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1. GENETIC RESOURCES ACTIVITIES

1.1. Introduction

During 1991 ICARDA continued to participate in the CGIAR's effort to collect, evaluate, conserve, and distribute germplasm of its mandated crops.

Over 2100 accessions collected in West and Central Asia and North Africa and just over 5000 new accesions received from other institutions were added to the ICARDA germplasm collections (Table 1).

Collecting of the adapted germplasm in unexplored or under explored regions of WANA or related environments continued to receive high priority in 1991.

An extensive collection mission for wheat wild relatives was carried out in the republics of Turkmenia, Uzbekistan and Tadzhikistan in Central Asia. Several populations of the rare Ae. juvenalis were found and collected, as well as natural hybrids between Aegilops species and Aegilops x Triticum hybrids. Local herbarium study revealed a new Aegilops species, Ae. kotschyi, for Turkmenia. As a result of the collecting activities in Central Asia, Libya and Syria and of several donations from collaborating institutes, the total holdings of Aegilops at ICARDA increased by 12.5 % to reach a total of 2100 accessions. The size and degree of documentation of this collection makes it one of the world's largest, representing all currently recognized taxa from almost all countries where they are occurring.

A collection trip to Jordan and an exploration mission to the Sweida region in Syria resulted in 114 new accessions of the barley wild progenitor, Hordeum spontaneum. In the latter mission, which focussed on wheat wild progenitors, 4 and 22 populations of

Table 1. Germplasm introduction in 1990/91.

Crops	Collected by GRU	Received from other institutions	New acquisitions (total)
Barley	66	2297	2363
Wild barley	127	76	203
Durum wheat	7	224	231
Bread wheat	17	44	61
Wheat wild species	151	124	151
Cereals-subtotal	368	2765	3009
Chickpea	103	2	105
Wild _Cicer_ spp.	3	5	8
Lentil	-	1	1
Wild _Lens_ spp.	28	19	43
Faba bean	96	80	176
Food legumes-subtotal	230	103	333
Medicago spp.	441	1505	1946
Vicia spp.	267	106	373
Lathyrus spp.	60	39	99
Trifolium spp.	280	237	517
Others	464	285	749
Forage species-subtotal	1512	2172	3684
Grand total	**2110**	**5040**	**7026**

Triticum urartu and _T. dicoccoides_ were sampled, respectively. Extensive morphological variation and high genetic diversity in loci coding for storage proteins were found in both wild wheat species. Two sites were identified as being especially suitable for research on _in situ_ conservation.

Pasture and forage legumes were collected at 108 sites in Algeria. A total of 1421 accessions were collected with Medicago, Vicia, Trifolium and Astragalus the most prevalent genera. In Syria 25 wild Lens and 3 wild Cicer populations were sampled. Faba bean landraces (87) were collected in Portugal along with 88 accessions of pasture and forage legumes.

To achieve sufficient seed quantity for germplasm storage, safety duplications and distribution, 7000 accesions were multiplied in the field or plastic house (Table 2).

A considerable effort was devoted to germplasm characterization and evaluation. In total, nearly 5300 entries were evaluated (Table 2). A number of accessions with positive traits were identified among barley from Afganistan, Algeria, China, Pakistan (Baluchistan region) and the republics of Uzbekistan and Turkmenia. Good sources for pod indehiscence and low pod drop were identified in lentil germplasm from Iran. Significant variation for frost tolerance and early vigor was found in a joint evaluation of Jordanian medics conducted with NCARTT (Jordan).

In a study of Syrian durum wheat landraces, annual rainfall, summer maximum and winter minimum temperature, potential annual evapotranspiration, soil organic matter content and total soil nitrogen content were site characteristics most frequently correlated to traits as grain yield, spike density, harvest index, and number of kernels per spike.

In 1991 much attention was paid to identification and elimination of duplicate accessions from ICARDA collection. Due to this effort, the total number of accessions in the active collection did not increase (Table 3). A detailed listing of the origins of the ICARDA germplasm collection is presented in Tables A4-7 of the Appendix.

The transfer of the active collection to the new storage facilities was completed and 32700 accessions are now being held in the long-term base collection at -22°C.

Table 2. Germplasm multiplication, characterization and evaluation in 1990/91.

Crops	Multiplied (no. of acc.)	Characterized or/and evaluated (no. of acc.)	(no. of traits)
Barley	559	990	15-22
Wild barley	-	196	14
Durum wheat	449	22	10
Bread wheat	-	31	13
Wheat wild species	398	277	16
Cereals-subtotal	1406	1516	-
Chickpea	1343	797	15
Wild *Cicer* spp.	92	-	-
Lentil	564	1246	13
Wild *Lens* spp.	62	-	-
Faba bean	457	33	3
Food legumes-subtotal	2518	2076	-
Medicago spp.	1223	887	4-17
Vicia spp.	1026	87	4
Pisum spp.	833	51	4
Trifolium spp.	-	363	4
Other	-	331	4
Forage legumes-subtotal	3082	1702	-
Grand total	**7006**	**5294**	**-**

Safety duplication of unique cereal germplasm accessions (15090) was finalized in CIMMYT, Mexico, and in food legumes the duplication has started with a dispatch of 600 faba bean accessions to the

Table 3. Status of ICARDA collections by origin (December 1991).

	Number of accessions originated from						
	WANA		Other countries		Unknown		Total
Crop	no.	(%)	no.	(%)	no.	(%)	no.
Barley	8284	43.4	7077	37.0	3741	19.6	19102
Wild *Hordeum* spp.	1363	71.0	541	28.2	16	0.8	1920
Durum wheat	12015	68.6	4252	24.3	1240	7.1	17507
Bread wheat	6387	93.3	412	6.0	47	0.7	6846
Other cult. wheat	140	47.4	50	17.0	105	35.6	295
Wild *Triticum* spp.	1039	94.2	35	3.2	29	2.6	1103
Aegilops spp.	1611	74.4	510	23.5	45	2.1	2166
Cereals-subtotal	30839	63.0	12877	26.3	5223	10.7	48939
Chickpea	6407	78.7	1601	19.6	136	1.7	8144
Wild *Cicer* spp.	257	98.8	3	1.2	-	-	260
Lentil	3645	55.4	2880	43.7	59	0.9	6584
Wild *Lens* spp.	289	84.3	46	13.4	8	2.3	343
Faba bean	1745	49.5	1241	35.2	541	15.3	3527
Food legumes-subtotal	12343	65.5	5771	30.6	744	3.9	18858
Medicago spp.	5127	89.7	325	5.7	262	4.6	5714
Vicia spp.	2280	49.9	1083	23.7	1209	26.4	4572
Pisum spp.	483	14.1	1776	51.9	1160	33.9	3419
Lathyrus spp.	1149	83.6	223	16.2	2	0.1	1374
Trifolium spp.	2731	95.6	56	2.0	71	2.5	2858
Other genera	2553	83.1	515	16.8	4	0.1	3072
Forages-subtotal	14323	68.2	3978	18.9	2708	12.9	21009
Grand total	**57505**	**64.7**	**22626**	**25.5**	**8675**	**9.8**	**88806**

Federal Institute of Agrobiology, Linz, Austria. Preliminary arrangements for safety duplication of chickpea and lentil collections with NBPGR, New Delhi, and ICRISAT, Hyderabad, India, respectively, have been concluded.

Testing ICARDA gene bank accessions for seed-borne viruses continued during 1991, and around 1800 accessions of barley, lentil and faba bean were identified as virus-free. Around 340 lentil accessions were freed from seed-borne infection during multiplication in the field.

Closer interaction with NARSs in the WANA region and collaborators outside the region resulted in a positive development in utilization of the GRU/ICARDA germplasm collection. During the year a total of 24056 seed samples were dispatched on request to users and collaborators in NARS in West Asia and North Africa (7986), at ICARDA (6392), and in other institutions (9678). This represents a 107 % increase over the last year total of 11600 accessions (Table 4). A detailed listing of germplasm distribution is presented in Tables A8-11 of the Appendix.

The germplasm documentation system used by the GRU was reviewed in 1991 and extensive modifications were initiated. Databases of crop collections were moved from the VAX/780 mainframe to PC's. The data records, passport data in particular, were examined for accuracy and consistency of information and updated as required. High priority was assigned to management of seed stock data.

A specialized training course on "Conservation of Plant Genetic Resources in Genebanks" was organized jointly with IBPGR and the Plant Genetic Resources Reseach Institute (PGRRI) in Menemen, Izmir, Turkey, with 19 participants from various WANA countries. This course was a highlight in the ongoing collaboration with IBPGR during 1991.

Table 4. Utilization of ICARDA collections in 1990/91. Distribution of germplasm to users in 1991.

User	Cereals		Food legumes		Forage legumes		Total 1990/91		Total 1989/90	
	no.	%	no.	%	no.	%	no.	%	no.	%
WANA	6550	36.2	423	29.3	1013	22.4	7986	33.2	348	3.0
ICARDA	3922	21.7	639	44.2	1831	40.6	6392	26.6	7186	61.8
Subtotal (= WANA)	10472	57.9	1062	73.4	2844	63.0	14378	59.8	7534	64.8
Others	7624	42.1	384	26.6	1670	37.0	9678	40.2	4088	35.2
Total	**18096**	**100.0**	**1446**	**100.0**	**4514**	**100.0**	**24056**	**100.0**	**11622**	**100.0**

This Annual Report wants to present the activities of the Genetic Resources Unit 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 1991 the respective projects and their chapters 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 Chapters 1.3.5. and 1.4.2.
- "Collection and characterization of germplasm of wild relatives of wheat", funded by the Netherlands, principal scientist Dr M.W. VAN SLAGEREN, is reported in Chapters 1.2.1., 1.3.6, 1.3.7., and 1.4.3.

- "Prescreening of germplasm collections on the basis of information on the environment of collection and evaluation data", funded by the Netherlands, principal scientist Mr. A. ELINGS, is reported in Chapter 1.4.1.

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

After strengthening facilities of the Seed Health Laboratory, the total number of lines tested for detection of seed-borne pathogens was increased by 55 % and 105 % in imported and dispatched seeds, respectively. Field inspection in the isolation area showed no exotic pathogens, which do not occur in Syria.

In the Virology Laboratory, the screening for barley yellow dwarf virus (BYDV) resistance in barley, bread wheat and durum wheat continued. Based on the results of the last four years, a cereal BYDV nursery was assembled and subsequently distributed in 1991 to 20 countries of the region. In addition, a total of 349 accessions of Aegilops spp., Triticum monococcum, T. dicoccoides and T. boeoticum, were evaluated for their resistance to BYDV and 34 accessions were identified as resistant/tolerant.

ELISA kits for detection of a cereal and three legume viruses were developed and distributed to a number of laboratories of the national programs in the WANA region.

J. Valkoun and GRU staff

1.2. New germplasm collected or introduced in 1990/91

1.2.1. Collection of wild relatives of wheat

In the frame work of the special project "Collection and characterization of germplasm of the wild relatives of wheat" collection trips have been made to Libya, the central Asian republics of the USSR and within Syria. These were joint missions with the respective national programs: the Agricultural Research Center (ARC), Tripoli, Libya, and the N.I. Vavilov All-Union Institute of Plant Industry (VIR) at Leningrad, Kara-Kala (Turkmenia) and Tashkent (Uzbekistan), USSR. The short trip within Syria was an informal mission and executed only by ICARDA's Genetic Resources Unit. Priority was given to the species of Aegilops and the wild species of Triticum while recording pertinent environmental data.

From 18-23 May, 1991, a collection mission was held in the Western part of Libya. Trips were made in the vicinity of Tripoli. Next to 12 samples of Aegilops ovata, three landraces of six-rowed barley were collected after consultation with the local farmers about the authenticity of the material. The area of sandy and sandstone soils proved much poorer in Aegilops species than the Jebl Ahdar in the east of the country, which was visited in 1990. A reported location of Ae. ventricosa just E of Tripoli could not be confirmed. With all five North African countries now covered for Aegilops a detailed study can be performed on the distribution, ecology and species composition of the genus in this region.

During May 1991 4 herbarium collections of Aegilops crassa and 4 of Ae. vavilovii were made on the ICARDA experimental fields at Breda and Boueidar, Syria. This material possesses good drought tolerance as none of these sites is irrigated.

This feature was again demonstrated during a herbarium / germplasm collection mission from 29-31 May to northeastern Syria. The result was 13 germplasm and 33 herbarium samples, including seven Aegilops species, one Aegilops variety and one bread wheat. The visited area included: (1) the road from Manbij to Hassake, and (2) the area east of the line Hassake - Qamishly. In the dry area of (1) only Ae. crassa and vavilovii were found. All other species are from area (2). The entire region (1-2) is characterized by overgrazing but most of the Aegilops species show good recovery capacity from this pressure. Obviously the presence was better where the crops were not yet harvested or where less grazing occurs. Especially the Qara Chok Dag hills are rich in species. It was here that the second location for Syria was found of Ae. juvenalis after Pabot found the first one in the 1950s in the Jebl Abd-el-Aziz mountains. The new site is located at the southwestern end of the range of the species. Along the Syrian-Turkish border there was a good presence of both varieties of Ae. speltoides. This forms a continuation of the major distribution area of this species in the adjacent parts of Turkey, outlined by HARLAN and DE WET (1967). Except for one spot both varieties were always growing together. In another location a natural hybrid was found of Ae. speltoides var. ligustica and bread wheat, Triticum aestivum. The wheat parent was also collected here. Although uncommon, several populations showing intermediate forms of both varieties were found (Plate 1). This is to be expected as Ae. speltoides is an outcrossing species and the two varieties are usually found growing together. The variety speltoides is generally taller, and its spikelet shows lemma awns only on the apical spikelet of its entire-falling spike. The variety ligustica is shorter, the lateral lemmas all extend into awns and each spikelet falls individually.

WITCOMBE (1980, 1981) reported the presence of the wild Triticum boeoticum and T. urartu on the Syrian-Turkish border. However, none

Plate 1. Intermediate forms between Ae. speltoides var. speltoides (extreme left) and var. ligustica (extreme right).

was found and it must be feared that these species are now extinct in northeastern Syria, most probably as a result of the grazing pressure.

An extended collection mission was carried out in the Central Asian republics of Turkmenia and Uzbekistan. Field work was done in the period 17 June to 9 July after study of herbarium material in Leningrad. As the locations visited are far apart the results for the two republics are presented separately in Table 5.

In Turkmenia the region around the station of the N.I Vavilov Institute at Kara-Kala was explored during several daytrips after initial collection around the Turkmenian capital Ashkhabad. Data on distribution of Aegilops species were compiled from the flora of Turkmenia and from the herbarium of the Botanical Institute of the Turkmenia Academy of Sciences in Ashkhabad. Herbarium study revealed a new species for the Republic, Ae. kotschyi, bringing the total at eight. Of these eight species, six were found during the collection mission as it was shown that both Ae. kotschyi and Ae. biuncialis were only present in regions, not planned to be covered by the mission. In all 64 accessions were collected, breaking down as follows: Aegilops crassa (7), Ae. cylindrica (5), Ae. juvenalis (2), Ae. squarrosa (21), Ae. triaristata (1), Ae. triuncialis (14), Hordeum bulbosum (bulbs collected from 1 population), H. spontaneum (8), H. vulgare-distichon (2), and H. vulgare-hexastichon (3). Hordeum vulgare samples represent confirmed landrace material. In addition to this germplasm material, 22 herbarium specimens were collected, representing four Aegilops species as well as a natural hybrid of Ae. triuncialis (female parent) x cylindrica (male parent) and a hybrid of Hordeum spontaneum x six-rowed vulgare. The expertise in the study of wild wheat relatives of Dr P.A. GANDILIAN, one of the counterparts, greatly contributed to this result. Germplasm was fully mature in the second half of June at 200-400 m altitude where most collecting was done. However, higher up in the Kopet Dag mountains (1250 m was reached) material was still green, suitable for herbarium specimens only. The number of germplasm collections does not represent the distribution of the Aegilops species as, in fact, all of them are rare except Ae. squarrosa and Ae. triuncialis, which are extremely abundant. Mixtures of these two species can provide a grassland cover estimated sometimes as more than 100 square meter in size. It was in such a field, with additional presence of Ae. cylindrica, that the natural hybrid Ae. triuncialis (female parent) x cylindrica (male parent) was found. The discovery of Ae. triaristata was also remarkable as this was the second time only in Turkmenia.

In Uzbekistan a nine-day survey was made of the Samarkand and Fergana valley regions. The itinerary included the following cities: Tashkent - Gallya-Aral - Samarkand - (into Tadzhikistan) Pendzhikent - Ayni - (back into Uzbekistan) - Kokand - Fergana -

Table 5. New accessions of Aegilops resulting from 1991 collection missions.

Species	Libya	Syria*	USSR Tur.	USSR Uzb.**	Total***
biuncialis	-	1/2	-	-	1
crassa	-	7/4	7	6	20
cylindrica	-	-	5	17	22
juvenalis	-	1/1	2	-	3
kotschyi	-	-/1	-	-	-
ovata	12	-	-	-	12
speltoides ligustica	-	1/5	-	-	1
speltoides speltoides	-	1/5	-	-	1
speltoides (intermediates)	-	-/2	-	-	-
squarrosa	-	-	21	15	36
triaristata	-	-	1	-	1
triuncialis	-	1/6	14	8	23
vavilovii	-	1/4	-	-	1
Grand total					**121**

* : left number = germplasm; right number = herbarium sample.
** : Tur. = Turkmenia; Uzb. = Uzbekistan (a small adjacent part of Tadzhikistan is included).
*** : numbers refer only to germplasm accessions.

Namangan - Angren - Tashkent. The result of this mission was a total of 65 germplasm and 14 herbarium samples. The germplasm collection breaks down as follows: Aegilops crassa (6), Ae. cylindrica (17), Ae. squarrosa (15), Ae. triuncialis (8), Triticum aestivum-compactum (2), Triticum aestivum-aestivum (5), Hordeum spontaneum (3), H. vulgare-distichon (4), H. vulgare-hexastichon (2), Vicia spp. (2), Medicago sp. (1). The 14 herbarium samples included seven Aegilops (representing three species), three of the natural hybrid Ae. cylindrica (female parent) x Triticum aestivum (male parent), two of Ae. crassa x T. aestivum, and in a mixed stand of Ae. cylindrica and Ae. triuncialis the natural hybrid between these two species was found once in either way (cylindrica as female and as male parent). As the number of collections shows, Ae. cylindrica and Ae. squarrosa were the most ubiquitous species with the other Aegilops species clearly more rare. It must be said, however, that the large number of Ae. squarrosa collected is partly the result of the advice of Dr G. WAINES of the University of California at Riverside to "collect the D-genome between Syria and China" and thus to provide for a valuable collection for wheat improvement.

An other remarkable feature encountered was the frequent natural hybridisation of Ae. cylindrica and bread wheat. This hybrid species has been published by expedition member Dr P.A. GANDILIAN as x Aegilotriticum cylindroaestivum Gand. Also the much rarer hybrid Ae. crassa x bread wheat was found twice. In all cases Aegilops was growing in the margin of and within the bread wheat field.

The crassa hybrid has the pubescent glumes and well developed lemma awns from the crassa mother, and the distict keel and the tough rachis from the aestivum father. All hybrids were sterile. Lastly an extensive collection of wheat and barley landraces in the Fergana valley was envisaged. This would have been a valuable addition to the same collections made by the Japanese in the Hindukush and Karakoram Mts. and by the mission of Drs. VALKOUN, DAMANIA et. al. in Tibet. It showed, however, that the overwhelming majority of the valley is (a) irrigated and (b) planted with cotton and maize. Only a few aestivum landraces could be found. More interesting was a field of several landraces just S of the Kugaminsky Mts., where at least two varieties of T. aestivum ssp. compactum were found within an array of ssp. aestivum landraces. They were identified by Dr P.A. GANDILIAN as vars. erinaceum Desv.

Table 6. Number of accessions and frequency distribution of Aegilops germplasm at ICARDA.

Species	accessions	percentage
triuncialis	391	18.61
ovata	339	16.14
squarrosa	218	10.38
biuncialis	198	9.42
cylindrica	156	7.42
peregrina	155	7.38
triaristata	110	5.23
speltoides	84	4.00
umbellulata	59	2.80
vavilovii	54	2.57
columnaris	50	2.38
ventricosa	45	2.14
kotschyi	44	2.09
crassa	37	1.76
caudata	33	1.57
searsii	31	1.47
comosa	23	1.09
longissima	19	0.90
mutica	19	0.90
bicornis	17	0.80
juvenalis	10	0.47
uniaristata	6	0.28
sharonensis	2	0.09
Total	**2100**	**100.00**

and icterinum Alefeld, and duly colected. This location is, however, outside the Fergana valley proper.

Numbers of germplasm and herbarium samples are presented in Table 5. Due to collecting activities and various donations the total of Aegilops accessions in ICARDA's genebank increased from 1826 at the end of 1990 to 2100, or 12.5%. The current holdings in percentage and number is presented in Table 6.

M. van Slageren

1.2.2. Collection of cereals in Jordan

A mission, aiming to collect wild progenitors and landraces of cereals was conducted in Jordan in June, 1991, jointly with the National Program (NCARTT). Landraces are still cultivated on small farms between Irbid in the north of the country and Ma'an in the south and between the Jordan valley in the west and Al Azraq in the east. The area covered by the expedition was highly diverse for edaphic and climatic conditions. In total 169 seed samples were collected from 103 sites with altitude ranging from 200 m below sea level in the Dead Sea area to 1600 m asl. Most of the samples were Hordeum spontaneum (92) and barley landraces (54), with additional collections of durum wheat (7), bread wheat (12), and Aegilops spp. (4). Durum and bread wheat were found as off types in the barley fields. For Aegilops a remarkable extension of the distribution of Ae. cylindrica was established with a location near the Dead Sea, the first one for Jordan.

In addition to the seed samples, a total of 50 soil samples representing 0-20 cm soil depth from most of the collection sites were taken. These will be analyzed for salinity, calcium carbonate, PH and soil texture at ICARDA's Soil Laboratory.

The entire collection will be planted for joint evaluation under two different environmental conditions: in Tel-Hadya, Syria, and at Baqa'a, Jordan, under supervision of NCARTT.

B. Humeid and M. Hamran

1.2.3. Exploration mission for wild relatives of cereals in Syria

A short exploration trip was conducted June 14-15, 1991 with the following objectives:

- Explore areas of distribution of wild Triticum spp. and wild barley, Hordeum spontaneum,
- Identify suitable site(s) for joint research with the Syrian

national program for in situ conservation of cereal wild relatives,

- Search for the wild diploid wheat, Triticum boeoticum,
- Collect wild cereal germplasm from sites not covered by previous missions.

In total, 25 sites were visited, 19 of these located in Sweida province on the high elevation basaltic plateau, 900 - 1650 m a.s.l., with an annual rainfall ranging between 230 and 420 mm. In total 48 samples were taken as follows: 22 Hordeum spontaneum, 18 Triticum dicoccoides, 4 T. urartu and 4 Aegilops spp.

Wild barley, H. spontaneum, was ubiquitous in the region, growing mostly on roadsides and borders of cultivated fields. In natural pastures or fallows, it usually was scattered and did not produce dense stands. The species was sometimes accompanied by Hordeum bulbosum which is abundant in the higher rainfall area east of the town of Sweida.

The region was exceptionally rich in wild Triticum spp., both in occurence and diversity of forms. Triticum dicoccoides, wild emmer, was frequently a dominant species in natural pastures, producing large stands which sometimes resembled "fields of wild wheat". It also was found on the roadside and bordering fields together with H. spontaneum.

Triticum urartu was the only diploid wild wheat encountered in the Sweida region. Though reported from previous collection missions, T. boeoticum, the other wild diploid species, was not found. However, many T. boeoticum accessions in the ICARDA GRU germplasm collection were recently reidentified as T. urartu and it is possible that only the latter species occurs in the region.

Two sites were identified as especially suitable for research on in situ conservation. One of them is an area of several hectares located 1 to 2 km west of Rashida. It is dominated by Triticum dicoccoides and T. urartu, but wild barleys, H. spontaneum and H. bulbosum, are also present. High diversity of forms of the two wild wheat species was found in sympatric populations in this area.

The other site is situated 10 km north-east of Quanawat where large stands of H. spontaneum and T. dicoccoides occur in the vicinity of cultivated cereal fields. This might facilitate gene flow between the wild progenitors and cultivated barley and wheat. Aegilops vavilovii, a D-genome species of Aegilops, also occurs at the site.

J. Valkoun

1.2.4. Legume collection mission in Portugal

A joint collection expedition with the Portugese national program (Estacao Nacional De Melhoramento De Plantas) was organized May 27 through June 6, 1991, to collect legumes in the central and southern central parts of Portugal: the provinces of Alto Alenteja, Baexo Alenteja, Ribatejo and Extremadura. This eleven day mission covered 102 sites with 297 germplasm samples taken (Table 7).

One of the major objectives of this mission was to collect faba bean germplasm with tolerance to mineral toxicity (specifically aluminum). To this end, soil samples were taken at each site for lab analyses. The most common biotic stresses noted in order of dominance were: Orobanche, chocolate spot, stem nematodes, rust and aphids. A total of 96 accessions of faba bean were collected, mostly from farmer fields and some threshing floors. These will be jointly characterized in nurseries in Portugal and at ICARDA this coming season.

Accessions of forage legumes were also collected, mainly of medics, vetch and Lathyrus (Table 7); other genera included Scorpiurus and Ornithopus. Several accessions of Aegilops and barley were also collected.

M. Tavares de Sousa and R. Martins Farias (ENMP) and L. Robertson

Table 7. Germplasm accessions collected in Portugal in 1991.

Genera	no. of accessions
Legumes	
Faba bean	96
Chickpea	64
Medicago	55
Vicia	7
Lathyrus	8
Scorpiurus	2
Ornithopus	3
Other food legumes	23
Cereals	
Aegilops	3
Barley	3
Other crops	33
Total	**297**

1.2.5. Collection of wild relatives of food legumes in Syria

To enrich the ICARDA collection of wild food legume relatives, a joint collection mission in Syria with the National Agricultural Research Center in Douma was conducted during June, 1991. This two week collection mission visited 28 sites and collected 31 germplasm samples of Lens (25 accessions) and Cicer (3 accessions). The areas covered by the mission included Palmyra, Aleppo, Hassake, Sweida, Dara'a and Damascus provinces. The sites varied in altitude between 420 to 1550 m. Accessions were collected from very dry sites around Palmyra at high elevations (1290 m) which have not been previously sampled.

Kh. Obari (ARC-Douma) and A. Ismail

1.2.6. Ecogeographic survey of pasture and forage legumes in Algeria

ICARDA's GRU and PFLP, in collaboration with the Institute Techniques des Grande Cultures (ITGC) of Algeria, conducted an ecogeographic survey of forage and pasture legume germplasm in Algeria. The objective of this mission was to fill an identified gap in the Algerian forage legume germplasm available in the ICARDA and Algerian collections. Vicieae, in particular, are under-represented in these collections.

Table 8. Genera collected in Algeria June 10 to July 7, 1991.

Taxa	**no. of accessions**
Medicago	384
Trifolium	280
Vicia	248
Astragalus	114
Scorpiurus	69
Trigonella	49
Lathyrus	45
Melilotus	44
Hippocrepis	43
Coronilla	41
Lotus	28
Aegilops	14
Onobrychis	14
Anthyllis	11
Ononis	10
Hedysarum	9
Ornithopus	7
Pisum	4
Potereum	4
Tetragonolobus	2
Hordeum	1
Total	**1421**

The collection mission covered 6000 km across northern Algeria, between the latitutes 36°50'N and 34°25'N, traversing the entire width of the country. The collection area was divided into three segments: 1) central (Algiers, Blida, Medea and Bouira), 2) west-southwest (Tiaret, Tlemcen, Ain Temouchent and Oran), and 3) eastern (Bordj Arreridj, Setif, Mila, Jijel, Baatna, Khenchela, Oum El Bouaghi, Constantine, Skikda, Guelma, Annaba and El Tarf). Altitudes ranged from 25 to 1750 m and precipitation from 200 to 1200 mm per annum with most areas normally receiving more than 350 mm.

Germplasm samples were collected from 21 genera (Table 8) totalling 1421 accessions. The most numerous genera collected were Medicago, Trifolium and Vicia. The vetch will be jointly evaluated at ITGC and ICARDA the next season. Soil samples were taken at each site to evaluate soil characteristics and to isolate Rhizobium strains.

A. Khaldoun and S. Hamrit (ITGC), and A. Shehadeh and W. Bou Moughlabay (PFLP).

1.3. Germplasm multiplication, characterization and evaluation

1.3.1. Characterization of new barley germplasm

Chinese barley landraces

A total of 302 seed samples of Chinese barley landraces received through University of Saskatchewan, Canada, were planted during 1990/91 season in the ICARDA post-quarantine area. The landraces were planted with ten ICARDA checks (Tadmor, Arta, Radical, Mari/Aths #2, Harmal, Roho, Arar, Tokak, Rihane-03, Steptoe) in November 1990 in non-replicated two-row plots. The plots were 1 m long with row and plot distance of 0.45 m and 0.9 m, respectively.

Since the season was dry at the early plant developmental stages, two additional irrigations of 40 mm each were applied on December 17, 1990 and February 14, 1991.

The materials were scored for the following characters in the field or in the laboratory:

growth habit, frost damage (2 scores), leaf color, early growth vigor, growth class, row type, heading time, hoodedness / awnedness, maturity time, lodging resistance, awn roughness, plant height (2 scores), kernel covering, grain color, lemma color, awn color, spike density, 1000 kernel weight, plot seed weight and powdery mildew reaction.

In general, large variation was observed for most of the traits. Similar to the results obtained in the evaluation of a large set of Chinese barley landraces in the 1989/90 season (GRU Annual Report for 1990), accessions which headed earlier than local checks were found in the experiment (Fig. 1). This early germplasm may have potential value in breeding programs for terminal drougth-stress

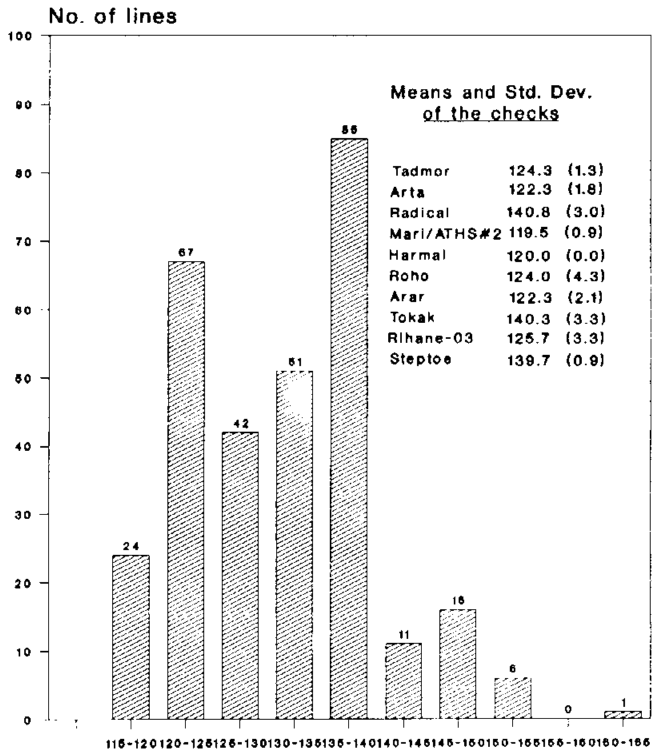

Fig. 1. Days to heading of Chinese barley landraces in 1990-1991 season.

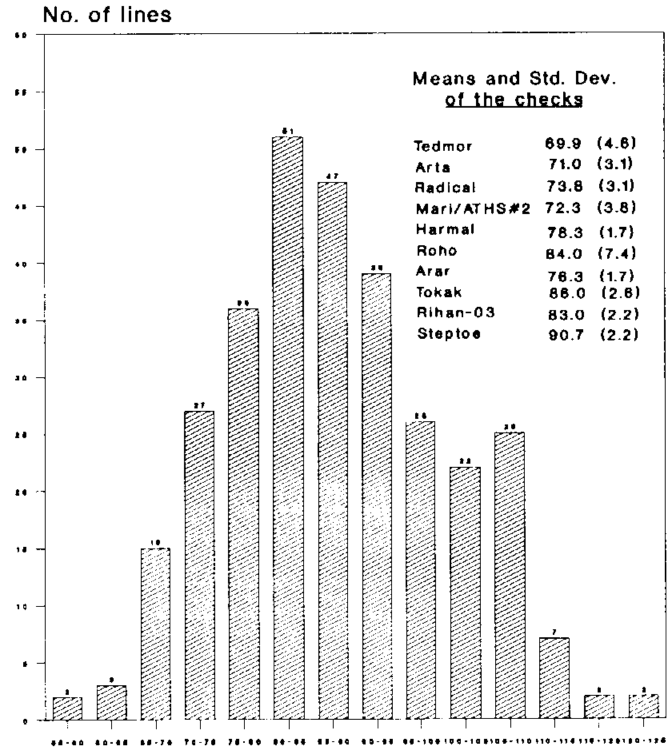

Fig. 2. Plant height (cm) for Chinese barley landraces in 1990-1991 season.

tolerance in the WANA region.

Tallness, which is also important in barley breeding for dry environments, was well represented in the Chinese germplasm (Fig. 2).

Algerian barley landraces

A total of 24 population samples and 425 single head progenies of barley landraces, collected by the joint ICARDA/ITGC mission in Algeria in 1990, were planted in the post-quarantine area at Tel Hadya for multiplication and preliminary evaluation. Experimental conditions, design and traits evaluated were the same as in the above experiment with Chinese barley.

The Algerian germplasm was, however, later in heading and maturity than local checks. Therefore, the late-maturing accessions were able to use the late rainfall of the season, which is rather atypical for northern Syria. As a result, 1000 kernel weight was mostly higher than in local checks (Fig. 3) and a number of accessions exceeded the best local checks in grain yield (Fig. 4). Medium to good cold tolerance and the late maturity of the Algerian barley landraces may be utilized in the barley breeding for highlands of the WANA region.

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1.3.2. Evaluation of barley germplasm from the USSR, Iran, Pakistan and Afghanistan

A total of 159 accessions of barley germplasm, originating from the (former) USSR (73), Pakistan (45), Afghanistan and Iran (21), were planted at the ICARDA principal station at Tel Hadya, Syria, in a evaluation trial with five checks (Tadmor, Radical, Roho, Arar, Rihane-03) on November 15, 1990. The experiment was of a simple lattice 13x13 design with two replications. The plots were of two rows, 3 m long and 37.5 cm apart. Two supplementary irrigations of

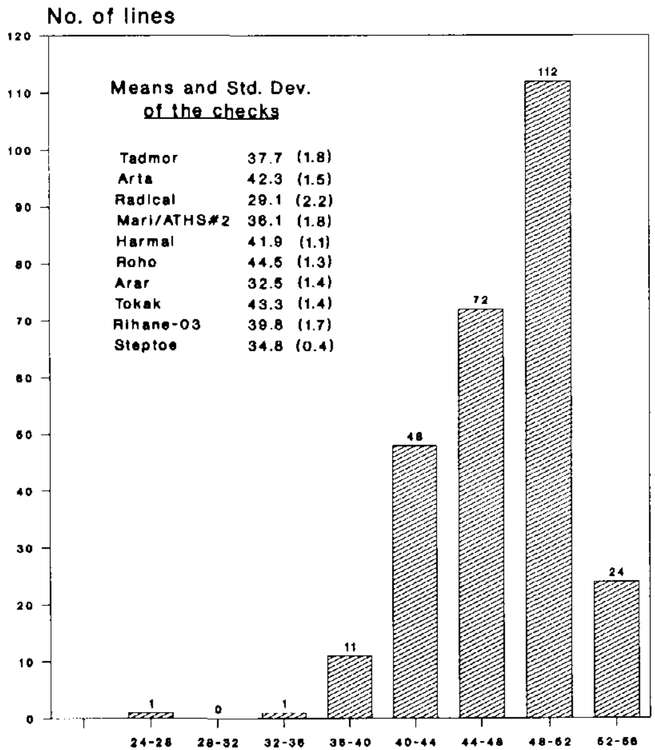

Fig. 3. 1000 kernel weight (g) for Algerian barley landraces in 1990-1991 season.

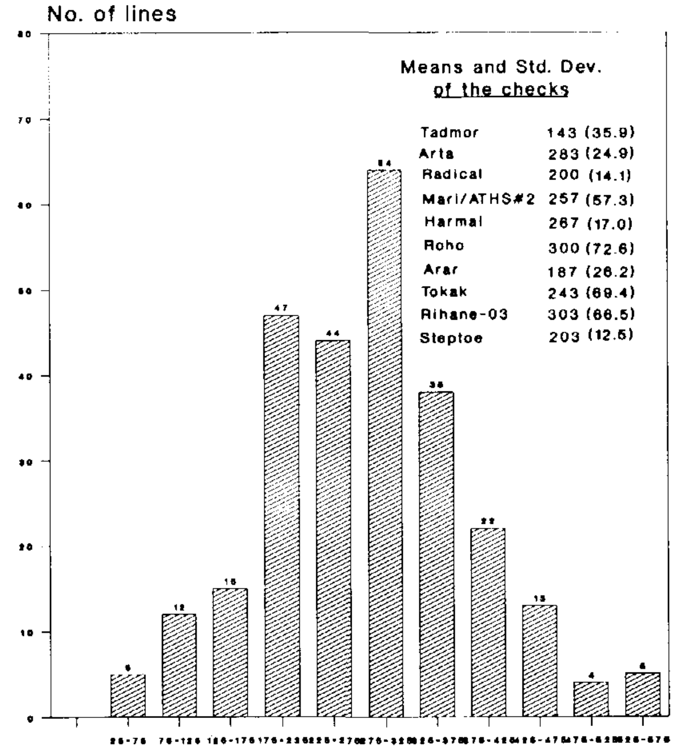

Fig. 4. Yield per plot (g) for Algerian barley landraces in 1990-1991 season.

40 mm each were applied on December 17, 1990, and February 13, 1991.

The following characters were scored: frost damage, growth habit, early vigor, leaf color, growth class, days to heading, row type, hoodedness/ awnedness, awn roughness, lodging resistance, plant height, days to maturity, 1000 kernel weight, plot weight and powdery mildew reaction.

As one of the main objectives of the study was to identify germplasm accessions with potential for barley improvement for the highlands in the WANA region, frost tolerance is an important trait. Results of the evaluation of late frost damage indicated that extensive variation, mostly based on lateness, in this character exists among the tested germplasm (Fig. 5). Accessions, which equalled the frost tolerant check Radical, originated from republics and regions of the former USSR (Uzbekistan, Turkmenia, the Caucasus region and Crimea), Iran and Afganistan. Good cold tolerance, similar to that of the check Tadmor, was found in some accessions from the Baluchistan province of Pakistan, as well as in a number of materials from the USSR, Afganistan and Iran. Most cold susceptible germplasm originated from the Gilgit and Baltistan provinces of Pakistan.

Compared to the locally adapted checks, the tested germplasm headed later, especially that from Russia, north of the Caucasus. Pakistani accessions were relatively early (Fig. 6) and a few early-heading accessions were also found among materials from Iran.
However, the late germplasm may give different results in the WANA highlands and on northern latitudes due to the longer vernalization period and/or longer days in the generative fase of plant development.

Plant height frequency distribution followed the pattern of heading time; Pakistani germplasm being the shortest and accessions from the former USSR being the tallest ones.

Mean plot grain yield of the tested germplasm was mostly below

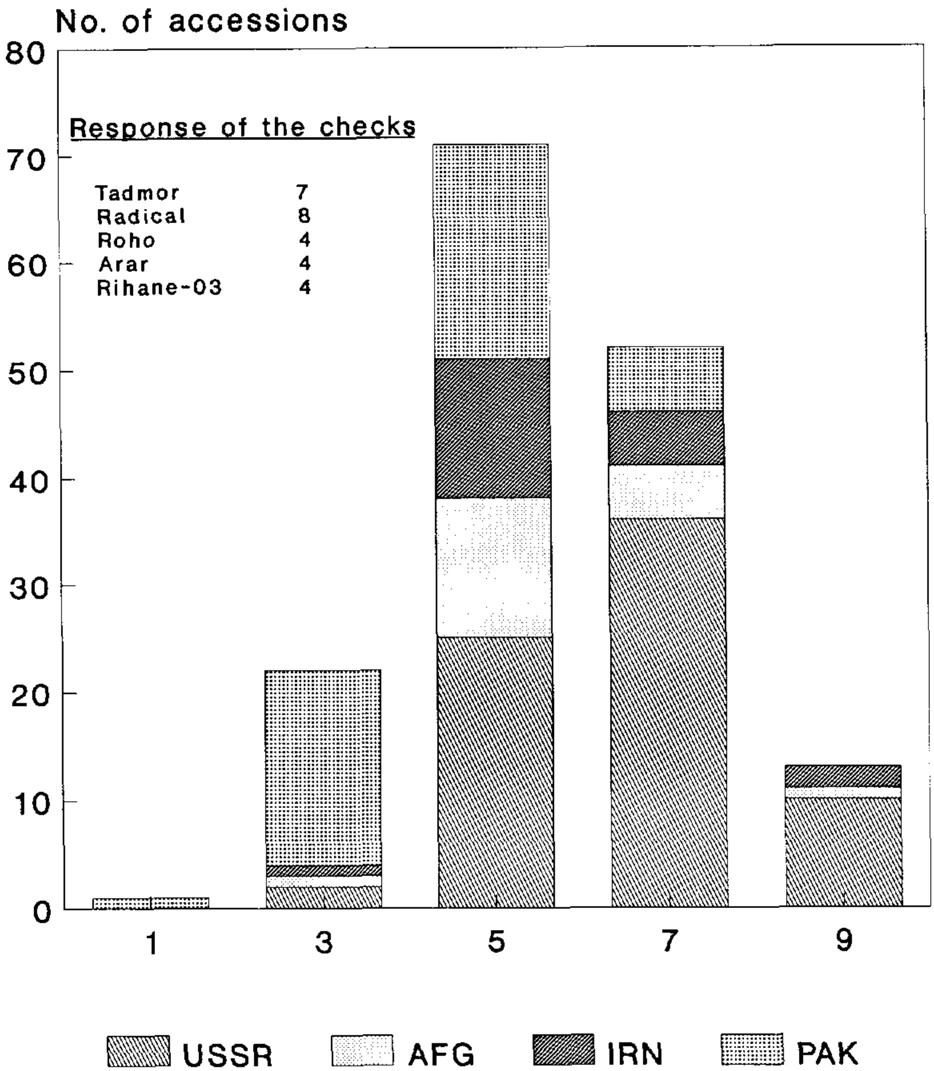

Fig. 5. Frost tolerance of barley landraces originating from USSR, Afghanistan, Iran and Pakistan (1-low, 9-high)

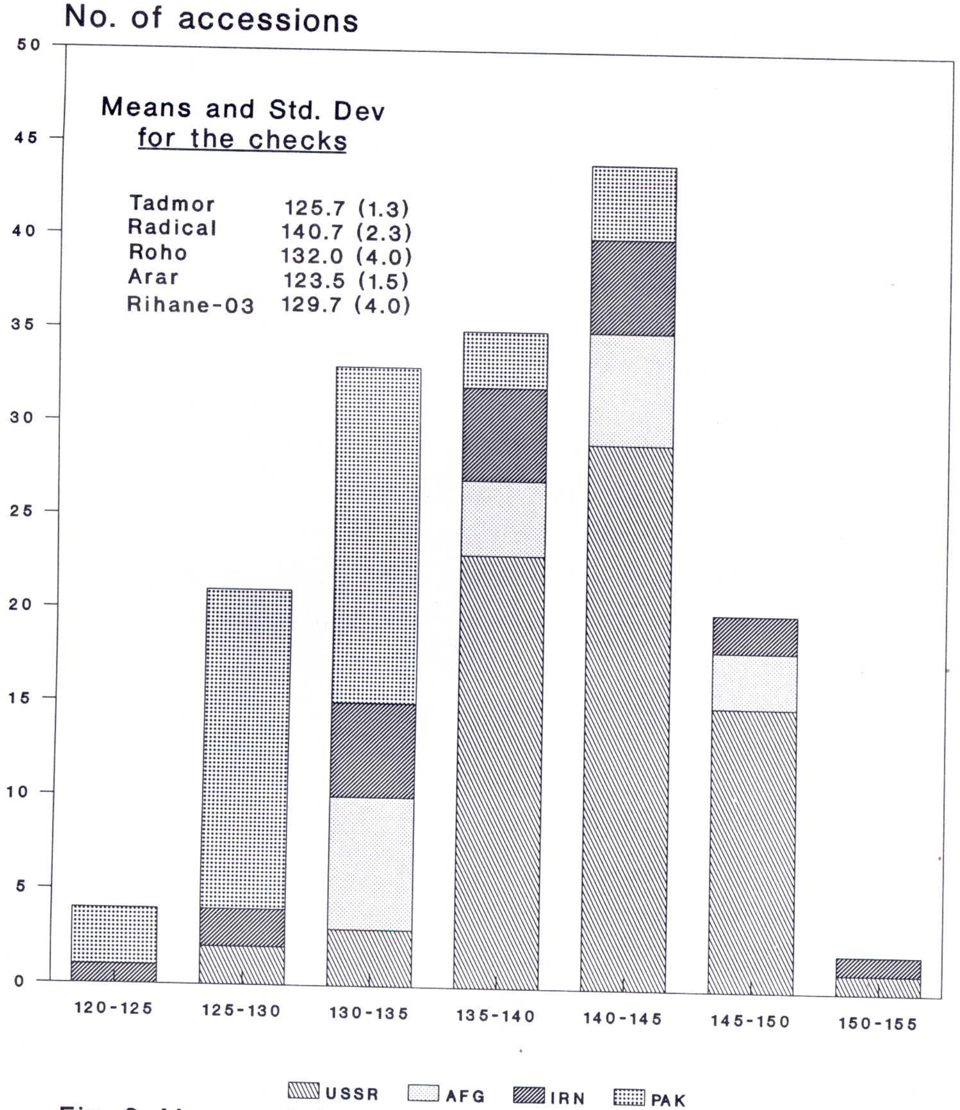

Fig. 6. Means of days to heading for barley landraces originating from USSR, Afghanistan, Iran and Pakistan.

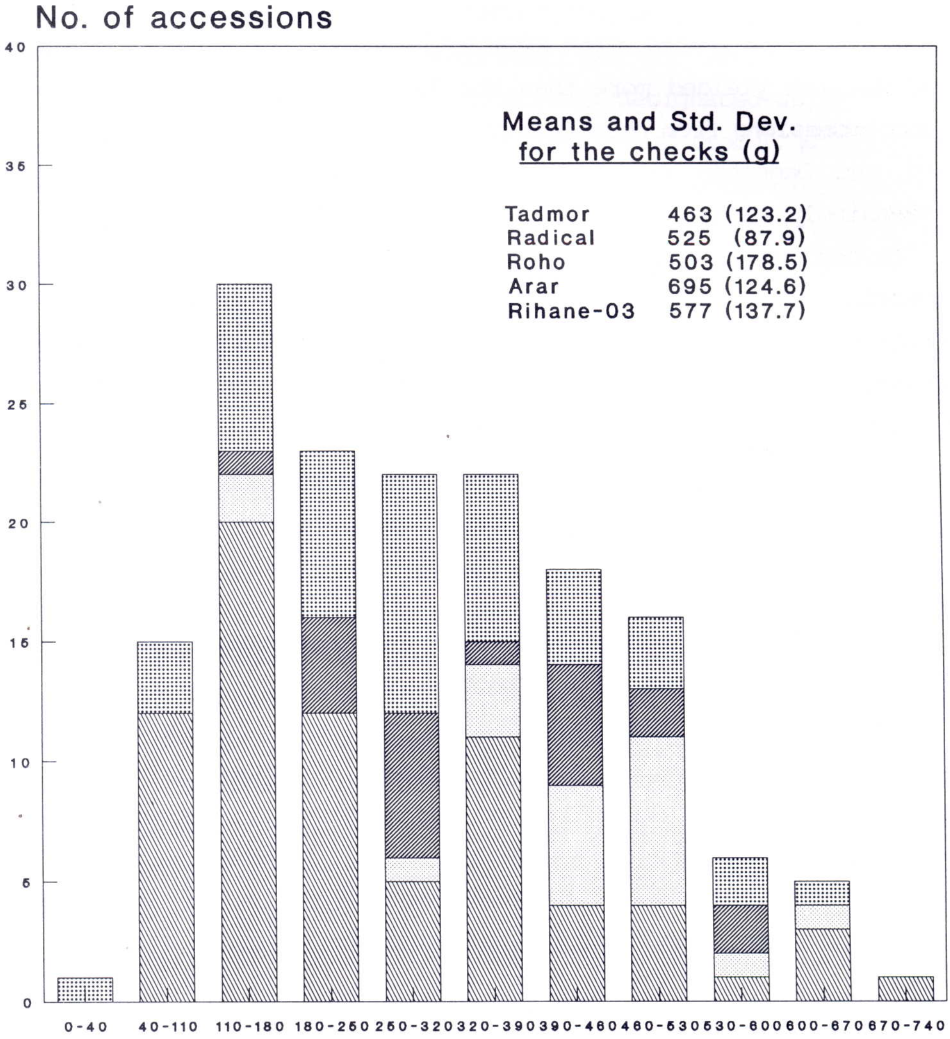

Fig. 7. Mean plot grain yield (g) for barley landraces originating from USSR, Afghanistan, Iran and Pakistan.

the local check level (Fig. 7). Nevertheless, about 50 % of accessions originating from Afganistan and the Baluchistan province of Pakistan yielded more than the local check Tadmor, as well as some accessions from republics of Uzbekistan, Turkmenia, Azerbaijan and the Dagestan region of Russia. Iranian germplasm varied extensively in the grain yield.

In conclusion, some barley germplasm from arid environments of central Asia (Afganistan, Baluchistan province of Pakistan, Uzbekistan and Turkmenia) and the Caucasus region (Dagestan and Azerbaijan) demonstrated good yield performance and frost tolerance in this experiment. However, the actual potential for the highlands of WANA should be evaluated in an additional trial in a highland environment.

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1.3.3. Disease resistance of durum and bread wheat lines derived from crosses with Triticum monococcum

The narrow genetic basis of disease resistance in the cultivated wheats is a matter of growing concern to plant breeders and pathologists since the occurrence of pathogen biotypes with new virulence may have disastrous consequences. In addition, available sources of resistance to diseases are limited to few major genes which are intensively used in wheat breeding programs all over the world.

On the other hand, there is diversity of disease resistance genes in primitive forms and wild relatives of wheat which represent a reservoir for the breeders' future needs. Since it is usually difficult to directly exploit these genetic resources in conventional plant breeding, special pre-breeding or germplasm enhancement programs are needed to transfer the resistance genes to forms and genetic backgrounds convenient to wheat breeders.

As a result of such a program, recently carried out in the

Research Institute of Crop Production in Prague - Ruzyne, Czechoslovakia, two genes for stem rust, one for leaf rust and one for powdery mildew resistance, tentatively designated as Sr Tm_1 (= Sr 35), Sr Tm_2, Lr Tm_1 and Pm Tm_1, were transferred from T. monococcum to durum and bread wheat genetic backgrounds. With the exception of Sr Tm_2, the genes proved to be effective to pathogen biotypes in Europe and Canada.

The major purpose of this study was to evaluate the effectiveness of the T. monococcum resistance genes to pathogen biotypes from the Near East and assess potential of this germplasm for wheat breeding for the West Asia and North Africa (WANA) region.

Resistance to yellow rust, Puccinia striiformis, was evaluated in the field infection nursery planted at the ICARDA principal experimental station, Tel Hadya, Syria. Stem rust, Puccinia graminis f. sp. tritici, and leaf rust, Puccinia recondita, resistance were tested also at adult stage, but under controlled environments in the plastic house. Tolerance to septoria tritici blotch, Mycospaerella graminicola, was evaluated in the field nursery at the Center's sub-station in Lattakia, Syria, a "hot spot" for this disease. In the rusts, both disease severity (%) and reaction type were scored. For septoria blotch a 0 - 9 scale was used.

The durum wheat derivatives were selfed progenies of the first backcross (T. durum x T. monococcum) x T. durum, i.e. the S_1 BC_1 generation, and they served as a tetraploid bridge in the gene transfer from the diploid to the hexaploid level. The hexaploid wheat lines were produced through repeated backcrosses of bread wheat cultivars to the tetraploid bridging lines. The Russian variety 'Yubileynaya' and the Czechoslovak variety 'Zlatka' were used for development of winter and spring bread wheat lines, respectively. The winter lines were selected at the S_1 BC_3 stage, whereas the TMG and TMR spring lines were derived from S_2 BC_3 and TME

Table 9. Disease reaction of wheat lines derived from crosses with *T. monococcum*.

Line	*T. mon.* gene	Yellow rust*	Leaf rust	Stem rust	Septoria blotch**
Durum wheat:					
G2-6	Lr Tm_1	40 MS	1 R	30 S	8/6
J3-9	Sr 35, Lr Tm_1	80 S	1 R	- -	6/4
K2-6	Lr Tm_1	45 MS	1 R	45 S	8/6
L1-14	-	20 M	30 MS	- -	6/5
L6-2	-	25 MS	15 MS	70 S	4/4
L6-11	-	40 MS	15 M	- -	5/4
L6-16	-	20 MS	20 MS	30 MS	4/4
3310 (check)	-	55 S	60 MS	70 S	8/6
3574 (check)	-	20 MS	35 MS	60 S	6/4
Bread wheat:					
Winter type					
TMG6-J17-8	Sr 35	25 MS	20 S	10 M	2/2
TMR5-J2-13	Lr Tm_1	50 S	1 R	30 S	3/2
TMR5-J14-1-1	Lr Tm_1	80 S	1 R	75 S	6/4
TMR5-J14-3	Lr Tm_1	55 MS	1 R	50 S	2/2
Yubileynaya (check)	-	55 MS	15 MS	70 S	2/1
Spring type					
TMG2-Z10-8	Sr 35	1 R	15 M	20 MS	6/4
TMR2-2-5	Lr Tm_1	1 R	5 M	80 S	6/5
TME6-1-1-21-1C-2	Sr Tm_2, Pm Tm_1	1 R	5 M	75 S	5/4
TME6-1-1-23-1C-1	Sr Tm_2, Pm Tm_1	5 R	10 M	70 S	6/5
TME6-1-1-23-1C-2	Sr Tm_2, Pm Tm_1	1 R	10 M	65 S	7/5
Zlatka (check)	-	1 R	10 MR	65 S	7/5

* : for rusts: % severity and reaction type; R = resistant, MR = moderately resistant, M = intermediate, MS = moderately susceptible, S = susceptible.

** : for septoria tritici blotch: 0 - 9 scale, 1st digit = vertical disease development, 2nd digit = disease severity.

lines from S_5 BC_1 generations, respectively. Durum wheat parental lines 3310 and 3574 and the bread wheat recurrent parents Yubileynaya and Zlatka were the checks.

Since no major gene for yellow rust resistance was transferred from T. monococcum, most lines were susceptible to the disease with the exception of spring bread wheat lines which were derived from crosses with cv. Zlatka (Table 9). This variety possesses a gene for adult plant resistance to yellow rust and the gene is, most probably, present in all these lines.

The Lr Tm_1 gene for resistance to leaf rust seems to be very effective to the biotypes used in this study (Table 9). The adult plant resistance to different populations of the pathogen (natural infection) was confirmed in the field experiment (see Chapter 1.3.5.). No virulence for this gene has been found until now in Europe and Canada and present results provide additional evidence on potential usefulness of this T. monococcum gene for leaf rust resistance breeding of durum and bread wheat.

The Sr 35 stem rust resistance gene produced intermediate infection types both in the seedling and adult stages. The same intermediate disease reaction was found in the present experiment; it may be therefore concluded that the gene is effective to local biotypes of the stem rust fungus (Table 9). However, the second T. monococcum gene for resistance to this pathogen, Sr Tm_2, was ineffective to the biotypes used, since the TME lines were susceptible to stem rust.

The bread wheat variety Yubileynaya possesses tolerance to septoria and this trait was also found in two lines derived from this parent.

Since powdery mildew reaction was not tested, effectivness of the Pm Tm_1 gene to local biotypes of the pathogen thus remains unknown.

In conclusion, the results of this experiment prove that two T. monococcum genes, Sr 35 and Lr Tm_1 are effective to local biotypes

of stem rust and leaf rust, respectively, and can be utilized in wheat breeding for the WANA region. In addition, the yellow rust resistance and septoria tolerance of some lines derived from their bread wheat parents may also be valuable for the disease resistance breeding in the WANA region.
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1.3.4. Agronomic evaluation of durum and bread wheat lines derived from crosses with Triticum monococcum

Depending on number of backcrosses, the tetraploid and hexaploid wheat lines originating from the Triticum monococcum wide hybridization program (see Chapter 1.3.3.) possess a certain amount of alien genetic information transferred together with the disease resistance genes. It is estimated that due to the genetic linkage with a resistance gene (linkage drag or "hitch-hiking effect") and in relation to the backcross generation, these lines contain the following average proportions of genetic material of the wheat species:

Line	T. monococcum %	T. durum %	T. aestivum %
tetraploid	13.6	86.4	-
hexaploid			
TMG and TMR	1.5	3.6	94.9
TME	5.2	11.9	82.9

The T. monococcum derivatives were planted in a field experiment at the ICARDA experimental farm Tel Hadya, Syria for agronomic evaluation with two main objectives: 1) to evaluate the effect of the alien genetic material on the agronomic performance of the lines in comparison with their recurrent cultivated parents used in the backcrosses; and 2) to assess adaptation of the lines and their cultivated parents to agro-ecological conditions of northern Syria.

A total of 20 lines derived from crosses with T. monococcum were planted in a 5 x 5 simple lattice design in two replications with two durum and three bread wheat local checks, Omrabi, Haurani and Mexipack, Cham 4, Sonalika, respectively. A plot consisted of four rows, 2.5 m long and 37.5 cm apart. The experiment was planted on November 18, 1991 and the field received supplementary irrigation of 40 mm on December 17, 1991.

The following traits were scored: frost damage (FD; 1 highest, 9 lowest), growth habit, leaf color, early vigor, growth class, days to heading (DH), plant height in cm (PH), plant waxiness, lodging resistance, days to maturity (DM), plot grain yield in g (GY), 1000 kernel weight in g (TKW) and leaf rust reaction type (LR; R = resistant, S = susceptible).

Adjusted mean values for five agronomic traits (Fd, DH, DM, TKW and GY) from simple lattice design and non-adjusted mean values for plant height and reaction to leaf rust are presented in Table 10.

Some shift towards frost tolerance, tallness and smaller grain can be noted for the tetraploid lines compared with their durum wheat recurrent parents (Table 10). Grain yield was at least the same, though the high $LSD_{0.05}$ value does not allow definitive conclusions. Due to high sensitivity to photoperiod, both the tetraploid derivatives of T. monococcum and their durum wheat parents headed much later than the local checks what affected their grain yield. This is believed to be the major cause of their poor adaptation to the local agro-ecological conditions. However, this drawback could be overcome in the crossing programs by using partners with low photoperiod sensitivity.

The winter bread wheat lines tested were fairly adapted to the semi-arid environment of northern Syria, most probably due to their low photoperiod sensitivity, inherited from the recurrent bread

Table 10. Agronomic characteristics of wheat lines derived from crosses with T. monococcum.

Line	FD*	DH*	DM*	PH**	TKW*	GY*	LR**
Tetraploid lines of durum wheat type:							
G 2/6	3.8	150.2	189.2	91.0	27.7	369.1	R
J 3/9	4.4	149.4	190.5	81.2	25.7	349.5	R
K 2/6	3.6	155.2	188.5	102.2	33.1	337.3	R
L 1/14	3.1	148.9	188.5	105.0	31.1	513.2	S
L 6/2	3.1	152.8	177.7	97.0	33.7	453.5	S
L 6/11	3.1	153.1	183.2	92.0	32.3	417.5	S
L 6/16	2.6	151.8	192.9	101.2	28.7	213.3	S
3310 (RP)+	2.0	148.9	193.7	76.5	35.3	268.9	S
3574 (RP)++	3.0	151.3	190.9	95.7	40.5	396.6	S
Omrabi (LC)***	3.9	138.7	183.4	88.2	33.0	779.1	S
Haurani (LC)***	3.4	134.9	177.7	81.2	30.3	460.8	S
Hexaploid lines of bread wheat type:							
winter type							
TMG6-J17-8	7.2	144.8	186.9	93.7	33.6	748.4	S
TMR5-J2-13	5.9	143.2	180.7	83.7	25.0	621.2	R
TMR5-J14-4-1	5.1	140.9	181.5	91.0	27.0	734.8	R
TMR5-J14-3	6.8	143.1	179.7	93.0	29.4	671.1	R
Yubileynaya (RP)	7.0	145.0	184.1	93.2	26.3	614.9	S

* : adjusted means for simple lattice design.
** : non-adjusted means for randomized block design.
*** : LC = local check.
\+ : RP = recurrent parent of the line G 2/6.
++ : RP = recurrent parent of the other tetraploid lines.

wheat parent, cv. Yubileynaya (Table 10). Agronomic performance of the lines was comparable with the variety Yubileynaya, but some of them were slightly earlier and also more productive. Suprisingly,

Table 10. (continued) Agronomic characteristics of wheat lines derived from crosses with T. monococcum.

Line	FD*	DH*	DM*	PH**	TKW*	GY*	LR**
spring type							
TMG2-Z10-8	3.1	158.0	186.7	83.2	27.3	444.0	S
TMR2-2-5	3.0	155.4	187.9	79.7	26.9	527.6	R
TME6-1-1-21	3.9	158.0	196.0	84.2	28.1	441.0	S
TME6-1-1-23-1	4.2	158.3	189.6	85.0	28.4	503.2	S
TME6-1-1-23-2	3.2	153.0	181.5	74.7	25.6	398.3	S
Zlatka (RP)	3.2	160.3	194.8	86.5	26.1	305.7	S
Mexipack (LC)***	3.4	144.8	181.4	97.0	35.5	685.6	S
Cham 4 (LC)***	2.8	138.5	175.9	76.2	25.2	616.3	S
Sonalika (LC)***	3.1	139.3	186.0	81.0	23.3	493.8	R
LSD (P< 0.05)	1.5	5.5	10.4	13.2	5.1	308.7	

* : adjusted means for simple lattice design.
** : non-adjusted means for randomized block design.
*** : LC = local check.
\+ : RP = recurrent parent of the line G 2/6.
++ : RP = recurrent parent of the other tetraploid lines.

they were equal in yield to the local bread wheat checks. Although they were a little later in heading, their frost tolerance was significantly higher. Therefore, these lines can be conveniently employed in stem and wheat rust resistance breeding programs for different target environments of the WANA region. Spring bread wheat lines were, on the contrary, performing much poorer than the winter ones. Them main reason for this was the high photoperiod sensitivity derived from their recurrent parent, cv. Zlatka. Nevertheless, some lines were somewhat earlier and more productive than Zlatka.

In general, results of this experiment indicate that the introduction of alien genetic information to durum and bread wheats did not lead to deterioration of their agronomic characteristics and, in some cases, the agronomic value was even improved. However, the wide hybridization program was originally targeted to the Central European environment, and in the agro-ecological conditions of northern Syria high photoperiod sensitivity affected the overall adaptation and agronomic performance of durum and spring bread wheat lines derived from wide crosses with T. monococcum.

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

Drought is the most important of all environmental constraints to wheat production in West Asia and North Africa (WANA). Nearly 75% of wheat in this area is produced under varying degrees of drought stress. Short periods of drought during critical periods of crop growth can lead to substantial reductions in crop yield. The genetic improvement of crops for increased tolerance to periods of drought and high temperatures during grain filling may be the only solution to this problem.

There are four major diseases in the WANA region, viz. yellow rust, common bunt, septoria tritici blotch and stem rust. In the process of enhancing germplasm through broadening the genetic base of resistance the project has sought disease resistance genes in several pools from the wild and primitive forms.

There are two essential steps toward the efficient utilization of potentially useful wild and primitive gene pools: (1) a comprehensive and reliable evaluation of genetic resources at hand for a wide range of characters that may be related to biotic and abiotic stress tolerance, and (2) transfer of desirable genes or gene complexes from wild and primitive backgrounds to those breeders lines or varieties adapted to specific target regions.

1.3.5.1. Characterization of Aegilops ovata from Italy

Thirteen samples of Aegilops ovata collected by the University of Pisa from Manfredonia (Foggia), Bari (Bari), Pisa (Toscana), Dopo S. Antonio, S. Forzorio, Dopo St. Lucia, Simbirizzi, Cagliari (Cagliari, Sardinia), Catania (Sicily), Rome (Lazio), Genova (Liguria), Ruinas, and Assolo (Oristano, Sardinia) were received at ICARDA in 1989 and multiplied in 1989-90. This germplasm was characterized and evaluated in 1990-91 for morphological traits and seed protein electrophoresis respectively. This work was carried out in scientific collaboration with the University of Pisa, Italy.

Electrophoresis

Seed proteins are products of many genes and their analysis can provide useful information about evolutionary relationships. The extraction of seed storage proteins (gliadins) with N, N'-dimethylformamide followed by polyacrylamide gel electrophoresis (PAGE) is mainly a function of the molecular weights of their polypeptide chains. The distance of migration of the bands in the gel is determined primarily by molecular weights and any differences in composition can assist in distinguishing complex patterns in proteins from one single seed to another.

When the storage protein (gliadin) electrophoretic banding patterns from 5 seeds per sample were examined, an unusual high molecular weight (HMW) omega gliadin band in the sample collected from Catania (Sicily) was noticed. This slowest moving band, which is synonymous with the slowest band in "Marquis", the Canadian bread wheat used as control, clearly suggests that this ovata sample may be a hybrid with some introgression of genes of the "D" genome (Fig. 8). This infusion may have come from Ae. cylindrica, since other Aegilops species having the "D" genome have not been reported from Italy. But this is not altogether surprising since KIMBER & FELDMAN (1987) mention that there are "many natural and artificial hybrids"

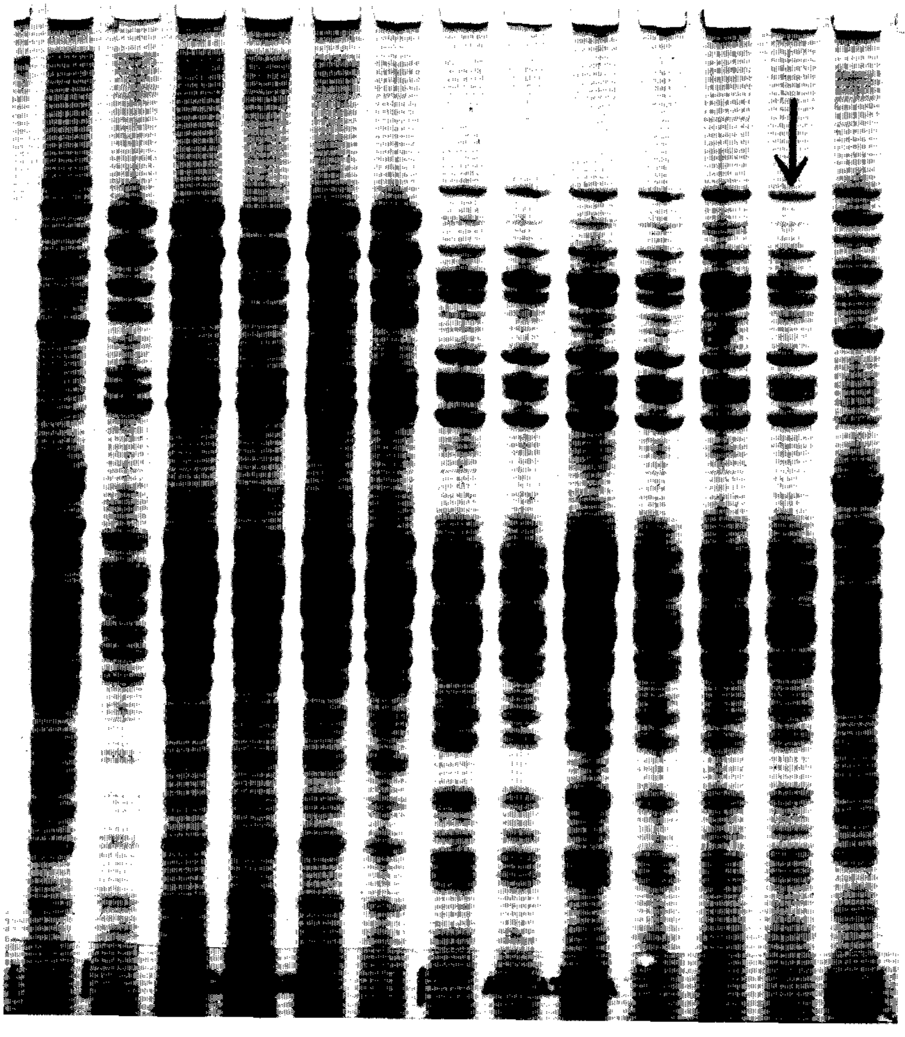

Fig 8. Electrophoretic banding patterns of gliadins from five single seeds of <u>Aegilops</u> <u>ovata</u> collected from Cagliari (Sardinia) and Catania (Sicily) in Italy. Banding pattern on extreme ends (M) is "Marquis", the Canadian bread wheat cultivar used as a reference. Arrow shows band in sample from Catania which has the same mobility as the slowest band in "Marquis".

of Ae. ovata. It is also possible that the wild species may have crossed naturally at some stage with cultivated T. aestivum (bread wheat) in a field close to its habitat. Surprisingly there was very little heterogeneity among the banding patterns of single seeds in a sample, indicating that the seeds may have come from a very narrow genetic base.

Morphology

It was observed that (a) culms lengths were longer in populations from mainland Italy, e.g. 60 cm for Rome to 51 for Genova, compared with 35-40 cm for those from Sardinia. (b) The average flag-leaf area was (in cm^2): Pisa 73.1, and Rome 62.6, against Bari 20.6, and S. Forzorio 38.1. (c) The number of tillers were highest at 190 in Assolo, and only 57 in Catania. (d) The spikes were also longer on the mainland (7.0 cm) against those from Oristano, Sardinia, i.e. 4.6 cm for Ruinas and 6.0 cm for Simbirizzi. The number of days after planting for four phenological stages in the life cycle are given in Table 11.

Table 11. Differences in number of days for four phenological stages of Aegilops ovata samples from provinces in Italy.

Province	**Flag-leaf emergence**	**Spike emergence**	**Days to flowering**	**Days to maturity**
Genova (GE)	141	153	159	195
Pisa (PI)	153	161	172	192
Rome (RM)	145	153	159	195
Manfredonia (FG)	153	161	172	195
Bari (BA)	145	153	159	195
Catania (CA)	145	153	159	200
S. Forzorio (CA)	145	153	159	195
Simbirizzi (CA)	145	153	159	195
Assolo (OR)	153	161	170	203
Ruinas (OR)	155	161	170	203

There were no significant differences in the physio-morphological characteristics, which is in contrast to the variability observed in the gliadin banding patterns from one sample to another.

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1.3.5.2. Evaluation of Aegilops spp. for stress tolerance

West Asia is the primary center of diversity and the origin of wheat. ICARDA's headquarters located at Tel Hadya falls within this center of diversity and hence is a favorable site for the characterization, evaluation and pre-breeding activities aimed at improvement of this crop. Despite this advantage, the utilization of non-conventional germplasm such as wild relatives and primitive forms has been slow in this region due to a number of factors given elsewhere.

During 1987-88 a total of 662 accessions of twenty-four Aegilops spp. were planted at Tel Hadya and Breda for evaluation against drought and other stresses, and the results were reported (CP Annual Report, 1988). Triticum monococcum, T. dicoccum, Cham 1 (durum wheat), Cham 4, and Nesser (bread wheat) were used as checks for comparison. In the subsequent three seasons, which were highly variable for temperatures and precipitation, a number of these accessions were dropped from the study due to their poor tolerance to frost, naturally occurring diseases, and drought. In the 1990-91 season, therefore, only 206 from the original 662 accessions had been selected as tolerant to diseases, frost and high temperatures and with good adaptation (Table 12).

The number of species has been reduced to just twelve with four species being dominant among these as the most tolerant and hence desirable for providing donor genes in wide crosses. But unfortunately there is low chromosome compatibility between these species and cultivated wheats. These four species are: Ae. biuncialis, columnaris, ovata, and triuncialis. They are all

Table 12. Species of Aegilops tolerant to drought, frost and heat stress over four seasons at Tel Hadya, Syria.

Species	Genome	No. of selected lines	%
biuncialis	4X, UM	50	25
caudata	2X, C	8	23
columnaris	4X, UM	27	53
kotschyi	4X, US	1	2
ovata	4X, UM	53	16
peregrina	4X, US	4	3
speltoides	2X, S	2	2
squarrosa	2X, D	2	1
triaristata	6X, UMUn	6	5
triuncialis	4X, UC	39	10
umbellulata	2X, U	5	8
vavilovii	6X, DMS	8	15
Total		**205**	

tetraploids. However, the most interesting germplasm from the point of view of wide crossing are the ones possessing the D genome, i.e. Ae. squarrosa (syn. T. tauschii) and Ae. vavilovii. But we have often found accessions of these two species to be susceptible to yellow rust during a wet spell and hence they should be used in crosses with cultivated wheats resistant to this disease. The most common disease in Aegilops species was yellow rust (Puccinia striiformis) and it affected mostly Ae. ovata, columnaris and vavilovii. Since most of the susceptible lines had been eliminated in the previous seasons, the number of lines which were affected were only 45 out of 205.

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1.3.5.3. Evaluation of Triticum dicoccoides for stress tolerance

The 1990-91 season was wetter than the previous two seasons. The accumulated total rainfall at Tel Hadya was almost 300 mm. The season was also characterized by rains fairly late in the season as well as a hail storm on 21 May 1991. These weather conditions during the season encouraged natural disease manifestations at Tel Hadya and several diseases were observed and recorded on wild and primitive forms.

Resistance to several diseases has been incorporated into cultivated wheat from closely related species of Triticum, Aegilops, and Agropyron by other workers. Out of 266 lines of T. dicoccoides (AABB 4X), the wild progenitor of durum wheat, planted at Tel Hadya, 75 were affected by yellow rust, 13 by leaf rust (Puccinia recondita) and 7 were affected by both rusts. In the 1990-91 season stem rust (Puccinia graminis f.sp. tritici) was also observed on three lines. One line in particular, selected from IC 600225, was affected by yellow, leaf, and stem rusts. However, in all above cases the disease attack was late in the life cycle and in almost all cases had no effect on the grain filling period. Hence seed production was not affected.

Over 100 lines of T. dicoccoides were tested at ICARDA's station in Breda and found resistant to frost, drought, rusts, and almost all of them had a higher protein content than the checks, Haurani, Cham 1 and Cham 3 (Cereal Improvement Program Annual Report, 1989). Table 13 presents information on other economically important traits of 20 lines of T. dicoccoides which were found resistant to frost both at Tel Hadya and Breda over three consecutive seasons.

It was noted that all six accessions from Lebanon were highly resistant to cold. These results were not surprising since they were collected from the higher altitudes in the Jebl Liban mountains. The samples from Lebanon were, on the whole, susceptible to yellow and leaf rusts.

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Table 13. *T. dicoccoides* accessions, resistant to frost at Tel Hadya and Breda over three consecutive seasons.

ACC.NO.*	TOTIL	DHE	PLH	PED	DMA
600609	4.17	147.7	75.5	25.5	176.5
600563	6.25	145.5	63.0	26.0	174.5
600763	5.25	154.2	79.2	28.2	180.5
600756	4.25	147.5	80.2	31.2	172.5
600722	7.00	155.5	84.7	33.0	181.7
600081	6.75	148.7	74.7	32.0	172.7
600219	6.50	143.5	67.0	27.5	171.5
600873	4.25	147.7	63.2	23.7	174.5
600714	7.00	152.0	76.5	28.2	178.5
600726	5.75	152.5	78.5	27.0	178.0
600692	5.00	152.7	74.0	27.0	177.7
600721	6.75	151.2	85.5	33.0	177.7
600688	8.50	152.0	75.5	32.0	178.5
600676	4.75	150.5	79.2	32.0	176.7
TER001**	3.75	156.2	71.7	21.7	185.7
TER002	5.25	151.5	78.7	26.5	179.0
TER003	5.25	152.2	73.2	25.7	178.0
TER004	5.75	157.2	73.2	26.5	185.5
TER005	4.50	155.0	68.25	23.2	182.7
TER006	4.50	150.2	78.5	26.7	177.7
Cham 4	16.0	145.0	68.0	30.0	180.0
Haurani	12.0	148.0	88.0	42.0	185.0
Mexipak	10.0	148.0	75.0	32.0	180.0

* : ACC.NO. - ICARDA gene bank number
TOTIL - Total number of fertile tillers
DHE - Days to heading
PLH - Plant height (cm)
PED - Peduncle length (cm)
DMA - Days to maturity
** : TER - Selections from accs. nos 600176/177/178 collected from Lebanon in 1988 by Dr S. Jana

1.3.5.4. Test for salinity tolerance using sand culture

There is a considerable increase in requests from scientists for wheat and barley germplasm tolerant to salinity. The processes that limit plant growth due to drought and salinity are similar. One of the constraints to improving salinity tolerance in the field is that both the timing and the intensity of exposure can influence yield. Because of variability inside a saline field as well as year to year variability depending on rainfall it is very difficult to obtain consistent results by making selections in a salinized field; ranking of lines changes year to year as different characters become more or less important. Hence, a move to screen germplasm for salinity tolerance in a controlled environment has been attempted.

The selection of cereals for salt tolerance is confounded by factors such as marked heterogeneity in the soil in terms of area and depth within a field, as well as from year to year in the same field, in the ionic composition of the soil solution. This is further compounded by associated environmental stresses, such as drought and high temperatures on one hand and water-logging on the other.

Experiments using sand culture techniques in a plastic house alleviate these problems to some extent. To explore the potential of this technique a small experiment was set up jointly with the Cereal Improvement Program on using this technique, for screening germplasm of wild species [Triticum boeoticum (2X), T. dicoccoides (4X)] for tolerance to salinity. Five accessions of each of the two wild species together with salt tolerant checks Senatore Capelli (4X) and Mexipak (6X) were sown in sand culture tanks in a plastic house with two salt concentrations viz. 100 mM and 150 mM. A simple lattice design with 8 replicates was used. The micronutrient used was Hoagland's solution at 0.5 strength. A third sand culture tank with only nominal salt solution (5 mM) was used as a control. The relative humidity was maintained at 60% and temperatures ranged from 15-25 degrees centigrade throughout the experiment. The experiment was sown on 8.11.90, emergence was three days later, and the plants were harvested on 26.2.91. The following observations were recorded: days to heading, no. of leaves on main tiller, flag-leaf size, total no. of tillers, peduncle length (cm), plant height (cm), no. of spikes per plant, and no. of spikelets per spike.

There was an aphid attack in the control tank in all replicates which was controlled by spraying the insecticide Pirimor. Plants in the other two tanks with saline irrigation were not attacked. The results of this experiment can be summarized as follows: (1) Two accs. of T. dicoccoides were tolerant to salt in all replicates and at both concentrations; (2) both checks confirmed their tolerance to salinity; (3) four T. boeoticum accs. were tolerant at only 100 mM in all replicates; (4) the rest of the entries were susceptible to salinity.

However, it was found that the sand culture technique was not suitable for screening a large number of germplasm accessions at a time due to the high number of replicates needed and the time required to obtain the results, and hence the feasibility of using hydroponic techniques was studied. This technique, which is similar to the one used at University of North Wales at Bangor, UK, required lesser number of days to distinguish between susceptible and tolerant accessions and can accommodate a much larger number of samples at one time than sand culture.

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1.3.5.5. Primitive wheat from the CIMMYT collection

One hundred and twelve primitive wheats received from CIMMYT in 1989 have now been evaluated at Tel Hadya over two seasons by the Genetic Resources Unit. Some T. carthlicum accessions were susceptible to naturally occurring yellow rust, whereas, T. compactum was affected by stem and leaf rusts. The high incidence of rusts in the 1990-91 season was probably due to late rains. T. carthlicum was previously cultivated in Iran, Iraq, and Caucasia. Several accessions which were resistant to rusts are presented in Table 14.

Table 14. Number of accessions, species, ploidy level and genomes of primitive wheat resistant to yellow and leaf rust.

No. of accs.	Species	Ploidy	Genome	%
2	T. boeoticum	2X	AA	100
9	T. monococcum	2X	AA	90
17	T. urartu	2X	AA	77
11	T. carthlicum	4X	AABB	100
8	T. dicoccum	4X	AABB	17
7	T. polonicum	4X	AABB	99
5	T. compactum	6X	AABBDD	100

Among the wild diploids 7 accessions of Triticum urartu were affected by yellow rust, but 19 were found to be resistant. Both accessions of T. boeoticum were resistant to the diseases.
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1.3.5.6. Prebreeding and development of genetic stocks

The wild progenitors of wheat are commonly sympatric with their cultivated forms. They differ, however, in phenotype and micro-adaptation toward the edges of cultivated fields, but remain sufficiently related genetically to cross and produce fertile hybrids with exchange of genes, particularly in the direction of the cultivated forms. However, breeders are adverse to use of 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. The real bottle neck, therefore, in the utilization of wild and primitive forms in crop improvement by breeders has been the lack of genetic stock lines with stabilized desirable characters in acceptable genetic background. Hence, 25 crosses between wild species (mainly T. dicoccoides as male parent) and durum wheat, and

Table 15. Days to heading and days to maturity of F_1s from crosses made with Triticum dicoccoides during 1989/90, Tel Hadya, Syria.

Parents		Acc.no.*	DHA**	DMA
T. durum (Haurani)	x T. dicoccoides	600340	159	189
T. durum (Haurani)	x T. dicoccoides	600474	165	199
T. durum (Cham 1)	x T. dicoccoides	600340	149	188
T. durum (Cham 1)	x T. dicoccoides	600415	147	188
T. durum (Cham 1)	x T. dicoccoides	600392	149	190
T. durum (Cham 1)	x T. dicoccoides	600435	149	189
T. dicoccum	x T. turanicum		166	193
T. dicoccum	x T. polonicum		159	190
T. dicoccum	x T. dicoccum		166	193
T. turgidum	x T. polonicum		164	197
Checks				
Cham 1			139	184
Haurani			146	180
Mexipak			142	175
T. dicoccum			161	190

* : refers to T. dicoccoides accessions only
** : DHA - Days to heading
DMA - Days to maturity

between durum wheat and primitive forms with disease resistance (T. dicoccum), were made during 1990 in order to develop genetic stocks with stable characters suitable for use by breeders at ICARDA and elsewhere.

Seeds obtained from the 25 crosses were planted at Tel Hadya, but only 10 out of these produced healthy plants; the rest were sterile or died due to hybrid necrosis. All surviving fertile F_1 plants were attacked by yellow rust and leaf rust due to susceptibiltiy under high rainfall conditions late in the season which encourages the development and spread of spores. Table 15 gives the heading and maturity times for the F_1 plants of these crosses. The seeds obtained will be sown in the next season for selection and tested in disease nurseries for yellow rust and common bunt in collaboration with the wheat pathologist in the Cereal Improvement Program.

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1.3.5.7. Research on alien gene transfer in wheat wild relatives at the University of Tuscia, Viterbo, Italy

Collaborative research within the framework of the project "Enhancing Wheat Productivity in Stress Environments Utilizing Wild Progenitors and Primitive Forms" continued in 1991 at the Department of Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy, under direct and overall supervision of Prof. C. CEOLONI and Prof. E. PORCEDDU, respectively. It comprises of several different research programs which can be grouped into two main topics: a) Alien gene transfer, and b) Assessment of alien genetic polymorphism through use of molecular markers.

Alien gene transfer

During 1990-91 two diverse approaches aimed at exploiting alien genetic variation for wheat improvement were carried out utilizing two of the most advanced cytogenetic techniques of genetic engineering. The first concerns the transfer of powdery mildew (Erysiphe graminis f. sp. tritici) resistance gene (Pml3) derived from Aegilops longissima into bread and durum wheats, and the second aims at the introduction of an Agropyron elongatum chromosomal segment, containing the Lr19 leaf rust resistance gene plus the Y gene (yellow pigment), into durum wheat.

1. Prior to attempting transfer, it was verified that the Pml3 gene, which is highly effective against mildew isolates of several origins, was located on the short arm of chromosome $3S^l$ of Aegilops

longissima. Subsequently, using a ditelosomic addition for the critical arm as donor line "proximal" transfers, i.e. bread wheat cv. Chinese Spring, resistant lines possessing complete chromosomes only were recovered through *ph1b* mediated homoeologous recombination.

In all, nine such recombinants were subjected to monosomic analysis and C-banding, both these tests indicated that, irrespective of the group-3 wheat monosome employed in the initial cross of the transfer scheme, in six of these the recombined wheat chromosome was 3B, and in the remaining three it was 3D.

In order to estimate the amount of alien chromatin introgressed in the different recombinants, genetic and cytogenetic analyses were preformed. In order to evaluate the residual pairing ability between every recombinant chromosome and each of its complete homologues, metaphase I pairing was assessed in mildew resistant F1s between each of seven transfer lines and its corresponding wheat ditelo line (3BS or 3DS), as well as $3S^l$(3B) or $3S^l$(3D) substitution lines developed.

In the case of the four 3B recombinants (called R1A, R4A, R6A, and R1B), the proximal wheat segment supported a proximate equivalent amount of pairing with telo 3BS in R1A, R4A, and R1B (about 42%), whereas in R6A such pairing was lower (only about 10%). This may suggest a possible larger portion of alien gene material present in the latter line compared to the former ones. Relative amount of pairing of the distal portions with the complete $3S^l$ confirmed this pattern. Such a trend was not observed in the case of 3D transfer lines in which a more continuous variation was noticed, i.e. R2A showed a 25% pairing with telo 3DS, R1D a 37%, and R2B about 44%.

A telocentric mapping experiment was then carried out pollinating normal Chinese Spring (susceptible to mildew) with the 2n=41+t resistant F1s derived from the [recombinant x ditelo] crosses. Data on the crossover frequency show a remarkably coincident trend with that shown by MI pairing analyses. Here too R1A, R4A, and R1B exhibit similar crossing over values (29%, 34.4%, and 32.7%, respectively).

In terms of mapping distance, calculated using the Kosambi function, their longissima-wheat chromatin breakpoints appear rather distantly located from the wheat centromere (about 34 cM for R1A, 42 for RA4, and 39 for R1B), whereas that of R6A seems much more proximal (about 10 cM). As for the 3D recombinants, again R2A shows minimum pairing with 3DS also having the minimum crossing over frequency (14% = 15 cM). But the reverse is true for R2B (40% crossing over = or > 50 cM), while R1D appears to be intermediate (with 29% crossing over = 33 cM).

So far no evidence is available for the physical location of the various break points on the chromosomal maps. Hence, in situ hybridization experiments were undertaken to determine the location of the break points. Results from this study, together with tests for isozyme and molecular markers associated with the transferred segments, will permit a thorough evaluation of the amount and content of the alien gene introduced into each line which will also determine the selection of the best lines for breeding purposes.

2. The Chinese Spring-Agropyron elongatum transfer No. 12, one of the transfer lines produced by the late Professor E.R. Sears to transfer the Agropyron Lr19 leaf rust resistant gene into bread wheat, is currently being used to introduce that alien segment into durum wheat. In fact, the same segment includes also the Y gene for yellow pigment in flour production in durum wheat, a characteristic highly desired by pasta consumers.

Transfer No. 12 line, in contrast to other transfers of the same set which involve wheat chromosome 7D, involves chromosome 7A. Thus, the transfer to selected durum wheat varieties can be obtained through homologous recombination between the wheat portion shared by the recombined and the normal 7A chromosome. A large number of such pentaploid progenies were recovered from crosses between transfer No. 12 and high yielding and superior pasta making durum cultivars. These will be employed as recurrent parents in subsequent backcrosses in which both the presence of Lr19 and the Y genes will be the criteria for further selection.

Assessment of alien genetic polymorphism through use of molecular markers

Molecular markers, such as Restriction Fragment Length Polymorphism (RFLP) and, Polymerase Chain Reaction (PCR) amplification by oligonucleotide primers specific for known or random (RAPD) sequences, were used for detailed genetic maps of several crop species during 1990-91. The main impediments to extensive exploitation of molecular markers for evaluating genetic polymorphisms in plant populations are: (1) the financial costs, and (2) the handling of radioactive material in the case of RFLPs. Therefore, non radioactive methods of detection, such as digoxigenin labelling and PCR amplification will be adopted.

Probes isolated from genomic and cDNA libraries derived from different genotypes were used to test genetic polymorphism between different species of wild wheats. Probes able to detect polymorphisms will be further exploited to assess genetic variability within wild species. Even though cDNA probes appear to detect more polymorphism, they were subsequently discarded for their low hybridization signal which is inadequate for digoxigenin labelling. Further extensive studies on RFLP variation in wild wheat relatives are in progress at the University of Tuscia's Department of Agrobiology and Agrochemistry.

Sequences coding for wheat storage proteins (prolamins), previously cloned through PCR amplification with specific primers, were used as probes. Molecular probes for alpha, beta, and gamma gliadins and for low-molecular-weight (LMW) and HMW glutenins were used for hybridization with genomic DNAs from the following Triticum species: T. boeoticum, urartu, dicoccoides, dicoccum, timopheevi spp. araraticum, carthlicum, turgidum var. durum, karamyshevii, jakubzineri, from aestivum the subspecies macha, compactum, spelta, sphaerococcum and aestivum, and T. vavilovii; and also from the following Aegilops species: speltoides, searsii, squarrosa spp. strangulata, cylindrica, juvenalis and crassa. The level of genetic polymorphism observed for these sequences is much higher than the random probes isolated from genomic libraries.

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1.3.5.8. Novel high molecular weight subunits of glutenins confirmed in Japanese hexaploid wheats

Glutenin is the protein constituent of flour of bread wheat T. aestivum which gives elasticity to the dough. It comprises 12 different subunits which are easily separated by sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE). Some of these subunits have been extensively studied since they are important in bread-making quality. PAYNE et al. (1983) reported unique high molecular weight (HMW) subunits in certain Japanese hexaploid varieties. They had by far the lowest relative mobility (and therefore, probably the highest molecular weight) of any HMW subunit of glutenin so far described in hexaploid wheat.

A collection of 130 Japanese bread wheat varieties were received at ICARDA's Genetic Resources Unit this year from the National Agriculture Research Center, Tsukuba, Japan. The same were planted in the isolation field for preliminary evaluation during the 1991-92 season. On screening these varieties with SDS-PAGE it was confirmed that varieties Akasabi Shiraza, Aoba Komugi, and Shirasagi Komugi possessed the unique HMW subunits. Although such HMW proteins have been reported previously in Aegilops umbellulata and other diploid Aegilops species possessing the S genome and confirmed by us, they were not detected hitherto in hexaploid wheats. However, it is unlikely that these subunits appear in Japanese varieties by outcrossing with a diploid Aegilops species because of different mobilities of the bands. It could have arisen from a recent gene mutation within the Japanese bread wheats. After multiplication during 1991-92 it is hoped to transfer these subunits through crosses with other good quality bread wheats in order to improve elasticity of the dough by forming large aggregates. After several generations of backcrossing with the selected good quality breeding line, it may be possible to determine the positive effect of this unique HMW subunit on the bread-making quality.

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1.3.6. Characterization of Aegilops germplasm

A set of 277 entries from Algeria, Bulgaria, Cyprus, Iraq, Libya, Morocco, Syria, Tunisia, Turkey and the USSR 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).

Qualitative and quantitative characters were evaluated on plot basis using the IBPGR wheat descriptor list. Qualitative characters 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 characters were evaluated on three single plants selected randomly 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

Table 16. **Minimum, maximum, mean and standard deviation for 3 characters in *Aegilops* germplasm (1991 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	34	33	65	47.72	7.39	147	195	172.76	14.04	2	4	3.61	0.73
caudata	5	43	70	55.70	9.92	154	183	173.2	11.84	6	11	8.16	0.89
columnaris	3	30	53	41.30	9.01	160	160	160.00	0	5	6	5.66	0.57
crassa	3	39	65	53.66	9.44	154	160	156.00	3.46	7	11	8.86	1.25
cylindrica	20	49	77	64.78	7.56	173	183	175.50	4.44	5	13	10.66	1.40
ovata	83	22	67	41.66	8.34	140	183	156.42	9.68	3	6	4.61	3.34
peregrina	15	35	71	51.38	7.29	154	173	159.33	10.56	3	7	5.11	0.89
squarrosa	7	40	65	53.17	6.20	154	183	170.85	12.69	8	13	10.48	1.22
triaristata	20	29	69	51.82	9.55	154	183	170.00	8.93	4	7	5.20	0.55
triuncialis	55	40	77	56.37	6.98	147	195	170.20	11.83	3	8	6.08	0.65
vavilovii	3	40	95	64.43	23.45	147	154	151.66	4.04	8	10	8.96	0.35
ventricosa	18	26	66	51.06	9.68	147	173	157.55	10.92	7	10	8.62	0.92
vavilovii	(I)*	45	80	62.94	7.00	147	183	156.54	9.24	8	11	9.36	0.70
triuncialis	(II)	36	80	58.97	9.28	154	154	145	0	5	7	6.26	0.41
searsii	(III)	26	55	47.24	2.77	154	173	163.4	8.61	6	13	10.75	1.77
biuncialis	(IV)	37	79	56.39	9.65	147	160	149	4.44	2	3	3.02	0.23

* : I–IV = Check

of 3 readings per individual plants), number of spikelets per spike, flag leaf length and width. In addition the number of days to heading and days to maturity were calculated starting from the day of first effective rain after planting (3 December 1990). Data on 3 quantitative characters are shown in Table 16.

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1.3.7. Diversity for important wheat diseases in a selection of the ICARDA Aegilops collection

During the 1990/1991 season a part of the Aegilops collection has been tested for three important fungal wheat diseases, viz. yellow rust [Puccinia striiformis Westend. f. sp. tritici], septoria tritici blotch [Mycosphaerella graminicola (Funkel) Sand.] and common bunt [Tilletia foetida (Wall.) Liro and T. caries (DC) Tull.]. Selection of material has been guided by the following principles: (1) sequential accession numbers to start at 400675 as the numbers 400001-400674 had already been tested for the same diseases; (2) accessions received or collected in the 1990 season to be excluded as they need to be multiplied first; and (3) to include as many species and of them as many different origins as possible in order to encompass a maximum variation (this was, however, limited by the availability of relevant passport data). Following these criteria 596 accessions were selected out of the initial set of 1824 entries. Of these 596 a further 176 were deleted due to insufficient amounts of seed and/or germination capacity, resulting in a final number of 420. Twenty 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, and only material of Ae. juvenalis, uniaristata and sharonensis was not available.

Yellow rust

The set of 420 accessions was planted on 12 December, 1990, in an unreplicated trial, using 8 seeds planted in 2 rows of 1 m each and 30 cm apart as the test plot. Randomisation 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 randomisation. During the trial a further 16 entries did not germinate and therefore the results, presented in Table 18, refer to a final total of 404 tested accessions.

Scoring of severity of the infection was done with the modified COBB's scale. A trace infection was scored as 1%. Field response, or reaction type, was classified with the categories R, MR, M, MS and S). Both severity and response were then 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, 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 (Table 18). Material with good resistance was defined as showing a severity of infection between 1 and 15% and a response of R-MR, which is a CI range of 0.2 to 6.0. A total of 177 accessions, or 44%, fell in this range (Table 17).

The results for yellow rust both at the individual accession and at the species level are varied (Table 18). An ACI up to 15 MR (= 6.0) or less is present in five species only (Ae. columnaris, comosa, speltoides, triaristata and triuncialis), but this includes two of the more widespread species of the genus, Ae. triaristata and Ae. triuncialis, while the ACI of the widespread Ae. biuncialis (7.1) and Ae. ovata (7.6) is only slightly above 6.0. Moreover, the ACI by species obscures promising regions (here: countries), present with species with a distictly higher overall ACI. Table 18 shows

Table 17. Number of resistant accessions to yellow rust in the Aegilops collection, screened in 1990/1991.

Severity and reaction type *	No. Accessions
1 R	112
5 R	5
10 R	17
15 R	3
1 MR	6
5 MR	15
10 MR	18
15 MR	1
Total	**177**

* = Trace severity put at 1%.

examples of this, e.g. Cyprus material of bicornis (ACI of 0.2 with 4 entries) and Syria material of peregrina (ACI of 6.8 with 8 entries). On the other hand there are countries in the five best performing species that show more susceptibiliy than the overall ACI. An example is Syria for triuncialis (ACI of 7.5 with 10 entries). Within a particular country resistance was generally present in most of the provinces involved. This, however, can be better analysed in the coming season when more material of promising countries will be taken into account. Lastly Ae. comosa and longissima can hardly be considered as results are based on, respectively, one and two entries only.

The results of the 1990/1991 survey serve as a useful starting point for a screening in the 1991/1992 season, based on the following considerations: (1) The resistance in the 176 promising accessions may be of a homozygous or heterozygous nature, showing in

Table 18. Resistance by Aegilops species and regions, resulting from 1990/1991 trial, Tel Hadya, Syria.

Species	Severity/Reaction range	ACI species	ACI country	No. pop.	Country
bicornis	1-40 / R-S	10.8	0.2	4	Cyprus
			14.6	5	Egypt
			22.5	2	Jordan
biuncialis	1-70 / R-S	7.1	2.5	7	Bulgaria
			0.8	6	Cyprus
			15.6	10	Jordan
			2.0*	1	Lebanon
			12.2	13	Syria
			2.2	16	Turkey
caudata	1-30 / R-S	8.2	0.2	2	Syria
			10.5	7	Turkey
columnaris	1-20 / R-S	2.8	4.0*	1	Lebanon
			2.5	8	Syria
			4.0*	1	Turkey
comosa	- / -	5.0	5.0*	1	Cyprus
crassa	5-30 / M-S	18.6	18.6	5	Syria
cylindrica	1-40 / R-S	28.6	25.5	10	Bulgaria
			30.6	15	Turkey
kotschyi	1-80 / R-S	34.9	31.4	7	Egypt
			44.5	11	Jordan
			8.0	3	Syria
longissima	5-20 / M	7.5	7.5	2	Jordan
mutica	10-40/ R-S	20.5	20.5	4	Turkey
ovata	1-80 / R-S	7.6	2.0	3	Bulgaria
			4.9	11	Cyprus
			5.3	9	Algeria
			22.1	15	Jordan
			4.1	12	Syria
			1.0	17	Turkey
peregrina	1-100/ R-S	16.7	15.0	2	Cyprus
			25.0	2	Egypt
			19.4	25	Jordan
			6.8	8	Syria
searsii	1-80 /MR-S	27.1	28.6	18	Jordan
			20.2	4	Syria
speltoides	1-20 / R-M	2.1	1.0	7	Syria
			6.0	2	Turkey

Table 18. (continued) Resistance by *Aegilops* species and regions, resulting from 1990/1991 trial, Tel Hadya, Syria.

Species	Severity/Reaction range	ACI species	ACI country	No. pop.	Country
squarrosa	10-55/ M-S	31.8	41.2	4	Pakistan
			13.0	2	Syria
triaristata	1-30 / R-M	2.3	6.8	4	Bulgaria
			0.3	5	Syria
			1.8	15	Turkey
triuncialis	1-40 / R-S	4.4	4.5	10	Bulgaria
			2.1	7	Cyprus
			0.2*	1	Algeria
			7.5	10	Syria
			3.9	29	Turkey
umbellulata	1-30 / R-S	9.8	18.0*	1	Lebanon
			7.4	3	Syria
			9.6	8	Turkey
vavilovii	5-80 / M-S	44.8	43.1	12	Jordan
			48.3	6	Syria
ventricosa	5-40 / M-S	25.1	27.2	10	Algeria
			5.0*	1	Egypt
Total				**404**	

* = Data on one accession; only CI calculated.

a possible segregation in the next generation. Thus they need to be retested. (2) More accessions of the five most promising species mentioned above will be tested, including new countries that are present in received or collected material from 1991. As most of the promising species are widespread a good potential for sources of resistance to yellow rust is present. (3) All countries available from the three species, not evaluated thus far will be included. (4) More material of countries that showed resistance in otherwise more susceptible species will be included. (5) All D genome species will be tested.

Septoria blotch / common bunt

Four seeds of all 420 accessions were tested in the plastic house for resistance to septoria blotch in the seedling stage. A detailed report is presented under studies on the host-pathogen system in the Cereal Improvement Program report for 1991. Also for the results on common bunt testing, see the report of the CIP.

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

Over 800 cereal breeding lines were evaluated for their reaction to BYDV using artificial inoculation by aphids. Results obtained are summarized in Table 19. The promising lines will be reevaluated the next growing season.

The most promising lines of the previous three years were pooled together and evaluated in four plots with rows of 1.5 m long. A number of traits including yield loss in comparison with a healthy control, were evaluated. Results of this re-evaluation are presented in Table 20. The cereal lines that performed well over a period of three years constituted the bulk of the BYDV nursery that we distributed to the national programs of the WANA region. Selected lines from other National or International BYDV programs, e.g. CIMMYT, U.S.A. (Davis, California), Canada (Agriculture Canada Ste-Foy/Laval University) and Chile were also added to this BYDV nursery, which was dispatched for the first time during the fall of 1991.

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1.3.9. Evaluation of cereal wild relatives as possible sources of BYDV resistance

A total of 349 accessions of Aegilops spp. and Triticum spp. were evaluated for their reaction to a PAV type of BYDV. Thirty four

Table 19. Evaluation of new cereal breeding lines after artificial inoculation with BYDV during 1990/91.

Cereal nursery	Number of lines tested	Lines with tolerance to infection
Durum wheat		
DKL-1991	140	37*, 43, 67, 76, 164, 177, 189, 191,
193,		197, 198, 209, 217, 233
DCB-1991	83	13, 14, 23, 24, 25, 28, 36, 38, 48
C-YD-DW-1990-91	52	22, 35, 45, 57, 48, 50, 51
Bread wheat		
WKL-1991	260	16, 28, 43, 46, 62 65, 78, 92, 106 111, 124, 138, 146, 185, 202, 241
C-YD-BW-1990-91	105	3, 4, 7, 12, 13, 14, 17, 22, 27, 28, 31, 32, 36, 45, 69, 104
Canada-BW-91	28	7, 13, 17, 18, 19, 20, 21, 22
Chili-BW-91	26	2, 5, 8, 10, 14, 18, 22, 26
Chili-BW-91	9	27, 28, 31, 32, 33
U.S.A.-DW-90	40	7, 9, 14, 15, 17, 18, 19, 21, 24, 25, 26, 30, 33, 35, 39, 56

* : Numbers refer to ICARDA nursery serial number, e.g. 37 is DKL-1991-37.

accessions were found to be BYDV resistant and virus concentration was found to be either extremely low or non detectable by ELISA

Table 20. Re-evaluation of cereal breeding lines which performed well over the last three years after artificial inoculation with BYDV during 1990-91.

Cereal nursery	lines with tolerance to infection
Bread wheat	
WCB-1990	3*, 19, 16, 31, 46, 4, 54, 83, 132, 155, 183
WON-MRA-90	8, 37, 43, 47, 59, 76, 82, 85, 94, 103, 104
WST-90	11, 21, 64, 69, 73, 79, 89, 95, 98
WKL-90	17, 23, 63, 64, 94, 126, 127, 129, 177
RWYT-LRA-90	5, 9, 16, 51
Canada-90	1, 24, 5, 6, 8, 11, 12
Durum wheat	
DCR-HAA-90	39, 47, 55, 134, 152
DCB-90	38, 71, 78, 80
DKL-90	24, 98, 115, 118, 121, 127, 135, 170, 187, 203
DST-90	2, 3, 27, 31
DON-HAA-90	11, 12, 14, 67, 72, 79, 91, 99
C-YD-DW-90	10, 22, 27, 31, 35
Barley	
BKL-90	38, 87, 104, 129, 188, 223, 267, 312, 319, 330
BLR	SLB-3-88, SLB-15-55, SLB-16-45, SLB-15-62, SLB-4-1

* : Numbers refer to ICARDA nursery serial number, e.g. 3 is WCB-1990-3.

(Table 21). Such promising lines will be subject to re-evaluation the next growing season.

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Table 21. Reaction of _Aegilops_ and _Triticum_ species to infection with BYDV, when the plants were artificially inoculated with BYDV, during the 1990-91 season at Tel Hadya, Syria.

Plant species	Total number of tested accessions	Number of resistant accessions*
Aegilops		
triuncialis	81	5
ovata	41	5
triaristata	32	3
cylindrica	24	2
biuncialis	27	1
ventricosa	12	0
umbellulata	14	2
caudata	11	0
peregrina	19	0
kotschyi	9	1
bicornis	9	2
speltoides	13	3
columnaris	4	1
mutica	3	0
comosa	1	0
longissima	2	0
vavilovii	2	1
crassa	1	0
searsii	4	0
squarrosa	2	0
Triticum		
monococcum	33	7
dicoccoides	5	1
boeoticum	1	0
Total	**349**	**34**

* : ELISA values for these accessions were less than twice that of the healthy mean.

1.3.10. Evaluation of Iranian lentil landraces

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 the ICARDA lentil germplasm accessions of Iranian origin. This evaluation was used to train an Iranian scientist in lentil germplasm evaluation.

The 861 lentil accessions were grown in an unreplicated trial with systematic checks (ILL 4400, ILL 4401, Precoz and Idleb). The plot size was 4 rows, 37.5 cm between rows, 3 m long (4.5 m^2) with 75 cm between plots. The seeding rate was 600 seed per plot. One check was repeated every 9 test entries.

Table 22. Distribution statistics for 861 Iranian lentil germplasm accessions evaluated at Tel Hadya, Syria, during 1990/91.

Descriptor		Mean	Min.	Max.	C.V. (%)
DFLR*	(days)	113.0	90.0	124.0	5
DMAT	(days)	162.0	136.0	173.0	5
PTHT	(cm)	27.0	18.0	35.0	9
HTFP	(cm)	16.0	9.0	23.0	16
HI	(%)	19.8	0.2	69.8	48
PROT	(%)	29.4	25.1	33.9	5
SWT	(g)	3.6	1.9	7.1	24
SYLD	(g/m^2)	37.0	0	226.0	86
STYLD	(g/m^2)	138.0	7.0	491.0	49
SPD		1.2	0.9	1.8	14

* : For descriptor abbreviations see text.

There were 17 characters observed: days to 50% flowering (DFLR), biomass in g/m^2 (BYLD), seed yield in g/m^2 (SYLD), straw yield in g/m^2 (STWYLD), 100 seed weight (SWT), days to 90% maturity (DMAT), plant height in g (PTHT), height to first pod in cm (HTFP), pod shedding (PDSH), pod dehiscence (PDDH), lodging susceptibility (LOD), seeds per pod (SPD), harvest index in % (HI), testa color (TCO), testa pattern (TPT), cotyledon color (COC), and testa pattern color (TPC).

Evaluation of distribution statistics (Table 22) reveals that the

Table 23. Frequency distributions for pod shedding, pod dehiscence and lodging susceptibility for 861 Iranian germplasm accessions evaluated at Tel Hadya, Syria during 1990/91.

Descriptor/Score	Frequency (%)
Pod shedding	
None	63.5
Low	32.5
Medium	3.8
High	0.1
Pod dehiscence	
None	97.0
Low	2.9
Medium	0.1
High	0.0
Lodging susceptibility	
None	0.0
Low	19.5
Medium	76.1
High	4.4
Cotyledon color	
Red/orange	22.5
Yellow	71.0
mixed	6.5

largest variation for quantitatively scored descriptors was for the yield descriptors SYLD, STYLD, and HI. Other descriptors with large C.V.s were SPD, HTFP and PTHT. The distribution for DFLR for the Iranian accessions (Fig. 9) is significantly offset from the means of the checks by more than 20 days later flowering. The SWT was significatly lower for the Iranian accessions compared to three checks (Fig. 10). The SYLD and STYLD distributions for the Iranian accessions were heavily skewed towards lower yield (Figs. 11 and 12) (skewness = 1.880 and 1.426, respectively), this being a consequence of the late flowering of these accessions at the evaluation site.

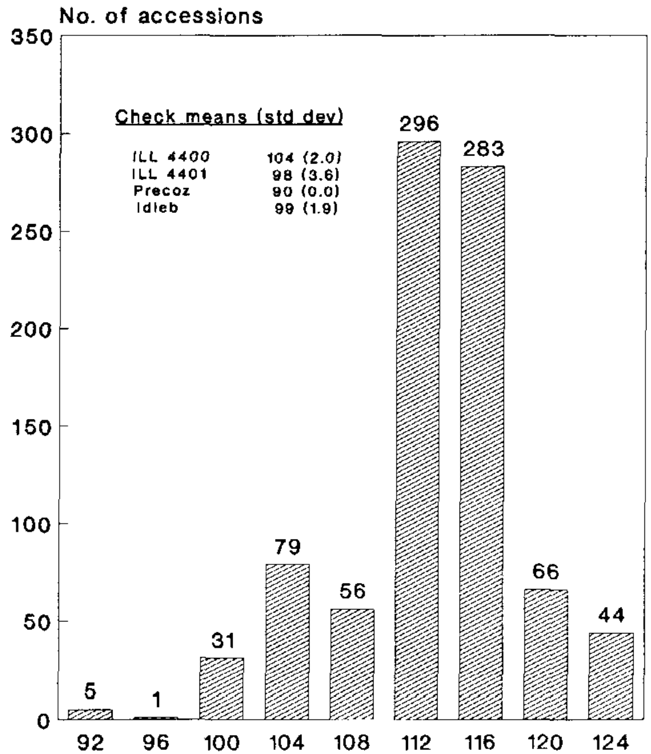

Fig. 9. Days to 50% flowering for 861 Iranian lentil accessions grown at Tel Hadya, Syria in the 1990/91 season.

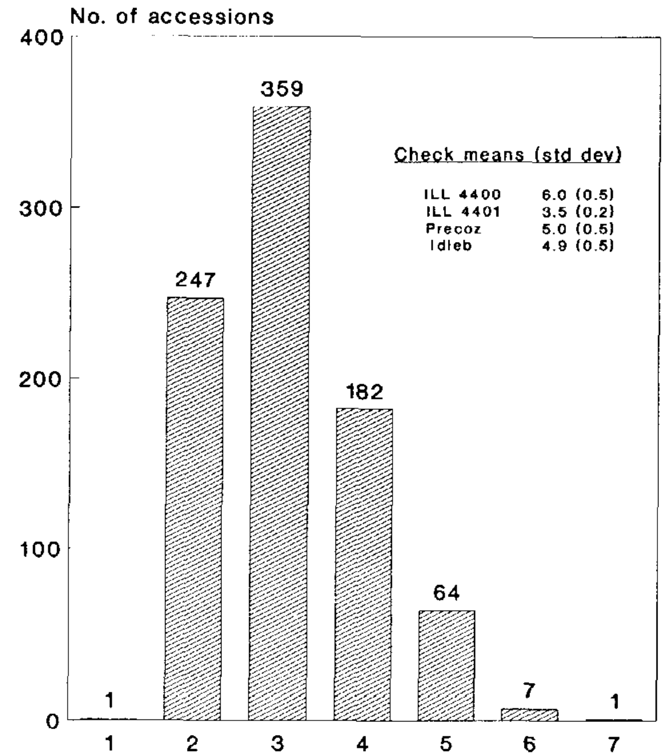

Fig. 10. One hundred Seed weight (g) for 861 Iranian lentil accessions grown at Tel Hadya, Syria in the 1990/91 season.

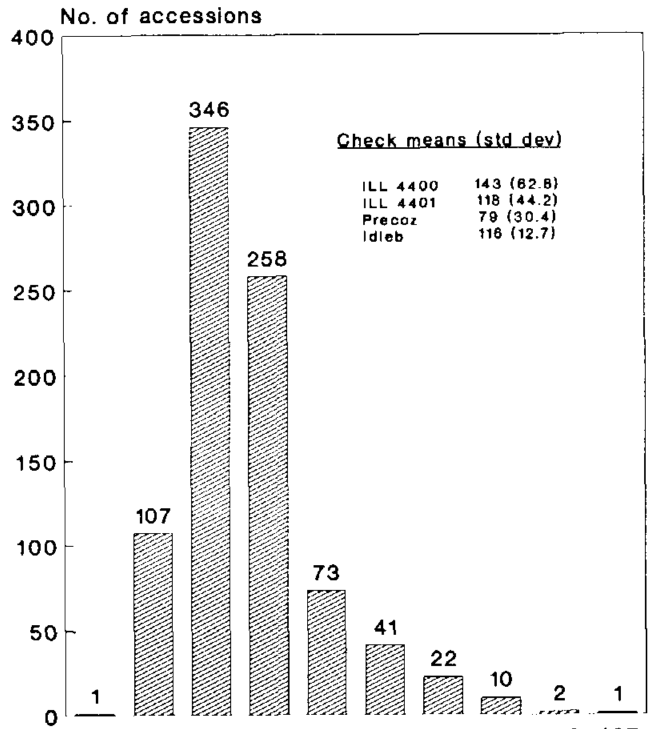

Fig. 11. Straw yield (g/m2) for 861 Iranian lentil accessio grown at Tel Hadya, Syria in the 1990/91 season.

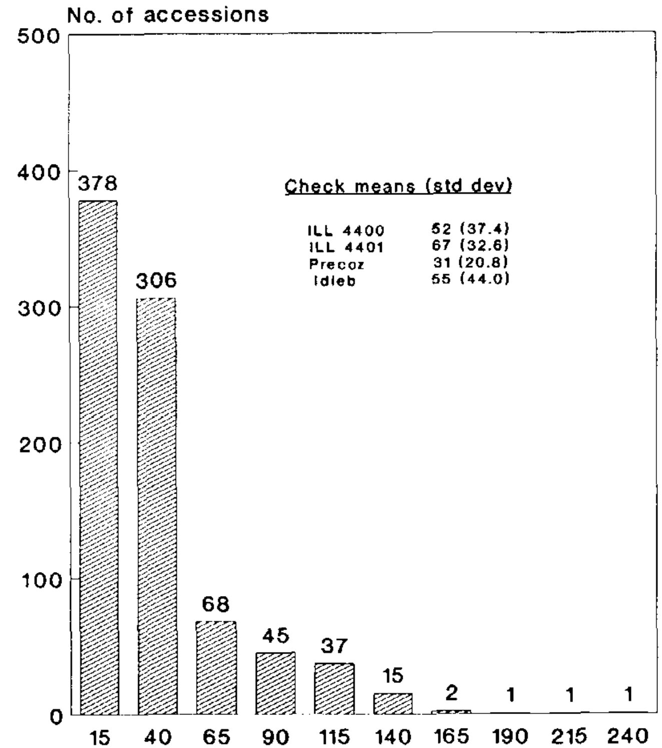

Fig. 12. Seed yield (g/m2) for 861 Iranian lentil accessions grown at Tel Hadya, Syria in the 1990/91 season.

Table 24. Correlations among descriptors for 861 Iranian lentil germplasm accessions evaluated at Tel Hadya, Syria, during 1990/91.

	Correlation					
Descriptor	**DMAT**	**PTHT**	**PROT**	**SWT**	**SYLD**	**STYLD**
DFLR (1)	0.499**	-0.035	0.157**	-0.066	-0.292**	0.056
DMAT		0.134**	-0.047	0.196**	-0.019	0.276**
PTHT			0.034	0.566**	0.210**	0.510**
PROT				-0.031	-0.360**	0.025
SWT					0.209**	0.239**
SYLD						0.688**

(1) : Descriptor abbreviations described in text
** : Significant at the 1% probability level

Distributions for PDSH and PDDH for the Iranian lentil accessions revealed that these accessions had mostly indehiscent pods and that there was low pod drop, both important traits for modern lentil production (Table 23). However, most accessions had a medium to high LOD, which would interfere with mechanical harvest. Cotyledon color was all red/orange or yellow.

Examination of the relationships among the quantitatively scored descriptors for these accessions revealed strong positive correlations among SYLD, STYLD, SWT and PTHT (Table 24). The taller accessions had higher seed and straw yields and also larger seed size. Higher straw yields were accompanied by higher seed yields. There was a significant negative correlation between DFLR and SYLD, e.g., the higher yielding Iranian accessions were the earliest flowering. There was a significant negative correlation between PROT and SYLD.

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1.3.11. Evaluation of chickpea landraces from Morocco, Syria and Jordan

A total of 713 chickpea landraces from Morocco (218), Syria (354) and Jordan (141) were evaluated for 15 descriptors to assess their potential use in the WANA region.

These chickpea accessions were evaluated in an unreplicated nursery with systematic checks (Ghab 1, Ghab 2, ILC 3470, Ghab 3, ILC 1929 and ILC1932). The plot size was 4 rows, 45 cm between rows, 3 m long (5.4 m^2) with 90 cm between plots. The seeding rate was 200 seed per plot. One check was repeated every 10 test entries.

The descriptors evaluated were: days to 50% flowering (DFLR), days to 90% maturity (DMAT), plant height in cm (PTHT), height to first pod in cm (HTFP), canopy width in cm (CAW), growth habit (GH), seed yield in g/m^2 (SYLD), biomass in g/m^2 (BYLD), harvest index in

Table 25. Means, ranges and C.V.s for agronomic descriptors for 354 chickpea accessions from Syria, 741 accessions from Jordan and 218 accessions from Morocco evaluated 1990/91 at Tel Hadya, Syria.

	Mean			Range			C.V. (%)		
Descriptor	SYR*	JOR	MAR	SYR	JOR	MAR	SYR	JOR	MAR
DFLR**	109	109	108	13	11	14	1.4	1.6	1.5
DMAT	156	156	157	24	18	24	2.5	3.1	2.8
PTHT	39	37	41	38	31	39	16.3	14.0	17.7
HTFP	15	17	17	23	23	34	30.4	27.8	31.2
CAW 33	32	32	57	67	69	27.9	37.6	37.1	
SYLD	133	124	117	273	243	255	36.4	36.5	39.4
SWT	39.1	34.9	37.5	64.3	33.1	50.4	16.6	20.8	23.1
PROT	24.1	25.0	24.6	4.6	3.6	5.8	3.2	3.1	4.3

* : SYR= Syria, JOR = Jordan, MAR = Morocco

** : Descriptor abbreviations given in text.

% (HI), seeds per pod (SPD), 100 seed weight in g (SWT), seed shape (SSH), testa texture (TATX), seed color (SCO) and protein % (PROT).

Examination of distribution statistics for chickpea accessions from Syria, Jordan and Morocco reveals similar patterns for the three countries of origin, except for mean SYLD, which stratified based on country of origin (Syria > Jordan > Morocco) and CAW which was smaller in Syria than in Jordan or Morocco (Table 25). There was little variation for PROT, DFLR and DMAT. All three countries had small variation for DFLR with a sharp peak about the mean (kurtosis = -0.048, -0.004 and -0.002, respectively) (Fig. 13).

Table 26. Frequency distributions for seed shape, growth habit and testa texture for 354 chickpea accessions from Syria, 141 from Jordan and 218 from Morocco evaluated at Tel Hadya, Syria, during 1990/91.

	Frequency (%)		
Descriptor/score	**SYR***	**JOR**	**MAR**
Seed Shape			
Kabuli	91.8	80.9	77.1
Intermediate	7.6	19.1	22.5
Mixed	0.6	0.0	0.4
Growth habit			
Semi-erect	1.4	17.0	26.6
Semi-spreading	76.6	68.1	65.1
Spreading	22.0	14.9	8.3
Testa texture			
Rough	91.8	92.2	92.2
Smooth	4.8	3.5	6.9
Tuberculated	3.1	3.5	0.9
Mixed	0.3	0.0	0.0

* : SYR = Syria, JOR = Jordan, MAR = Morocco

Table 27. Correlations of SYLD, SWT, DFLR and PTHT for 354 chickpea accessions from Syria, 141 accessions from Jordan and 218 accessions from Morocco evaluated at Tel Hadya, Syria during 1990/91.

	SYLD (1)			SWT		
Desc.(2)	**SYR(2)**	**JOR**	**MAR**	**SYR**	**JOR**	**MAR**
DFLR(1)	-0.155**	-0.278**	-0.014	-0.176**	-0.050	0.179*
DMAT	-0.022	-0.422**	-0.067	-0.014	0.038	-0.067
PTHT	-0.224**	0.189*	0.326**	0.111	0.233**	0.406**
HTFP	-0.311**	0.355**	0.247**	0.132*	0.317**	0.207**
CAW	0.017	-0.108	0.088	0.019	-0.085	-0.013
SYLD	-	-	-	0.350**	0.351**	0.257**
SWT	0.350**	0.351**	0.257**	-	-	-
PROT	-0.188**	-0.022	-0.067	-0.316	-0.066	-0.361**

	DFLR (1)			PTHT		
Desc.(2)	**SYR**	**JOR**	**MAR**	**SYR**	**JOR**	**MAR**
DFLR	-	-	-	-0.031	-0.035	0.03
DMAT	0.208*	0.371**	-0.021	0.237**	0.181*	0.120
PTHT	0.031	-0.035	-0.030	-	-	-
HTFP	-0.124*	-0.1848	0.006	0.254**	0.233**	0.287**
CAW	0.073	0.170	-0.004	0.541**	0.405**	0.523**
SYLD	-0.155**	0.278**	-0.04	0.224**	0.189*	0.326**
SWT	-0.176**	0.050	-0.179*	0.111	0.233**	0.406**
PROT	-0.212**	0.156	-0.107	-0.106	-0.108	-0.351**

(1) : Descriptor abbreviations given in text.
(2) : SYR = Syria, JOR = Jordan, MAR = Morocco, Desc. = descriptor.
*,** : Significant at 5% and 1% levels of probability, respectively.

There was high variation for all three countries of origin for SYLD (Table 25 and Fig. 14), however, each country had different distribution patterns.

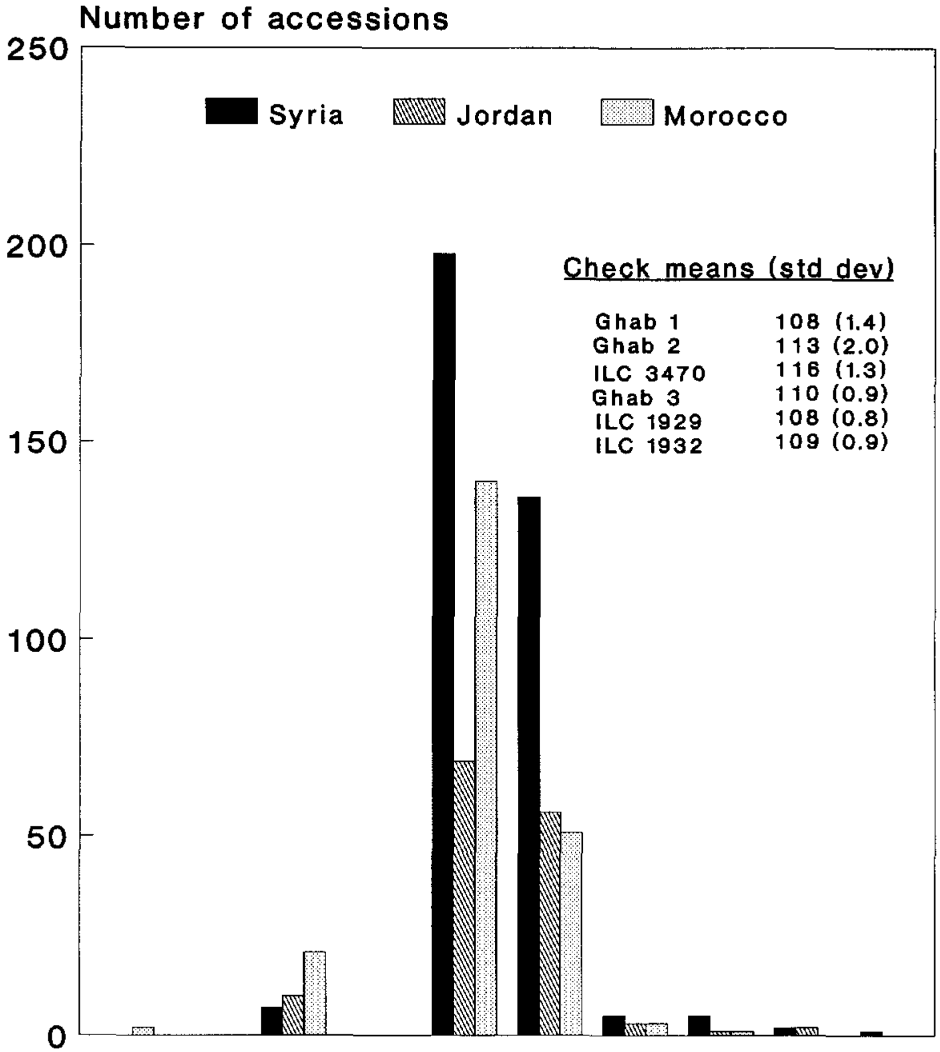

Fig. 13. Days to 50% flowering for chickpea accessions from Syria, Jordan and Morocco.

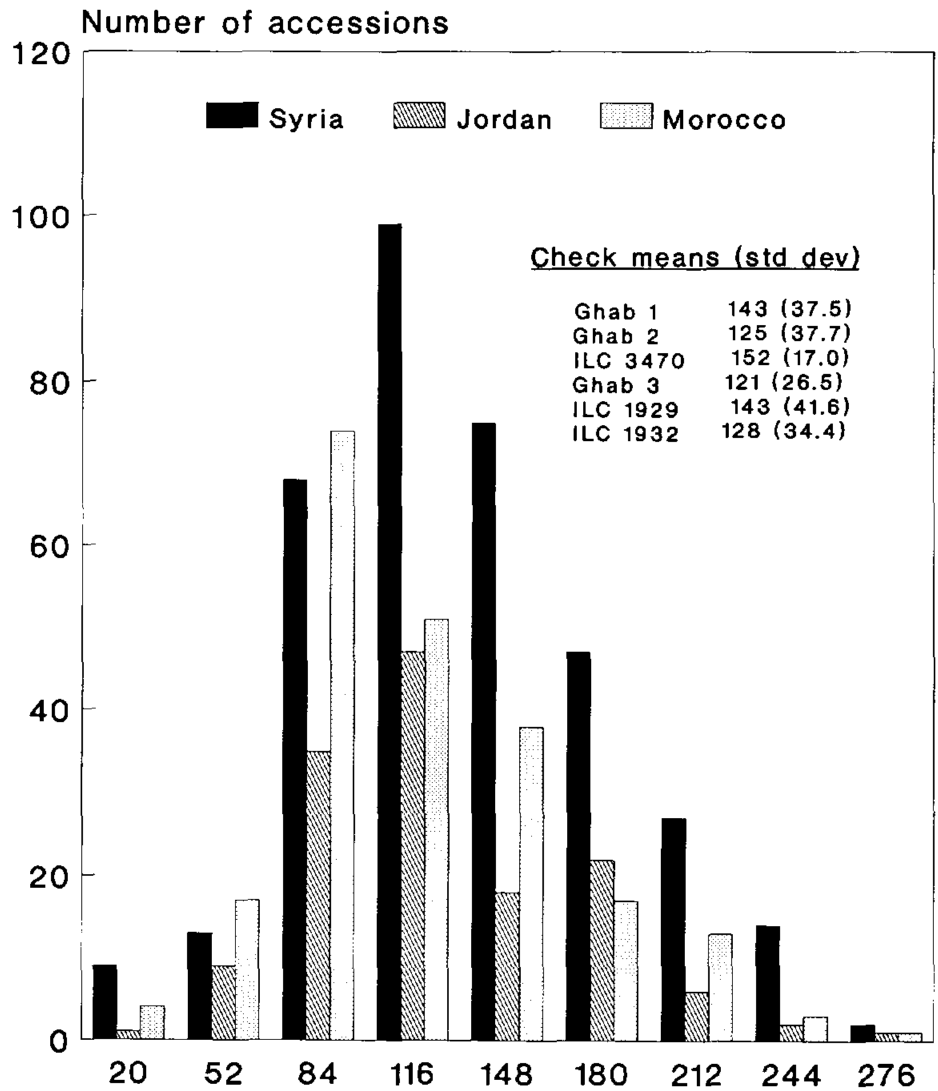

Fig. 14. Seed yield (g/m2) for chickpea accessions from Syria, Jordan and Morocco.

Distributions for Jordan and Morocco were similar for SSH, GH and TATX (Table 26). However, the distribution for Syria for SSH was different in that there was more kabuli and less intermediate seed types. Also, for Syria there were much less semi-erect accessions and more semi-spreading and spreading, which may be related to the higher porportion of cold tolerance found for Syrian germplasm vs. Jordanian or Morocco germplasm.

Correlations for SYLD, SWT, DFLR and PTHT with the other quantitatively scored descriptors for each country of origin are given in Table 27. Except for DFLR for Morocco, the three countries of origin had similar trends for correlations among these descriptors. SYLD had significant positive correlations with SWT, PTHT, HTFP and SWT for all countries of origin. Large significant postive correlations were found between CAW and PTHT for the three countries.

L.D. Robertson and A. Ismail

1.3.12. Screening for bean yellow mosaic virus (BYMV) resistance in faba bean

Two hundred faba bean pure lines were evaluated, using artificial aphid inoculation for their reaction to BYMV during 1991. Six faba bean lines, BPLs 1694, 1729, 1679, 1663, 1665, and 1767 showed a low disease index. However, such resistant lines were not uniform in their reaction to the virus.

Within each line, individual plants behaved differently; some had mild symptoms, others had no symptoms but virus multiplication could be detected and a third group had no symptoms and no virus multiplication.

Seeds of plants from each faba bean line representing the last category were harvested separately and will be increased the next season and re-evaluated.

K. Makkouk

1.3.13. Characterization of food, pasture and forage legumes

Newly received chickpea germplasm (64) was multiplied and evaluated in a nonreplicated trial with two repeated local checks and data on 10 traits was collected. These accessions were mostly from China and USSR with a few from Algeria and Turkey. One accession from China (ILC 8277) had a one hundred seed weight of 52.9 g. There were 277 new lentil accessions multiplied and evaluated in a nonreplicated trial with two repeated local checks and data on 10 traits was collected. Most accessions were from Nepal with a few from Algeria and Morocco. Thirty-three new faba bean accessions from Algeria, China and Bulgaria were multiplied and evaluated for eight traits. Details of characterization are given in Table 2 in Section 1.1. of this report.

New accessions of Medicago, Vicia, Lathyrus, Pisum, Trifolium, and other genera were multiplied and characterized for five traits (days to flowering, flower color, days to podding, days to maturity and frost damage). In general, there were problems with frost damage in all multiplications of new accessions; most of these for all genera were from joint collection missions with NCARTT (Jordan) in 1989 and 1990. There were 590 new accessions of medics, all collected from Jordan in 1989-90, multiplied with species identification and representative herbarium speciemens taken. New accessions of Vicia (87), Lathyrus (37), Pisum (34), Trifolium (363), and of other genera (331) were multiplied with species identification and representative herbarium specimens taken. Details of the characterization are given in Table 2 in Section 1.1.
L.D. Robertson

1.3.14. Evaluation of medics of Jordanian origin

Based on joint ecogeographical surveys with NCARTT of forage legumes in Jordan in 1989 and 1990, a joint evaluation experiment was conducted with NCARTT in the 1990/91 season for the medics collected from these missions. The objectives for these evaluation experiments were: 1) to multiply, characterize and store medic germplasm from the collection missions, 2) to identify genotypes which have useful characteristics for further development, and 3) to further train NCARTT counterpart staff in plant genetic resources management and evaluation skills.

There were 313 medic accessions tested at Tel Hadya and 276 tested at Baqa'a, Jordan (accessions from Jordan were common with Tel Hadya). The five checks used were IFMA 1991, 716, 2123, and the cultivars 'Circle Valley' and 'Jemalong'. Seeds were planted in Jiffy-7 pots December 9, 1990 and transplanted January 28, 1991 for both locations. Plot size was one row 3 m long with 1.35 m between

Table 28. Descriptors evaluated for Jordanian medic accessions at Tel Hadya, Syria and Baqa'a, Jordan, in 1990/91.

Syria	Jordan
Frost damage (FROST)*	Viability (VIABL)
Branches/plant (BR)	Growth habit (GH)
Random branch length (BRLR)	Longest branch length (BRLL)
Longest branch length (BRLL)	Branches/plant (BR)
Pods/inflorescence (NODFF)	Pods/inflorescence (PODFF)
Internode length (INLN)	Internode length (INLN)
Days to flowering (DFLR)	Days to flowering (DFLR)
Nodes to first inflorescence (NODFF)	Nodes to first inflorescence (NODFF)
Petiole length (PETLN)	Petiole length (PETLN)
Leaf area (LA)	Leaf area (LA)
Days to maturity (DMAT)	Peduncle length (PEDLN)
Hundred pod weight (HPDW)	Hundred pod weight (HPDW)
Seeds/hundred pods (SDPHPD)	Seeds/hundred pods (SDPHPD)
Seed weight/hundred pods (HPSW)	Seed weight/hundred pods (HPSW)
Maturation period (MATP)	Days to podding (DPOD)
Thousand seed weight (SWIT)	Spine length (SPINL)
	Spine hardiness (SPINH)
	Spine hook (SPINK)
	Vigor (VIGOR)

plots and 20 plants per plot. The medic accessions were planted in an unreplicated nursery with systematic planting of checks. Descriptors evaluated at the two locations are given in Table 28.

There was little variation for phenological traits (Table 29), except MATP, the difference between DMAT and DFLR (measured at the onset of flowering), which is a function of the length of the flowering period and maturation period. While there were similar mean DFLRs for both evaluation sites, the range was larger for Jordan by 10 days. Except for BRLL, HDPW and NODFF, those descriptors measured at both locations had similar means, ranges and C.V.s.

Table 29. Distribution statistics for Jordanian medic accessions evaluated at Tel Hadya, Syria (312 accessions), and Baqa'a, Jordan (274 accessions), during 1990/91.

	Mean		**Min.**		**Max.**		**CV(%)**	
Descriptor	**SYR**	**JOR**	**SYR**	**JOR**	**SYR**	**JOR**	**SYR**	**JOR**
DFLR* (days)	114	111	100	99	133	142	5.5	5.6
DMAT (days)	170	-	117	-	180	-	6.8	-
MATP (days)	56	-	9	-	80	-	23.2	-
DPOD (days)	-	152	-	145	-	157	-	2.2
BR	5.4	5.2	2.6	0.8	9.8	9.0	20.8	22.3
BRLL (cm)	24.2	34.9	6.0	13.6	59.6	57.8	31.5	24.8
ININ (cm)	2.4	2.8	0.6	0.5	5.7	8.0	33.4	46.2
LA (cm^2)	2.2	3.6	0.6	0.8	6.4	10.0	44.7	49.8
PODPF	2.0	2.6	1.0	0.8	11.5	14.0	80.2	94.3
HPDW (g)	11.3	9.2	0.1	0.2	25.0	25.7	56.1	57.1
NODFF	3.5	7.3	0.8	3.0	7.2	15.0	34.0	26.5
SWIT (g)	6.3	-	0.4	-	17.4	-	45.9	-

* : Descriptor abbrevations as per text.

There was considerable variation for FROST and VIGOR in these medic accessions, with more than 10% of the accessions rated with high frost tolerance and very vigorous (Table 30). Variation was

Table 30. Frequency distributions for medic accessions for FROST, VIGOR, SPINL, SPINH and SPINK scored at Syria and Jordan during 1990/91.

Descriptor/score	Frequency (%)	Location	no. accessions
Frost*		Syria	312
1	16.7		
3	52.6		
5	23.7		
7	7.1		
9	0.0		
VIGOR**		Jordan	276
1	11.6		
3	25.4		
5	42.0		
7	21.0		
9	0.0		
SPINL***		Jordan	274
Absent	27.5		
1-2 mm	36.6		
3-4 mm	22.1		
> 4 mm	13.8		
SPINH		Jordan	274
Absent	27.5		
Soft	10.5		
Semi-soft	18.5		
Hard	43.5		
SPINK		Jordan	274
Absent	27.5		
With hook	46.4		
Without hook	26.1		

* : 1 = very tolerant, 9 = completely drilled
** : 1 = very strong vigor, 9 = very poor vigor
*** : Abbreviations of descriptors are as per text.

also substantial for the spine descriptors SPINL, SPINH and SPINK, with all possible scores well represented in these accessions.

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1.4. Genetic resources supportive research

1.4.1. Agroecological characterization of Syrian durum wheat landraces

Germplasm evaluation results are often of limited applicability, due to considerable genotype x environment interactions. Extrapolation of single-site evaluation results is difficult or even impossible when genotype x environmental interactions are significant. To overcome this problem, extensive multi-locational or multi-seasonal evaluation would be needed, although this is normally not possible because of financial constraints. Hence, an efficient evaluation methodology is required, in which the properties of large numbers of accessions in various climatic conditions can be investigated.

Assuming that populations have evolved in their collection region, the agro-ecological characteristics of the environment of origin will greatly determine, and should be useful in describing their genotypic constitution. Interactions of the genotype with different environments will determine plant growth and development. It may thus be expected that the environmental characteristics of the region of origin could be related to evaluation results at locations with other environmental conditions. Information on the location and environmental characteristics of collecting sites is routinely recorded, but although this passport and collection information is as valuable as the seeds themselves in view of assessment of their properties, it is seldomly considered in interpretation of field trials.

Collecting missions for durum wheat landraces [Triticum turgidum L. var. durum (Desf.) Mackey] in various parts of Syria in 1987 and 1988 yielded a total of 185 populations. Fifty-nine of these had their putative origin at or in the vicinity of their collection sites, and were considered representative for their respective environments.

Since rainfall amount and distribution is a dominant factor in dry matter production in arid environments, four locations in Syria, characterized by different long-term rainfall averages, were selected for agronomic evaluation: Tel Hadya, Breda, Homs and Izra'a. The experiments were grown in 1988-89 and 1989-90 for all locations, but observations for Tel Hadya 1988-89 were discarded since plants matured in March, possibly due to residual herbicides. Actual rainfall (Table 31) was below average in both seasons. Homs did not receive particularly more precipitation than the other sites, however, for both seasons of the experiment, the soil contained residual moisture from rainfall or irrigation in the previous season.

Table 31. Total seasonal precipitation at the four evaluation sites.

Location	Season	Total seasonal precipitation (mm)
Tel Hadya	89-90	234
Breda	88-89	195
	89-90	183
Homs	88-89	276*
	89-90	218*
Izra'a	88-89	222
	89-90	266

* : additional soil moisture of previous season available to crop.

For each experiment, 38 landrace populations and 3 checks were sown at two levels of nutrient availability in two replicates. Natural fertility represented one level of nutrient availability, the other level was created through additional nitrogen and phosphorus application. A randomized complete block design with two

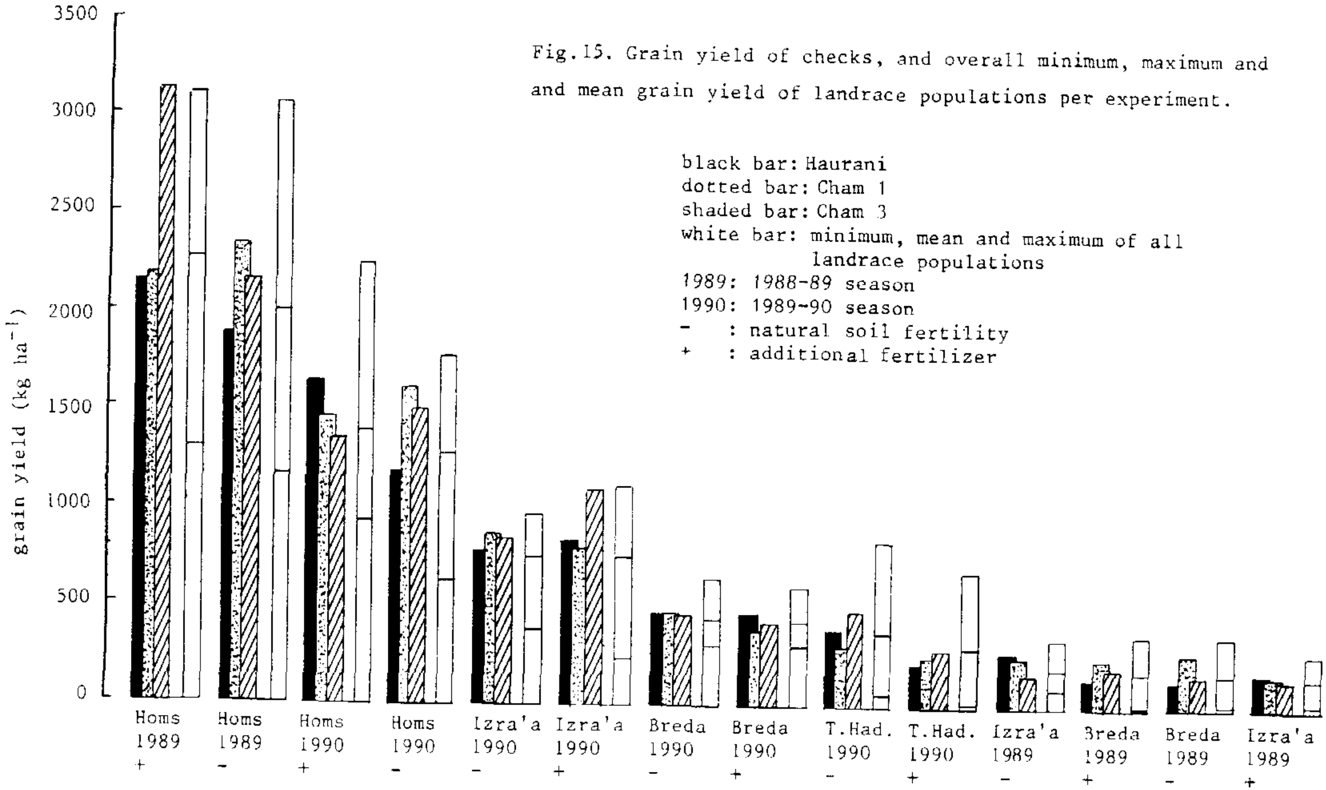


Fig.15. Grain yield of checks, and overall minimum, maximum and and mean grain yield of landrace populations per experiment.

replicates was used for each experiment. A combined analysis of variance was done for Breda, Homs and Izra'a.

The study's overall objective is to develop a method that enables the application of results of a single-evaluation for forecasting crop behaviour in other years and at locations with different climatic conditions. This report relates evaluation results to the agro-ecology of collection regions, and studies classification of plant characters in collection regions and landrace groups.

1.4.1.1. Yield observations

Evaluation results as mean values over all landrace populations per location, year and fertilizer level are presented in Table 32. Considerable differences were observed among locations. Homs showed satisfactory performance in both seasons, and to a lesser extent Izra'a in 1990, whereas the other locations and years showed very low yields.

Mean grain yield of landraces was lower than that of one or more of the checks However, maximum grain yield was achieved by individual landraces (Fig. 15). Only in the highest yielding experiment (Homs 1989, with additional fertilizer), was Cham 3 highest yielding. In many cases, fertilizer application resulted in a decrease of kernel density and grain yield (Table 32).

Relating grain yield to regions of origin was difficult. At best, weak tendencies could be identified, indicating that landrace populations originating from mountainous areas performed relatively well in high yielding experiments. Regions with intermediate climatic conditions, e.g. Idleb, northeastern Syria, Homs and Hauran, provided populations that yielded relatively moderate to good in all experiments.

Although variation within landrace groups was also high, differentiation with respect to grain yield on the basis of landrace groups proved more successful than based on regions of origin (Table

Table 32. **Mean values of evaluation results per location, year and fertilizer level. Standard deviations per experiment are given in brackets.**

Location	Season	Fertilizer*	Plant height (cm)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total dry weight (kg ha^{-1})	Harvest index	Spike density (m^{-2})	Kernels per spike	1000 kernel weight (g)	Kernel density (m^{-2})
Tel Hayda	89-90	-	50.6	376	1774	2150	0.173	187.4	6.88	29.0	1229
		+	47.2	297	1895	2162	0.135	192.6	5.24	28.4	1080
			(7.2)	(199)	(421)	(552)	(0.059)	(30.1)	(2.57)	(3.3)	(163)
Breda	88-89	-	43.1	172	987	1163	0.150	87.3	6.45	31.2	407
		+	44.0	178	1017	1195	0.154	85.9	6.78	31.1	358
			(5.0)	(78)	(297)	(351)	(0.045)	(29.8)	(2.63)	(2.2)	(93)
	89-90	-	58.6	434	1400	1834	0.237	151.9	9.27	31.2	1570
		+	58.0	431	1438	1869	0.232	156.3	9.06	31.1	1507
			(5.0)	(90)	(242)	(295)	(0.036)	(24.5)	(2.14)	(2.6)	(64)
Homs	88-89	-	107.3	2020	5161	7181	0.292	-	-	40.6	3988
		+	109.2	2279	5541	7820	0.294	-	-	41.6	4434
			(10.9)	(457)	(1604)	(1886)	(0.382)			(4.5)	(713)
	89-90	-	101.6	1284	5547	6831	0.191	304.8	10.03	42.5	3736
		+	101.7	1418	5756	7174	0.199	329.7	10.59	40.8	3132
			(10.7)	(377)	(1566)	(1724)	(0.050)	(50.2)	(2.20)	(3.4)	(776)
Izra'a	88-89	-	49.4	200	1102	1302	0.158	136.3	6.10	24.9	904
		+	48.5	163	1233	1396	0.118	131.3	5.08	24.7	472
			(4.5)	(57)	(320)	(346)	(0.033)	(22.6)	(1.59)	(2.4)	(254)
	89-90	-	82.1	765	3833	4598	0.175	247.2	9.07	34.8	2442
		+	81.1	754	4948	5702	0.136	267.7	8.85	32.2	2271
			(5.0)	(113)	(1122)	(1122)	(0.042)	(36.4)	(1.52)	(2.3)	(578)

* : - = natural soil fertility.
+ = with additional fertilizer.

33). Haurani, the most widespread landrace within Syria, performed relatively well to very well in all experiments, in contrast to Baladi, which generally performed relatively poorly. The Bayadi, Sweidi and Shihani landrace groups were highest yielding in the lowest, medium and highest yielding experiments, respectively. Sheirieh performed well, except in the lowest yielding experiment, and the performance of Hamari was variable.

This more pronounced stratification suggests that genotypes within landrace groups are relatively uniform. Nevertheless, it remains probable that plant characters are largely determined by the environment in the domestication area. If so, then it must be concluded that since the fifth millenium B.C., durum wheat landrace groups evolved within relatively small areas with specific climatic conditions, followed by dispersion of some groups without losing their characteristics. This probably has occured only recently, otherwise dispersed landrace groups would have been less uniform in agronomic characteristics due to different environmental pressures.

Yields of landraces under sub-optimal conditions demonstrated that selection of locally adapted plants can contribute to achieving breeding goals. Although in general, certain landraces possess desirable traits lacking in other germplasm, such as resistance to drought and cold, early plant vigour and long peduncle, these are not common to all landraces. Furthermore, landrace populations showing superior performance under all conditions could not be identified in these trials. High variability in grain yield of landrace populations was observed, which indicates differential response to environmental variation (genotype x environmental interaction). This may be related to the fact that traditional Syrian agriculture has developed geographical diversification of populations with their buffer capacity based on their genotypically heterogeneous nature which adjusts for seasonal environmental variation.

Table 33. Grain yield (kg ha^{-1}) and standard deviation (in brackets) per experiment per landrace group.

Location	Season	Fertilizer*	Overall mean	Landrace group						
				Haurani	Baladi	Bayadi	Shihani	Hamari	Sveidi	Sheirieh
Homs	88-89	+	2279	2267 (451)	2124 (452)	1754 (187)	2646 (326)	1989 (199)	2706 (79)	3033
Homs	88-89	-	2020	2031 (507)	1841 (418)	1834 (74)	2030 173)	2040 (328)	2401 (228)	1927
Homs	89-90	+	1418	1495 (320)	1402 (185)	1051 (71)	1426 (348)	1565 (147)	1278 (228)	1336
Homs	89-90	-	1284	1364 (227)	1272 (308)	1064 (254)	1175 (273)	1180 (114)	1310 (167)	1179
Izra'a	89-90	-	765	802 (109)	718 (146)	794 (100)	710 (138)	783 (61)	752 (128)	938
Izra'a	89-90	+	754	807 (145)	652 (245)	856 (32)	811 (85)	574 (199)	865 (192)	727
Breda	89-90	-	434	464 (80)	429 (65)	362 (16)	447 (58)	412 (35)	413 (53)	420
Breda	89-90	+	431	433 (57)	389 (34)	543 (87)	485 (9)	423 (29)	470 (45)	432
Tel Hadya	89-90	-	376	401 (152)	327 (132)	282 (174)	346 (95)	439 (153)	424 (102)	395
Tel Hadya	89-90	+	297	318 (129)	221 (103)	232 (49)	379 (278)	305 (122)	295 (148)	505
Izra'a	88-89	-	200	228 (32)	171 (57)	226 (24)	203 (123)	192 (84)	171 (21)	221
Breda	88-89	+	178	209 (62)	125 (63)	212 (90)	169 (17)	264 (115)	151 (19)	142
Breda	88-89	-	172	214 (67)	146 (110)	242 (12)	123 (18)	154 (72)	133 (46)	122
Izra'a	88-89	+	163	186 (56)	130 (65)	219 (12)	128 (96)	131 (34)	166 (85)	183

* : - = natural soil fertility.
+ = additional fertilizer.

1.4.1.2. Plant characters and site characteristics

The pattern of interrelationships among plant characters in different experiments was comparable. This consistency facilitates interpretation of relationships between collection site and plant characteristics at evaluation, and the interpretation of a specific experiment in terms of forecasting crop behaviour under different growth conditions.

Latitude and altitude of the collection sites were rarely significantly correlated to any of the plant characters, and longitude and soil P only in a few cases. However, annual rainfall, summer maximum temperature, winter minimum temperature, potential annual evapotraspiration, soil organic matter content and total soil N content were significantly correlated to plant characters in higher frequencies. Harvest index and number of kernels per spike and, to a lesser extent, grain yield and spike density were the plant characters most frequently significantly correlated to site characteristics (Table 34).

1.4.1.3. Evaluation of frost tolerance

Low temperature tolerance is a desirable plant characteristic for autumn-sown cereals in continental and mountainous areas of the Mediterranean region, which are characterized by winter and unpredictable late frosts in spring. Landraces are a source for cold tolerance in cereal breeding, since some possess a wide genetic variation for this character.

Evaluation for frost tolerance was conducted at Tel Hadya, during the 1989-90 crop cycle. A two-week period of below-zero daily minimum temperatures was recorded at the beginning of 1990. During the remainder of January and February a number of shorter periods with night-frosts of decreasing severity occurred. In March a one-week period of frosts occurred with a minimum of -8.9 °C. Whereas early season frosts are characteristic for the climate at Tel Hadya,

Table 34. General form of significant correlation between site characteristics and plant characters.

	plant character							
Site characteristic	Plant height	Grain yield	Straw yield	Total dry matter	Harvest index	Spike density	Kernels per spike	1000 kernel weight
Rainfall		(-)	(+)	(+)	(-)	(+)	(-)	(+)
Max. Aug. temp.	(+)	(+)	(-)	(-)	(+)	(-)	(+)	(-)
Min. Jan. temp.		(-)	(+)	(+)	(-)	(+)	(-)	(+)
Evaporation	(+)	(+)	(-)	(-)	(+)	(-)	(+)	(-)
Soil org. matter		(-)	(+)	(+)	(-)	(+)	(-)	(+)
Soil nitrogen		(-)	(+)	(+)	(-)	(+)	(-)	(+)

(+) : positive correlation.
(-) : negative correlation.

the probability of such severe frosts after mid-March, however, may be as low as once in a century.

This temperature pattern provided an opportunity to evaluate tolerance in locally evolved landrace germplasm to both early and late season frosts. The January frost period coincided with early tillering, and the March frosts occurred just before the plants reached the first node stage.

The January frosts caused little apparent foliar damage. Germplasm evolved in Syria is presumably well adapted to local environmental conditions. Durum wheat, since it evolved in the fifth millenium B.C. in the Fertile Crescent from cultivated emmer, has yearly been exposed to local temperature regimes, such as early season frosts. The little damage caused by the early frosts in January, which were not particularly severe, suggests that pre-frost acclimatation was sufficient, and that tolerance has evolved naturally.

Severe foliar damage due to late frosts occurred to landrace populations originating from the coastal region of Tartous and the western littoral mountains (Table 35). Although the probability of severe frosts in March is very low, and this specific environmental condition may have had minor evolutionary influence, observations indicate that tolerance to late season frosts is determined by most probably low temperatures during earlier winter months. During the months November - March, mean minimum temperatures inland are lower than in coastal regions, which is reflected in higher cold tolerance of germplasm originating from inland regions.

Classification of landrace populations into landrace groups gave a bimodal distribution: the Baladi landrace group showed a mean damage score of 4.0, whereas other groups scored an average of 1.6. This corresponds with the geographical distribution pattern of the Baladi landrace group, which was collected mainly from the coastal region of Tartous, whereas other landrace groups originated from

Table 35. Late March frost damage to check varieties and landraces, classified per region of collection and landrace group.

	number of populations	frost damage*	
		mean	range
Checks			
Haurani		1.5	
Cham 1		4.9	
Cham 3		3.5	
Regions of collection			
Tartous	10	4.9	2.0 - 6.5
Homs	6	2.1	1.3 - 4.3
Hauran	14	1.8	1.0 - 3.0
Jezira	10	1.4	0.8 - 1.8
Aleppo	6	1.1	0.3 - 1.8
Idleb	3	1.1	0.3 - 1.8
Landrace groups			
Baladi	14	4.0	1.0 - 6.5
Sheirieh	1	2.0	-
Hamari	3	1.8	1.3 - 2.3
Nab el Jamal	3	1.7	0.3 - 4.3
Haurani	18	1.6	0.8 - 3.0
Bayadi	5	1.5	1.3 - 1.8
Sweidi	4	1.5	1.0 - 2.3
Shihani	1	1.5	-
Overall mean	**49**	**2.3**	

* : measured on a 0-9 scale: 0 = no damage, 9 = 90% or more damaged.

other parts of the country.

1.4.1.4. Resistance to fungal diseases

Indigenous landrace germplasm often possesses well functioning resistance against locally prevalent diseases, since natural selection is likely to be successful in creating the most stable complex of resistance loci, alleles and genotypes. Therefore, landraces are an important source of resistance in plant breeding. The presence of disease resistance in landraces can be related to the geographical distribution of disease incidence, as determined by agro-ecological characteristics of cultivation areas affecting disease development. Such information is helpful in planning germplasm collection missions.

Fourty-nine landrace populations were evaluated for response to the fungal diseases common bunt [Tilletia foetida (Wall.) Liro and T. caries (DC) Tull.], yellow rust [Puccinia striiformis Westend. f. sp. tritici], and septoria blotch [Mycosphaerella graminicola (Funkel) Sand.], which are the most frequently encountered wheat diseases in Syria.

In general, resistance levels to common bunt of the populations collected more inland, i.e., the Hauran, Aleppo and Jezira regions were highest (Table 36). The highest average severity for yellow rust was found in populations originating from coastal sites and the Jezira region. Regions with low average severity could not be identified. Yellow rust reaction type varied widely for most regions, although the majority of individual population scores fell in the categories moderate and moderately susceptible. No regions were characterized by low mean scores for septoria blotch, and on average, susceptibility to septoria blotch appears common in durum wheat landraces from Syria.

It appears that host resistance was positively (common bunt and septoria blotch) or negatively (yellow rust) related to environmental characteristics favourable for development of that particular disease, and to disease incidence, in the collection regions. The negative relationship in the case of yellow rust could not be explained.

Landrace groups were characterized by different levels of disease resistances. Variation in response to the three diseases was

Table 36. The response of Syrian durum wheat landraces, per collection region and landrace group, to the diseases common bunt, yellow rust and septoria tritici blotch.

	common bunt			yellow rust					septoria tritici blotch			
	no. pop.	% infected spikes		no. pop.	% severity		reaction type, range	ACI(1)	no. pop.	score(2)		
		mean	range		mean	range				mean(3)	range	
											v.d.	sev.
Collection region												
Hauran	12	9	0-25	13	32	22-50	R-S	24	13	7/5	6-8	4-7
Quneitra	1	11	-	1	30	-	M-MS	23	1	7/6	-	-
Homs	6	10	4-18	6	39	13-60	MR-S	33	6	5/5	3-7	3-8
Coast	10	13	4-22	10	45	18-65	R-S	37	10	6/4	4-7	2-5
Idleb	3	21	10-30	3	27	15-48	R-S	20	3	6/4	6	4
Aleppo	6	7	4-17	6	22	8-38	R-S	15	6	7/5	7	4-6
Jezira	8	6	1-14	10	45	21-80	MR-S	38	10	6/4	4-8	2-6
Landrace group												
Haurani	16	9	0-25	18	31	21-50	R-S	23	18	7/5	7-8	5-7
Baladi	14	11	4-22	14	40	14-65	R-S	32	14	6/4	4-7	2-5
Bayadi	3	5	4- 6	3	28	13-38	MR-S	24	3	7/6	7	6
Shihani	4	4	1-11	5	50	21-75	MR-S	47	5	6/4	4-8	2-6
Hamari	3	10	4-16	3	23	8-48	R-MS	13	3	6/6	3-7	4-8
Sweidi	4	20	10-30	4	33	15-53	R-S	28	4	6/4	5-6	4
Nab el Jamal	1	2	-	1	80	-	MS	64	1	5/4	-	-
Sheirieh	1	17	-	1	60	-	MS-S	52	1	5/3	-	-
overall mean	46	10		49	37			29	49	6/5		
s.d.		7			17			16		1/1		

1) : average coefficient of infection
2) : measured on a scale 0-9
3) : 1st digit = vertical disease development (v.d.), 2nd digit = disease severity (sev.)

generally higher among landrace groups than among regions, as was also observed in the case of phenotypical variation patterns of plant characters of the same material.

Collection and evaluation of landrace germplasm may therefore best be organized according to collection regions established on the basis of agro-ecological information, in combination with a taxonomic classification into landrace groups, which could yield the widest variation.

1.4.1.5. Glutenin and phenotypic diversity

Glutenin and phenotypic diversity of the landrace populations was compared and related to geographical and climatological characteristics. Composition of the high molecular weight subunits of the storage protein glutenin fraction in the kernels was analysed via Sodium Dodecyl Sulphate - Polyacrylamide Gel Electrophoresis (SDS-PAGE). Glutenin diversity was determined using GREGORIUS' level of population differentiation (δ_T) and the SHANNON-WEAVER index (I). The phenotypic diversity was determined on the basis of the coefficients of variation of 10 phenological and morphological traits (GRU Annual Report 1990).

Five Glu-A1 and nine Glu-B1 alleles that had not yet been described were found. The glutenin diversity indices appeared highly correlated (Table 37). A highly significant positive correlation coefficient between the glutenin and phenotypic diversity indices was found, which suggests that both types measure genetic diversity, although their genetic bases are obviously different.

Four types of geographic distribution of alleles were distinguished: (a) alleles that are common and widely distributed (6 alleles), (b) alleles that are common in a restricted area (7), (c) alleles that appear in two random populations (6), and (d) alleles that are very rare and appear in only one population (6). All

Table 37. Correlation coefficients between estimates of genetic and phenotypic diversity indices within Syrian durum wheat landrace populations. All values are significant at p = 0.01.

Diversity index	Diversity index			
	$\delta_{T,band}$	$\delta_{T,alld}$	I	CV_{phen}
$\delta_{T,band}$		0.94	0.98	0.40
$\delta_{T,alld}$	0.94		0.99	0.35

$\delta_{T,band}$: GREGORIUS' level of population differentiation based on banding patterns of grain glutenin.
$\delta_{T,alld}$: GREGORIUS' level of population differentiation based on glutenin alleles.
I : SHANNON-WEAVER index.
CV_{phen} : average normalized phenotypic coefficient of variation.

common glutenin alleles were found in landraces from the western coastal and mountainous part of Syria, which could indicate that genetic material is introduced into the eastern part of the Mediterranean basin from other regions, from where alleles are disseminated further.

Populations with the highest diversity indices originated from the coastal areas and adjacent mountains, the northwestern part of the country, the area around Damascus, and the Hauran, whereas the lowest genetic diversity was found in populations from eastern Syria. This distribution has its parallel in environmental site characteristics, although correlations of site characteristics were stronger with the glutenin diversity indices than with the phenotypic diversity index (Table 38). All indices were positively correlated with annual precipitation, minimum January temperature and altitude of the collection site. There was a negative correlation between genetic diversity and the maximum August

Table 38. Correlation coefficients between estimates of diversity within populations and environmental site characteristics.

Diversity index	Altitude	Annual rainfall	Max. August temperature	Min. January temperature
$\delta_{T,band}$	0.259*	0.408**	-0.480**	0.249*
$\delta_{T,allel}$	0.193	0.482**	-0.483**	0.319**
CV_{phen}	0.065	0.222*	-0.255*	0.138

$\delta_{T,band}$: GREGORIUS' level of population differentiation based on banding patterns of grain glutenin
$\delta_{T,allel}$: GREGORIUS' level of population differentiation based on glutenin alleles

* : significant at $p < 0.05$
** : significant at $p < 0.01$

temperature. Thus, there appears to be a negative correlation between diversity and yield limiting factors, such as late season water shortage and heat stress.

1.4.1.6. Conclusions

Regions with moderate climatic conditions provided landraces with relatively stable yields. This observation supports the practice of utilization of germplasm from such regions. Germplasm from regions with extreme environmental conditions should be useful for specific stress factors. An example is tolerance to late frosts, which is most likely to be found in germplasm originating from inland regions, where mean minimum winter temperatures are lower than in coastal areas.

Results of yield and disease evaluations showed that an effective first step in evaluation of landrace germplasm seems to be taxonomic sub-classification into landrace groups, followed by agronomic evaluation of a representative part of the collection. Prediction of the best performing accessions seems unlikely, but the fact that a number of correlations between collection site characteristics and evaluation results appear to have wider validity, suggests that experimental establishment of such relationships may lead to identification of groups from which successful selections or crosses are most likely to be made.

Because of the significant positive correlation coefficient between the glutenin and phenotypic diversity indices, the higher correlations shown by glutenin diversity indices with site characteristics as compared to the phenotypic diversity index, and because glutenin diversity is easier to determine and is independent of environmental influences, this index seems most suitable for diversity studies.

A. Elings, O.F. Mamluk, M.M. Nachit (both Cereal Improvement Program) and Th.J.L. van Hintum (Centre for Genetic Resources, the Netherlands)

1.4.2. Strategies for wheat germplasm conservation in Ethiopia

The variation in Ethiopian tetraploid wheats was so great when VAVILOV explored that region in 1927 that he mistakenly classified Abyssinia as a 'center of origin'. Later VAVILOV (1951) concluded that it was a 'center of diversity' since no wild wheat relatives were found, and HARLAN (1971) confirmed that the center of origin of all wheats was in the 'fertile crescent' of the Near East.

Wheat is grown mostly on the plateau in Ethiopia at an elevation of 1600-2900 meters above sea level. In addition to Triticum durum and T. aestivum, other primitive forms such as T. aethiopicum, T. polonicum, T. dicoccum, T. compactum, and T. aestivum ssp. aestivum (formerly known as ssp. vulgare) are also grown, occasionally in mixtures. However, most of these are early maturity types with a high percentage of anthocyanin in the kernel coats as well as melanin in the spikes. It has been observed that kernel pigmentation is influenced to some extent by altitude. In many areas of wheat cultivation in Ethiopia farmers associate the purple color of kernels with more nutritious bread-making qualities as well as higher yields.

At present, the gene bank of the Plant Genetic Resources Center/Ethiopia (PGRC/E) at Addis Ababa has a total of 10825 cereal accessions, which includes 2675 accessions collected locally and 4429 accessions received as repatriation from other institutions. Almost all material from Ethiopia in this collection are landraces with a large number of distinct morphotypes since it is common to find farmers growing durum, bread, poulard and club wheats in the same field. This heterogeneity of forms presents some problems to the gene bank manager and users such as plant breeders. In order to minimize these difficulties and constraints to utilization, the PGRC/E at Addis Ababa, in collaboration with the University of Reading, UK, and the Genetic Resources Unit, ICARDA, has begun a collaborative research study to separate each component of these heterogeneous populations on the basis of morphological characters, and to evaluate them both at Debre Zeit, Ethiopia (alt. 1900 m), and at Tel Hadya, Syria (alt. 350 m). The results will be used to support a Ph.D. thesis by Mr. HAILU MEKBIB who is the scientist in charge of evaluation and utilization of germplasm at PGRC/E.

Ethiopian wheats are important because of their rust resistance, long coleoptile, short culm, low tillering, earliness, and resistance to drought. They can survive deep seeding. On the other hand, they can also possess susceptibility to leaf rust, although they are highly resistant to stem rust and, in addition, have weak straw and are prone to lodging if fertilizers are applied. They also tend to be low yielding although more tolerant to heat and moisture stress. Their use in breeding has remained limited because of insufficient knowledge on their variability and utility of specific traits with desirable genes.

A collection of 64 morphotypes separated from 18 original population samples of old landraces, which were all collected from over 2500 m altitude by PGRC/E, were sown at Tel Hadya together with Boohai and DZ 04118 as Ethiopian checks, and Haurani and Cham 1 as local checks. Experiment design was in a randomized block in three replicates with 3 rows each of 0.5 m in length with 20 cm between the rows and 40 cm between the accessions. Sprinkler irrigation of 25 mm was applied three times during early spring due to lack of rain. Over 20 physio-morphological characters were recorded in the field and 1000-kw, protein content (%), and vitreousness was recorded in the laboratory.

<u>Grain quality characteristics of Ethiopian wheats</u>

After harvest the 64 morphotypes were sent to the Cereal Quality Laboratory at the Cereal Improvement Program for evaluation of 1000-kw, protein content (%), and seed color. Scoring the total protein content in the kernels was carried out using the Near-Infrared Reflectance (NIR) analyzer, and every 10th sample was also subjected to monitoring by the micro Kjeldahl test to verify the accuracy of the NIR method. Only two morphotypes had very high protein content (> 16%), whereas three had a high protein content (14.5-14.9%) and these were characterized by brown to purple colored kernels. The rest had a low or very low protein content. Eight morphotypes had a 1000-kw between 27-32 g classifying them as small, and eight were between 33-39 g and were considered as medium (WILLIAMS <u>et</u> <u>al</u>., 1986). The rest of the morphotypes were considered very small seeded. These results confirm the generally low yielding characteristics of the old Ethiopian wheats. Table 39 presents the protein content and 1000-kw of morphotypes derived from selected landraces. Simple statistics of these two important quality characters are given in Table 40.

Table 39. Grain quality characteristics of some promising morphotypes of landraces from Ethiopia.

no.*	TKW (g)	Protein (%)	Seed color**	no.	TKW (g)	Protein (%)	Seed color
High Protein Content (%)							
19	20.5	16.4	B	38	23.2	15.0	B
22	22.5	14.5	B+P	33	16.7	16.0	B
33	16.7	16.0	B	58	22.4	14.9	B+P
Medium 1000-kw (g)							
5	32.1	10.9	B	48	33.4	12.0	S
8	31.7	10.7	S	51	37.7	10.4	S
13	31.9	10.8	B	52	37.7	9.7	S
14	31.9	11.9	B	53	33.0	9.7	B
17	31.8	11.6	P	54	39.1	10.6	S
35	31.4	9.8	B	63	34.6	10.4	S
36	31.4	10.4	S	64	36.1	9.6	S

* : no. refers to morphotype number.
** : color codes: S = Straw, B = Brown, and P = Purple

Table 40. Simple statistics for protein content and 1000-kw of 64 landraces of wheat from Ethiopia.

Mean	C.V.	Min.	Max.	Range	Variance
Protein content (%)					
11.7	13.7	8.3	16.4	8.1	2.6
1000-kw (g)					
26.6	19.2	16.7	39.1	22.4	26.3

Electrophoretic variation in gliadins

Initial results from electrophoretic studies on gliadins (storage proteins of wheat) by the method suggested by TKACHUK & MELLISH (1980) seem to indicate a high degree of genetic variation in these landraces, as can be expected. In at least two original population samples (Nos 5027 and 6984) the almost entire high-molecular-weight (HMW) omega-gliadin component was missing. In another case, the within components gliadin banding patterns were identical (accession No. 214601) or very heterogeneous (accession No. 214602), both of which were separated as two different morphotypes from a single original landrace population (accession No. 204709). This once again shows that gliadin banding patterns are independent of the homogeneity and heterogeneity of morphotypes.

Research on primitive germplasm from Ethiopia is continuing at the University of Reading and at the Genetic Resources Unit, ICARDA, and results so far indicate that the material is extremely interesting and a valuable addition to the world collection being maintained at the gene bank at ICARDA.

H. Mekbib (PGRC/E, Addis Ababa, Ethiopia), A.B. Damania, H. Altunji and B. Pickersgill (University of Reading, UK)

1.4.3. 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 between brackets): the Al Faateh University (63), Tripoli, Libya; the N.I. Vavilov All-Union Institute for Plant Industry (133) and the V.L. Komarov Botanical Institute of the Academy of Sciences of the USSR (1459), both in St. Petersburg, Russia; the Botanical Institute of the Turkmenia Academy of Sciences (235), Ashkhabad, Turkmenia; the Institute of Botany, Uzbek Academy of Sciences, (372), Tashkent, Uzbekistan. Especially the herbaria in the former USSR yielded unique information on the distribution of Aegilops in that country. Former ICARDA visiting scientist Dr Z. KHALIKOULOV was here of invaluable help as nearly all labels had to be translated from Cyrillic-written Russian to English. These data add to the valuable germplasm that was collected in this region in June-July 1991.

During herbarium and literature studies in the Netherlands and U.K. material was examined from the herbaria of Bratislava (47), Copenhagen 497), Gatersleben (163), Kew (382), Pisa (39) and Washington (501); during a short trip to the U.S.A. material was studied from the herbaria at Chicago (126), Davis (56), New York (195), Riverside (700), and St. Louis (326). Material studied in the Netherlands was received on loan by the Laboratory for Plant Taxonomy of the Agricultural University at Wageningen.

As a result of this work the so-called "special part" of the taxonomic revision was nearly completed during 1991. Presentation of data in the special part, which deals with the taxa at genus- and species level, is illustrated here with the example of Aegilops crassa. The so-called "general part" consists of chapters on, amongst others, morphology, phylogeny, ecology, distribution, relationships with other genera in the next higher taxa (such as tribes), and serves to put the studied taxon in a wider perspective.

Before properly understanding the presentation of data below it may be helpful to consider the role of taxonomic research in general and to see its place in the genetic resources activities.

LAWRENCE (1951), in his "Taxonomy of Vascular Plants" defined taxonomy as follows: "It is a science that includes identification, nomenclature and classification of objects of biological origin; when limited to plants it is often referred to as systematic botany". The three elements of this definition can be explained as follows:

Identification is the determination of a taxon (such as a species) as being identical with or similar to another and already known element.

Nomenclature deals with the determination of the correct scientific name of a known plant according to a nomenclatural system, thus providing a means by which it can be referred. For plants this system is provided by the "International Code for Botanical Nomenclature" or ICBN.

Classification is the placing of a plant in groups or taxa according to a particular plan or sequence (species in a genus, genera in families etc.). The particular plan may be widely differing: from purely morphologic to, for instance, strictly genomic.

As a result of his work a taxonomist should be able at the end of, especially, a monographic study of a (plant) group to answer the following questions:

- How can they be recognised? (**identification**)
- What is their correct and unambiguous name? (**nomenclature**)
- What are their closest relatives? Any other plants with similar properties or comparable genetic systems? (**classification**)
- Where do they grow? (**distribution**)
- In what kind of habitat? (**ecology**)
- Any useful properties? (**uses**)

A clear, preferably concise, system in a group of crop relatives is most important for a gene bank. This enables researchers more easily to become sure about the identity of their materials, and gene bank managers to hand out correctly identified seeds, bearing, ideally, names that are agreed upon by all users. Obviously the possibility to come up with concise revisions varies widely among crops and their wild relatives. Genera such as <u>Pennisetum</u>, Phaseolus and Vigna will remain complex and large, while Lens and Zea will remain small. Within Aegilops it proved possible to reduce the amount of accepted taxa to roughly 10% of its last revision (HAMMER 1980), making gene bank management of this group a lot easier.

Most present-day taxonomic revisions try to create order into the often chaotic legacy of taxonomic, floristic, regional and/or monographic work that has been done before on the particular group. In the case of Aegilops this is aggravated by the fact that (1) part of the genus occurs in Europe, the botanically most intensively studied part of the world, and (2) because of its obvious importance as direct relative to one of the world's most important crops, wheat.

With the inventory almost completed the results for the taxonomy and nomenclature of Aegilops are as follows:

1. There are 443 names published in Aegilops at the genus (and hybrid-genus) level or below (including subgenus, section, species, subspecies, variety, subvariety and forma), of which 390 are at the species level or below; in addition there are 98 names published in Triticum at (hybrid-) genus level and below; 10 names published in Amblyopyrum; and 21 names in the hybrid genus x Aegilotriticum.

2. This present total of 572 names (probably expanding to around 585 after completion of the survey) is now to be combined with a taxonomic concept which uses more broadly defined taxa, lumping many smaller ones together rather than keeping them separate. The results are for Aegilops: 1 genus, 5 sections, 22 species and 5 varieties (33 names in total); for Amblyopyrum: 1 genus, 1 species and 1 variety (3 names in total); for the hybrid genus x Aegilotriticum: 1 genus and around 20 "species" (that is: natural hybrids or amphidiploids described as such).

3. Subdivision of a genus in subgenera or sections (or both) is,

in my opinion, largely a matter of taste and for use in problems with identification. Although in the case of Aegilops the extensive knowledge of the genome systems has added extra weight to proposed subdivisions of the genus, and this will also be the case in the new revision.

The example of Ae. crassa, presented below, involves 19 names at various levels, as well as two ploidy levels (tetraploid and hexaploid). Material described as Ae. trivialis, and reported to be hexaploid, did not show any morphological characters warranting a separate status. The example demonstrates the role of the ICBN in that the very name trivialis from its nomenclature is illegitimate in view of Article 63.1. When ZHUKOVSKY published his revision in 1928 he subdivided Ae. crassa into the ssp. macrathera, vavilovii (later at species level), and trivialis. The last subspecies was described as being the "typical form", and according to Art. 63.1 the name crassa should have been used instead as the so-called autonym.

When first described each taxon must be identified with a so-called nomenclatural type to which the new name is attached (Arts. 7.1. - 7.3). In the example below these types are indicated; the holotype being that sample from where the author's herbarium is placed (in the case of Ae. crassa this is the BOISSIER herbarium at Geneva, coded as G-BOIS). Also indicated are the homotypic synonyms, which are names in various combinations that are based on the same type (collection). Usually this is only one name; the case of platyathera / macrathera, however, shows two names related to the same type. Also listed are the heterotypic synonyms. These are taxa based on different types of which the revisor of a group concludes that they belong to one and the same (newly defined) taxon. As a result all listed names and combinations eventually fall under Ae. crassa, using a wide concept that includes all the variation observed that was previously given separate status.

As is usual in taxonomic publications names are followed by a listing of relevant literature dealing with the taxon. In the example given this is shortened to mainly (recent) floristics and the two previous monographs (ZHUKOVSKY 1928 and EIG 1929).

Aegilops crassa Boiss.

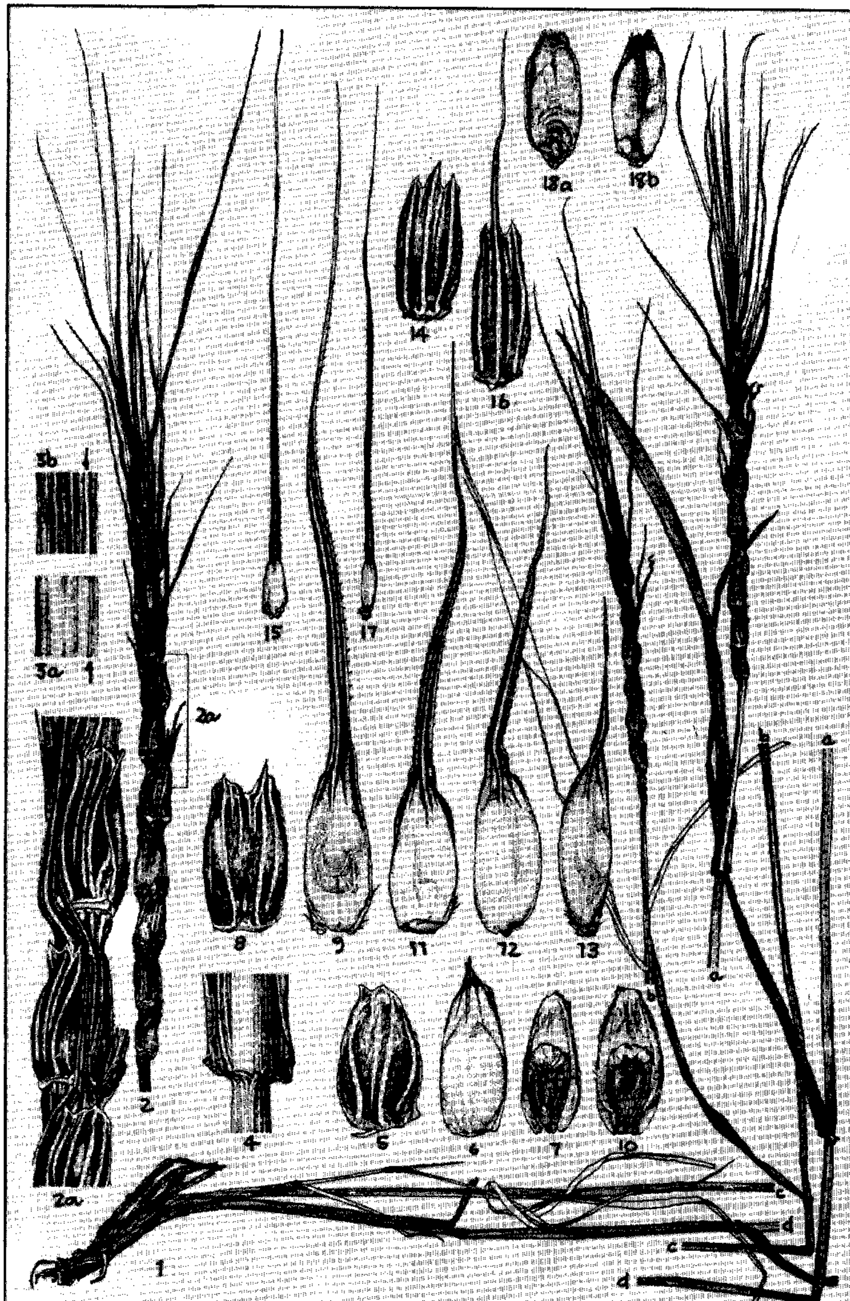
Boissier, Diagn. pl. orient., Sér. 1,7: 129 (1846), Fl. orient. 5: 677 (1884): Post, Fl. Syria (ed. 1) 900 (1896), (ed. 2) 2: 787 (1933); Zhukovsky, Bull. Appl. Bot., Gen., Pl. Breeding 18(1): 456, 550 (1928); Eig, Rep. spec. nov. reg. veget., Beih. 55: 91 (1929a, as var. typica); Nevski in Komarov (ed.), Fl. URSS 2: 671 (1934, Russian) / 535 (1963, English); Parsa, Fl. Iran 5: 825 (1952); Ovchinnikov, Fl. Tadschikistan SSR 1: 338 (1957); Mouterde, Nouv. Fl. Liban, Syrie 1: 151 (1966); Bor in Rechinger, Fl. Lowland Iraq 111 (1964), Fl. Iranica 70/30: 194 (1970, as var. crassa); Bor, Fl. Iraq 9: 180 (1968, as var. crassa); Goloskokov, Ill. det. Kazachstan pl. 1: 124 (1969); Takhtadzjan & Fedorov, Fl. erevana (ed. 2) 366 (1972); Tzvelev in Fedorov (ed.), Zlaki SSSR: 158 (1976, Russian) / 226 (1984, English); Hammer, Feddes Rep. 91: 234 (1980b, as ssp. crassa var. crassa fo. crassa); Migushova & Chakimova, Bull. WIR 119: 76 (1982); Davis, Fl. Turkey 9: 238 (1985, as ssp. crassa); Nikitin & Geldykhanov, Descr. Pl. Turkmenistan 46 (1988).

Type: (Iran) Ad canales in planitie prope ruinas urbis Persepolis, 16.IV.1842, Kotschy 248 (holo: G-BOIS; iso: BM, C, K, L, LE, MO, OXF, P);

Homotypic synonyms:

Triticum crassum (Boiss.) Aitch. & Helmsl.; Aitchison & Helmsley, Trans. Linn. Soc., Ser. 2,3: 127 (1888); Kimber & Feldman, Wild Wheat 72 (1987).

Gastropyrum crassum (Boiss.) A. Löve; A. Löve, Feddes Rep. 95: 501 (1984).


18a
18b
14
16
15
17
3b
3a
2a
8
9
11
12
13
4
5
6
7
10
2
2a
1
a
b
c
d

Heterotypic synonyms:

Aegilops platyathera Jaub. & Spach; Jaubert & Spach, Ill. pl. orient. 4: 17, Tab. 313 (1851). Type: (Turkey / Syria / Iraq) "Mesopotamia", inter Mardin et Mosul, Aucher-Eloy 2913 (holo: P; iso: BM, K, OXF). Homotypic synonyms: Aegilops crassa Boiss. var. β macrathera Boiss.; Boissier, Fl. orient. 5: 677 (1884). Triticum crassum (Boiss.) Aitch. & Helmsl. var. macratherum (Boiss.) Thell.; Thellung, Fl. adv. Montpellier 150 (1912). Aegilops crassa Boiss. ssp. macrathera (Boiss.) Zhuk.; Zhukovsky, Bull. Appl. Bot., Gen., Pl. Breeding 18(1): 553 (1928). nom. superfl.

Aegilops crassa Boiss. var. flavescens Pop.; Popova, Bull. Appl. Bot., Pl. Breeding 13: 477 (1923). Type: (Kazachstan / Uzbekistan) "Turkestan", Syr-Darja, Popova s.n. (holo: LE ? not seen).

Aegilops crassa Boiss. var. fuliginosa Pop.; Popova, Bull. Appl. Bot., Pl. Breeding 13: 477 (1923). syn. nov. Type: (Kazachstan / Uzbekistan) "Turkestan", Syr-Darja, Popova s.n. (holo: LE ? not seen). Homotypic synonym: Aegilops crassa Boiss. fo. fuliginosa (Pop.) Hammer, Feddes Rep. 91: 234 (1980b).

Aegilops crassa Boiss. var. rubiginosa Pop.; Popova, Bull. Appl. Bot., Pl. Breeding 13: 477 (1923). syn. nov. Type: (Kazachstan /

(See left page) Fig. 16. Aegilops crassa. 1, habitus (x 1/2); 2, spike (x 3/4); 2a, enlarged part of spike, showing spikelets in situ (x 2 1/2); 3a, abaxial side of leaf, midway (x 2); 3b, adaxial side of 3a (x 2); 4, stem, leaf sheath, ears and leaf blade (x 2); 5-7, lowest floret of lowest fertile spikelet in a spike: 5, glume, 6, lemma, 7, palea with immature seed (5-7 all x 2 1/2); 8-13, spikelet in centre of spike: 8, glume, 9, lemma, 10, palea with immature seed (8-10 lowest floret of the spikelet), 11, lemma of upper glume of spikelet, 12, lemma of third fertile floret, 13, lemma of fourth fertile floret (8-13 all x 2 1/2); 14-17 apical spikelet: 14, glume of lower floret (x 2 1/2), 15, lemma of lower floret (x 1), 16, glume of upper floret (x 2 1/2), 17, lemma of upper floret (x 1); 18a, dorsal side of mature seed (x 2 1/2); 18b, ventral side of mature seed (x 2 1/2). 1-18 from Humeid et al. BMW 6-6.

Uzbekistan) "Turkestan", Syr-Darja, Popova s.n. (holo: LE ? not seen). Homotypic synonym: Aegilops crassa Boiss. fo. rubiginosa (Pop.) Hammer, Feddes Rep. 91: 234 (1980b).

Aegilops crassa Boiss. var. glumiaristata Eig; Eig, Bull. Soc. Bot. Genève, Sér. 2(19): 328 (1928), Rep. spec. nov. reg. veget., Beih. 55: 92 (1929a). Type: (Turkmenia / Uzbekistan) Amu-Darja, 30.IV.1915, Popov(a) s.n. (holo: LE, not seen). (added in EIG 1929a: Afghanistan, Badghis, Aitchison 461 (holo: K; iso: A, BM, LE) and (Iran), prov. Hamadan, Pichler s.n. (holo: G-BOIS). Homotypic synonym: Gastropyrum glumiaristatum (Eig) A. Löve & McGuire; A. Löve, Feddes Rep. 95: 502 (1984).

Aegilops crassa Boiss. ssp. trivialis Zhuk.; Zhukovsky, Bull. Appl. Bot., Gen., Pl. Breeding 18(1): 554 (1928). nom. illeg. Type: not indicated. Homotypic synonym: Aegilops trivialis (Zhuk.) Migush. & Chakim.; Migushova & Chakimova, Bull. WIR 119: 76 (1982).

Diagnostic characters: Robust, loosely tufted annuals; plant height excluding spike awns (10-)20-40 cm; spikes moniliform (= like a string of beads), with 0-2 rudimentairy and (4-)6-9(-12) fertile spikelets; glumes densely covered with closely adpressed, whitish hairs; lemmas gradually tapering into long, flat awns that are wide at the base; lemma awns more strongly developed towards apical part of spike; spike disarticulating barrel-shaped (that is a spikelet with the rachilla of the next higher spikelet falls as a unit).

(**Description:**)

Distribution: central, western and northwestern Iran, southward to Shiraz prov.; central and northern Iraq; northern Afghanistan; southernmost parts of Kazachstan; western Kirgizia; Turkmenia; Uzbekistan; Tadzhikistan; northern and northeastern Syria and adjacent sourthern Turkey; rare in northern Jordan and Lebanon. Uncommom throughout its range.

Ecology: A drought tolerant species growing under (100-)150-350 mm annual rainfall in steppe, fallow, arid grasslands, along roadsides, within as well as in margins of cultivation (e.g. of wheat with which it occasionally hybridizes), and on rocky slopes. Occasional within cultivation. Found on a variety of soil types: clay, (sandy-) loam and sand. As the main area of distribution of Ae. crassa in Asia is mountainous and at higher latitudes this indicates a general adaptation to cooler climates.

Altitude: From -260 m (Jordan valley region) up to 1650 m.

Flowering and fruiting time: May to July.

Genome: DM (2x = 4n = 28) (CHENNAVEERAIAH 1960: 92), and DDM (2x = 6n = 42). The hexaploid forms of this species have been reported and published as Aegilops trivialis.

Vernacular names: Aytzagn hastlig (Armenian); Aegilops tolsti (Russian); Jorin bogdayli-tchair (Turkmenian); Khasmaldokh (Uzbek).

M. van Slageren

1.4.4. Prolamine diversity in sympatric populations of Triticum urartu and T. dicoccoides in Syria

The main purpose of this preliminary study was to assess genetic diversity in wild wheat populations from southern Syria, which, in turn, might lead to the identification of sites of special genetic interest, leading in the longer term to the development of guidelines for research on in situ conservation.

As a follow-up to an exploration mission in the Sweida province, Syria (see Chapter 1.2.3. of this Annual Report) three populations of Triticum urartu and seven populations of T. dicoccoides were analyzed for gliadin diversity. In addition, variation in high-molecular-weight (HMW) subunits of glutenin was studied in population no. 22 of T. urartu and no. 21 of T. dicoccoides.

Gliadin and glutenin of wheat belong to the same family of storage proteins, the prolamins. These proteins display large polymorphism when studied by gel electrophoresis and are, therefore, good indicators of genetic diversity.

Three major prolamin-coding loci have been identified and located on the chromosomes of bread wheat. According to the literature, the genes controlling HMW subunits of glutenin occur on the long arms of chromosomes 1A, 1B and 1D, while genes for ω-gliadins and γ-gliadins are located on the short arms of the same set of chromosomes. Genes for the α- and β-gliadins occur on the short arms of chromosomes 6A, 6B and 6D. Following the same pattern, genes for prolamins in the wheat wild progenitors, diploid T. urartu and tetraploid T. dicoccoides, are located on chromosomes 1A, 6A and 1A, 1B, 6A, 6B, respectively. Gliadin loci on homoeologous chromosomes 1 contain 6 to 10 copies of genes coding for ω- and γ-gliadins, similar to the number of α/β gliadin genes (5 to 10) in the loci on homoeologous chromosomes 6.

The genes within a locus are tightly linked and inherited as a bloc because intra-locus recombinations are extremely rare. This facilitates identification of different blocs in the electrophoregrams and their assignment to the specific loci.

Electrophoresis of gliadins was performed as follows. One seed from each plant was crushed to a fine powder and extracted with 1.5 M N,N-dimethylformamide for one hour and centrifuged. Gel was prepared by the method of TKACHUK & MELLISH (1980). Five microliters of extracted sample were loaded in each well. The gels were run on a a vertical Bio-Rad apparatus at a constant temperature of 12°C and a current intensity of 45 mA for about 3 hours, then stained in 12% trichloracetic acid with Coomassie Brillant Blue R-250 overnight at room temperature, and destained in tap water, again overnight and at room temperature.

In this study an attempt was made to dissect the overall variation observed in the electrophoregrams into allelic blocs controlled by Gli-A1 and Gli-A2 in T. urartu and Gli-A1, Gli-A2, Gli-B1 and Gli-B2 in T. dicoccoides. The bloc variants were considered as different genotypes of the loci and were taken as a basis for calculations of genetic diversity, both in the populations and the loci. Single bands of the electrophoregrams were characterized by their relative electrophoretic mobility (Rm) taking the bands 24, 50 and 79 of the bread wheat cv. Marquis as points of reference. NEI's heterozygosity index ($H_{t.j.}$) and SHANNON's information index ($h_{s.j}$) were used as statistics to measure genetic diversity in the wild wheat populations. As the results for the calculations of NEI's index were not very different, data for SHANNON's information index, as well as the mean diversity H calculated on its basis, are presented only (Tables 41 and 42). SHANNON's index is considered to be a convenient measure of both richness and evenness of genetic diversity.

1.4.4.1. Gliadin diversity in Triticum urartu

Electrophoretic characterization of 12 plants from the Triticum urartu population no. 22 (sympatric with T. dicoccoides no. 21) is shown in Fig. 17. Interpretation of diploid wheat electrophoregrams is easier because the two gliadin blocs, controlled by Gli-A1 and Gli-A2, do not overlap and can be clearly identified. Variation in ω,γ- and β-gliadins is due to genotype differences in the Gli-A1 locus, whereas α-gliadin polymorphism can be entirely assigned to genetic diversity in Gli-A2. In spite of the high genetic diversity in both loci, as is shown in Table 41, some bands were monomorphic in all plants analyzed, e.g. 23 and 27 in ω-gliadins, 46 in γ-gliadins and 71 in α-gliadins. Another interesting feature is the presence of very fast-moving α-gliadins in all individuals and slow-moving ω-gliadins in some plants (lanes 9 and 12 in Fig. 17).

Values of the SHANNON's index ($h_{s.j}$), and mean diversity for two gliadin loci (H_j) and three populations (H_s) are presented in Table 41. Though the number of individuals characterized per population was low (6-12), values of the SHANNON's information index and their

Table 41. Genetic diversity for gliadins in <u>Triticum</u> <u>urartu</u> populations.

Pop. no.	**22**	**18**	**16**	**H_j****
Locus	**n = 12***	**n = 7**	**n = 6**	**N = 25**
Gli-A1	1.120	1.735	1.014	1.290
Gli-A2	1.516	1.272	1.014	1.267
H_s***	1.318	1.504	1.014	1.279+

* : number of plants analyzed from the population.
** : mean diversity for the loci.
*** : mean diversity for the populations.
\+ : overall genetic diversity (H).

means are high. In total, 9 different genotype variants were identified in each of the two loci among 25 plants. Mean genetic diversity H_j for Gli-A1 and Gli-A2 loci was nearly the same. However, values of H_s indicate differences in genetic diversity among the populations. <u>T</u>. <u>urartu</u> has been reported to possess very low genetic diversity when studied by allozyme electrophoresis by other workers. However, our data based on gliadin characterization, demonstrate that this is not the case, at least for these populations from southern Syria.

1.4.4.2. Gliadin diversity in <u>Triticum</u> <u>dicoccoides</u> populations

The wild emmer, <u>Triticum</u> <u>dicoccoides</u>, is a tetraploid species with two homoeologous genomes A and B and, consequently, has double the number of gliadin coding loci and genes in comparison to the diploid <u>Triticum</u> <u>urartu</u>. This difference results in higher complexity of gliadin electrophoregrams in <u>T</u>. <u>dicoccoides</u>, as is shown in Fig. 18., which represents 10 individuals from population no. 21. The additional loci, Gli-B1 and Gli-B2, control the intensively stained

Table 42. Genetic diversity for gliadins in _T._ _dicoccoides_ populations.

Pop. no.	21	17	14	25	34	40	45	H_j**
Locus	**n=10***	**n=10**	**n=4**	**n=10**	**n=7**	**n=6**	**n=10**	**N=57**
Gli-A1	1.609	1.030	1.039	1.332	1.735	1.334	1.089	1.310
Gli-B1	1.359	1.030	1.039	1.332	1.735	1.334	1.471	1.328
Gli-A2	1.193	1.030	1.039	1.054	1.352	1.098	1.418	1.169
Gli-B2	1.609	1.030	1.039	1.332	1.463	1.334	1.279	1.279
H_s***	1.443	1.030	1.039	1.263	1.571	1.275	1.314	1.276

* : number of plants analyzed from the population.
** : mean diversity for the loci.
*** : mean diversity for the populations.
\+ : overall genetic diversity (H).

bands in the fast-moving ω-gliadin (Rm 28-40) and β-gliadin regions, respectively. The α-gliadins (Rm >70) are coded by Gli-A2, while variation in slow-moving ω-gliadins and dark γ-gliadin bands seems to be mostly controlled by Gli-A1. No monomorphic band was found across the populations. However, some bands, e.g. 45, were predominant and monomorphic in the majority of the populations sampled (Fig. 18). In some individuals a double band of slow-migrating ω-gliadins (see lanes 2, 6, 8 and 9 in Fig. 18) of the same Rm (14 and 19) as in _T._ _urartu_ (lanes 9 and 12 in Fig. 17) was detected. Since the two populations, represented in Figs. 17 and 18, are sympatric this might indicate a gene flow and introgression between the diploid and tetraploid wheats in their natural habitat.

The data in Table 42 show high genetic diversity in all populations and loci studied. In spite of a low number of plants sampled per population (4-10) the H_s values indicate inter-population differences in genetic diversity, while inter-loci differences, between the H_j values, are lower. The range of SHANNON's index

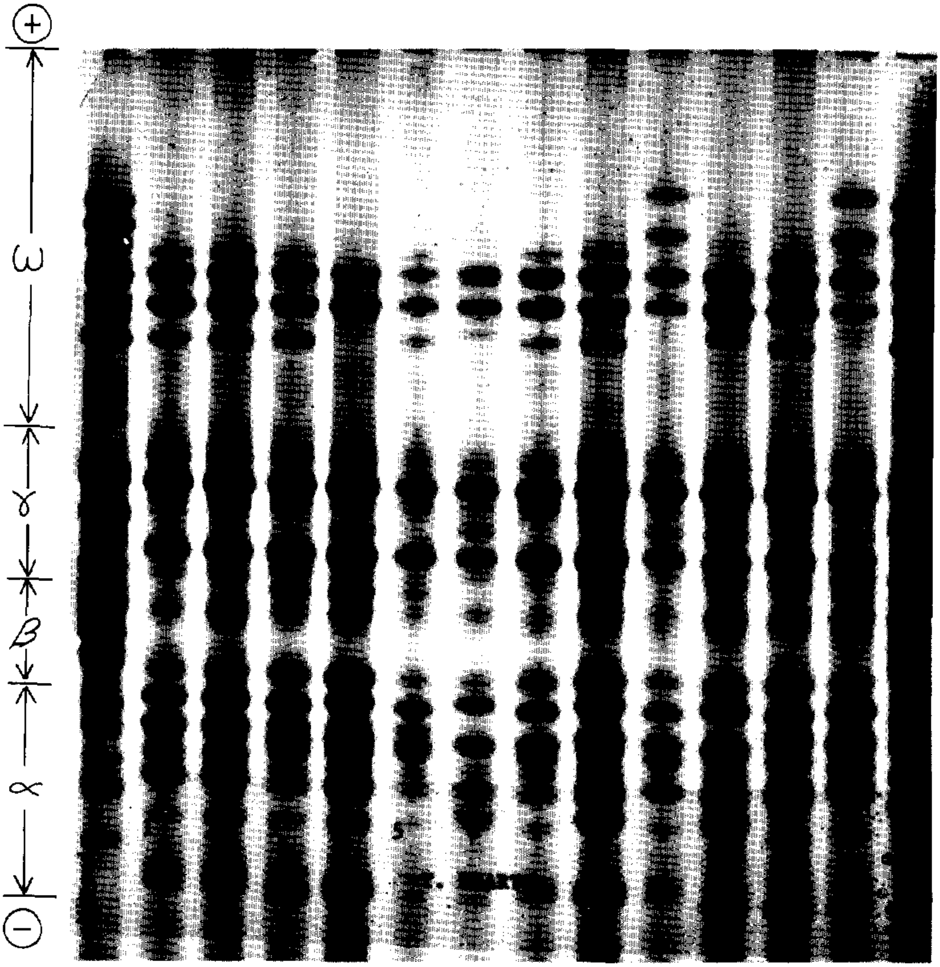


Fig. 17. Gliadin diversity in Triticum urartu population no. 22.

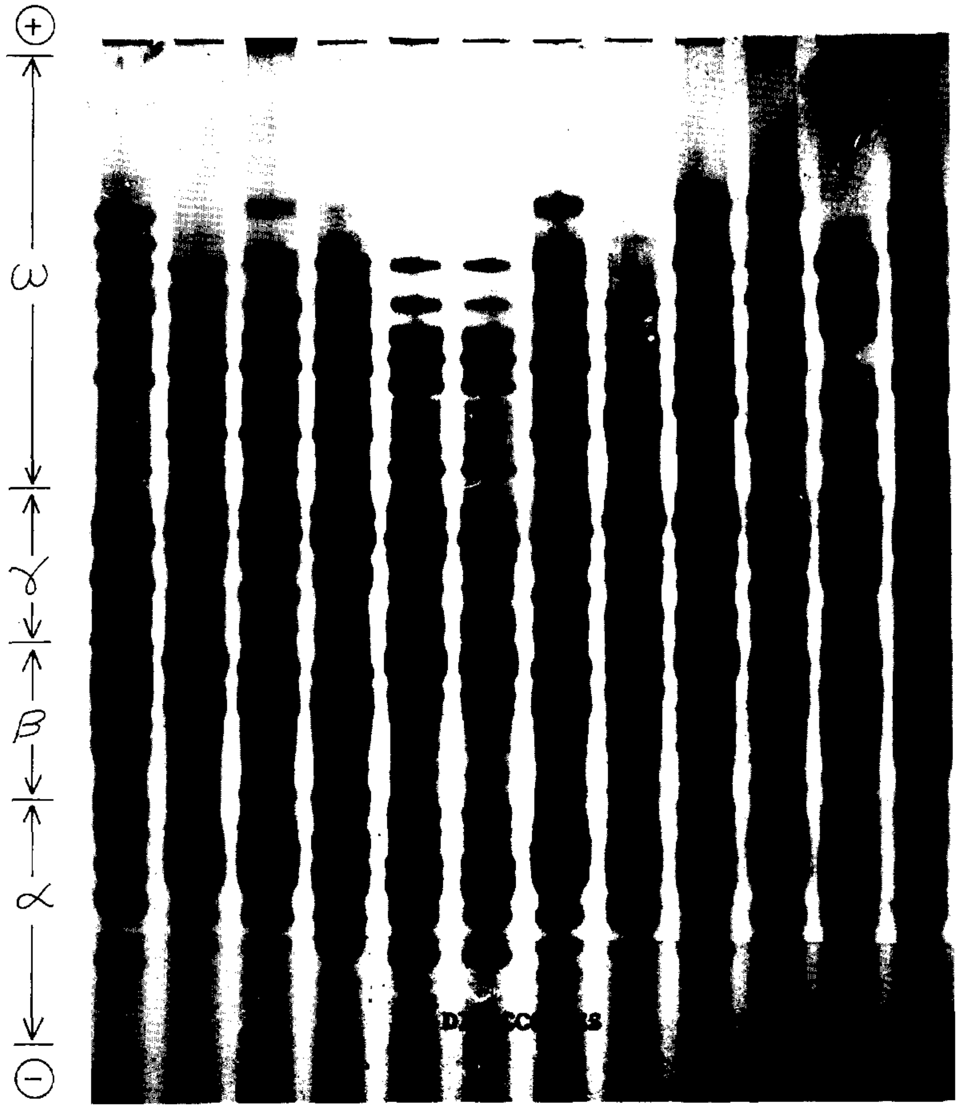


Fig. 18. Gliadin diversity in Triticum dicoccoides population no. 21.

values, as well as the population mean values (H_s), are similar to those in T. urartu (Table 41), and the values of the overall genetic diversity for 57 and 25 individuals of T. dicoccoides and T. urartu, respectively, are almost the same, i.e. H = 1.276 and H = 1.279.

The number of genotype variants per locus in T. dicoccoides varied from 17 in Gli-A2, 22 in Gli-B2, 24 in Gli-A1 to 26 in Gli-B1.

1.4.4.3. Characterization of HMW glutenin subunits

High-molecular-weight (HMW) subunits of glutenin in T. urartu and T. dicoccoides were fractionated by one-dimensional SDS-PAGE electrophoresis. Since only one population per each species was sampled, genetic diversity data were not calculated.

Table 43. Presence of HMW glutenin subunits in genotypes found in two populations of wild wheats.

Species/ Population	Genotype	Occurence of HMW subunits $1A_x$	$1A_y$	$1B_x$	$1B_y$	Number of plants
T. urartu	I	+	+	( )*	( )	8
no. 22	II	-	+	( )	( )	2
T. dicoccoides	I	+	+	+	+	1
no. 21	II	+	-	+	+	5
	III	-	-	+	+	3
	IV	+	-	+	-	1

* : no B genome present in T. urartu.

Genes controlling the HMW subunits of glutenin occur on the long arm of homoeologous chromosomes 1. The loci are collectively called Glu-1 and they are coding for two subunits of the "x" and "y" type. Some genes have been reported to be inactive in different Triticum spp. and a similar phenomenon was also found in the present study in two sympatric populations of the wild wheats, T. urartu and T. dicoccoides.

The data in Table 43 demonstrate diversity in HMW glutenin subunit inactivation. In diploid T. urartu both subunits coded by Glu-A1 locus were present in most plants, however, two individuals lacked the $1A_x$ subunit.

This is, to our knowledge, the first reported case of $1A_x$-subunit gene inactivity in T. urartu. Prevalence of three active genes for HMW subunits of glutenin in T. dicoccoides corresponds to reports by other authors.

J. Valkoun, H. Altunji and A.B. Damania

1.5. Documentation of Genetic Resources

Documentation of collections is an important genebank function with direct relevance to all other activities starting from acquisition of new germplasm and ending with provision of samples to users. Deficiencies in the germplasm documentation system, either at the level of completeness and accuracy of information on accessions or at the level of efficiency of data handling and data analysis, can negatively affect work of the entire gene bank. With this in mind the Genetic Resources Unit at ICARDA critically examined in 1991 its documentation system, which had been in operation for a number of years using VAX 11/750 and VAX 11/780 computers. This assessment led to the decision to modify the current system and to implement a new system using Personal Computers (PCs) to take advantage of newer computer technology.

The modifications of the documentation system concern:

(1) the descriptor scheme in use,

(2) composition and structure of database files for crops, and

(3) software for data handling.

As per (1), the changes are mainly addition of new descriptors. Crop databases are gradually being expanded to cover information on the quantity and quality of seeds in base and active collections (stock control descriptors). Modifications of passport descriptors are also being made to remove ambiguity. This should simplify recording and interpreting of information but it usually leads to increase in the number of descriptors.

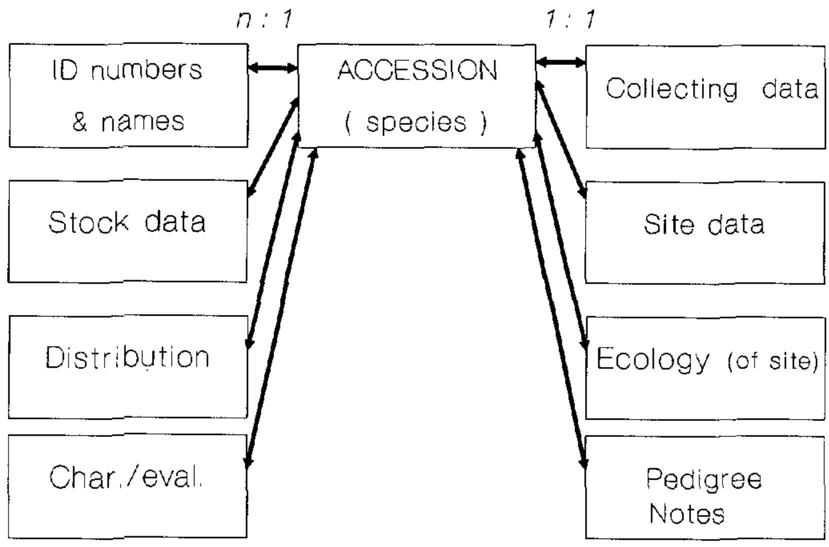
Efficiency of data handling largely depends on the structure of the database. In the earlier GRU documentation system, there was a tendency to maintain files with large numbers of fields or descriptors. Currently, the GRU maintains a larger number of files with fewer, but more closely related, descriptors. The structure of a typical crop database in the new format is shown on Fig. 19. It is apparent here that the descriptors for which we expect many recordings or values, e.g., accession identifiers (names and/or numbers), are distinguished from the descriptors with only one possible value (on the left- and right-hand side of the main record for an accession respectively). Database performance tests indicate that the changes in design of the database have brought gains in speed of data retrieval and reduced disk memory requirements.

A menu-driven program to handle databases in the above structure has been developed using the CLIPPER development system. The databases can also be accessed through dBASE III+ or dBASE IV.

The passport data files for all crops were transferred from the VAX computer to PCs and reorganized to fit the new structure. During the latter process a close look at the data records was taken in order to verify the accuracy and consistency of information. The job proved to be very time consuming because many errors, inconsistences and gaps in the data were found. Attempts were made to resolve the problems as soon as they were identified. Data of cereals and partially of food legume germplasm had been extensively reviewed and updated in previous years (see Annual Reports) and, therefore, higher priority was assigned to, and more time spent on, work with passport data of forage legumes.

In addition to reviewing the passport data files for individual crops or genera, attention was also paid to cross-checking of crop databases for consistency of data formats and gaps in information. This applies particularly to germplasm collected during multi-crop missions which was subsequently documented by different people using different standards. As a priority, the data for germplasm collected by ICARDA (17800 accessions, or 20% of the total holdings) were verified, discrepancies removed and gaps in the data filled

Fig. 19. Structure of database



according to the original collectors' records.

The importance of this work can be illustrated with the following. The GRU is proceeding with safety duplication of its collections, whereby ICARDA's chickpea collection will be duplicated at ICRISAT. In the past there has been substantial chickpea germplasm exchange between the two centers, and they have received independently a large number of accessions from the same donors, e.g., ALAD and USDA. It was agreed to duplicate only that part of ICARDA's collection which does not overlap with ICRISAT's collection. For this work the databases of both collections have been compared and approximately 1000 accessions were found to be "duplicates" in addition to 2500 accessions which are the same because of direct exchange of material between ICRISAT and ICARDA.

Work on this project was also very useful to clarify ambiguity and/or gaps in information.

Two catalogues have been published in 1991: for Kabuli chickpea and for durum wheat germplasm, developed respectively in cooperation with the Legume and Cereal Improvement Programs. The publications contain both passport information and evaluation data on agronomic traits. Unlike catalogues of other crops published earlier by ICARDA, the chickpea catalogue uses scores for all quantitative traits. For the 10 continous measurement characters the scores were determined by the 'distance' of measured values from the overall mean.

Exchange of data on computer diskettes is gradually becoming the standard method of communication with genebanks in WANA and elsewhere, especially when voluminous data files are transferred. At present the GRU usually sends both diskettes and listings in response for information and for larger seed despatches.

The new database software has also been applied to two international databases: for wild wheat relatives and for forage and pasture legumes collected in the Mediterranean basin. The history and the content of both databases are described in GRU's Annual Report for 1990. A new program enables improved cross-referencing of samples from different collections. It also reduces disk space requirements and provides more user-friendly access to the data through a set of menus. After incorporating updates from ICARDA's collections and data received from USDA at the end of 1991, copies of the databases will be distributed to information contributors and scientists interesting in making searches.

J. Konopka and A. Antypas

1.6. Germplasm management

1.6.1. Viability testing of cereal germplasm

In the 1990-91 season, a total of 6881 cereal accessions, 3442 of barley and 3439 of durum wheat, were tested for viability. The germination tests were carried out in the laboratory on accessions from the medium-term store (the so-called "active collection"). Seed from each accession was tested by putting four replications of 20 seeds on blotting paper in Petri dishes. Germination was evaluated after seven-day incubation at 20°C.

Results of the testing for barley germplasm (Fig. 20) indicated that 69% of the tested accessions had a high viability percentage (>90%) and a total of 91% of the tested barley germplasm showed good germination (>80%). The remaining 9% of accessions will be rejuvenated because of the insufficient viability.

Adding this year's number with last year's (GRU Annual Report 1990: 78) indicates that 90% of the grand total of 5519 tested barley accessions have a good germination.

For durum wheat germplasm the viability tests gave almost the same results as with barley (Fig. 21). Of 3439 tested accessions 68% showed high viability and a total of 91% of the accessions had a good germination percentage, while 9% of the tested materials need rejuvenation. Similar to barley, this year's data added to last year's results indicates that 90% of the total tested durum wheat accessions over these two years (5786) have a good germination.

B. Humeid and GRU staff

1.6.2. Safety duplication

Safety duplication of unique cereal germplasm accessions, 15090 in total, was finalized in CIMMYT, Mexico. This total consists of 5351 barley, 7440 durum wheat, 1237 bread wheat and 1062 wheat wild

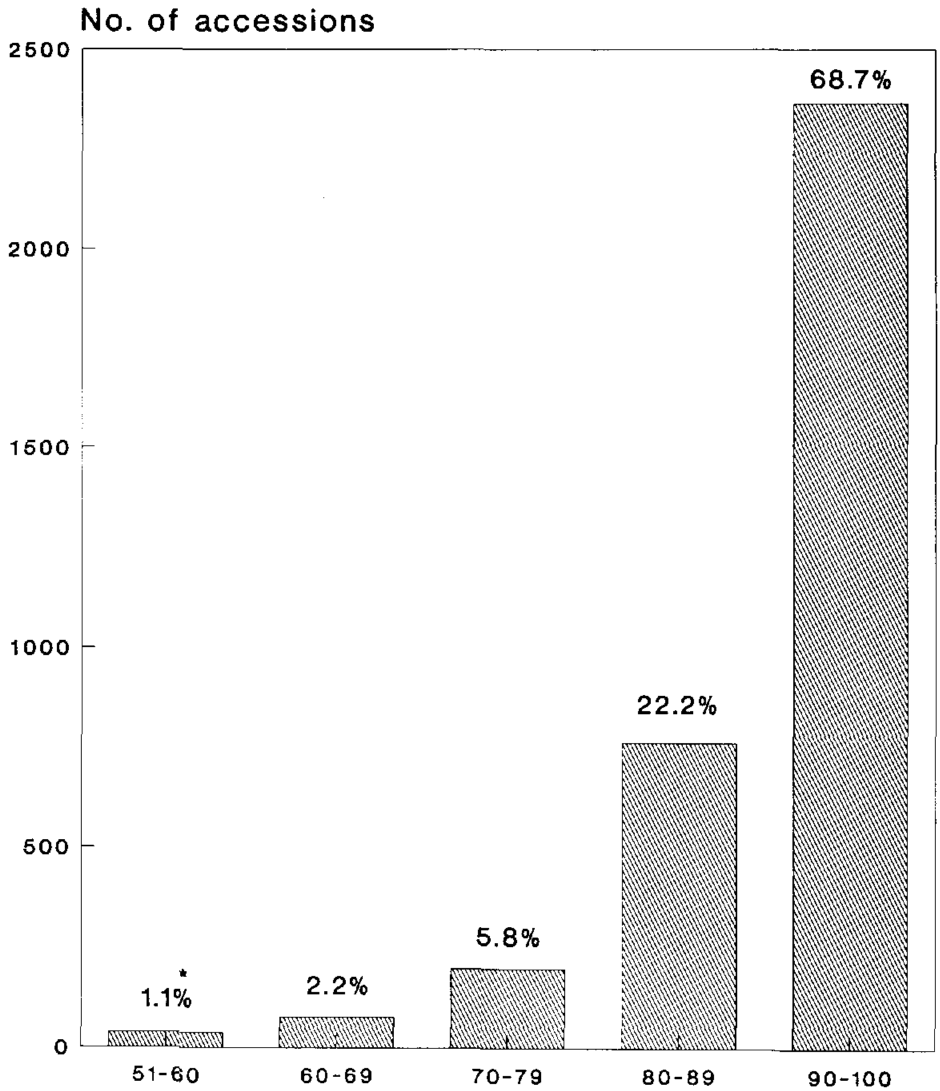


Fig. 20. Barley germplasm viability test (3442 accessions)
* : % of the total number

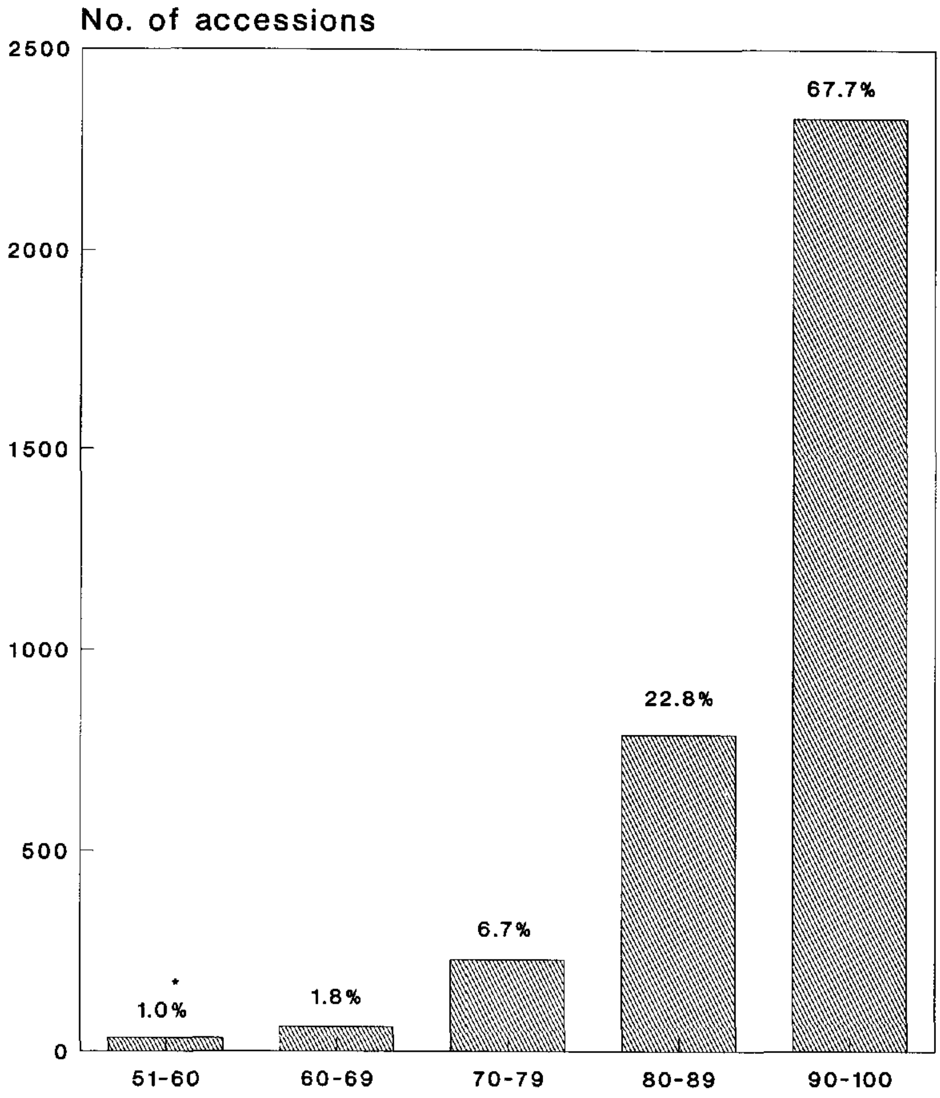


Fig. 21. Durum wheat germplasm viability test (3439 acc.)
* : % of the total number

relatives accessions.

In food legumes the duplication of faba bean started with a deposition of 600 accessions in the Federal Institute of Agrobiology, Linz, Austria.

B. Humeid and GRU staff

1.6.3. Cleaning germplasm in the gene bank from seed-borne infections

This work is a part of a continuing effort by the Genetic Resources Unit to free its germplasm accessions from seed-borne virus infections. During 1991 the Virology Laboratory tested 940 accessions of barley, 730 of lentil and 300 of faba bean. In approximately 10% of the accessions seed-borne virus was detected, and such accessions will be freed from seed-borne infections by planting them the next season where infected seedlings will be identified and eliminated, with seeds harvested only from healthy plants which will then be deposited in the gene bank.

In addition, during germplasm multiplication in the field, 340 lentil accessions were freed from seed-borne infections by eliminating infected plants at the late flowering - early podding stage.

K. Makkouk and W. Radwan

1.6.4. Laboratory testing of preserved barley and lentil germplasm of the GRU

In order to clean up the preserved germplasm from seed borne pathogens at the ICARDA GRU genebank, the SHL this year is year examined the sanitary status of this germplasm by conducting as a first step, seed health testing. It is understood that this process will take several years. Therefore, the SHL started testing preserved barley and lentil accessions. Although the number of accessions tested was not large, results showed that a high

Table 44. Seed health tests conducted on germplasm seeds from ICARDA genebank in 1990/91.

Crop	Lines tested	Test carried out	Pathogens observed
Lentil	205	Freezer blotter test	Ascochyta spp. (146); Fusarium spp. and Ascochyta spp. (9)
Barley	564	Freezer blotter test Centrifuge wash test	Fusarium spp. (119); Helminthosporium spp. (37); Fusarium spp. and Helminthosporium spp. (8); Tilletia caries and/or Tilletia foetida (200); T. spp. and Urocystis agropyri (11)

percentage of lentil accessions were infected by Ascochyta spp., whereas barley accessions proved infected by T. caries and/or T. foetida and Fusarium spp (Table 44). It is obvious that a feasible strategy to eliminate detected pathogens and to rank pathogens in order of importance should be attempted.

A. El-Ahmed and S. Asaad

2. SEED HEALTH ACTIVITIES

The ICARDA Seed Health Laboratory (SHL) plays an important role in ensuring safe reciprocal seed exchange between ICARDA and cooperators of national and international institutions. The SHL is active in training national cooperators on detection techniques for seed-borne pathogens/pests and responsive to the evolving needs of NARSs.

2.1. Activities on newly introduced seeds

During the period November, 1990 - October 1991, 98 consignments from cooperators in 35 countries were received after passing Syrian Quarantine Authorities.

2.1.1. Laboratory testing and treatment

In order to control insects pests carried by consignments and as a routine procedure at ICARDA, all incoming seeds are immediately fumigated (aluminum phosphide) or treated at -18 °C for seven days. Seeds are then inspected visually for symptoms of infection, soil particles, weed seeds, bunt balls and nematode galls. Different techniques for seed health testing are applied (Tables 45 and 46) for about 50 % of the imported seeds. The total number of tested lines was about 55% more than the previous year. Prior to planting, seeds which were not treated by the sender were treated at the SHL with Vitavax 200 (for cereals) and thiabendazole or benomyl with tridemorph + Maneb (for legumes).In the 1991 season, two quarantine pathogens, which do not occur in Syria were detected (Tilletia indica and T. contraversa) in some consignments of wheat which were subsequently destroyed.

Table 45. Seed health tests conducted on cereal seeds newly introduced to ICARDA in 1990/91.

Crop	Number of lines Tested	Clean	Infected	Tests carried out	Pathogens observed
Durum wheat	794	731	63	Karnal bunt test	Tilletia caries and/or T. foetida (63)*
Bread wheat	6952	3614	3338	Karnal bunt test	Tilletia caries and/or T. foetida (507); T. spp. and T. contraversa (216); T. indica (2270); T. spp, T. indica and T. contraversa (320); Urocystis agropyri (25)
Barley	295	188	107	Centrifuge wash test Freezing blotter test	Helminthosporium spp. (12); Fusarium spp. (70); F. spp. and Helminthosporium spp. (25)
Triticale	52	52	-	Centrifuge wash test	-
Wild wheat	50	41	9	Centrifuge wash test	Tilletia caries and/or T. foetida (9)
Total	8143	4626	3517		

* : Numbers in parentheses refer to infested entries.

Table 46. Seed health tests conducted on food and forage legumes and brassica seeds newly introduced to ICARDA in 1990/91.

Crop	Number of lines Tested	Clean	Infected	Tests carried out	Pathogens observed
Lentil	32	25	7	Freezing blotter test	*Fusarium* spp. (2); *Botrytis* spp. (2); *Ascochyta* spp. (3)
Faba bean	22	21	1	Agar media test	*Fusarium* spp. (1)
				Test for stem nematode	
Chickpea	40	40	-	Agar media test	-
Pea	4	1	3	Test on *Pseudomonas*	*Pseudomonas* sp. (3)
				F agar	-
Brassica	9	9	-	XTS agar media test	-
				Centrifuge wash test	-
				Freezing blotter test	-
Safflower	3	3	-	Freezing blotter test	-
				Agar media test	-
Vetch	5	5	-	Freezing blotter test	-
				Agar media test	-
Medic	30	26	4	Freezing blotter test	*Fusarium* spp. (3);
				Agar media test	*Ascochyta* spp. (1)
				Test for stem nematode	-
Forage legumes	6	6	-	Freezing blotter test	-
Total	**151**	**136**	**15**		

2.1.2. Field inspection

As per Center policy, imported seeds proved to be free of quarantine pathogens were planted only in the isolation area for one cycle as a precaution against inadvertent introduction of pathogens and pests. Newly introduced material covered approximately 19 ha. Careful field inspection in all plots revealed one exotic pathogen (Urocystis agropyri).

2.2. Activities on seed dispatched internationally

In 1991, 519 consignments of regular nurseries (201) and specific trait germplasm (318) of cereal and food and forage legumes were distributed from Aleppo to 72 countries. This represented a 13% increase in seed dispatch over the previous season. After testing all exported seeds were provided with phytosanitary certificates issued by the Syrian authorities.

2.2.1. Laboratory testing and treatment

Seed health testing was conducted on seed samples from plots where disease symptoms were observed on plants. Compared to the previous year, the total number of lines tested increased by 105%. Detailed information on identified pathogens is summarized in Table 47. Nevertheless, seed samples of all bread wheat plots were tested and those which proved contaminated by Urocystis agropyri were eliminated. Unless specific requests were made by the recipient for untreated seed, all dispatched seeds were treated with fungicides. Legume seeds were also routinely fumigated.

2.2.2. Field inspection

In the 1990/91 season much effort was spent on field inspection. The seed increase plots of different crops destined for

Table 47. Seed health tests conducted on seeds dispatched internationally from ICARDA in 1990/91.

Crop	Number of lines Tested	Clean	Infected	Tests carried out	Pathogens observed
Durum wheat	550	407	143	Centrifuge wash test	*Tilletia caries* and/or *T. foetida* (141); *Urocystis agropyri* (2)*
Bread wheat	1062	926	136	Centrifuge wash test	*Tilletia caries* and/or *T. foetida* (113); *Urocystis agropyri* (23)
Barley	1296	654	642	XTS agar medium test Centrifuge wash test Freezing blotter test	*Helminthosporium* spp. (43); *Fusarium* spp. (445); *Fusarium spp.* and *Helminthosporium* spp. (154)
Wild wheat	306	303	3	Centrifuge wash test	*Tilletia caries* and/or *T. foetida* (3)
Lentil	83	49	34	Freezing blotter test	*Fusarium* spp. (34)
Chickpea	144	70	74	Freezing blotter test Agar media test	*Fusarium* spp. (74)
Total	**3441**	**2409**	**1032**		

* : Numbers in parentheses refer to infested entries.

international distribution as well as seed multiplication fields of cereal and food and forage legumes were carefully inspected on about 90 ha at appropriate growth stages.

Particular attention was paid to flag smut (Urocystis agropyri) and barley stripe mosaic virus (BSMV). In addition to these two pathogens, the potentially seed-borne pathogens detected during the season were: Tilletia caries and/or T. foetida, Ustilago nuda, U. tritici, Pyrenophora graminea, P. teres, Rhynchosporium secalis, Fusarium oxysporium, Ascochyta spp., Botrytis spp., Cercospora fabae, BBSV and Orobanche spp. Infected or even suspected plants were rogued and burned. Plots showing symptoms of flag smut were not harvested.

A. El-Ahmed and S. Asaad

3. VIROLOGY ACTIVITIES

During the 1990-91 season, activities of the virology lab. focused on the following: (1) survey of viruses of faba bean and lentils in a number of WANA countries, (2) survey of seed-borne viruses of barley, faba bean and lentil in Syria, (3) evaluation of cereal breeding lines and wild relatives for barley yellow dwarf virus (BYDV) resistance (see sections 1.3.8. and 1.3.9.), and (4) evaluation of faba bean lines for bean yellow mosaic virus (BYMV) resistance (see section 1.3.12.). Activities also included regular testing for seed-borne viruses in seeds dispatched in international nurseries and testing gene bank accessions to free them from seed-borne infections. The virology lab continued to provide ELISA kits for virus testing to a number of NARSs laboratories upon request.

3.1. Legume viruses

3.1.1. Survey of virus diseases

Thirteen lentil and 267 faba bean samples from plants showing virus infection symptoms, and collected from Algeria, Egypt, Jordan, Libya, Syria and Tunisia, were tested for virus identification. In faba bean, bean yellow mosaic virus was most common. The newly described faba bean necrotic yellows virus (FBNYV) was detected in faba bean samples from Jordan and Syria. Other viruses were also detected (Table 48). In lentil, in addition to other viruses luteoviruses and FBNYV were detected at a high frequency (Table 49). FBNYV was also found to be naturally occurring in chickpea and a number of forage legumes which belong to the genera Medicago, Melilotus, Trifolium and Vicia.

K. Makkouk and S. Kumari

Table 48. Viruses in faba bean samples with virus-like symptoms collected during the spring of 1991.**

Country	No. of plants sampled	no. of plants found positive to antisera of					
		BBSV*	BBMV	BYMV	PSbMV	FBNYV	BWYV
Algeria	2	0	2	0	0	0	0
Egypt	23	0	0	23	0	0	1
Jordan	10	0	0	5	0	8	0
Libia	47	0	4	31	0	0	0
Syria	162	11	13	95	27	65	0
Tunisia	23	3	11	0	0	0	1
Total	**267**	**14**	**30**	**154**	**27**	**73**	**2**

Table 49. Viruses in lentil samples with virus-like symptoms collected from Algeria, Egypt, Libya, and Syria during 1990 and 1991.**

Country	No. of plants sampled	no. of plants found positive to antisera of					
		BBSV*	BYMV	PSbMV	BBMV	FBNYV	Luteovirus
Algeria	43	2	1	1	0	8	13
Egypt	5	0	1	2	0	1	1
Libya	6	0	0	0	0	0	0
Syria	239	25	24	25	6	131	68
Total	**293**	**27**	**26**	**28**	**6**	**140**	**82**

* : BBSV = broad bean stain virus, BBMV = broad bean mottle virus, BYMV = bean yellow mosaic virus, PSbMV = pea seed-borne mosaic virus, FBNYV = faba bean necrotic yellows virus, BWYV = beet western yellow's virus.

** : Identification was based on serological tests (ELISA).

3.1.2. Survey of seed-borne viruses in Syria

A survey was conducted in Syria during 1991 to assess the status of the rate of seed-borne virus infections in seeds that farmers use to sow of faba bean, lentil and barley. Seeds were collected directly from farmers at planting time and then brought to the laboratory for serological tests (ELISA). Results obtained indicate that barley stripe mosaic virus (BSMV) infection rate in barley seed ranged from 0.0 to 25.9%; broad bean stain virus (BBSV), been yellow mosaic virus (BYMV) or pea seed-borne mosaic virus (PSbMV) in lentil seed ranged from 0.0 to 2.8%; and BBSV, BYMV or PSbMV infection rate in

Table 50. Testing for virus diseases in barley, lentil and faba bean, collected from different locations in Syria during the fall of 1990.

	Barley*		Lentil**		Faba bean**	
Locations	no. of seeds tested	% seed infection	no. of seeds tested	% seed infection	no. of seeds tested	% seed infection
Aleppo	10500	2.8	1500	0.4	2450	0.2
Raqqa	21500	0.8	1050	0.1	1550	0.0
Deir Ezzor	3000	0.0	350	0.0	1300	0.4
Hassakeh	4000	0.1	300	2.8	300	0.0
Kamishly	4500	2.5	3950	0.5	300	0.0
Edlib	3500	0.9	4475	0.3	600	0.0
Hama	2500	6.6	1650	0.0	900	0.0
Homs	2000	15.9	350	0.3	1200	0.0
Damascus	3000	24.3	1400	0.1	1500	0.2
Dara'a	2000	25.9	3900	0.0	1250	0.5
Suweida	500	22.3	1800	0.2	-	-

* : Barley seeds were tested for the presence of barley stripe mosaic virus (BSMV).

** : Lentil and faba bean seeds were tested for the presence of broad bean stain virus (BBSV), pea seed-borne mosaic virus (PSbMV) and bean yellow mosaic virus (BYMV).

faba bean seed ranged from 0.0 to 0.5% (Table 50).

K. Makkouk and W. Radwan

3.1.3. Yield loss evaluation

A number of food legumes (chickpea, faba bean, lentil and pea) and forage legume crops were evaluated for their reaction to infection with pea seed-borne mosaic virus, a virus often detected in lentil and pea in Syria. Yield loss in response to infection varied between 41 and 66 % in food legume crops, and from 12 to 36% in forage legume crops (Table 51). It should be mentioned that natural

Table 51. Effect of pea seed-borne mosaic virus (PSbMV) infection on yield of food and forage legume crops, evaluated in field plots during the growing season 1990-91 at Tel Hadya, Syria.

Crop	Grain yield (grams/plot)***		yield loss (%)
	Healthy	PSbMV-Infected	
Food legumes			
Chickpea	516.3	175.8**	66.0
Faba bean	1047.0	622.5*	40.5
Lentil	535.3	296.3*	44.6
Pea	505.8	256.8*	49.2
Forage legumes			
Vicia sativa "IFVI 594"	151.3	140.0	-
Vicia narbonensis "IFVI 2933"	495.5	338.3*	31.7
Lathyrus sativus "IFLA 513"	501.5	441.5**	12.0
Lathyrus ochrus "IFLA 585"	354.5	228.0**	35.7

* : Significant at P = 0.05 when compared with the healthy control.

** : Significant at P = 0.01 when compared with the healthy control.

*** : Yield grams per plot of 2 x 1.2 m, replicated four times.

PSbMV infection of chickpea is rare, and the high losses encountered with this crop in the experiment are unlikely to occur, whereas for the other crops evaluated, yield loss values obtained represented potential damage to the crops if prevailing conditions lead to high disease incidence.

K. Makkouk and S. Kumari

3.2. Cereal viruses

3.2.1. Evaluation of traits of potential use in screening for BYDV resistance in cereal crops

A number of quantitative traits such as disease index, biomass, grain weight, harvest index, thousand kernel weight, height and hectoliter weight were evaluated as potential indicators of yield loss induced by BYDV infection. Correlations between yield loss (%) and the above traits are summarized in Table 52. In barley and durum wheat the correlation between yield loss and grain weight or harvest index was highly significant. In bread wheat correlations were highly significant for biomass and grain weight. In all cases, it was evident that disease index was not a good indicator for yield loss, even in barley, where symptoms are thought to be useful in screening for BYDV resistance. One of the barley lines evaluated (JLB7-17) produced very mild BYDV symptoms, but suffered a yield loss 40 % in response to BYDV infection.

K. Makkouk and W. Ghoulam

3.3. Seed testing

3.3.1. Testing seed samples for international nurseries

Five hundred seventy six lentil seed lots and 134 faba bean seed lots destined for international nurseries were tested for the

Table 52. Correlation coefficients between yield loss in barley, bread wheat and durum wheat in response to artificial inoculation with BYDV and different quantitative traits.

	Yield loss		
Traits	**Barley**	**Bread wheat**	**Durum wheat**
D.I.***	0.2850	0.3037	-0.0643
Biomass	-0.4197	-0.4197	-0.1857
GR.WT.	-0.7806**	-0.5192**	-0.6675**
H.I.	-0.6021**	-0.3424*	-0.5979**
TKW	0.0230	-0.0222	-0.3641
Height	-0.3671*	-0.1385	-0.1377
HLW	-0.2211	-0.3303*	-0.0042
HLW Loss (%)	0.4398*	0.4484*	0.1585

* : Significant at P = 0.05.
** : Significant at P = 0.01.
*** : D.I. = Disease Index, GR.WT. = grain weight, H.I. = Harvest Index, TKW = thousand kernel weight, HLW = hectoliter weight.

presence of seed-borne infections. Seed-lots which did not meet the standards set by ICARDA and by the importing countries were discarded.

K. Makkouk and W. Ghoulam

4. TRAINING

4.1. Training in genetic resources activities

In-country training course in Turkey

A specialized training course on "Conservation of Plant Genetic Resources in Seed Genebanks" was organized jointly by the Plant Genetic Resources Research Institute (PGRRI), Menemen, Izmir, Turkey, the International Board for Plant Genetic Resources (IBPGR), Rome, Italy, and ICARDA at PGRRI during 14-25 October. The program covered a range of topics relevant to the conservation of genetic resources: diversity of crops, field collecting, conservation techniques, multiplication / regeneration and documentation. Lectures were delivered by experts from PGRRI, IBPGR and ICARDA. The GRU contributed with lectures on ex-situ conservation and documentation of genetic resources. The course was attended by 19 participants from national programes of Afganistan (1), Egypt (1), Iran (1), Libya (1), Morocco (1), Syria (1), Tunisia (1), Yemen (1) and Turkey (11) who participated in classroom and field activities.

Individual training

A number of trainees received individual training in various aspects of genetic resources at the Genetic Resources Unit in ICARDA Headquarters, Tel Hadya. Data on the individual training are summarized in Table 53.

4.2. Training in seed health activities

A training course on seed health testing was conducted at Tel Hadya in cooperation with the Seed Unit. Seven trainees from WANA countries attended the course. An on-the-job training course on

Table 53. Trainees in genetic resources activities in 1990/91.

Topic	Type of course	No. of trainees	Country	Duration of course
Conservation of plant genetic resources in seed banks	in-country	19	Turkey	two weeks
Germplasm documentation	individual	1	Syria	two weeks
Wild wheat evaluation	individual	2	Syria	four weeks
Germplasm evaluation	individual	1	Egypt	two weeks
Seed bank management	individual	1	India	one week
Lentil evaluation	individual	1	Iran	six months
Medic evaluation and identification	individual	2	Algeria/ Syria	two weeks

seed health testing including field inspection was carried out for three scientists from the Syrian Quarantine Division (for six months) and one trainee from Jordan (for two weeks). Aspects of seed health were covered in lectures and a practical in the residential course of the Cereal Improvement Program. A lecture on management of quarantine area was conducted in a Farm Management training course.

4.3. Training in virology

Fifteen individuals from Lebanon, Libya and Syria received 2-3 weeks training on different aspects of virus research. A graduate student from the University of Damascus completed her Ph.D. thesis research during 1991 working on chickpea viruses.

GRU staff

5. PAPERS PUBLISHED IN 1991

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6. GRU STAFF LIST IN 1991

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Dr Larry Robertson**	Legume Germplasm Curator
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Ms. Elena Iacono**	Research Fellow, Italy
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Mr. Fawzi Sweid	Research Assistant II
Mr. Ali Abdullah Ismail	Research Assistant II
Mr. Ali Shehadeh	Research Assistant II
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J. Valkoun

APPENDIX

The following tables are presented in the appendix:

Table A1. Monthly precipitation (in mm) for the 1990/91 season.

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Total
1990/91 season	1.6	7.8	19.0	21.7	71.9	35.0	73.3	38.7	21.1	0.0	0.0	0.0	290.1
Long term aver. (13 s.)	0.5	24.5	48.5	53.8	61.0	50.2	43.8	28.4	14.2	3.0	0.0	0.1	328.0
% of long term average	320	32	39	40	118	70	167	136	149	0	n/a	0	88

Table A2. Monthly air temperature (°C) for the 1990/91 season in Tel Hadya.

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Mean max.	34.0	29.4	22.1	15.3	11.2	13.3	18.1	23.8	27.9	35.3	35.3	36.6
Mean min.	16.9	12.8	7.2	2.6	0.9	1.6	6.3	8.2	12.1	17.1	21.1	21.8
Average	25.5	21.1	14.7	9.0	6.1	7.5	12.2	16.0	20.0	25.1	28.3	29.3
Abs. max.	37.8	35.1	29.4	19.8	18.3	27.8	31.3	33.3	41.5	39.7	39.7	39.8
Abs. min.	13.9	5.1	-0.4	-5.5	-5.5	-6.4	-4.6	2.9	6.7	8.4	16.6	17.0

Table A3. Frost events during the 1990/91 season in Tel Hadya.

Frost events	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
No. of frost days	1	9	13	9	3	-	-	35
Abs. min. (°C)	-0.4	-5.5	-5.5	-6.4	-4.6	-	-	-6.4
No. of frost events at 5 *cm above ground*	2	11	14	14	4	-	-	45
Abs. min. (°C)	-1.6	-7.1	-8.0	-8.5	-6.6	-	-	-8.5

Table A4. Status of ICARDA collections by origin (December 1991).

Origin	Cereals	Legumes	Forages	Total
WANA	**30839**	**12343**	**14323**	**57505**
Afganistan	178	1109	139	1426
Algeria	1728	90	1714	3532
Cyprus	166	181	365	712
Egypt	456	216	192	864
Ethiopia	9572	829	327	10728
Iran	224	2663	335	3222
Iraq	107	116	222	445
Jordan	1243	554	2113	3910
Lebanon	139	148	214	501
Libya	52	1	173	226
Morocco	1239	370	425	2034
Oman	115	4	23	142
Pakistan	988	462	89	1539
Palestine	1016	57	44	1117
Saudi Arabia	8	-	1	9
Sudan	3	139	20	162
Syria	1721	1326	5466	8513
Tunisia	1944	312	85	2341
Turkey	4412	1543	2267	8222
United Arab Em.	7	-	-	7
Yemen	2	72	109	183
ICARDA lines	5519	2151	-	7670
EUROPE	**7375**	**2005**	**2913**	**12293**
Albania	4	2	19	25
Austria	73	1	1	75
Belgium	2	2	21	25
Bulgaria	270	60	73	403
Czechoslovakia	29	40	37	106
Denmark	100	1	13	114
Finland	12	-	16	28
France	123	48	108	279
Germany	941	96	293	1330
Great Britain	128	82	325	535
Greece	716	138	270	1124

Table A4. (continued) Status of ICARDA collections by origin (December 1991).

Origin	Cereals	Legumes	Forages	Total
EUROPE (continued)				
Hungary	117	41	247	405
Ireland	3	-	-	3
Italy	969	147	470	1586
Malta	4	-	22	26
Netherlands	15	11	98	124
Norway	-	1	1	2
Poland	30	58	69	157
Portugal	754	86	118	958
Romania	70	37	5	112
Soviet Union	1697	299	193	2189
Spain	166	784	38	988
Sweden	45	5	450	500
Switzerland	771	2	1	774
Yugoslavia	336	64	25	425
ASIA	**2913**	**2386**	**307**	**5606**
Bangladesh	-	36	-	36
Bhutan	30	-	-	30
China	2512	80	20	2612
India	205	2239	226	2670
Indonesia	-	1	-	1
Japan	144	7	56	207
Mauritius	-	1	-	1
Mongolia	2	-	1	3
Nepal	20	20	3	43
Sri Lanka	-	2	-	2
Thailand	-	-	1	1
AFRICA	**188**	**7**	**19**	**214**
Central Africa	2	-	-	2
Gabon	-	-	2	2
Kenya	23	-	3	26
Malawi	-	3	-	3

Table A4. (continued) Status of ICARDA collections by origin (December 1991).

Origin	Cereals	Legumes	Forages	Total
AFRICA (continued)				
Nigeria	–	1	4	5
Rwanda	2	–	–	2
Senegal	–	–	3	3
Somalia	–	2	–	2
South Africa	151	1	2	154
Tanzania	1	–	–	1
Uganda	–	–	4	4
Zaire	–	–	1	1
Zimbabwe	9	–	–	9
AMERICA	**2333**	**1361**	**612**	**4306**
Argentina	61	12	3	76
Bolivia	10	1	–	11
Brazil	32	4	1	37
Canada	243	173	41	457
Chile	51	687	3	741
Colombia	575	52	–	627
Costa Rica	–	1	–	1
Ecuador	6	98	1	105
Greenland	1	–	–	1
Guatemala	3	1	1	5
Mexico	92	149	2	243
Paraguay	–	–	4	4
Peru	30	41	–	71
United States	1218	140	552	1910
Uruguay	8	2	2	12
Venezuela	3	–	2	5
Australia	66	11	111	188
New Zealand	2	1	16	19
Unknown	5223	744	2708	8675
Total	**48939**	**18858**	**21009**	**88806**

Table A5. Status of cereal collections by origin (December 1991).

Origin	B*	WB	DW	BW	OCW	WW	Aeg.	Total
WANA	**8284**	**1363**	**12015**	**6387**	**140**	**1039**	**1611**	**30839**
Afganistan	84	8	78	4	-	-	4	178
Algeria	113	12	1074	457	-	-	72	1728
Cyprus	7	4	101	1	-	-	53	166
Egypt	157	8	203	68	-	-	20	456
Ethiopia	2674	-	4847	2051	-	-	-	9572
Iran	49	42	93	5	-	-	35	224
Iraq	20	2	76	5	1	1	2	107
Jordan	135	128	271	17	1	489	202	1243
Lebanon	-	-	25	-	-	3	111	139
Libya	7	7	5	1	-	-	32	52
Morocco	731	4	237	204	-	1	62	1239
Oman	46	-	-	60	9	-	-	115
Pakistan	172	3	19	738	3	-	53	988
Palestine	1	926	31	-	-	40	18	1016
Saudi Arabia	3	-	5	-	-	-	-	8
Sudan	3	-	-	-	-	-	-	3
Syria	491	206	375	85	3	216	345	1721
Tunisia	476	-	1170	289	-	-	9	1944
Turkey	768	13	1679	949	121	289	593	4412
United Arab Em.	7	-	-	-	-	-	-	7
Yemen	-	-	2	-	-	-	-	2
ICARDA lines	2340	-	1724	1453	2	-	-	5519
EUROPE	**2626**	**498**	**3352**	**311**	**49**	**30**	**509**	**7375**
Albania	2	-	1	-	1	-	-	4
Austria	31	-	42	-	-	-	-	73
Belgium	-	-	2	-	-	-	-	2
Bulgaria	29	-	78	1	4	8	150	270
Czechoslovakia	4	-	10	1	9	5	-	29
Denmark	100	-	-	-	-	-	-	100
Finland	12	-	-	-	-	-	-	12
France	34	-	80	9	-	-	-	123
Germany	867	1	71	2	-	-	-	941
Great Britain	109	-	15	4	-	-	-	128
Greece	4	-	699	3	-	-	10	716

Table A5. (continued) Status of cereal collections by origin (December 1991).

Origin	B*	WB	DW	BW	OCW	WW	Aeg.	Total
EUROPE (continued)								
Hungary	49	2	64	2	-	-	-	117
Ireland	1	-	2	-	-	-	-	3
Italy	7	442	495	4	19	2	-	969
Malta	-	-	4	-	-	-	-	4
Netherlands	12	1	-	2	-	-	-	15
Poland	6	-	24	-	-	-	-	30
Portugal	-	-	634	16	-	-	104	754
Romania	24	-	39	6	1	-	-	70
Soviet Union	343	36	793	251	14	15	245	1697
Spain	10	1	152	2	1	-	-	166
Sweden	22	15	3	5	-	-	-	45
Switzerland	680	-	90	1	-	-	-	771
Yugoslavia	280	-	54	2	-	-	-	336
ASIA	**2644**	**28**	**166**	**68**	**1**	**5**	**1**	**2913**
Bhutan	30	-	-	-	-	-	-	30
China	2458	22	25	6	1	-	-	2512
India	52	-	130	22	-	-	1	205
Japan	83	6	10	40	-	5	-	144
Mongolia	2	-	-	-	-	-	-	2
Nepal	19	-	1	-	-	-	-	20
AFRICA	**131**	**-**	**54**	**3**	**-**	**-**	**-**	**188**
Central Africa	1	-	1	-	-	-	-	2
Kenya	1	-	22	-	-	-	-	23
Rwanda	-	-	2	-	-	-	-	2
South Africa	129	-	19	3	-	-	-	151
Tanzania	-	-	1	-	-	-	-	1
Zimbabwe	-	-	9	-	-	-	-	9

Table A5. (continued) Status of cereal collections by origin (December 1991).

Origin	B*	WB	DW	BW	OCW	WW	Aeg.	Total
AMERICA	**1658**	**15**	**635**	**25**	**-**	**-**	**-**	**2333**
Argentina	6	10	44	1	-	-	-	61
Bolivia	7	1	2	-	-	-	-	10
Brazil	-	-	32	-	-	-	-	32
Canada	100	-	140	3	-	-	-	243
Chile	3	-	48	-	-	-	-	51
Colombia	567	-	8	-	-	-	-	575
Ecuador	2	-	4	-	-	-	-	6
Greenland	1	-	-	-	-	-	-	1
Guatemala	-	-	3	-	-	-	-	3
Mexico	1	1	89	1	-	-	-	92
Peru	10	-	19	1	-	-	-	30
United States	957	3	241	17	-	-	-	1218
Uruguay	1	-	5	2	-	-	-	8
Venezuela	3	-	-	-	-	-	-	3
AUSTRALIA	**18**	**-**	**45**	**5**	**-**	**-**	**-**	**68**
Australia	18	-	43	5	-	-	-	66
New Zealand	-	-	2	-	-	-	-	2
Unknown	3741	16	1240	47	105	29	45	5223
Total	**19102**	**1920**	**17507**	**6846**	**295**	**1103**	**2166**	**48939**

* : B = Barley
WB = Wild Barley
DW = Durum Wheat
BW = Bread Wheat
OCW = Other Cultivated Wheat
WW = Wild Wheat
Aeg. = Aegilops

Table A6. Status of food legume collections by origin (December 1991).

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
WANA	**1745**	**3645**	**289**	**6407**	**257**	**12343**
Afganistan	94	118	-	875	22	1109
Algeria	33	14	-	43	-	90
Cyprus	104	28	3	46	-	181
Egypt	69	93	-	54	-	216
Ethiopia	378	376	-	66	9	829
Iran	15	901	7	1740	-	2663
Iraq	64	22	-	30	-	116
Jordan	23	368	12	143	8	554
Lebanon	36	70	-	28	14	148
Libya	-	1	-	-	-	1
Morocco	96	54	-	220	-	370
Oman	4	-	-	-	-	4
Pakistan	24	185	-	253	-	462
Palestine	4	1	2	33	17	57
Sudan	115	2	-	22	-	139
Syria	331	479	124	360	32	1326
Tunisia	31	17	-	264	-	312
Turkey	137	332	141	778	155	1543
Yemen	13	59	-	-	-	72
ICARDA lines	174	525	-	1452	-	2151
EUROPE	**764**	**562**	**46**	**631**	**2**	**2005**
Albania	-	2	-	-	-	2
Austria	1	-	-	-	-	1
Belgium	-	2	-	-	-	2
Bulgaria	3	32	-	25	-	60
Czechoslovakia	12	20	-	8	-	40
Denmark	-	-	-	-	1	1
France	15	8	5	20	-	48
Germany	68	27	-	1	-	96
Great Britain	73	1	-	8	-	82
Greece	29	91	-	18	-	138
Hungary	15	24	-	2	-	41

Table A6. (continued) Status of food legume collections by origin (December 1991)

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
EUROPE (continued)						
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	51	107	9	132	-	299
Spain	322	177	5	279	1	784
Sweden	5	-	-	-	-	5
Switzerland	2	-	-	-	-	2
Yugoslavia	14	23	21	6	-	64
ASIA	**104**	**1893**	**-**	**388**	**1**	**2386**
Bangladesh	-	36	-	-	-	36
China	79	1	-	-	-	80
India	11	1843	-	384	1	2239
Indonesia	1	-	-	-	-	1
Japan	6	1	-	-	-	7
Mauritius	-	1	-	-	-	1
Nepal	5	11	-	4	-	20
Sri Lanka	2	-	-	-	-	2
AFRICA	**1**	**2**	**-**	**4**	**-**	**7**
Malawi	-	-	-	3	-	3
Nigeria	-	-	-	1	-	1
Somalia	-	2	-	-	-	2
South Africa	1	-	-	-	-	1

Table A6. (continued) Status of food legume collections by origin (December 1991).

Origin	Faba Bean	Lentil	Wild Lens	Chickpea	Wild Cicer	Total
AMERICA	**363**	**420**	**-**	**578**	**-**	**1361**
Argentina	1	11	-	-	-	12
Bolivia	1	-	-	-	-	1
Brazil	-	4	-	-	-	4
Canada	171	2	-	-	-	173
Chile	-	341	-	346	-	687
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	24	-	109	-	140
Uruguay	1	1	-	-	-	2
AUSTRALIA	**9**	**3**	**-**	**-**	**-**	**12**
Australia	9	2	-	-	-	11
New Zealand	-	1	-	-	-	1
Unknown	541	59	8	136	-	744
Total	**3527**	**6584**	**343**	**8144**	**260**	**18858**

Table A7. Status of forage legume collections by origin (December 1991).

Origin	Medic.*	Vicia	Pisum	Lath.	Trif.	Other forages	Total
WANA	**5127**	**2280**	**483**	**1149**	**2731**	**2553**	**14323**
Afganistan	1	25	53	21	39	-	139
Algeria	668	267	9	45	280	445	1714
Cyprus	222	96	8	37	-	2	365
Egypt	45	15	1	3	19	109	192
Ethiopia	43	-	174	110	-	-	327
Iran	155	58	4	27	90	1	335
Iraq	129	11	2	7	72	1	222
Jordan	661	109	27	40	537	739	2113
Lebanon	168	43	1	-	2	-	214
Libya	172	1	-	-	-	-	173
Morocco	399	10	9	3	-	4	425
Oman	-	-	-	-	-	23	23
Pakistan	-	13	12	26	6	32	89
Palestine	36	-	-	2	6	-	44
Saudi Arabia	-	1	-	-	-	-	1
Sudan	-	-	15	-	5	-	20
Syria	1741	918	84	457	1196	1070	5466
Tunisia	76	2	-	4	3	-	85
Turkey	611	711	83	367	476	19	2267
Yemen	-	-	1	-	-	108	109
EUROPE	**253**	**981**	**1320**	**199**	**37**	**123**	**2913**
Albania	-	14	5	-	-	-	19
Austria	-	-	1	-	-	-	1
Belgium	1	18	-	2	-	-	21
Bulgaria	-	60	1	12	-	-	73
Czechoslovakia	3	17	3	12	2	-	37
Denmark	-	2	10	1	-	-	13
Finland	-	2	14	-	-	-	16
France	6	48	39	3	12	-	108
Germany	3	81	98	18	1	92	293
Great Britain	-	2	322	1	-	-	325
Greece	17	98	48	106	1	-	270
Hungary	5	131	74	8	-	29	247
Italy	178	273	15	-	4	-	470

Table A7. (continued) Status of forage legume collections by origin (December 1991).

Origin	Medic.*	Vicia	Pisum	Lath.	Trif.	Other forages	Total
EUROPE (continued)							
Malta	2	20	-	-	-	-	22
Netherlands	-	2	95	1	-	-	98
Norway	-	-	1	-	-	-	1
Poland	-	16	49	4	-	-	69
Portugal	20	71	16	11	-	-	118
Romania	-	3	2	-	-	-	5
Soviet Union	6	78	87	16	6	-	193
Spain	6	24	3	-	5	-	38
Sweden	2	12	434	2	-	-	450
Switzerland	-	-	-	1	-	-	1
Yugoslavia	4	9	3	1	6	2	25
ASIA	**1**	**49**	**248**	**2**	**7**	**-**	**307**
China	1	-	19	-	-	-	20
India	-	-	217	2	7	-	226
Japan	-	48	8	-	-	-	56
Mongolia	-	-	1	-	-	-	1
Nepal	-	1	2	-	-	-	3
Thailand	-	-	1	-	-	-	1
AFRICA	**1**	**3**	**13**	**-**	**2**	**-**	**19**
Gabon	-	2	-	-	-	-	2
Kenya	-	-	1	-	2	-	3
Nigeria	-	-	4	-	-	-	4
Senegal	-	-	3	-	-	-	3
South Africa	1	1	-	-	-	-	2
Uganda	-	-	4	-	-	-	4
Zaire	-	-	1	-	-	-	1

Table A7. (continued) Status of forage legume collections by origin (December 1991).

Origin	Medic.*	Vicia	Pisum	Lath.	Trif.	Other forages	Total
AMERICA	**15**	**17**	**169**	**12**	**7**	**392**	**612**
Argentina	-	-	3	-	-	-	3
Brazil	-	-	1	-	-	-	1
Canada	2	5	28	6	-	-	41
Chile	3	-	-	-	-	-	3
Ecuador	-	-	1	-	-	-	1
Guatemala	-	-	1	-	-	-	1
Mexico	-	-	2	-	-	-	2
Paraguay	-	3	-	1	-	-	4
United States	9	9	131	4	7	392	552
Uruguay	1	-	-	1	-	-	2
Venezuela	-	-	2	-	-	-	2
AUSTRALIA	**55**	**33**	**26**	**10**	**3**	**-**	**127**
Australia	55	33	11	10	2	-	111
New Zealand	-	-	15	-	1	-	16
Unknown	262	1209	1160	2	71	4	2708
Total	**5714**	**4572**	**3419**	**1374**	**2858**	**3072**	**21009**

* : Medic. = Medicago
Lath. = Lathyrus
Trif. = Trifolium

Table A8. Distribution of GRU germplasm to users in 1991.

Country	Cereals	Food Legumes	Forage Legumes	Total
Afghanistan	-	-	60	60
Algeria	1032	-	7	1039
Australia	-	-	42	42
Bulgaria	74	-	-	74
Canada	1833	-	-	1833
China	45	-	49	94
Egypt	229	12	-	241
France	58	3	-	61
Germany	47	9	81	137
Hungary	91	-	-	91
India	18	-	-	18
Italy	216	4	560	780
Japan	429	-	-	429
Jordan	732	-	220	952
Korea	481	-	-	481
Lebanon	-	-	17	17
Mexico	116	-	-	116
Morocco	2918	-	3	2921
Oman	-	-	56	56
Pakistan	-	380	-	380
Poland	-	36	9	45
Portugal	-	6	-	6
Soviet Union	59	-	-	59
Sweden	17	-	-	17
Switzerland	12	-	-	12
Syria	141	31	526	698
Tunisia	260	-	100	360
Turkey	1238	-	15	1253
United Kingdom	24	91	125	240
United States	4104	235	813	5152
ICARDA	3922	639	1831	6392
Total	**18096**	**1446**	**4514**	**24056**

Table A9. Distribution of cereals in 1991.

Country	Barley	Wild Barley	Durum Wheat	Bread Wheat	Wild Wheat	Total
Algeria	-	-	1032	-	-	1032
Bulgaria	74	-	-	-	-	74
Canada	1833	-	-	-	-	1833
China	24	-	-	16	5	45
Egypt	2	9	-	-	218	229
France	-	-	-	-	58	58
Germany	24	-	-	-	23	47
Hungary	67	-	-	-	24	91
India	12	6	-	-	-	18
Italy	87	-	20	57	52	216
Japan	103	-	17	-	309	429
Jordan	482	-	250	-	-	732
Korea	481	-	-	-	-	481
Mexico	-	-	86	-	30	116
Morroco	225	-	2603	90	-	2918
Soviet Union	-	-	-	-	59	59
Sweden	-	17	-	-	-	17
Switzerland	-	-	12	-	-	12
Syria	61	80	-	-	-	141
Tunisia	170	-	-	90	-	260
Turkey	24	-	180	-	1034	1238
United Kingdom	24	-	-	-	-	24
United States	4104	-	-	-	-	4104
ICARDA	2642	184	149	70	877	3922
Total	10449	296	4349	323	2689	18096

Table A10. Distribution of food legumes in 1991.

Country	Chickpea	Wild Cicer	Lentil	Wild Lens	Faba Bean	Total
Egypt	-	8	-	4	-	12
France	-	3	-	-	-	3
Germany	-	-	-	-	9	9
Italy	-	4	-	-	-	4
Pakistan	-	16	364	-	-	380
Poland	-	-	-	36	-	36
Portugal	6	-	-	-	-	6
Syria	-	3	5	23	-	31
United Kingdom	62	-	-	-	29	91
United States	1	234	-	-	-	235
ICARDA	83	207	17	332	-	639
Total	**152**	**475**	**386**	**395**	**38**	**1446**

Table A11. Distribution of forages in 1991.

Country	Medic.*	Trif.	Lath.	Vicia	Pisum	Other Genera	Total
Afghanistan	24	-	15	21	-	-	60
Algeria	7	-	-	-	-	-	7
Australia	-	-	-	42	-	-	42
China	-	-	-	26	11	12	49
Germany	-	74	-	-	-	7	81
Italy	560	-	-	-	-	-	560
Jordan	210	-	-	10	-	-	220
Lebanon	-	-	-	-	17	-	17
Morroco	-	-	-	3	-	-	3
Oman	56	-	-	-	-	-	56
Poland	-	-	-	-	9	-	9
Syria	4	-	7	13	1	501	526
Tunisia	40	-	30	30	-	-	100
Turkey	-	-	-	-	-	15	15
United Kingdom	-	-	30	84	11	-	125
United States	550	-	89	118	56	-	813
ICARDA	-	-	707	973	-	151	1831
Total	**1451**	**74**	**878**	**1320**	**105**	**686**	**4514**

* : Medic. = Medicago
Trif. = Trifolium
Lath. = Lathyrus