism through use of molecular markers

Research on cytogenetics of wild relatives of wheat is being carried out at the Department of Agrobiology and Agrochemistry of the University of Tuscia, Viterbo, Italy.

Alien gene transfer

The ongoing alien gene transfer projects are particularly aimed at durum wheat improvement. The cytogenetic methodology which allows controlled introgressions of selected alien traits into wheat is commonly referred to as "chromosome engineering". Such an approach is based on manipulations of the meiotic recombination process (Ph mutants), through which it is possible to overcome the impediment to pairing and recombination that corresponding but not perfectly homologous (=homoeologous) chromosomes of more or less distantly related Triticeae species normally have with those of wheat. Chromosomal segments containing desired alien traits can thus be transferred into corresponding members of the recipient wheat genome.

With wild Triticeae species as original donors, the following target genes were identified: a) a gene for resistance to wheat powdery mildew (Pm13), derived from the wild diploid Aegilops longissima; b) a gene for leaf rust resistance (Lr19), derived from Agropyron elongatum; and c) a gene (Y), tightly linked to the latter one, which is desirable for incorporation into durum cultivars, for possible improvement of the yellowness of their milling products. These are discussed as follows:

a) The Pm13 gene is a dominant gene for resistance to wheat powdery mildew originally coming from Aegilops longissima (2n=14), which has been highly effective in several countries. Using the ph1b wheat mutant to induce pairing and recombination between the critical alien chromosome arm (3Ss) and its homoeologous chromosomes of common wheat, stable resistant recombinant lines were obtained, each carrying a chromosomal segment containing Pm13. One of the recombinants, which were assigned to wheat chromosome 3B and showed a relatively small genetic length for the alien segment containing Pm13, has been recently used in a further development of such transfer work aimed at introducing the highly effective Pm13 gene into durum wheat.

Effective resistance genes are, in general, very limited in cultivated materials. In Italy, for instance, one of them, the Pm4a gene deriving from T. dicoccum cv. Khapli and carried by several currently grown durum varieties, still displays a relatively good behavior under field conditions, though mildew biotypes which are virulent on seedlings of Pm4a varieties are increasingly being isolated from pathogen populations. Thus, the Pm13 gene is being transferred from the chromosomally engineered common wheat into both fully susceptible and also Pm4 bearing durum cultivars.

Backcrosses of the pentaploid F_1s to the selected recurrent parents are currently under way, during which, together with the chromosome number assessment, a parallel selection is being performed for Pm13 alone or in combination with Pm4, using, in the latter case, appropriate mildew biotypes which allow discrimination between the two resistance genes.

b) Sears's common wheat-Agropyron elongatum transfer no. 12 is particularly attractive for durum breeding, not only because, being the transfer on chromosome 7A, no further induction of homoeologous recombination is needed, but also because of the unique gene content of this set of Agropyron transfers. All of them, in fact, appear to carry, tightly linked to the highly effective leaf rust resistance gene Lr19, a gene, named Y for "yellow pigment", presumably controlling carotenoid pigment production.

This association, which prevented the use of the Lr19 resistance in common wheat, as a yellow flour definitely represents a negative attribute for its milling products, can instead be of interest for durum improvement. In fact, for best customer acceptance, pasta products require semolina or flour of maximum yellowness. However, little attention has been generally given so far to this trait.

Leaf rust is perhaps the most important disease affecting durum wheat cultivation under the temperate climates typical of the Mediterranean countries and Lr19 has turned out to be among the most effective genes in several leaf rust epidemics in Italy and in several other countries. Therefore, with transfer no 12 as a donor line, we have aimed for a double breeding objective using a number of selected durum cultivars as recipient ones.

Pentaploid progenies all gave the typical fleck reaction when artificially inoculated at the seedling stage with a leaf-rust population. Backcrosses are being carried out to the durum recurrent varieties using the Lr19 gene as a co-transfer marker, at least in the first generations of selection.

One of the available micro-tests for measuring the semolina "yellow index", which has been shown to be highly correlated with its carotenoid content, has been employed to compare Chinese Spring with its Agropyron transfer no. 12, the latter revealing a 30% increase of this value. The same measurement will be carried out on the material under selection, as soon as chromosomally stable progenies are be obtained.

<u>Assessment of alien genetic polymorphism through use of molecular markers</u>

Genetic variability of <u>T</u>. <u>dicoccoides</u> populations and of several other <u>Triticum</u> species has been assessed by use of molecular markers. Specifically, PCR (Polymerase Chain Reaction) analysis of high and low molecular weight glutenin sequences has been used to assess the genetic variation within and between <u>T</u>. <u>dicoccoides</u> populations. In both cases, the PCR products showed a good degree of polymorphism. In addition, 30 RFLP (Restriction Fragment Length Polymorphism) clones, isolated from a <u>T</u>. <u>urartu</u> genomic library, have been used to evaluate the genetic relationship between <u>Triticum</u> species.

Fourteen species were used for this research: <u>T</u>. <u>monococcum</u>, <u>T</u>. <u>boeoticum</u>, <u>T</u>. <u>urartu</u>, <u>T</u>. <u>dicoccoides</u>, <u>T</u>. <u>dicoccum</u>, <u>T</u>. <u>carthlicum</u>, <u>T</u>. <u>durum</u>, <u>T</u>. <u>turanicum</u>, <u>T</u>. <u>aetiopicum</u>, <u>T</u>. <u>polonicum</u>, <u>T</u>. <u>timopheevi</u>, <u>T</u>. <u>aestivum</u>, <u>T</u>. <u>vavilovii</u>, and <u>T</u>. <u>spelta</u>. Each hybridizing band obtained in Southern blotting experiments was treated as a unit character and its presence or absence in each genotype was recorded as 1 (presence) or 0 (absence). Data have been analyzed using the NTSYS-pc computer program employing correspondence analysis. All the hybridizing bands revealed by the available 30 clones were used to develop a dissimilarity matrix, from which a dendrogram was constructed.

This experiment confirmed that diploid species are differentiated from tetraploid and hexaploid ones. Within the diploids, all the examined accessions of <u>T</u>. <u>monococcum</u> and <u>T</u>. <u>boeoticum</u> appeared to be closely related but separated from those of <u>T</u>. <u>urartu</u>. This last species, as expected, turned out to be closer than <u>T</u>. <u>monococcum</u> and <u>T</u>. <u>boeoticum</u> to the polyploid wheat species.

C. Ceoloni, E. Porceddu, L. Ercoli, E. Iacono, and Lan Qiang (Univ. of Tuscia) and A. B. Damania

1.4.4. Genetic structure of wild wheat populations in Syria

As a result of the collection mission to the southern provinces of Syria (see Section 1.2.1. of this Annual Report), six populations of Triticum dicoccoides and four populations of Triticum urartu were sampled from eight sites where single heads were collected at a distance of 15 - 20 m in transects 350 - 800 m long (Table 44). Single heads, as well as 19 bulk population samples of wild Triticum spp., were studied for seed storage protein polymorphism utilizing PAGE analysis of gliadins to estimate genetic diversity in the natural populations. In addition, study of single heads provided information on the spatial distribution pattern of the diversity of the populations.

Table 44. Number of single head samples of wild wheats collected in southern Syria

	Site No.								
Species	**2**	**3**	**4**	**5**	**7**	**8**	**14**	**16**	**Total**
T. dicoccoides	75	-	-	25	40	31	30	25	226
T. urartu	-	25	30	25	-	-	30	-	110

Initial results of the single head analyses showed remarkable differences between populations of T. dicoccoides from different habitats. Large populations from the high plateau in the Jebel Al-Arab area in the province of Sweida displayed very high overall diversity of gliadins, as well as variation over a short distance on the transects through populations. Both single-band mutations and recombinations of entire gliadin blocks seemed to be involved in generating new genetic diversity. The large extent of the gliadin variation may indicate that these are old populations (Figure 24).

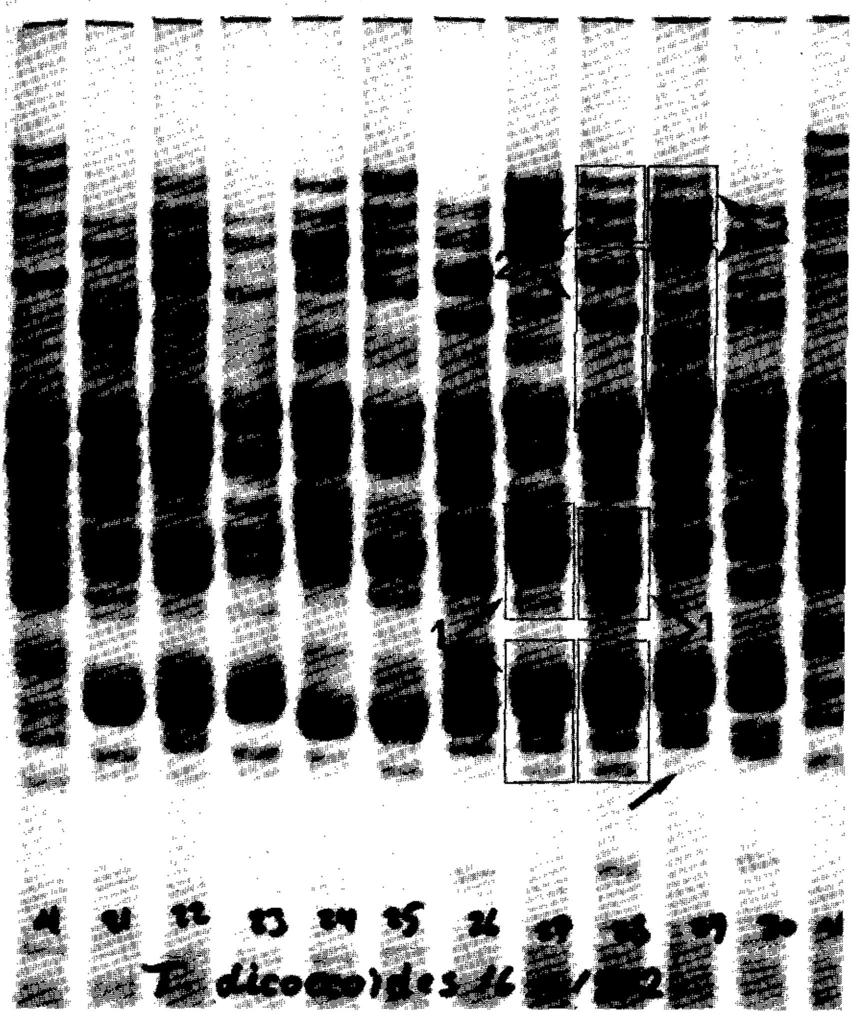

Figure 24. *Gliadin variation in plants of the transect in the* **high diverse T. dicoccoides population No. 16 from the province of Sweida (single arrow represents single-band mutation in allelic block Gli-A2, 1-double arrow represents recombination of the entire allelic block Gli-A2 with different Gli-B2 blocks, and 2-double arrow represents recombination of entire allelic block Gli-B1 with different Gli-A1 blocks)**

However, the smaller T. dicoccoides populations, which were found at the base of isolated valleys of the Anti-Lebanon mountains in the vicinity of Zabadani, Damascus province, showed lower overall diversity. The lack of diversity and occurrence of only a few single-band mutations in some segments of the transects indicated that these populations are probably of recent origin and may have arisen from single "founder" genotypes (Figure 25).

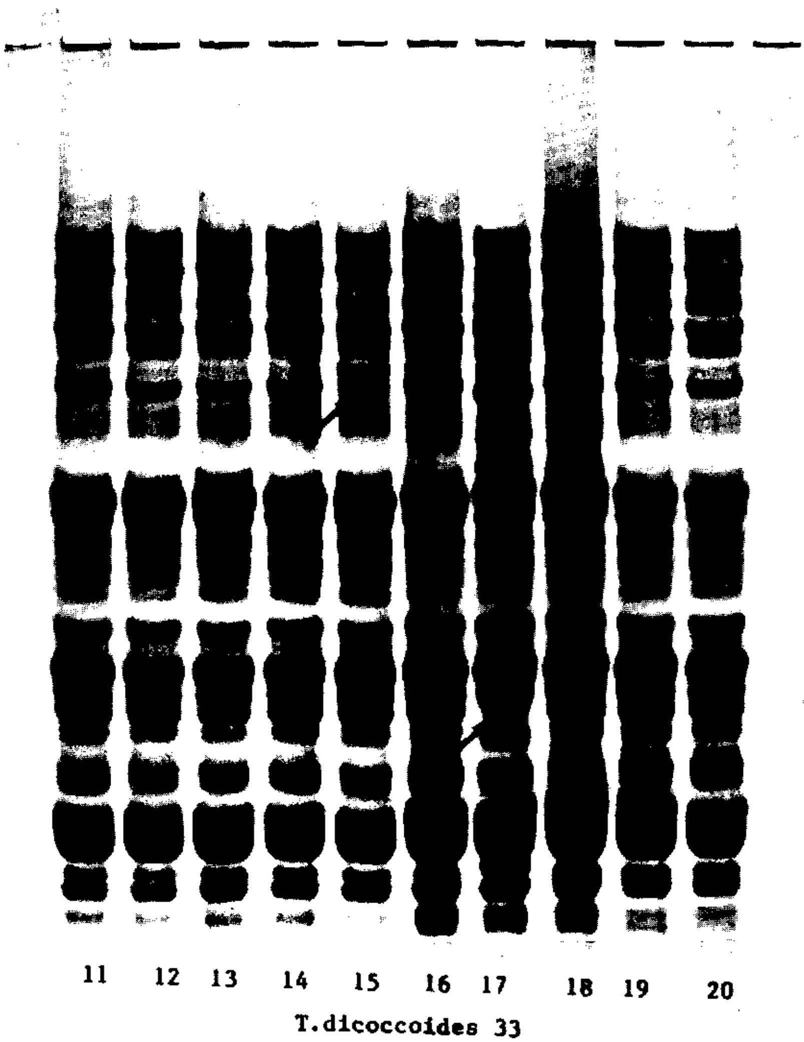

Figure 25. Gliadin variation in plants of the transect in the low diverse T. dicoccoides population No. 33 from the Anti-Lebanon mountains (single arrow represents single-band mutation on allelic block Gli-A2)

The implications of these findings are important in deciding the appropriate germplasm conservation strategy. It is practically impossible to conserve for the extensive diversity of these large populations from the Sweida region. An ex situ collection should be complemented with an in situ (on site) conservation of the populations in their original habitat to conserve the maximum genetic diversity.

In ex situ preservation, the dynamic evolution of a population sample is interrupted, but if appropriate in situ conservation strategies are adopted, in collaboration with the national programs, the original populations can not only be safely conserved, but the process of natural evolution is permitted to continue, perhaps resulting in further release of useful variability.

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1.4.5. Photothermal response in barley from China, Algeria, Egypt and Syria

As with other long-day annual cereals, the phenology of barley depends on its response to temperature and day length. Photothermal characterization of landraces in the barley collection can, therefore, provide very useful information, since the adaptation of germplasm to different agro-ecological conditions is closely related to crop phenology.

The objectives of the research were as follows:

a. Determine the parameters of the photothermal response,
b. Estimate the importance of these parameters for heading time in Syria, and
c. Classify the germplasm according to the parameters of the photothermal response.

Material for the study was selected from the recent introductions from China and barley landraces collected jointly by ICARDA and NARS in Algeria, Egypt, and Syria. The choice of the germplasm was based on the results of an preliminary evaluation in the field (GRU Annual Report 1990, Sections 1.3.2 and 1.3.3). A total of 131 Chinese landraces, 13 single head progenies derived from Algerian landraces, 14 single head progenies produced from Egyptian landraces and 11 single head progenies developed from landraces collected in Syria were included in the study.

The main experiment was planted at the ICARDA experimental farm Tel Hadya, Syria in two plastic houses with different temperature and day length regimes using both vernalized and non-vernalized germinated seed. Treatments A and B were planted on November 5, 1991, in a plastic house with a temperature of 25°C, and treatments C and D on November 11, 1991, in another plastic house with a diurnal temperature 25°C/15°C. Evaluation of heading time was terminated by March 1, 1992.

The experimental treatments were as follows:

Treatment A - vernalization 60 days; long-day diurnal regime (16 hours of additional artificial light, 8 hour dark),

Treatment B - as treatment A, but no vernalization,

Treatment C - vernalization 60 days; natural, short-day regime without extra light (day length < 12 hours during the whole period), and

Treatment D - as treatment C, but no vernalization.

One row per accession (half-row vernalized and half-row non-vernalized treatment) was planted in each plastic house. Heading time was scored when 50% of the main tillers headed. Other traits evaluated were plant height, spikelet groups/spike, spike length, and number of tillers.

An additional experiment was planted in the field on November 19, 1991, with the same accessions in a non-replicated design, with one row per accession.

The following traits were evaluated: growth habit, frost damage, days to heading, days to maturity, row type, kernel cover, and yield/plot.

Data on days to heading of the Chinese landraces in 1990 were taken from the preliminary evaluation experiment of 1989/90.

For the analysis of the photothermal response the following variables were used:

1. DAHELDV - earliness *per se* = days to heading in treatment A,
2. DAHELD - days to heading in treatment B,
3. DAHESDV - days to heading in treatment C,
4. DAHESD - days to heading in treatment D,
5. BA - vernalization response in days, computed as BA=DAHELD-DAHELDV,
6. CA - photoperiod response in days, computed as CA=(DAHESDV-12.4)-DAHELDV,
7. DC - short-day vernalization response in days, computed as DC=DAHESD-DAHESDV,
8. DB - photoperiod response of non-vernalized plants in days, computed as DB=(DAHESD-12.4)-DAHELD,
9. DAHE1990 - days to heading in 1989/90 experiment, and
10. DAHE1992 - days to heading in 1991/92 experiment

The constant of 12.4 days was calculated and subtracted from the values obtained in treatments C and D to compensate for the difference in degree-days between the long-day vs. short-day treatments.

Although the relationship of some of the variables 1 to 8 to parameters of the photothermal response and crop phenology is obvious, it is not so straightforward in the others. Therefore, basic statistics, correlation and factor analysis were employed to elucidate the relationship between the variables and the factors involved. Only 127 accessions were included in the analysis, since cases with missing data had to be excluded. These were mostly accessions with very high vernalization and/or photoperiod responses from the northeastern provinces of China (Hebei, Shanx, Heilongjiang, Henan, and Shandong).

As expected, mean values for variables 1 to 4 (Table 45) showed that vernalized plants grown under the long-day conditions headed earlier than in the other treatments, while plants in the short-day, non-vernalized treatment D headed latest. The delay in heading time of non-vernalized plants was influenced by the day length and was much shorter in the short-day treatment (22.7 vs 7.7 days). This phenomenon was found in barley earlier and was called 'short-day vernalization'.

Table 45. Basic statistics and factor analysis data for 127 barley accessions studied for photothermal response

Variable[a]	Mean	Std.dev.	Communality	Factor1	Factor2	Factor3
DAHELDV	54.3	6.6	0.935	-0.149	-0.144	**0.945**
DAHELD	77.0	22.2	0.971	**0.965**	-0.075	0.185
DAHESDV	89.7	8.4	0.996	-0.126	0.750	0.646
DAHESD	97.5	7.0	0.712	0.443	0.242	0.676
BA	22.7	22.6	0.992	**0.991**	-0.031	-0.093
CA	23.1	7.4	0.976	-0.009	**0.981**	-0.115
DC	7.7	7.6	0.678	0.548	-0.608	-0.090
DB	8.1	20.1	0.861	**-0.913**	0.167	0.030

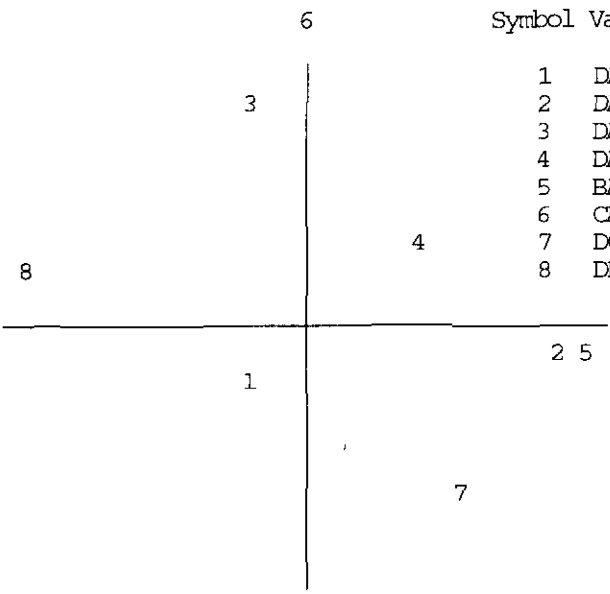
a : For variable abbreviations, see text.

Simple correlations revealed close associations between the variables DAHELD and BA and DB ($r=0.96^{**}$ and -0.95^{**}, respectively). The former figure indicates that vernalization sensitivity is the only factor involved in DAHELD, whereas the latter correlation results from the fact that with short days, the vernalization-sensitive genotypes headed earlier than with long-day conditions and the 'spring' (vernalization insensitive) genotypes extended heading time because of their photoperiod sensitivity.

Using factor analysis for variables, three factors were extracted which explained 89.0% of the total variance and the individual contributions of factor 1, factor 2 and factor 3 were 43.7%, 28.3%, and 17.0%, respectively.

Data obtained from the rotated factor matrix are presented in Table 45. Bold numbers indicate close associations of the individual variables with the factors. Factor 1 is linked to vernalization response, as indicated by the strong associations with DAHELD and BA. The very high value of CA for factor 2 implies that photoperiod response is a major component of that factor. Factor 3 is closely associated with DAHELDV, i.e., treatment A, in which the effect of vernalization and photoperiod were excluded and the heading time resulted from the response to a sum of the effective daily temperatures (degree-days). This response is called earliness <u>per</u> <u>se</u> or earliness in the narrow sense and, as the data show, the variable DAHELDV is the best indicator of that response. The variable DC, which can be interpreted as vernalization response under short-days, was related somewhat more to factor 2 than factor 1 (Table 45, Figure 26). This implies that vernalization response in the short-day treatment is substantially affected by photoperiod.

Figure 26. Factor-loadings plot of the variables of photothermal reaction[a]



Symbol	Variable[b]	Coordinates	
1	DAHELDV	-.149	-.144
2	DAHELD	.965	-.075
3	DAHESDV	-.126	.751
4	DAHESD	.443	.241
5	BA	.991	-.031
6	CA	-.009	.981
7	DC	.548	-.608
8	DB	-.913	.166

a : Factor 1 is horizontal and factor 2 is vertical axis, respectively.
b : For variable abbreviations, please see text.

The relationships between the variables of photothermal response is shown in Figure 26, where the variables are plotted using factor 1 and 2 after an orthogonal (varimax) rotation of the two factors.

A set of 93 Chinese accessions, in which 1990 and 1991 data on days to heading in Tel Hadya in the field were available, was subjected to stepwise regression analysis to determine the relationships between parameters of the photothermal response and heading time in the field. When variables associated with a single factor (DAHELDV, BA, and CA) were included in the analyses, the following regression equations and coefficients of determination were obtained:

DAHE1990= 78.5 + 0.571 DAHELDV + 0.433CA R^2=0.377

DAHE1992=122.9 + 0.335 DAHELDV + 0.291CA R^2=0.402

These equations indicate that in both years earliness per se and photoperiod sensitivity determined heading dates in the field. The planting date in 1990 was 26 days later than that in 1991. When this period of time is subtracted from the 1991 constant, the new value, 96.9 days, becomes similar to the 1990 constant and the difference can be explained by the later onset of higher temperatures in the spring. Although the variable BA was included in the analyses, it did not appear in the equations and this suggests that vernalization response had little effect on heading time. The period of low winter temperatures was, therefore, sufficient for vernalization of the sensitive genotypes.

When all variables, including those with the compound effect (DAHELD, DAHESDV, DAHESD, DB, and DC), were included in the computations, DAHESDV remained in the equations as a single variable showing almost the same coefficients of determinations as in the previous analysis:

DAHE1990 = 76.2 + 0.482 DAHESDV R^2 = 0.366

DAHE1991 = 120.2 + 0.307 DAHESDV R^2 = 0.392

Consequently, DAHESDV, a variable associated relatively closely with both factor 2 (photoperiod response) and factor 3 (earliness per se, see Table 45), reflects well the factors important for the heading time in the field in northern Syria.

Hierarchical cluster analysis was employed to classify the accessions according to parameters for photothermal response. The variables DAHELDV, BA and CA, which were the most closely associated with the factors related to plant phenology, i.e., earliness per se, vernalization, and photoperiod response, respectively, were used for the cluster analysis.

A level of twelve clusters were considered sufficient for classification of the diversity in the photothermal response. The mean values for accessions in the clusters and their three-digit formulae are given in the Table 46. The formulae were derived from the mean values transformed to a numerical scale, in which 1 was low, 2 medium, and 3 high response. The first digit in the formula corresponds to the value for earliness per se, the second and the third indicate vernalization and photoperiod response, respectively.

Table 46. Cluster characteristics - mean values (days) and cluster formulas

Cluster	No.acces.	DAHELDV[a]	BA[a]	CA[a]	Formula[b]
1	10	54	29	26	1 2 2
2	7	56	-1	37	2 1 3
3	42	51	5	26	1 1 2
4	5	51	57	37	1 3 3
5	4	50	38	38	1 2 3
6	20	52	48	26	1 3 2
7	9	75	0	12	3 1 1
8	17	62	3	20	2 1 2
9	18	51	57	18	1 3 2
10	6	49	5	9	1 1 1
11	1	61	45	-4	2 3 1
12	6	64	39	20	3 2 2

a : For variable abbreviations, see text.
b : For explanation, see text.

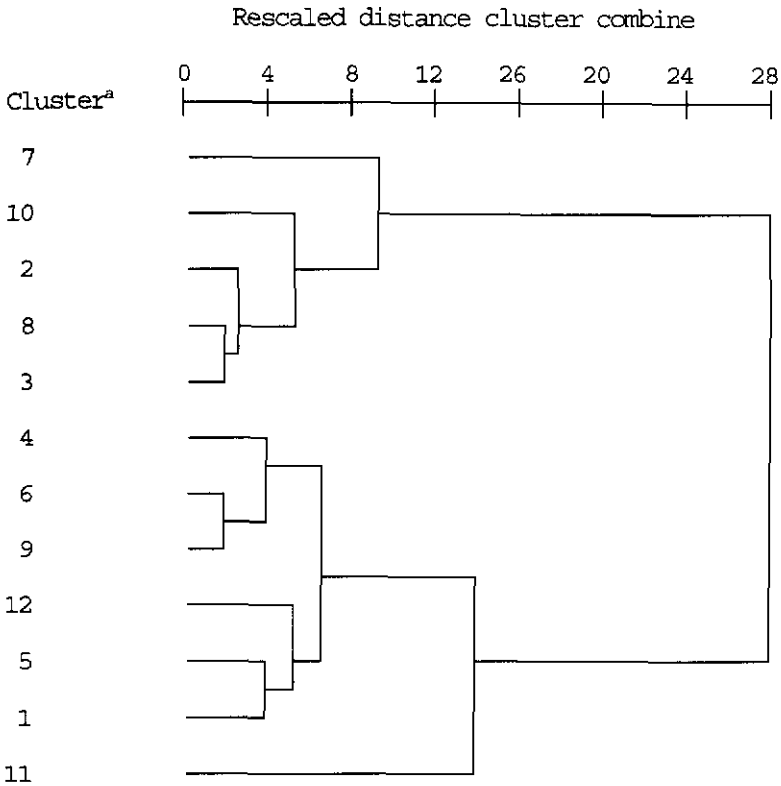
Data in Table 46 show large diversity for photothermal characteristics and their combinations. Earliness per se ranged from 49 days in cluster 10 to 75 in cluster 7. Response to vernalization extended from complete insensitivity or negligible sensitivity in clusters 2, 3, 7, 8, and 10 ('spring' barley), to medium (clusters 1, 5, and 12) and high sensitivity in clusters 4, 6, 9, and 11. The latter can be considered true 'winter' types. Considerable variation was also found in the photoperiod response, ranging from insensitivity or low sensitivity (clusters 7, 10, and 11) to high sensitivity in clusters 2, 4, and 5. Clusters with medium photoperiod sensitivity had the highest frequencies.

Relationships between the clusters is shown in Figure 27, which was drawn using the squared Euclidean distances. Cluster 11 stood apart and included only one accession of photoperiod-insensitive winter barley. The other clusters were distributed into two large groups: vernalization-insensitive (spring barley) and medium to high vernalization-sensitive barley. Clusters pairs 6-9 and 3-8 display high similarity.

The distribution of accessions of different geographical origins in the clusters is presented in Table 47.

Chinese germplasm displayed high diversity in photothermal response and is represented in all the clusters (Table 47), however, only one accession occurred in cluster 12, which is otherwise mostly formed by Algerian germplasm. Medium response to photoperiod was characteristic for all accessions from WANA (West Asia and North Africa) countries, with the exception of one Syrian accession originating from a high-rainfall coastal region. Chinese germplasm was, however, very diverse in the photoperiod response, ranging from insensitivity (clusters 7, 10, and 11) to high sensitivity (clusters 2, 4, and 5) and could be used as a donor of genes for phenology manipulations in breeding programs for different target environments.

Egyptian barley showed low diversity for the photothermal characteristics, since clusters 3 and 8 are similar, differing only somewhat in earliness per se. Algerian and Syrian barley



a : Cluster numbers explained in text.

Figure 27. Dendrogram for 12 clusters of the photothermal response in barley

landraces were more variable, with differences between and within landraces.

Data on photothermal response of single-head progenies from Algeria and Syria are presented in Table 48. Although the other photothermal characteristics showed some within-population variation, the highest diversity was found in the vernalization response, e.g., in Algerian landrace 48 and Syrian landraces 4 and 6. In spite of the low effect of the vernalization response on the heading time in the semi-arid regions of Syria, this factor may be important for limiting frost damage in cold winters that occur frequently in central Syria where the two populations were

Table 47. Distribution of accessions of different geographical origin in the clusters

Formula[a] Cluster	122 1	213 2	112 3	133 4	123 5	132 6	311 7	212 8	132 9	111 10	231 11	322 12	Total
China prov.:													
Hebei	1								1				2
Shanxi		4	5		1	1	1						12
Shandong		1	2	1		1				1	1		7
Henan				1	2					1			4
Shaanxi	1			1	1	2						1	6
Heilongjiang							1	1					2
Liaoning			2					2					4
Gansu		2	3						1				6
Jiangsu			2			2			3				7
Shanghai	2					4				2			8
Hubei	1		1			2			3	3			10
Hunan			2			4		1	2				9
Sichuan			1				3	3					7
Yunnan	1		10					3					14
Jiangxi				1					2				3
Beijing			1				1						2
Zhejiang				1		1	2		3				7
Countries:													
Algeria			2			2		4				4	12
Egypt			10					3					13
Syria	4		1			1	1		2			1	10
Total	10	7	42	5	4	20	9	17	18	6	1	6	145

a : For explanation, see text.

Table 48. Earliness _per se_ (DAHELDV), vernalization (BA), and photoperiod (CA) response in single-head progenies derived from Algerian and Syrian landraces

SH Progeny	Original Population	Country	DAHELDV[a]	BA[a]	CA[a]	Cluster
DZ-1-13	1	Algeria	60	9	20	8
DZ-1-15	1	Algeria	60	3	22	8
DZ-21-56	21	Algeria	62	7	22	8
DZ-38-2	38	Algeria	64	5	17	8
DZ-38-8	38	Algeria	58	11	24	3
DZ-40-54	40	Algeria	66	42	19	12
DZ-40-66	40	Algeria	63	36	22	12
DZ-40-129	40	Algeria	66	45	15	12
DZ-48-183	48	Algeria	59	49	23	6
DZ-48-219	48	Algeria	60	37	25	12
DZ-48-225	48	Algeria	60	50	26	6
DZ-48-232	48	Algeria	59	11	23	3
BM-1-20	1	Syria	53	30	23	1
BM-1-51	1	Syria	54	28	22	1
BM-4-4	4	Syria	54	57	23	9
BM-4-70	4	Syria	55	31	25	1
BM-4-81	4	Syria	57	30	23	1
BM-6-36	6	Syria	62	44	20	12
BM-6-56	6	Syria	55	14	27	3
BM-6-115	6	Syria	58	48	23	6
BM-9-1	9	Syria	72	0	15	7

a : For variable abbreviations and explanation, see text.

collected.

The small number of landraces and their single-head progenies analyzed does not allow definite conclusions on the structure of the populations. Nevertheless, these preliminary results indicate that considerable genetic diversity in the photothermal response is maintained within the landrace populations, providing them with a buffering capacity against adverse effects of a highly variable and stressful environment in the WANA region.

J. Valkoun and M. Tahir (CP)

1.4.6. Taxonomic study of Aegilops

In the frame work of the taxonomic revision of Aegilops and the wild species of Triticum, the herbaria of the following institutions were visited, partly in conjunction with collection missions (number of inspected herbarium sheets in parenthesis): Istituto ed Orto Botanico, University of Bologna (54), Bologna, Italy; Museo Botanico, University of Firenze (483), Florence, Italy; Istituto Botanico Hanbury ed Orto Botanico (69), University of Genova, Genova, Italy; Dipartemento di Scienze Botaniche (187), University of Pisa, Pisa, Italy; Dipartemento di Biologia Vegetale (270), University of Torino Torino, Italy; Département de Biologie Végétale (1063), University Claude Bernard at Lyon, France; Institut de Botanique (1023), Montpellier, France; Conservatoire et Jardin Botaniques de la ville de Genève (1349), Chambésy/Genève, Switzerland; Department of Plant Taxonomy and Geography (336), Institute of Botany of the Academy of Sciences of Armenia, Yerevan, Armenia; Botany Department (54), Armenian Institute of Agriculture, Yerevan, Armenia; and Biology Department (104), American University of Beirut, Beirut, Lebanon.

The herbaria in France, Italy, and Switzerland were studied during a mission in June, 1992, aimed at solving many remaining typification problems in the framework of the taxonomic revision of Aegilops. Invaluable help was received from Dr E. Gandilian-Nazarova in Yerevan, Armenia, who translated all the Cyrillic-written labels of the Armenian institutes into English.

During herbarium and literature studies in the Netherlands and the U.K., additional material was examined from the herbaria of Barcelona (166), Berlin (10), Coimbra (48), Edinburgh (500), Kew (323), Lund (757), Prague (148), and Tübingen (82). Material studied in the Netherlands was received on loan by the Laboratory for Plant Taxonomy of the Agricultural University at Wageningen.

The database on herbarium specimens of wild wheats now includes around 19000 entries from 61 herbaria. The database will be converted into a D-base file, enabling rapid sorting by attribute, which will include: genus, species and variety names, country, province (in most cases), location, collectors, and coded herbarium abbreviations following the Index Herbariorum, edition 8 (Holmgren et al., 1990). Herbarium samples made in conjunction with ICARDA missions are linked to the germplasm database and will thus, provide much more data on biotic and abiotic factors.

As a result of this work, the so-called "special" or "taxonomic" part of the revision was completed during 1992. The special part comprises the nomenclature, description, distribution, ecology, altitudinal distribution, flowering and fruiting time, genome type, vernacular names (if any), notes (if any), and a selection of examined specimens of the 22 species and five varieties recognized in the revision. A preliminary example of the presentation of a species in the special part is shown in the GRU Annual Report for 1991, pp. 107-111. The so-called "general" part will be added, consisting of chapters on, amongst others, history, morphology, phylogeny, ecology, distribution, and relationships with other genera in the Triticeae tribe.

Many new data on the distribution of the accepted taxa have now been compiled, both relating to herbarium specimens and germplasm accessions. The international symposium on "Evaluation and utilization of biodiversity in wild relatives and primitive forms for wheat improvement", held at ICARDA 12-15 October, 1992, offered the opportunity to present some notes on the distribution patterns of important sections of the genus Aegilops L., viz. the section Sitopsis Jaub. & Spach, comprising the S-genome species, and the sections Monoleptatera Eig and Pachystachys Eig, comprising the D-genome species. These sections are chosen for their close relation with cultivated wheat: one (maybe several) of the species of the Sitopsis contributed the B-genome, and Ae. tauschii Coss. (common synonym: Ae. squarrosa L.) contributed the D-genome to bread wheat.

The B-genome species show sympatric growth in parts of Palestine and Jordan, mainly due to the presence of Aegilops longissima, searsii, and sharonensis in this region. For the distribution of Ae. speltoides, this region is at the southwesternmost extreme,

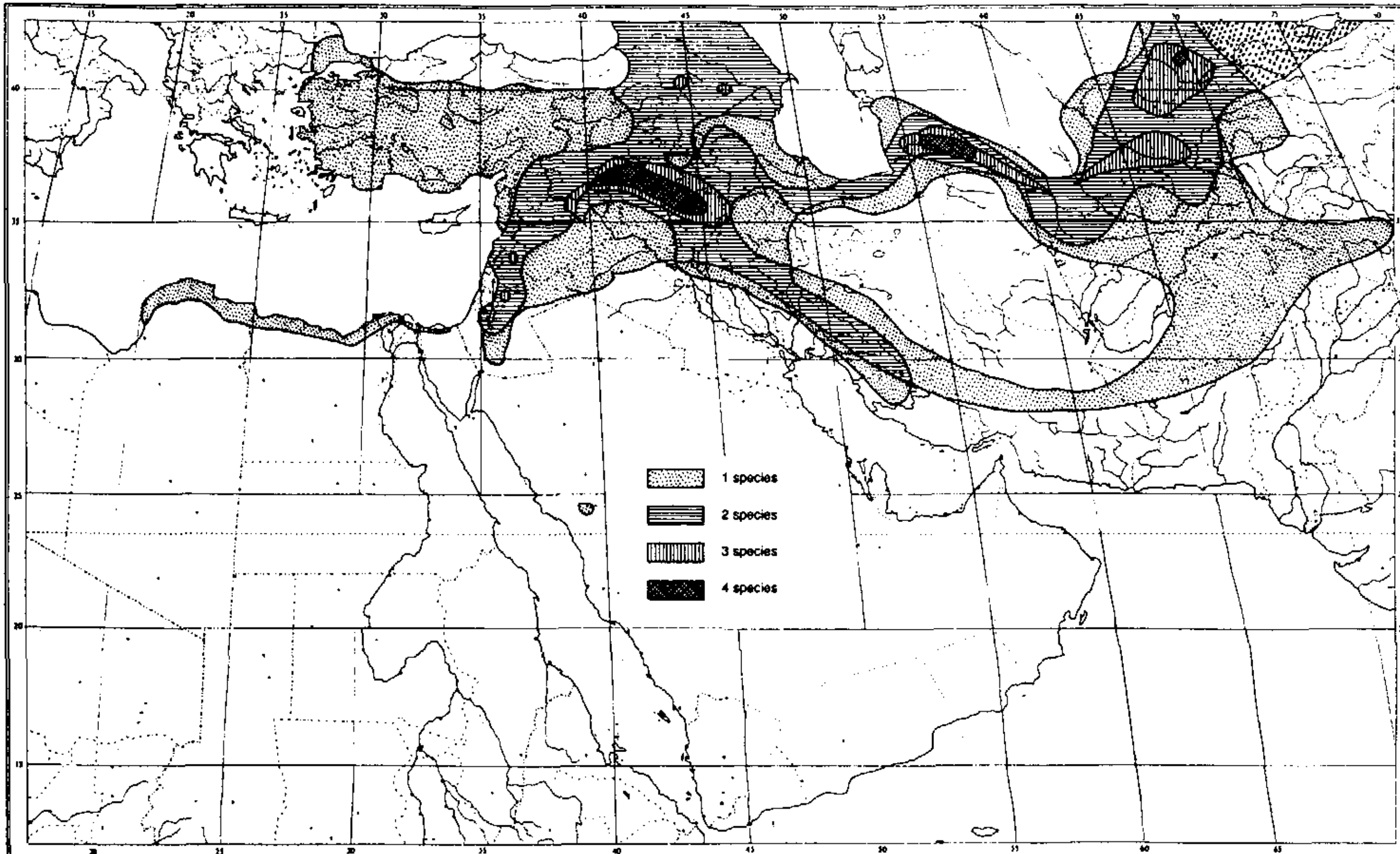


Figure 28. Sympatric distrubution of D-genome species of <u>Aegliops</u>

being mainly represented along the Fertile Cresent and in most parts of Turkey. However, for the domestication of emmer wheat, the western arc of the Fertile Crescent seems the most likely place.

The sympatric growth of the D-genome species (Ae. tauschii, cylindrica, crassa, juvenalis, vavilovii, and ventricosa) is more complicated, as is shown in Figure 28. The central part of the Fertile Cresent is again the region with the greatest diversity for these species, with additional sympatric growth in the Kopet Dag mountains of Turkmenia, and in mountainous regions in Uzbekistan and Tadzhikistan. Only one species, ventricosa, occurs mainly west of the Fertile Cresent, while the others have spread to the north and east of this major area of diversity of the genus. There appears to be a kind of gap in the distribution of these species, formed by the great salt deserts in eastern Iran (the Dasht-e-Kavir and the Dasht-e-Luz) and by western Afghanistan. This does not mean, however, that the most likely species, crassa and tauschii, do not occur there, but rather that nobody crossed this region to search for them. In general, D-genome species are found at higher latitudes and altitudes, and may show better adaptation to cold than most species of Aegilops.

Table 49. Summary of distribution of Aegilops and Amblyopyrum species

Species	Takhtajan (1986) term	Notes
Aegilops		
bicornis	Mediterranean element	(both varieties) Confined to coastal areas of Libya, Egypt, Palestine; rarely more inland. Uncommon.
biuncialis	Mediterranean / Western Asiatic element	Mainly Aegean, also Turkey, Cyprus, western arc of FC* and Transcaucasia. Locally abundant.

Table 49. (continued)

Species	**Takhtajan (1986) term**	**Notes**
caudata	Mediterranean element	Greece, Turkey; scattered but in most parts of FC. Locally abundant.
comosa	Mediterranean element	(both varieties) Mainly Greece. Turkish locations probably all historical. Var. comosa new for Cyprus. Uncommon.
columnaris	Mediterranean / Western Asiatic element	Westward to Crete;rare in Iran; mainly in Turkey and western arc of FC, but scattered in eastern part as well. Uncommon.
crassa	Western Asiatic element	Throughout, but mainly northern part of FC; well presented in Central Asia up to Tian Shan mountain ranges. Occasionally in steppe (Syria, W Iraq). Locally common.
cylindrica	Mediterranean / Western Asiatic / Circumboreal element	Widespread, with tendency to weed behaviour. Adventive in Europe and USA. Mainly at higher latitudes. Common throughout, but rare in W part of FC.
juvenalis	Western Asiatic element	Mainly Armeno-Iranian, Turanian and Turkestanianprovinces. Scattered in N part of FC. Rare.
kotschyi	Mediteranean / Western Asiatic element	Coastal Libya, Egypt. Throughout FC but mainly western arc. Scattered in Central Asia, eastern arc of FC, Kuwait and E Saudi Arabia. Locally common.
longissima	Mediterranean element	Coastal Egypt, Palestine; rare in Jordan. Limited distribution and uncommon to rare.
neglecta	Mediterranean / Western Asiatic / Circumboreal element	Widespread in S Europe, westward to Portugal; rare in western North Africa; scattered throughout FC; eastward to W Turkmenia. Locally abundant.

Table 49. (continued)

Species	Takhtajan (1986) term	Notes
ovata	Mediterranean / Western Asiatic / Circumboreal element	Throughout southern Europe and North Africa (more rarely in the eastern parts); only western arc of FC. Adventive in central and northwestern Europe. Common.
peregrina	Mediterranean element	(both varieties) Mainly western part of FC and locally common. Rare in Greece, Egypt, Turkey. Both vars. adventive in Morocco.
searsii	Mediterranean element	Limited to Palestine, Syria, Jordan, Lebanon. Uncommon.
sharonensis	Mediterranean element	Endemic in Sharon plain, Palestine, and S Lebanon. Locally common.
speltoides	Western Asiatic element	(both varieties) Widespread in but mainly limited to entire FC. Locally common.
tauschii	Western Asiatic element	Almost exclusively east of 40° longitude in Western Asiatic subregion. Only northern part of FC. Common.
triuncialis	Mediterranean / Western Asiatic / Circumboreal element	Widespread in southern Europe ,Western and central Asia; less so in western part of North Africa. Common. Var. persica rare and only Western Asiatic.
umbellulata	Mediterranean / Western Asiatic element	Turkey, Iran, and mainly northern and eastern FC. Uncommon.
uniaristata	Mediterranean element	Adriatic coast, Greece; rare in Turkey. Uncommon, but mainly rare.
vavilovii	Western Asiatic element	Western and northern FC. Uncommon to rare.
ventricosa	Mediterranean / Circumboreal element	Western parts of North Africa and Mediterranean; rare in Italy, Libya, and Egypt. Uncommon.

a : FC = Fertile Cresent (see text).

A summary of the distribution areas of all Aegilops and Amblyopyrum species is presented in Table 49, together with a general characterization in the terminology of Takhtajan's (1986) Floristic Regions of the World.

M. van Slageren

1.4.7. Relationships among wild Lens species and genetic diversity within Lens species

Stepwise discriminant analysis was run with the quantitative descriptors for the four wild Lens species evaluated in Section 1.1.12 and DFLR, DAP, DDFLR, DDAP, PTHT, PWX, PWY, LFTL LFTW, LFL, LPP, LAP, and LFL were selected for further analysis. Discriminant analysis was run using canonical functions of the 13 descriptors selected above and the three canonical functions were found significant by Wilks lamda.

Overall, there was a correct species classification rate of 79.4% based on quantitative traits. Hierarchical cluster analysis based on species centroids of canonical functions (all three significant) from the above discriminant analysis indicated that L. orientalis and L. odemensis were the most closely related species, with this set related to L. nigricans (Figure 29). L. ervoides was very distinct from the other wild Lens species. Most other researchers have found similar results using isozyme, RFLP

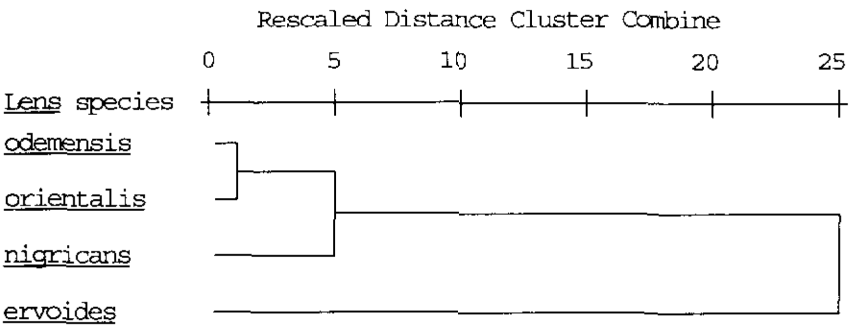


Figure 29. Dendrogram of Lens species based on canonical discriminant function centroids developed from quantitative descriptors

and DNA analysis, with the exception of the interchange of nigricans and L. ervoides. However, in a recent paper Rosa and Jouve (1992) have found the same relationships among wild Lens species, including the positons of L. nigricans and L. ervoides with 11 polymorphic isozyme loci using Spanish accessions.

Qualitative descriptor frequencies were used to cluster the four wild Lens species (Figure 30) with similar results found with the

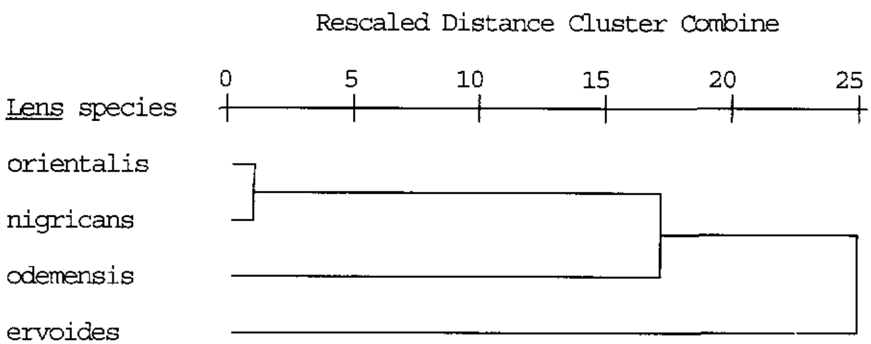


Figure 30. Dendrogram of Lens species based on frequencies for qualitative descriptors

exception that L. nigricans and L. odemensis were interchanged and L. odemensis was closer to L. ervoides. The phylogeny tree developed by cluster analysis from eight isozyme loci (Figure 31) was very similar to the results from quantitative descriptors

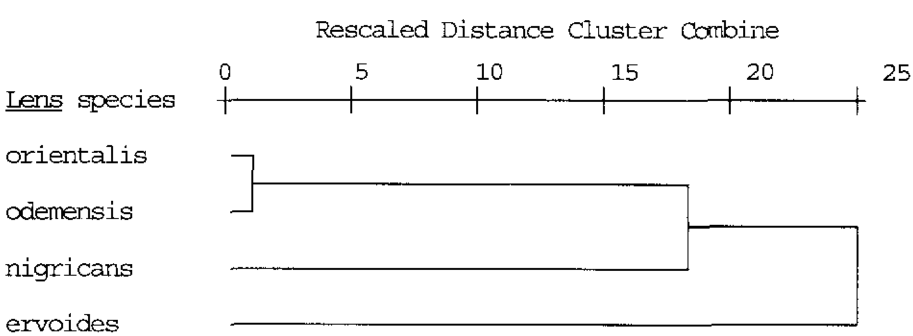


Figure 31. Dendrogram of Lens species based on frequencies for eight isozyme loci

(Figure 29), with the only change being that L. nigricans moved closer to L. ervoides.

The results from Figures 29-31 suggest that the species L. orientalis and L. odemensis are the closest related wild Lens species and that L. nigricans is fairly closely related to this cluster, with L. ervoides set aside from the other three wild species. The results of others with isozymes and DNA techniques are similar, except for the interchange of L. nigricans and L. ervoides.

For L. orientalis, the 126 accessions with geographical origin information were clustered according to five regions (EturNEsyr=eastern Turkey and northeastern Syria, 15 accessions; SturNWsyr=southern Turkey and northwestern Syria, 74 accessions; Ssyr=southern Syria, 18 accessions; Ntur=northern Turkey, 8 accessions; Wtur=western Turkey, 11 accessions).

Using canonical discriminant function centroids developed from the quantitative descriptors (three significant) heirarchical cluster analysis revealed that the most closely related regions were the northern part of Syria and southeastern Turkey (Figure 32). Southern Syria was fairly closely related to this cluster,

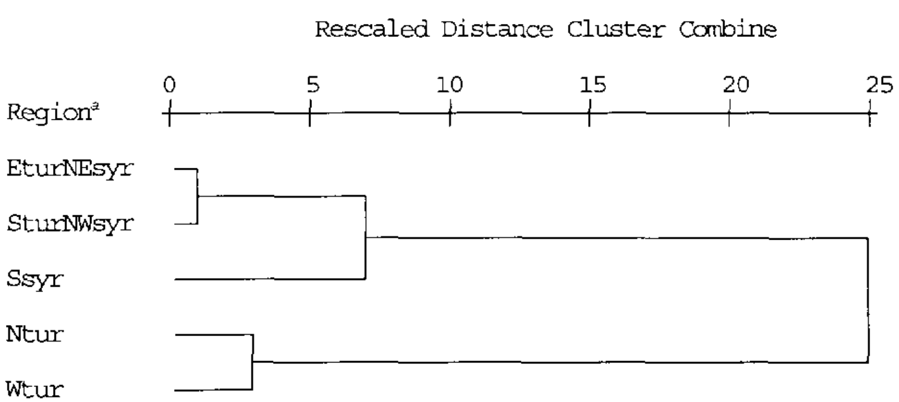


Figure 32. Dendrogram of five sub-regions ([a]see text for description) for Lens orientalis developed based on canonical function centroids developed from discriminant analysis of quantitative descriptors

however, northern and western Turkey formed a closely linked cluster that was not related to the other three regions. The results from using the eight isozyme loci were similar for the cluster for the northern Syria and southeastern Turkey cluster (Figure 33). However, northern Turkey stood by itself and western Turkey and southern Syria formed a tightly linked cluster that was linked with the cluster for northern Syria and southeastern Turkey.

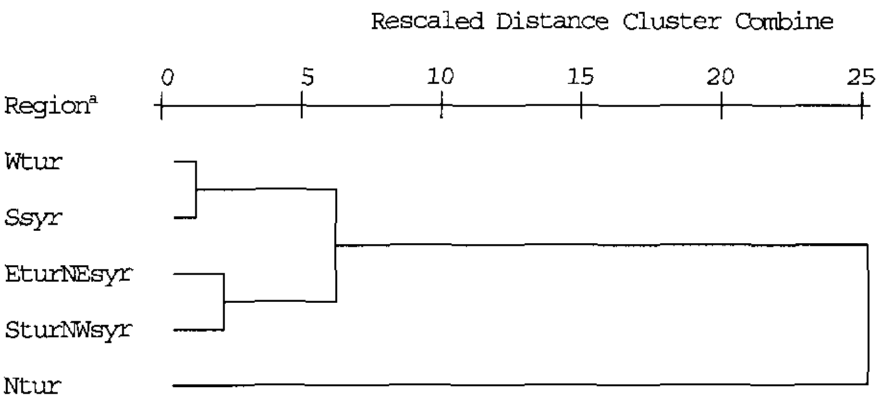


Figure 33. Dendrogram of five sub-regions ([a]see text for description) for Lens orientalis developed based on eight isozyme descriptors

Overall, there seems to be a relationship of isozyme and quantitative descriptor information to geographical region of origin. The area of southeastern Turkey and northern Syria forms a tightly linked group, with southern Syria fairly closely linked with this cluster, based on both quantitative and isozyme descriptors and northern Turkey is quite distinct from this group.

Data from eight isozyme loci were used to calculate genetic diversity for the four wild species of Lens based on the Shannon Weaver Information index and Nei's heterozygosity index (Table 50). These diversity measures indicate that the most genetic diversity was with L. orientalis, followed by L. nigricans and L. odemensis, with the least diversity for L. ervoides. L. orient-

Table 50. Genetic diversity of the four Lens species as measured by eight isozyme loci using the Nei's heterozygosity index (H_e) and the Shannon-Weaver Information index (H)

	Species (H_{s*j})[a]			
Locus	orientalis n=142	odemensis n=30	nigricans n=90	ervoides n=33
PGI-1	0.042	0.145	0.000	0.000
PGI-2	0.128	0.000	0.000	0.000
PGD-1	0.807	0.145	0.061	0.363
PGD-2	0.042	0.451	0.000	0.000
ACP	0.185	0.245	0.241	0.590
ME-1	0.147	0.145	0.106	0.590
ME-2	1.339	0.271	0.226	0.698
AAT-4	0.629	0.000	0.241	0.000
H	0.415	0.225	0.109	0.280
H_e	0.214	0.112	0.046	0.139

a : H_{s*j} is H on a per locus basis.

alis showed at least 50% higher diversity than the other species.

The accessions for L. orientalis were subdivided into the five sub-regions as above for determining differences in genetic diversity for these regions by use of the eight isozyme loci. The highest genetic diversity was found for the southeastern Turkey and northern Syria regions and northern Turkey, followed by western Turkey (Table 51). The lowest diversity was for southern Syria.

The loci with the highest genetic diversity and polymorphism were the PGD-1, ACP, ME-1, and ME-2 loci. These showed genetic diversity for all four species (Table 50). However, PGI-2 showed diversity for only one species and the other loci showed diversity for only two species. For Lens orientalis , PGD-1 and ME-2 showed the highest diversity.

M. Ferguson and L.D. Robertson

Table 51. Genetic diversity for five geographical regions for _L. orientalis_ as measured by eight isozyme loci using the Nei's heterozygosity index (H_e) and the Shannon-Weaver Information index (H)

	Region (H_{s*j})				
Locus	**Ntur n=7**	**Wtur n=11**	**Etur/ NEsyr n=13**	**Ssyr n=18**	**Stur/ NWsyr n=65**
PGI-1	0.410	0.000	0.000	0.000	0.000
PGI-2	0.683	0.000	0.000	0.000	0.000
PGD-1	0.956	0.586	0.688	0.591	0.673
PGD-2	0.000	0.000	0.000	0.216	0.000
ACP	0.000	0.601	0.000	0.000	0.157
ME-1	0.000	0.000	0.271	0.000	0.216
ME-2	0.599	0.760	1.672	0.636	1.367
AAT-4	0.000	0.305	0.271	0.000	0.769
H	0.331	0.282	0.363	0.180	0.398
H_e	0.214	0.163	0.182	0.119	0.217

a : H_{s*j} is H on a per locus basis.

1.5. Documentation of genetic resources

Documentation of a sample in a genebank starts at the receipt of material and continues throughout its life span. The initial data on samples entering the germplasm collections (usually passport data only) is gradually expanded following characterization and evaluation work done by curators and cooperators. The files related to availability of material and its distribution to users have to be kept up to date to assist in collection management. The Documentation Section of GRU routinely handles the data for newly acquired material, the data from current experiments, and seed stock control information.

The GRU's documentation system was significantly altered in 1991 after acquisition of Personal Computers (see GRU Annual Report of 1991). In 1992 the software was further 'tuned' to increase flexibility and performance of data handling. In particular, functions related to seed stock control, label generation, export of data to different packages, etc. were implemented. The main emphasis, however, was placed on perusal of existing data for inaccuracies, inconsistences and gaps.

The collection data concerning germplasm acquired during ICARDA missions in 15 years were verified. The summaries of missions (species collected, sites visited, and collectors and organizations involved with missions) are being compiled for publication in 1993; detailed data will be available through a specialized database. In order to take advantage of map preparation software, the latitude-longitude coordinates of sites were estimated, when needed, by referring to locality details and consultation of maps.

The passport data of material donated to ICARDA collections were also examined and compared with records from donors. Due to GRU involvement in the establishment of a barley core collection, priority was assigned to improvement of documentation for barley. ICARDA's data base was compared with data obtained from the Small

Grains Collection of USDA (donor of more than 12000 accession), as well as the database established by the European Cooperative Program for Plant Genetic Resources (ECP/GR). The exercise proved to be very useful. For instance, the origin of approximately 3500 accessions was clarified, missing collection numbers and site details were obtained, etc. Experience gained during linking the databases will certainly be useful for production of a regional database for barley.

Speedy transfer of data obtained during evaluation of samples in the field or in the laboratory to computer files, which can be subsequently processed, is of paramount importance in research. Traditionaly, the experimental data are written in field books or forms and than typed in into the data files. This is a tedious, error prone, and time consuming process. In 1992 GRU introduced "PSION Organizer II" datalogers to facilitate and significantly reduce the time of data entry. Necessary software was developed. The devices were used in the labs and field testing will take place in 1993.

Germplasm collections maintained by GRU are being duplicated in base collections in other organizations. Full documentation of samples is always sent along with seeds. In addition, an "Agreement on Safety Duplication of ICARDA's Genetic Resources Data at IBPGR" has been developed and databases of all crops were duplicated in 1992. According to the above agreement, the data sets will be replaced annually.

J. Konopka and A. Antypas

1.6. Germplasm management

1.6.1 Viability testing of cereal germplasm

Monitoring germplasm viability is an on-going activity at the Genetic Resource Unit since 1990. Up to date, 50% (10123 accessions) of barley germplasm accessions have been tested for viability, this includes 4842 viability tests conducted in the 1991/1992 season. The germination tests were carried out in four replications in the laboratory on seeds stored in the medium-term store (active collection).

Results of viability testing indicate that 91% of the tested accessions had a high viability percentage (>90%) and a total of 9665 accessions, which represents 95.5% of the tested barley, showed good germination (>80%). The remaining 4.5% of the accessions will be rejuvenated due to insufficient viability.

For durum wheat germplasm, results of viability testing indicated that 83% of the tested accessions (7486) had a high viability percentage (>90%) and a total of 6686 accessions, which represents 89.3% of the tested durum accessions, showed good germination (>80%). These results include 2839 viability tests conducted in the season 1991/92. The remaining 10.7% of the tested accessions will be rejuvenated due to insufficient viability.

B. Humeid and GRU staff

1.6.2. Monitoring viability for rejuvenated germplasm

All germplasm materials which showed low viability during germination tests in 1990/91, and which were planted for rejuvenation in the 1991/92 season, were retested for viability after harvest. In total, fresh seed of 1237 accessions (599 barley and 638 durum wheat) had been retested for viability and stored in the medium-term store (active collection).

B. Humeid and GRU staff

1.6.3 Cleaning gene bank accessions from seed-borne viruses

Cleaning gene bank accessions from seed-borne viruses was conducted in two different directions. Seeds stored in the gene bank were tested and accessions being multiplied were tested and infected plants were eliminated to permit harvest only of clean seeds.

Seeds of 900 barley accessions and 400 lentil accessions from the gene bank were tested and around 10% of the accessions were found to contain seed-borne infections. Healthy accessions will be stored in the gene bank and infected ones are destined for cleaning during the next grown season.

K. Makkouk and W. Radwan

2. SEED HEALTH ACTIVITIES

The major activity of the ICARDA Seed Health Laboratory (SHL) in the 1991/92 season was to ensure freedom of incoming/outgoing genetical materials from seed-borne pathogens/pests. The SHL was also active in training of national scientists in seed health testing.

2.1 Activities on incoming seeds

During the 1991/92 season the SHL received 110 seed consignments from cooperators of 33 countries, after being released from the Syrian Quarantine Authority. In order to prevent introduction of exotic insects to Tel Hadya station, all incoming seeds were immediately fumigated with phostoxin (aluminum phosphide) or treated at -18 °C for 7 days before the consignment was opened.

2.1.1 Laboratory testing and treatment

After registration, seeds were inspected visually for disease symptoms (discoloration, bunt balls, and nematode galls) and impurities (soil particles, weed seeds, etc.). Tables 52 and 53 show that the total number of tested lines was 11868 (11570 cereals and 298 legumes). This was about 43% more than the previous season.

Special attention was given to pathogens which do not occur in Syria (Tilletia indica, and T. contraversa) and to pathogens which are known to occur in Syria, but where there is risk of introducing new races (Urocystis agropyri on wheat, Accochyta rabiei and Fusarium oxysporum f.sp. ciceri on chickpea, Ustilago spp. on wheat and barley, T. caries and T. foetida on wheat, and Xanthomonas translucens on cereals). The detected pathogens during this season were similar to that of the previous season. Many bread wheat lines (2774) were found contaminated with the quarantine pathogens T. indica, T. contraversa, and U. agropyri,

Table 52. Seed health tests conducted on cereal seeds newly introduced to ICARDA in 1991/92

Crop	Number of lines: Tested	Found Clean	Found Infected	Tests carried out	Pathogens observed
Durum wheat	565	520	54	Karnal bunt test or centrifuge wash test	Tilletia caries and/or T. foetida (44)[a] Urocystis agropyri (1)
Bread wheat	9327	4542	4785	Karnal bunt test or centrifuge wash test	Tilletia caries and/or T. foetida (2011), Urocystis agropyri (11); T. contraversa (88), T. indica (2240), Tilletia spp., T. indica, T.contraversa, and U. agropyri (435)
Barley	999	856	143	Centrifuge wash test Freezing blotter test	Helminthosporium spp. (19), Fusarium spp. (50), Fusarium. spp. and Helminthosporium spp. (69). Tilletia spp (5)
Triticale	351	346	5	Centrifuge wash test	Tilletia indica (5)
Wild wheat	327	310	17	Centrifuge wash test	Tilletia caries and/or T. foetida (17)
Wild barley	1	1	-	Centrifuge wash test	-
Total	**11570**	**6575**	**4995**		

a : Numbers in parenthesis refer to infested entries.

Table 53. Seed health tests conducted on food and forage legumes and oil seeds newly introduced to ICARDA in 1991/92

Crop	Number of lines			Tests carried out	Pathogens observed
	Tested	Found Clean	Found Infected		
Lentil	14	12	2	Freezing blotter test agar media test	Fusarium spp. (2)[a]
Faba bean	182	177	5	Agar media test	Fusarium spp. (3) Ascochyta spp. (2)
Chickpea	47	45	2	Agar media test	Fusarium sp (1), Ascochyta sp. (1)
Pea	3	1	2	Test on king's B agar	Pseudomonas sp. (2)
Oil seeds	48	35	13	Freezing blotter test Agar media test	Fusarium spp. (9); septoria spp. (2) Phoma spp. (2)
Vetch	1	1	-	Freezing blotter test	-
Medic	3	3	-	Freezing blotter test Test for stem Nematode	-
Total	**298**	**274**	**24**		

a : Numbers in paranthesis refer to infested entries.

and were subsequently destroyed (Table 52). Legume seeds received were only sporadicly contaminated by one on more of the pathogens indicated in Table 53.

Seeds which were not treated by the sender were treated at the SHL with the appropriate fungicide.

2.1.2 Field inspection

In order to detect any exotic pathogen that was not evident at the time of seed inspection at the SHL, so as to protect ICARDA germplasm from infection, and as per center policy, all imported seeds proved free of quarantine pathogens were planted at the Post-entry Quarantine Area for one generation. In the 1991/92 cycle, about 18 ha were planted to imported seeds. The field inspections were carried out two times for all plots and revealed one quarantine pathogen (U. agropyri). Infected plants were rogued and burned.

2.2. Activities on Seed Dispatched Internationally

In the 1991/92 season, 440 total consignments of international nurseries (210) and specific trait germplasm (230) were distributed from ICARDA, accompanied by phytosanitary certificates and certificates of origin to cooperators in 81 countries. This represented about on 18% decrease in seed dispatch compared to the previous season.

2.2.1. Laboratory testing and treatment

Seed health testing was carried out on samples of harvested plots from Tel Hadya station. Special attention was given to samples from plots where seed-borne diseases were found during field inspection and whenever special declaration was requested by the recipient to indicate the absence of a specific pathogen. Samples infected with U. agropyri were discarded from shipment.

Information on number of tested and infected lines and detected pathogens are summarized in Table 54. The total number of tested

Table 54. Seed health tests conducted on seeds dispatched internationally from ICARDA in 1991/92

Crop	Number of lines			Tests carried out	Pathogens observed
	Tested	Found Clean	Found Infected		
Durum wheat	611	448	163	Centrifuge wash test	Tilletia caries and/or T. foetida (160), Urocystis agropyri (3)[a]
Bread wheat	721	382	339	Centrifuge wash test	Tilletia caries and/or T. foetida (332), Urocystis agropyri (7)
Barley	1230	613	617	Centrifuge wash test Freezing blotter test	Helminthosporium spp. (40), Fusariumspp. (466), Fusarium spp. and Helminthosporium spp. (56); Urocytis agropyri (5); Tilletia spp.(50)
Wild wheat	42	31	11	Centrifuge wash test	Tilletia caries and/or T.foetida (11)
Lentil	117	92	25	Freezing blotter test	Fusarium spp. (34) Ascochyta sp. (1)
Chickpea	410	284	126	Freezing blotter test Agar media test	Fusarium spp. (126)
Pea	87	76	11	Test on King's B agar	Pseudomonas sp. (11)
Medic	101	101	-	Test for stem nematode	-
Total	**3319**	**2027**	**1292**		

a : Numbers in parenthesis refer to infested entries.

lines decreased by about 3% compared to the previous season. All outgoing seeds are treated with fungicides / insecticides, unless specific request is made by the consignee.

2.2.2 Field inspection

Field inspection was carried out two times during the season at appropriate growth stages. It covered about 145 ha of seed increases / multiplication plots of different crops destined for international dispatch. The occurrence of flag smut in these plots was low during the season, but the number of contaminated fields was higher (4 fields compared to 1 field in the previous season). Barley stripe mosaic virus was frequent in some barley plots. Several potential seed-borne pathogens were inspected during the season. They were: Fusarium oxysporum, Pyrenophora graminea, Rhynchosporium secalis, T. caries and/or T. foetida, Ustilagon uda, U. tritici, broad bean stain virus, and Orobanche spp. Infected or even suspected plants were rogued and burned.

A. El-Ahmed and S. Asaad

3. VIROLOGY LABORATORY

The virology laboratory continued this year to be involved in a wide range of research and service activities. The interaction with national programs of the region was intensified further, through joint surveys and receiving colleagues from different WANA countries, who spent varied periods of time from a few weeks to a few months, receiving training in new techniques for sensitive virus detection in seeds or leaves of infected plants.

3.1. Legume viruses

3.1.1. Survey of virus diseases

3.1.1.1. Faba bean necrotic yellows virus

Faba bean necrotic yellows virus (FBNYV) is a newly characterized virus with small isometric particles around 18 nm in diameter, with a single stranded DNA and is persistently transmitted by aphids. This virus, confused for some time with bean leaf roll virus, proved to be very damaging to faba bean and other legumes. Because of its potential importance in the WANA region, a preliminary survey was conducted to evaluate its distribution in the region. The results suggest that FBNYV is prevalent in Algeria, Egypt, Ethiopia, Jordan, Lebanon, Syria, and Turkey (Table 55). There was a good indication that this virus was epidemic in Egypt and an intensive survey for this virus in Egypt is planned for 1993.

K.M. Makkouk and S.G. Kumari

3.1.1.2. Luteoviruses

In the past, the belief was that bean leaf roll virus is the most common luteovirus in cool season legumes. Testing samples over the last few years has shown some serological variability among the samples identified as bean leaf roll virus on the basis of symptoms. Using three polyclonal antisera for three distinct luteoviruses;

Table 55. Serological (ELISA) detection of faba bean necrotic yellows virus (FBNYV) in legume samples with symptoms suggestive of virus infection collected from different countries of West Asia and North Africa during 1990-1992

	Number of plants infected with FBNYV /Total number of plants tested			
Country	**Faba bean**	**Lentil**	**Chickpea**	**Forage legumes**
Algeria	0/2	8/43	1/1	-
Egypt	16/56	9/25	4/22	13/34[a]
Ethiopia	2/5	-	-	-
Jordan	8/18	-	-	-
Lebanon	4/17	14/35	4/47	-
Libya	0/47	0/6	-	-
Sudan	0/5	-	-	-
Syria	99/229	152/308	79/185	19/27[b]
Tunisia	0/23	-	-	-
Turkey	17/34	20/76	98/143	-
Total	**146/436**	**203/493**	**186/398**	**32/61**

a : Clover samples.
b : Forage legumes were *Medicago*, *Melilotus*, *Trifolium*, and *Vicia*.

bean leaf roll virus (BLRV), beet western yellows virus (BWYV) and a newly identified luteovirus at ICRISAT, chickpea luteovirus (CPLV), showed that in Lebanon, Syria, and Turkey there is more than one luteovirus affecting chickpea, faba bean, and lentil (Table 56). Such information has consequences on screening for virus resistance in these crops.

K.M. Makkouk and S.G. Kumari

3.1.1.3. Lentil seed-borne viruses in Syria

Lentil fields in northern, southern, central, and northeastern regions of Syria were surveyed during 1990-1992 to determine the presence of the two lentil seed-borne viruses, pea seed-borne

Table 56. *Viruses in chickpea, faba bean, and lentil samples with virus-like symptoms collected from Lebanon, Syria, and Turkey during May of 1992. Identification was based on serological reaction (ELISA)*

Country Crop	No. of plants tested	No. of plants found positive to BWYV	CPLV	BLRV
Lebanon				
Chickpea	47	1	5	1
Faba bean	17	0	0	3
Lentil	35	3	8	0
Syria				
Chickpea	152	53	36	43
Faba bean	20	2	8	9
Lentil	69	8	5	0
Turkey				
Chickpea	143	20	20	17
Faba bean	34	2	5	0
Lentil	76	5	3	2
Total				
Chickpea	342	74	61	61
Faba bean	71	4	13	12
Lentil	180	16	16	2

mosaic (PSbMV) and broad bean stain (BBSV) viruses. A total of 104 fields were surveyed and 200 lentil seedlings, soon after emergence, were collected from each field. Serological (ELISA) tests revealed the presence of PSbMV in 1% of the samples collected from the southern region only, whereas BBSV was detected in 0.21, 0.19, 0.26, and 3.35% of the samples collected from the above mentioned four regions, respectively.

K.M. Makkouk and S.G. Kumari

3.1.2. Yield loss and seed-transmission rates in lentils.

The yield of 20 lentil genotypes was evaluated after artificial inoculation with PSbMV. Losses due to infection varied between 3%

in 'Red Chief' and 61% in 'ILL 6245'. Variability in PSbMV seed-transmission rates was also evaluated for the same lentil genotypes and seed transmission rates varied between 0.0 and 1.7%. It is worth noting that the two genotypes 'Palouse' and 'Red Chief', which had the least yield loss due to PSbMV infection, also had extremely low seed-transmission rates (Table 57).

Table 57. Reaction of twenty lentil genotypes after artificial inoculation with pea seed-borne mosaic virus (PSbMV) during the growing season 1991-1992

No.	Genotype	Origin	Pedigree	Percent Yield loss	Estimated seed transmission rate (%)
1.	ILL 4400	Syria	Syrian Local	33	1.3
2.	ILL 4401	Syria	Syrian Local	37	0.0
3.	ILL 5582	Jordan	78S 26002	24	0.0
4.	ILL 5588	Jordan	78S 26013	49	1.5
5.	ILL 5699	ICARDA	FLIP84-27L	38	0.0
6.	ILL 5700	ICARDA	FLIP84-29L	35	0.4
7.	ILL 5816	ICARDA	FLIP84-147L	21	0.0
8.	ILL 5873	ICARDA	FLIP85-35L	32	0.2
9.	ILL 5994	ICARDA	FLIP86-8L	31	0.6
10.	ILL 6015	ICARDA	FLIP86-29L	50	0.2
11.	ILL 6193	ICARDA	FLIP87-3L	27	0.0
12.	ILL 6198	ICARDA	FLIP87-8L	15	0.0
13.	ILL 6220	ICARDA	FLIP87-30L	38	1.1
14.	ILL 6226	ICARDA	FLIP87-36L	44	0.0
15.	ILL 6229	ICARDA	FLIP87-39L	29	0.0
16.	ILL 6245	ICARDA	FLIP87-55L	61	0.8
17.	Chilean 78	U.S.A.	-	40	1.7
18.	Crimson	U.S.A.	-	14	0.2
19.	Palouse	U.S.A.	-	6	0.0
20.	Red Chief	U.S.A.	-	3	0.2

Another field experiment was conducted to evaluate yield loss of the lentil cultivar 'Syrian Local' in response to infection with the two viruses PSbMV and BBSV. Results showed that yield loss due to virus infection at the pre-flowering, flowering, and pod setting growth stages were 24, 31, and 35% for BBSV and 28, 27, and 23% for PSbMV, respectively. In the same experiment, seed transmission rates of the two viruses were determined. Results indicated that BBSV seed-transmission rates were 20.6, 19.1, and 1.5%; PSbMV seed-transmission rates were 2.2, 1.5, and 0.4% when plants were inoculated at pre-flowering, flowering, and pod setting growth stages, respectively.

K.M. Makkouk and S.G. Kumari

3.2. Cereal viruses

3.2.1. Effect of resistance to BYDV in barley on BYDV movement

Migration of BYDV was evaluated under greenhouse conditions in four resistant and two susceptible barley genotypes. ELISA tests revealed that virus particles reached the root system of the susceptible genotypes 6-15 days earlier than in resistant ones (Figure 34). The study showed that slow virus movement could be one factor which contributed to the mechanism of BYDV resistance in barley. The possible use of this characteristic to differentiate between BYDV-resistant and susceptible barley genotypes will be investigated during the coming season.

K.M. Makkouk and W. Ghoulam

3.3. Testing for seed-borne viruses

3.3.1. Testing seed samples for international nurseries

Eight hundred lentil seed lots destined for international nurseries were tested for the presence of possible seed-borne infections. Seed lots which did not meet the health standards set by ICARDA and by the importing countries were discarded.

K.M. Makkouk and W. Radwan

3.3.2. Cleaning barley seed stocks

In collaboration with the Agriculture Research Center in Syria, seed

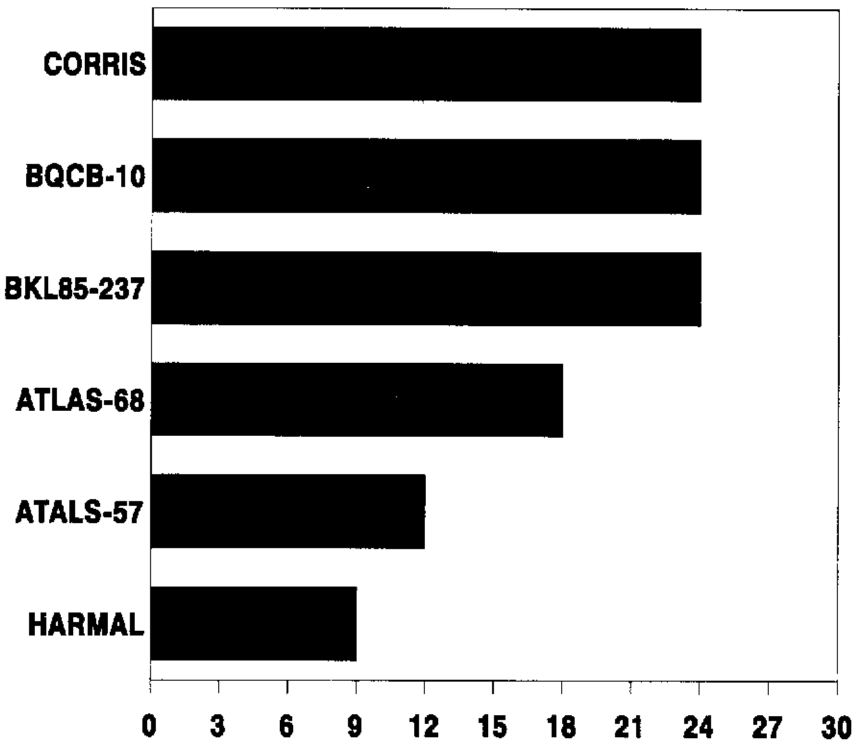


Figure 34. Period of time after inoculation (days) required for barley yellow dwarf virus to reach the roots of resistant (Corris, BQCB-10, BKL 85-237, and Atlas 68) and susceptible (Atlas 57 and Harmal) barely genotypes

stocks of five barley cultivars were cleaned from seed-borne barley stripe mosaic virus. Plants of all cultivars were tested individually and those found infected were eliminated. It was possible to produce virus-free stocks for the cultivars Zanbaka, Tadmor, Rihane 03, and WI 2291. It was not possible to completely clean the cultivar Arabi Aswad, and efforts will continue next season to produce a healthy stock of this cultivar.

K.M Makkouk and W. Radwan

3.3.3. Roguing faba bean increases

In collaboration with the Seed Health Laboratory, around 2.5 hectares of faba bean were inspected and rogued three times during the spring of 1992. Plants suspected to be virus-infected were eliminated.

K.M. Makkouk and W. Radwan

3.4. Production of ELISA kits

Over the last 3 years a number of legume and cereal viruses were purified at the ICARDA virology lab. and polyclonal antisera in rabbits were produced. From these antisera, after testing them for quality, ELISA kits were prepared and made available for laboratories of the national programs in WANA. In each kit there is enough immunoglobulins and enzyme conjugate to test 2000 samples. The following ELISA kits are now available:

Legume viruses

- Broad bean mottle virus
- Broad bean stain virus
- Broad bean wilt virus
- Chickpea luteovirus
- Cucumber mosaic virus
- Alfalfa mosaic virus

Cereal viruses

- Barley yellow dwarf virus
- Barley strip mosaic virus

K.M. Makkouk and S.G. Kumari

4. TRAINING

4.1. Training in genetic resources activities

On request of the NARS in WANA, a number of trainees received individual training in the Genetic Resources Unit at ICARDA Headquarters, Tel Hadya, Syria, in activities relating to plant taxonomy and species identification, germplasm evaluation, and documentation. Dr. N. Maxted, a consultant from the University of Southampton, U.K., assisted in training for a legume identification course. A summary of the training is presented in Table 58.

Table 58. Trainees in genetic resources activities in 1991/92

Topic	Type of course	No. of trainees	Country	Course duration
Forage legume identification	short	8	Syria, Algeria, Tunisia	2 weeks
Forage legume identification	individual	1	Tunisia	2 weeks
Chickpea evaluation	individual	1	Iran	3 weeks
Germplasm documentation	individual	1	Syria	2 weeks
Classification of wild _Triticum_	individual	1	Syria	1 week

4.2. Training in seed health activities

Three scientists from the Syrian Quarantine Direction were trained for six months on seed health testing and field inspection. One scientist from China was trained for two months on seed health testing. The SHL personnel have covered in lectures and practicals seed health aspects in the residential courses of the improvement programs and in country training courses as well.

4.3 Training in virology

During 1992 the virology laboratory received five visiting scientists from Syria, Egypt, Lebanon, and the Netherlands, for a period of two to eight weeks each. The laboratory also received eight trainees from Oman, Lebanon, and Syria.

A three week intensive virology course was conducted in Egypt in collaboration with FAO, ICAMAS, and ORSTOM.

GRU Staff

5. PUBLICATIONS

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6. GRU STAFF LIST IN 1992

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Dr Ardeshir B. Damania	Cereal Germplasm Curator
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Mr. Ali Abdullah Ismail	Research Assistant II
Mr. Ali Shehadeh	Research Assistant II
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Jan Valkoun

APPENDIX

The following tables are presented in the appendix:

Table A1.	Monthly precipitation (in mm) for the 1991/92 season.
Table A2.	Monthly air temperature (°C) for the 1991/92 season in Tel Hadya.
Table A3.	Frost events during the 1991/92 season in Tel Hadya.
Table A4.	Status of ICARDA collections by origin (December 1992).
Table A5.	Status of cereal collections by origin (December 1992).
Table A6.	Status of food legume collections by origin (December 1992).
Table A7.	Status of forage legume collections by origin (December 1992).
Table A8.	Distribution of germplasm in 1992.
Table A9.	Distribution of cereals in 1992.
Table A10.	Distribution of food legumes in 1992.
Table A11.	Distribution of forages in 1992.

Table A1. Monthly precipitation (in mm) for the 1991/92 season

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Total
1991/92 season	0.0	73.0	25.2	74.0	62.3	75.4	15.8	0.4	23.0	3.5	0.0	0.0	**352**
Long term aver. (13 s.)	0.5	28.0	46.9	55.2	61.0	52.0	41.9	26.4	14.9	3.1	0.0	0.0	**329**
% of long term average	0	261	54	134	102	145	38	2	154	113	-	-	**107**

Table A2. Monthly air temperature (°C) for the 1991/92 season at Tel Hadya

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Mean maximum	34.3	28.0	20.1	11.2	7.8	8.5	15.9	23.9	28.0	32.7	34.9	37.6
Mean minimum	17.1	13.2	6.8	2.5	-1.5	-0.3	1.2	5.6	10.5	15.5	18.8	21.1
Average	25.7	20.6	13.5	2.3	3.2	4.1	8.6	14.8	19.3	24.1	26.9	29.4
Absolute maximum	40.3	35.6	24.6	14.3	13.5	13.2	23.6	30.8	38.4	38.6	40.6	42.5
Absolute minimum	12.1	8.2	0	-4.5	-8.8	-6.2	-7.2	-0.2	5.5	11.8	11.2	18.2

Table A3. Frost events during the 1991/92 season

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
Number of frost days	1	7	19	13	13	1	-	57
Absolute minimum (°C)	0.0	-4.5	-8.8	-6.2	-7.2	-0.2	-	-8.8
Number of frost events at 5 cm above ground	3	10	19	21	16	1	-	70
Absolute minimum (°) at 5 cm above ground	-0.5	-5.4	-9.6	-6.8	-8.3	-0.2	-	-9.6

Table A4. Status of ICARDA collections by origin (December 1992)

Origin	Cereals	Food Legumes	Forage Legumes	Total
WANA	**32545**	**12894**	**14644**	**60083**
Afghanistan	272	1112	157	1541
Algeria	1739	105	1689	3533
Armenia	35	-	-	35
Cyprus	164	181	405	750
Egypt	492	216	158	866
Ethiopia	9578	829	330	10737
Iran	500	2664	478	3642
Iraq	135	116	229	480
Jordan	1255	556	2068	3879
Lebanon	173	148	265	586
Libya	128	1	174	303
Morocco	1251	372	822	2445
Oman	113	4	21	138
Pakistan	982	444	62	1488
Palestine	1024	57	44	1125
Saudi Arabia	8	-	1	9
Syria	1734	1714	5177	8625
Tunisia	2251	312	117	2680
Turkey	4841	1597	2446	8884
United Arab Em.	7	-	-	7
Yemen	147	72	1	220
ICARDA lines	5716	2394	-	8110
EUROPE	**8332**	**2095**	**3676**	**14103**
Albania	4	2	19	25
Austria	90	1	1	92
Belgium	8	2	21	31
Bulgaria	256	78	76	410
Czechoslovakia	147	41	45	233
Denmark	110	1	16	127
Finland	44	-	16	60
France	159	48	143	350
Germany	1105	101	295	1501
Greece	729	142	420	1291

Table A4. (cont.) Status of ICARDA collections by origin (December 1992)

Origin	Cereals	Food Legumes	Forage Legumes	Total
Hungary	136	40	252	428
Ireland	3	-	-	3
Italy	537	147	614	1298
Malta	4	-	28	32
Netherlands	32	11	98	141
Norway	5	1	1	7
Poland	135	58	70	263
Portugal	770	86	193	1049
Romania	75	37	9	121
Soviet Union[a]	2119	361	288	2768
Spain	381	785	261	1427
Sweden	77	5	450	532
Switzerland	778	2	3	783
United Kingdom	158	82	327	567
Yugoslavia[a]	470	64	30	564
ASIA	**4451**	**2666**	**310**	**7427**
Bangladesh	-	36	-	36
Bhutan	30	-	-	30
China	2881	107	20	3008
India	551	2239	229	3019
Indonesia	-	1	-	1
Japan	294	6	56	356
Korea	195	-	-	195
Mongolia	4	-	1	5
Nepal	496	275	3	774
Sri Lanka	-	2	-	2
Thailand	-	-	1	1
AFRICA	**213**	**146**	**41**	**400**
Central Africa	2	-	-	2
Gabon	-	-	2	2
Kenya	22	-	4	26
Malawi	-	3	-	3

Table 4A. (cont.) Status of ICARDA collections by origin (December 1992)

Origin	Cereals	Food Legumes	Forage Legumes	Total
Mauritius	-	1	-	1
Nigeria	-	1	4	5
Rwanda	2	-	-	2
Senegal	-	-	3	3
Somalia	-	2	-	2
South Africa	168	-	3	171
Sudan	6	139	20	165
Tanzania	1	-	-	1
Uganda	-	-	4	4
Zaire	-	-	1	1
Zimbabwe	12	-	-	12
AMERICA	**3795**	**1371**	**649**	**5815**
Argentina	76	12	3	91
Bolivia	17	-	2	19
Brazil	33	4	4	41
Canada	331	175	41	547
Chile	57	688	18	763
Colombia	577	52	-	629
Costa Rica	-	1	-	1
Ecuador	8	98	2	108
Greenland	1	-	-	1
Guatemala	5	1	1	7
Mexico	109	149	3	261
Paraguay	2	-	4	6
Peru	130	41	4	175
United States	2434	148	555	3137
Uruguay	8	2	10	20
Venezuela	7	-	2	9
OCEANIA	**123**	**12**	**176**	**311**
Australia	123	11	160	294
New Zealand	-	1	16	17
Unknown	1695	719	2800	5214
TOTAL	**51154**	**19903**	**22296**	**93353**

a : Germplasm received by GRU prior to 1991.

Table A5. Status of cereals collections by origin (December 1992)

Origin	Barley	Wild Barley	Durum Wheat	Bread Wheat	Wild Wheat	Aeg.[a]	Total
WANA	**9233**	**1391**	**12222**	**6665**	**1248**	**1786**	**32545**
Afghanistan	176	8	79	4	-	5	272
Algeria	125	12	1074	457	-	71	1739
Armenia	-	-	-	5	7	23	35
Cyprus	7	4	101	1	-	51	164
Egypt	191	8	203	70	-	20	492
Ethiopia	2679	-	4847	2052	-	-	9578
Iran	156	56	93	5	-	190	500
Iraq	50	2	75	5	1	2	135
Jordan	132	128	271	17	509	198	1255
Lebanon	-	2	25	-	3	143	173
Libya	83	7	5	1	-	32	128
Morocco	740	4	237	208	-	62	1251
Oman	44	-	-	60	9	-	113
Pakistan	179	3	16	735	3	46	982
Palestine	7	927	32	-	40	18	1024
Saudi Arabia	3	-	5	-	-	-	8
Syria	447	215	377	85	267	343	1734
Tunisia	599	-	1270	373	-	9	2251
Turkey	1183	15	1679	982	409	573	4841
United Arab Em.	7	-	-	-	-	-	7
Yemen	89	-	58	-	-	-	147
ICARDA lines	2336	-	1775	1605	-	-	5716
EUROPE	**4022**	**69**	**3390**	**338**	**42**	**471**	**8332**
Albania	2	-	1	-	1	-	4
Austria	48	-	42	-	-	-	90
Belgium	6	-	2	-	-	-	8
Bulgaria	31	-	78	1	12	134	256
Czechoslovakia	94	-	25	27	-	1	147
Denmark	110	-	-	-	-	-	110
Finland	44	-	-	-	-	-	44
France	70	-	80	9	-	-	159

Table A5. (cont.) Status of cereals collections by origin (December 1992)

Origin	Barley	Wild Barley	Durum Wheat	Bread Wheat	Wild Wheat	Aeg.[a]	Total
Germany	1032	-	71	2	-	-	1105
Greece	18	-	699	3	-	9	729
Hungary	70	-	64	2	-	-	136
Ireland	1	-	2	-	-	-	3
Italy	16	-	516	5	-	-	537
Malta	-	-	4	-	-	-	4
Netherlands	29	1	-	2	-	-	32
Norway	5	-	-	-	-	-	5
Poland	111	-	24	-	-	-	135
Portugal	16	-	634	16	-	104	770
Romania	29	-	40	6	-	-	75
Soviet Union[b]	771	52	793	251	29	223	2119
Spain	224	2	153	2	-	-	381
Sweden	55	14	3	5	-	-	77
Switzerland	687	-	90	1	-	-	778
United Kingdom	139	-	15	4	-	-	158
Yugoslavia[b]	414	-	54	2	-	-	470
ASIA	**4176**	**39**	**166**	**69**	**-**	**1**	**4451**
Bhutan	30	-	-	-	-	-	30
China	2810	39	25	7	-	-	2881
India	398	-	130	22	-	1	551
Japan	244	-	10	40	-	-	294
Korea	195	-	-	-	-	-	195
Mongolia	4	-	-	-	-	-	4
Nepal	495	-	1	-	-	-	496
AFRICA	**156**	**-**	**54**	**3**	**-**	**-**	**213**
Central Africa	1	-	1	-	-	-	2
Kenya	-	-	22	-	-	-	22
Rwanda	-	-	2	-	-	-	2
South Africa	146	-	19	3	-	-	168
Sudan	6	-	-	-	-	-	6
Tanzania	-	-	1	-	-	-	1
Zimbabwe	3	-	9	-	-	-	12

Table A5. (cont.) Status of cereals collections by origin (December 1992)

Origin	Barley	Wild Barley	Durum Wheat	Bread Wheat	Wild Wheat	Aeg.[a]	Total
AMERICA	**3116**	**21**	**635**	**23**	**-**	**-**	**3795**
Argentina	17	13	45	1	-	-	76
Bolivia	14	1	2	-	-	-	17
Brazil	1	-	32	-	-	-	33
Canada	188	-	140	3	-	-	331
Chile	10	-	47	-	-	-	57
Colombia	569	-	8	-	-	-	577
Ecuador	4	-	4	-	-	-	8
Greenland	1	-	-	-	-	-	1
Guatemala	2	-	3	-	-	-	5
Mexico	18	1	89	1	-	-	109
Paraguay	2	-	-	-	-	-	2
Peru	110	-	19	1	-	-	130
United States	2170	6	241	17	-	-	2434
Uruguay	3	-	5	-	-	-	8
Venezuela	7	-	-	-	-	-	7
OCEANIA	**75**	**-**	**43**	**5**	**-**	**-**	**123**
Australia	75	-	43	5	-	-	123
Unknown	190	20	1241	48	140	56	1695
TOTAL	**20968**	**1540**	**17751**	**7151**	**1430**	**2314**	**51154**

a : Aeg.=Aegliops.
b : Germplasm received by GRU prior to 1991.

Table A6. Status of food legumes collections by origin (December 1992)

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
WANA	**1628**	**3988**	**315**	**6700**	**263**	**12894**
Afghanistan	94	118	-	878	22	1112
Algeria	33	26	-	46	-	105
Cyprus	104	28	3	46	-	181
Egypt	69	93	-	54	-	216
Ethiopia	378	376	-	66	9	829
Iran	15	901	7	1741	-	2664
Iraq	64	22	-	30	-	116
Jordan	23	370	12	143	8	556
Lebanon	36	70	-	28	14	148
Libya	-	1	-	-	-	1
Morocco	96	56	-	220	-	372
Oman	4	-	-	-	-	4
Pakistan	24	165	-	254	1	444
Palestine	4	1	2	33	17	57
Syria	329	542	163	645	35	1714
Tunisia	31	17	-	264	-	312
Turkey	137	375	128	800	157	1597
Yemen	13	59	-	-	-	72
ICARDA lines	174	768	-	1452	-	2394
EUROPE	**764**	**619**	**64**	**641**	**7**	**2095**
Albania	-	2	-	-	-	2
Austria	1	-	-	-	-	1
Belgium	-	2	-	-	-	2
Bulgaria	3	41	-	34	-	78
Czechoslovakia	12	21	-	8	-	41
Denmark	-	-	-	-	1	1
France	15	8	5	20	-	48
Germany	68	32	-	1	-	101
Greece	29	95	-	18	-	142
Hungary	15	23	-	2	-	40

Table A6. (cont.) Status of food legumes collections by origin (December 1992)

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
Italy	57	11	6	73	-	147
Netherlands	10	1	-	-	-	11
Norway	-	1	-	-	-	1
Poland	40	18	-	-	-	58
Portugal	14	14	-	58	-	86
Romania	33	3	-	1	-	37
Soviet Union[a]	51	147	27	132	4	361
Spain	322	176	5	280	2	785
Sweden	5	-	-	-	-	5
Switzerland	2	-	-	-	-	2
United Kingdom	73	1	-	8	-	82
Yugoslavia[a]	14	23	21	21	6	64
ASIA	**104**	**2147**	**-**	**414**	**1**	**2666**
Bangladesh	-	36	-	-	-	36
China	79	2	-	26	-	107
India	11	1843	-	384	1	2239
Indonesia	1	-	-	-	-	1
Japan	6	-	-	-	-	6
Nepal	5	266	-	4	-	275
Sri Lanka	2	-	-	-	-	2
AFRICA	**115**	**5**	**-**	**26**	**-**	**146**
Malawi	-	-	-	3	-	3
Mauritius	-	1	-	-	-	1
Nigeria	-	-	-	1	-	1
Somalia	-	2	-	-	-	2
Sudan	115	2	-	22	-	139

Table A6. (cont.) Status of food legumes collections by origin (December 1992)

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
AMERICA	**362**	**431**	**-**	**578**	**-**	**1371**
Argentina	1	11	-	-	-	12
Brazil	-	4	-	-	-	4
Canada	171	4	-	-	-	175
Chile	-	342	-	346	-	688
Colombia	43	8	-	1	-	52
Costa Rica	-	1	-	-	-	1
Ecuador	97	-	-	1	-	98
Guatemala	-	1	-	-	-	1
Mexico	7	25	-	117	-	149
Peru	35	2	-	4	-	41
United States	7	32	-	109	-	148
Uruguay	1	1	-	-	-	2
OCEANIA	**9**	**3**	**-**	**-**	**-**	**12**
Australia	9	2	-	-	-	11
New Zealand	-	1	-	-	-	1
Unknown	541	35	7	136	-	719
TOTAL	**3523**	**7228**	**386**	**8495**	**271**	**19903**

a : Germplasm received by GRU prior to 1991.

Table A7. Status of forage legumes collections by origin (December 1992)

Origin	Medics	Vicia	Pisum	Lath.[a]	Trif.[a]	Other forages	Total
WANA	**5791**	**2247**	**467**	**1180**	**2741**	**2218**	**14644**
Afghanistan	18	25	53	21	40	-	157
Algeria	730	226	9	35	271	418	1689
Cyprus	263	96	8	36	-	2	405
Egypt	51	15	1	3	20	68	158
Ethiopia	46	-	174	110	-	-	330
Iran	299	58	4	27	90	-	478
Iraq	136	11	2	7	72	1	229
Jordan	666	109	26	41	537	689	2068
Lebanon	218	43	1	-	2	1	265
Libya	173	1	-	-	-	-	174
Morocco	531	14	9	4	-	264	822
Oman	-	-	-	-	-	21	21
Pakistan	5	13	12	26	6	-	62
Palestine	37	-	-	2	5	-	44
Saudi Arabia	-	1	-	-	-	-	1
Syria	1744	922	84	480	1219	728	5177
Tunisia	108	2	-	4	3	-	117
Turkey	766	711	83	384	476	26	2446
Yemen	-	-	1	-	-	-	1
EUROPE	**948**	**1045**	**1320**	**203**	**37**	**123**	**3676**
Albania	-	14	5	-	-	-	19
Austria	-	-	1	-	-	-	1
Belgium	1	18	-	2	-	-	21
Bulgaria	1	60	1	14	-	-	76
Czechoslovakia	11	17	3	12	2	-	45
Denmark	3	2	10	1	-	-	16
Finland	-	2	14	-	-	-	16
France	41	48	39	3	12	-	143
Germany	5	81	98	18	1	92	295
Greece	167	98	48	106	1	-	420

Table A7. (cont.) Status of forage legumes collections by origin (December 1992)

Origin	**Medicago**	**Vicia**	**Pisum**	**Lath.**[a]	**Trif.**[a]	**Other forages**	**Total**
Hungary	10	131	74	8	-	29	252
Italy	322	273	15	-	4	-	614
Malta	8	20	-	-	-	-	28
Netherlands	-	2	95	1	-	-	98
Norway	-	-	1	-	-	-	1
Poland	1	16	49	4	-	-	70
Portugal	95	71	16	11	-	-	193
Romania	4	3	2	-	-	-	9
Soviet Union[b]	36	142	87	17	6	-	288
Spain	229	24	3	-	5	-	261
Sweden	2	12	434	2	-	-	450
Switzerland	2	-	-	1	-	-	3
United Kingdom	1	2	322	2	-	-	327
Yugoslavia[b]	9	9	3	1	6	2	30
ASIA	**2**	**49**	**248**	**2**	**9**	**-**	**310**
China	1	-	19	-	-	-	20
India	1	-	217	2	9	-	229
Japan	-	48	8	-	-	-	56
Mongolia	-	-	1	-	-	-	1
Nepal	-	1	2	-	-	-	3
Thailand	-	-	1	-	-	-	1
AFRICA	2	3	28	-	8	-	41
Gabon	-	2	-	-	-	-	2
Kenya	1	-	1	-	2	-	4
Nigeria	-	-	4	-	-	-	4
Senegal	-	-	3	-	-	-	3
South Africa	1	1	-	-	1	-	3
Sudan	-	-	15	-	5	-	20
Uganda	-	-	4	-	-	-	4
Zaire	-	-	1	-	-	-	1

Table A7. *(cont.) Status of forage legumes collections by origin* **(December 1992)**

Origin	Medicago	Vicia	Pisum	Lath.[a]	Trif.[a]	Other forages	Total
AMERICA	**52**	**17**	**169**	**12**	**6**	**393**	**649**
Argentina	-	-	3	-	-	-	3
Bolivia	2	-	-	-	-	-	2
Brazil	3	-	1	-	-	-	4
Canada	2	5	28	6	-	-	41
Chile	18	-	-	-	-	-	18
Ecuador	1	-	1	-	-	-	2
Guatemala	-	-	1	-	-	-	1
Mexico	-	-	2	-	-	1	3
Paraguay	-	3	-	1	-	-	4
Peru	4	-	-	-	-	-	4
United States	13	9	131	4	6	392	555
Uruguay	9	-	-	1	-	-	10
Venezuela	-	-	2	-	-	-	2
OCEANIA	**103**	**33**	**26**	**11**	**3**	**-**	**176**
Australia	103	33	11	11	2	-	160
New Zealand	-	-	15	-	1	-	16
Unknown	353	1210	1160	9	68	-	2800
TOTAL	**7251**	**4604**	**3418**	**1417**	**2872**	**2734**	**22296**

a : Lath.=Lathyrus, Trif.=Trifolium.
b : Germplasm received by GRU prior to 1991.

Table A8. Distribution of GRU gerplasm to users in 1992

Country	Cereals	Food Legumes	Forage Legumes	Total
Algeria	201	-	-	201
Australia	46	1232	-	1278
Bangladesh	-	36	97	133
Bulgaria	65	-	-	65
Belgium	-	4	-	4
Canada	60	97	203	360
China	-	11	-	11
Czechoslovakia	5	5	-	10
Daghestan	2	-	-	22
Denmark	-	27	-	27
Egypt	193	336	299	828
France	56	-	10	66
Germany	28	220	-	248
Greece	-	-	10	10
India	31	151	214	396
Italy	3884	152	139	4175
Iran	-	690	-	690
Iraq	58	-	-	58
Japan	116	10	59	185
Jordan	331	504	-	835
Mexico	678	31	-	709
Morocco	3500	-	25	3525
Pakistan	-	16	33	49
Poland	-	133	-	133
Russia	30	6	-	36
South Africa	15	99	-	114
Syria	189	100	-	289
Tunisia	24	208	-	232
Turkey	29	1	-	30
United Kingdom	24	-	-	24
United States	9	147	10	166
ICARDA	7147	1543	517	9207
Total	**16741**	**5759**	**1616**	**24116**

Table A9. Distribution of cereals in 1992

Country	Barley	Wild barley	Durum wheat	Bread wheat	Wild wheat	Total
Algeria	201	-	-	-	-	201
Australia	46	-	-	-	-	46
Bulgaria	35	-	-	-	30	65
Canada	-	21	-	-	39	60
Czechoslovakia	-	-	-	-	5	5
Egypt	159	4	-	5	25	193
France	-	-	-	-	56	56
Germany	24	3	1	-	-	28
India	21	10	-	-	-	31
Italy	-	-	3854	-	30	3884
Iraq	58	-	-	-	-	58
Japan	-	-	-	-	116	116
Jordan	69	12	250	-	-	331
Mexico	-	-	-	-	678	678
Morocco	-	-	2603	897	-	3500
South Africa	-	-	-	-	15	15
USSR/Russia	-	-	-	-	52	52
Syria	50	10	76	29	24	189
Turkey	24	-	-	-	5	29
Tunisia	24	-	-	-	-	24
United Kingdom	24	-	-	-	-	24
USA	-	-	-	-	9	9
ICARDA	678	-	1779	707	3983	7147
Total	**1413**	**60**	**8563**	**1638**	**5067**	**16741**

Table A10. Distribution of food legumes in 1992.

Country	Chickpea	Wild Cicer	Lentil	Wild lentil	Faba Bean	Total
Australia	-	93	1093	46	-	1232
Bangladesh	-	-	36	-	-	36
Belgium	-	-	-	4	-	4
Canada	-	-	97	-	-	97
China	-	-	-	-	11	11
Czechoslovakia	-	-	1	-	4	5
Denmark	-	-	-	-	27	27
Egypt	-	-	-	20	316	336
Germany	-	-	-	-	220	220
India	40	4	92	15	-	151
Iran	-	228	139	323	-	690
Italy	-	85	46	-	21	152
Japan	-	-	-	-	10	10
Jordan	-	-	502	-	2	504
Mexico	-	-	19	-	12	31
Pakistan		16	-	-	-	16
Poland	-	-	-	36	97	133
Russia	6	-	-	-	-	6
South Africa	50	-	49	-	-	99
Syria	50	-	50	-	-	100
Tunisia	-	-	-	-	208	208
Turkey	-	-	1	-	-	1
USA	4	3	-	-	140	147
ICARDA	1046	182	52	263	-	1543
Total	**1196**	**611**	**2177**	**707**	**1068**	**5759**

Table A11. Distribution of forages in 1992.

Country	Medics	Trif.[a]	Lath.[a]	Vicia	Pisum	Other genera	Total
Bangladesh	-	-	97	-	-	-	97
Canada	-	-	203	-	-	-	203
Egypt	-	-	99	200	-	-	299
France	10	-	-	-	-	-	10
Greece	-	-	10	-	-	-	10
India	-	-	165	26	5	18	214
Italy	100	39	-	-	-	-	139
Japan	-	-	-	59	-	-	59
Morocco	-	-	-	25	-	-	25
Pakistan	-	-	33	-	-	-	33
USA	10	-	-	-	-	-	10
ICARDA	40	-	53	402	4	18	517
Total	**160**	**39**	**660**	**712**	**9**	**36**	**1616**

a : Trif.=Trifolium, Lath.=Lathyrus.

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