THE INSTITUTES FOR APPLIED RESEARCH
BEN-BURION UNIVERSITY OF THE NEGEV

BGUN-ARI-30-96

DETERMINATION OF GENETIC VARIATION FOR MODELING EFFICIENT GERMPLASM COLLECTION STRATEGIES

Second Annual Report August 1994-December 1995

Samuel Mendlinger[1], Rina Kamenetsky[2], Nicolai Orlovsky[3], Mohemet Durikov[3] and Kanat Sarsenbaev[4]

[1]Institute for Agriculture & Applied Biology,
Institutes for Applied Research, Ben-Gurion University of the Negev
[2]Volcani Institute, Bet Dagan, Israel
[3]Institute for Desert Research, Ashkabad, Turkmenistan
[4]Kazakh Botanical Garden, Almaty, Kazakhstan

Submitted to AID-CDR-CAR-13-057
(File No. 86497101, 88337101)

Beer-Sheva, Israel April 1996

SECTION I

A. Research Objectives-

For the past 70 years, i.e. during most of the Soviet period, Central Asia underwent, and is still undergoing, serious loss of indigenous germplasm; i.e. genetic erosion. This was due to an array of causes including: (i) severe industrial pollution; (ii) radiation fallout and pollution; (iii) misguided agricultural policies; (iv) urbanization; (v) monocultural agricultural practices; and (vi) the introduction of new cultivars that were required to be grown in place of indigenous landraces or cultivars. Only since the breakup of the Soviet Union has it become possible to examine the extent of genetic erosion.

This is a trilateral program between scientists from Israel, Turkmenistan and Kazakhstan. Its primary objective is to obtain quantitative information on the extent and structure of genetic variation and genetic diversity in the gene pool of important crops from Central Asia. This is necessary in order to: (i) have a base to quantify the extent of genetic erosion over time; (ii) understand the effects of the loss of genetic diversity on the extent and structure of existing genetic variation and diversity in the Central Asian gene pool; (iii) develop efficient collecting and evaluation strategies that maximize the number of genes and gene complexes that can be collected and evaluated with the minimum number of plants needed to be collected and evaluated in order to minimize cost, space and infrastructure needed.

In order to have as useful a program as possible, it was agreed by all P.I.s to examine one species or species groups in each of the three levels of genetic resource utilization:

a. primary - the existing weedy forms, landraces, primitive cultivars and varieties and breeding lines of a crop. We chose melons, *Cucumis melo*. It is widely grown throughout Central Asia and the region is considered to be one of the species' most important centers of genetic diversity;

b. secondary - the wild progenitors of a crop. We chose wild barley, *Hordeum spontaneum*, which is the progenitor of cultivated barley. It is widely found throughout Israel and Turkmenistan and reportedly in southern Kazakhstan and can easily be crossed with cultivated barley for genetic exchange.

c. tertiary - wild species that are related to a crop and with special breeding techniques can be hybridized with the crop. We chose several species of wild onions, *Allium*.

B. Research Accomplishments-

It was decided by all P.I.s to develop integrated collecting and research programs.

1. collections - The germplasm was to be collected using a strategy developed by one of us (S.M.) for collecting populations of annual wild grasses and for vegetable landraces and/or populations. Seeds from each plant from each population or primitive variety were bagged separately. Each barley population was classified as to: (i) its geographical position in the species range (whether it is

in the core or the periphery); (ii) to its ecological position (whether it is in the central or main ecological niche or in a marginal niche); and (iii) region (Israel, Turkmenistan or Kazakhstan). Important ecological and climatological information and data was obtained for each population. The *Allium* ssp. were collected as populations with both seeds and bulbs collected. When possible *Cucumis melo* was collected as primitive varieties or landraces and each fruit initiated the beginning of an accession.

a. Israel

In April-May 1994 Dr. Mendlinger collected ten populations of barley from the mesic and xeric environments of Israel. The collected populations included both central and marginal as well as core and peripheral. Each population consisted of between 50-70 individual plants. The collections were planned and conducted with Mr. Usken Batilova of Kazakhstan and Mr. Azat Nourberdyev of Turkmenistan; both scientists were spending a six month training period in Dr. Mendlinger's laboratory for determining genetic variation in barley.

b. Turkmenistan

In May 1994 a collecting trip for wild barley and wild onions was conducted in eastern, southern and parts of western Kazakhstan. The collecting team consisted of scientists from Turkmenistan and Israel and was planed and coordinated by Drs. Orlovsky, Durikov and Mendlinger. Twenty one populations of barley and eight of onions were collected. During the summer of 1994, the Turkmen P.I.s, either alone or with Israeli scientists, collected 51 landraces or primitive varieties of melons. (Unfortunately, the origin of many of the landraces is unknown, only were they were obtained or bought). Seed was given to Israel and to Kazakhstan for evaluation.

In 1995, the Turkmenistan P.I.s, after coordinating with the Israeli and Kazakh P.I.s, conducted a collecting trip in eastern and northern Turkmenistan for all three targeted species groups. The region is primarily semi-arid and arid but in some areas an extensive canal system exists for irrigation. Collected were:

a. barley - four populations were collected, all from well irrigated areas;

b. melons - Twenty-one primitive varieties or landraces were collected, most at or near the Turkmenistan-Uzbekistan border;

c. onions - no populations were found.

c. Kazakhstan

In 1994 Dr. Sarsenbaev collected 27 varieties of melons from Kazakhstan. In 1995 the Dr. Sarsenbaev conducted three collecting trip. The first was for wild barley and onions and was conducted in June, 1995 in the southern mountains and foothills of Kazakhstan. No populations of wild barley were found and he believes that they are either absent or very rare and isolated in Kazakhstan. This is against the conventional wisdom of the species' range and is an important finding. Eight populations of wild onions were found and collected. Plants from these populations were subsequently planted for evaluation in Kazakhstan and Israel

The second trip, in July 1994, was for melons and covered southern Kazakhstan and northern Uzbekistan. He collected 34 primitive varieties, most from Kazakhstan.

The third collecting trip, also for melons, was conducted with Dr. Mendlinger in August and covered south-western Kazakhstan and the Aral Sea region. They collected almost twenty primitive varieties, including some from soils which are very saline.

Dr. Sarsenbaev gave seed from the collected varieties to the other P.I.s for field and quality evaluation.

2. Genetic Evaluation-

a. *Hordeum spontaneum,* wild barley

Two field trials and biochemical analyses were conducted in Israel during 1994-1995 for determining the genetic, phenological and morphological variation present in the wild barley populations collected in the first two years of the program.

1 .The first field trial was designed to examine the effects of different sowing dates on phenological and morphological variation in wild barley. Sixteen and ten populations from Turkmenistan and Israel respectively were examined; the populations represented different ecological and geographical areas in each country. Fifteen mother plants from each population were chosen at random and three seeds from each plant were used (almost all seed from the same plant are homozygote and identical). Three sowing dates were chosen: November 1, November 25 and December 20. For each sowing date, one seed/mother plant was sown in the greenhouse and transplanted into the field at three weeks old. Each sowing date consisted of three blocks with 5 plants per population in a row (each representing a different mother plant) per block. The field consisted of 1.5 meter wide raised beds with a single drip line containing 2-liter per hour drippers spaced 0.5 meters apart in each bed. One seedling per mother plant was transplanted next to each dripper. The plants received irrigation and fertilization as needed via the drippers.

The plants were examined for an array of vegetative and reproductive traits including: a longitudinal study of the number and height of vegetative and reproductive tillers, time of reproductive tillers, date of harvest, the height, number of nodes, number of spikelets and yield of the first three shoots. The results are only know being analyzed and will be presented in next year's report.

The research was conducted jointly by Azat Nourberdyev (Turkmenistan) and Sergei Volis (Israel).

2. In order to investigate the extent and structure of genetic variation in wild barley and its relationship to: (i) species distribution (core vs. periphery); and (ii) local environmental conditions (favorable or central vs. unfavorable or marginal) structural proteins from plants from 29 populations of H. spontenaum from both Turkmenistan (23) and Israel (6) were examined electrophoretically. Starch gel electrophoresis was performed on 20-25 seedlings/population for 16 water soluble loci. Nineteen populations from the above population set were studied morphologically and phenologically in a field trial which examined two water treatments: low (i.e. drought) and high (i.e. optimum irrigation). Table 1 presents these populations and important climatic and ecological information.

The study found the following:

a. a high level of genetic diversity which did not differ significantly between Turkmenistan and Israel;

b. of the total genetic variation 51% was found within populations, 35% between populations and only 14% between countries (Table 2).;

c. 53% of the alleles were both widespread and common. 29% locally common and 18% rare and restricted;

d. genetic differentiation was unrelated to geographic distance in Turkmenian populations and reflected geographic closeness in Israeli populations;

e. the allozyme frequencies significantly correlated with environmental parameters (geographic and climatic) and were associated with distinct geomorphologic areas of different relief, climate and vegetation;

f. the level of polymorphism and expected heterozygosity and the allozyme frequencies were unrelated to such population parameters as population size and degree of isolation;

g. populations from the species periphery had higher variability in morphological and phenological traits, higher resistance to water stress but lower phenotypic plasticity than core populations.

The results strongly emphasizes the importance of covering the species geographic and climatic range and the variety of its habitats for effective germplasm collection.

This work was conducted jointly by Sergei Volis (Israel) and Yerlan Turuspekov (Kazakhstan).

3. Genetic variation of water soluble structural proteins via starch gel electrophoresis- Using horizontal starch gel electrophoresis, the protein profiles of between 25-30 plants of 14 populations collected in 1994 (8 Turkmenian and 6 Israeli) were determined using sixteen water soluble leaf proteins: PGM (1 locus), PGI (2), MDH (2), 6-PGD (2), EST (3), ACPH (3), GP (1), GDH (1) and CAT (1). For each population, the allele frequencies, the mean number of alleles per locus (A) and the proportion of loci polymorphic (P) were calculated and the degree of genetic similarity determined. The structure of genetic variation was determined using Shannon's information index to partition the total genetic diversity in a manner similar to the field data; i.e. into its within population, between populations of a region and between region components.

The data is still being analyzed but preliminary results are presented here: the allele frequencies in Table 3 and the mean number of alleles, A, the proportion of loci polymorphic, P, and the expected number of heterozygotes, He, in Table 4. This work was conducted by Usken Batilova

b. *Allium ssp.*- wild onions

In the second year the principal aim was to collect targeted species of wild onions in Kazakhstan and Turkmenistan and to continue the living collections in Israel.

1. collection trips - The collecting trips are described above. Due to small populations sizes, whenever possible, a population collection of onions consisted of a maximum of 5-7 bulbs plus seed from at most 5 plants.

2. living collections- the living collections in Kazakhstan, Turkmenistan and Israel are continuing to be examined in an array of traits. The results will be presented in the final report.. In the latter, the populations were added to an already existing living collection of onions from Central Asia.

3. field trial- In Israel bulbs of the collected species which were planted at Sde Boker, Israel in August, 1993 (*A. vavilovii* and *A. scabriscarpum*) and November, 1993 (*A. pskemens*) were continued to be followed and traits examined. During the vegetative season phenological and morphological observations were conducted. Adult plants developed normally.

c. *Cucumis melo*- melon

Field trials were conducted in Israel and Kazakhstan and genetic variation via starch gel electrophoresis was conducted in Israel by a Kazakh scientist.

Israel

1. field trial -

a). summer 1994. The Turkmen and Kazakh accessions were examined for an array of phenological, morphological and fruit quality analyses during a summer and winter field trials. On June 2, 1994, five plants of each accession (53 accessions were examined) were transplanted into the field. The field consisted of 1.5 meter wide raised beds with a single drip line with 2-liter/hour drippers spaced 0.5m apart running down the middle of each bed. The five plants of each accession were transplanted in a row and each plant was given a code number. During the growing season, passport data was obtained from each plant using the system developed for melons by IPBGR. These included important vegetative traits (e.g. leaf color, leaf shape, growth rates), reproductive traits (e.g. time of flowering, sex of flowers) and fruit traits (e.g. fruit weight, color, size). In addition to passport data, we also: (i) determined the number and timing of female flowers; and (ii) determined fruit quality and constituents (e.g. TSS, reducing sugars, glucose, fructose, EC, pH, acidity). The work was conducted by Yvonne Rosengartner (Israel) and Uzken Batilova (Kazakhstan). A similar field trial was conducted in the summer of 1995 on the varieties collected in 1994. The work was performed by Umuzat Bertova.

b). winter 1994/1995- After analyzing the results from the first field trial, 32 Turkmenistan and 14 Kazakhstan accessions were selected for winter field trials in hot houses. Two sets of experiments were conducted: (i) sowing in October for the autumn-winter growing season; and (ii) sowing in January for the winter-spring growing season. Between 4-6 plants per accession were grown in a hot house in each growing season. As in the first field trial, both passport and quality data were examined. The results are still being analyzed and will not be discussed here. The work was conducted by Yvonne Rosengartner (Israel).

2. biochemical genetic variation - the genetic profiles of 45 Central Asian accessions/varieties were examined in 16 loci. Additional accessions are presently being analyzed and we would like to wait until all are examined before presenting a complete analysis of the data. Nevertheless, Table 5 presents some of the data from this experiment.

The work was done by Usken Batilova (Kazakhstan) who continued this work when he returned to Kazakhstan,

Kazakhstan (translated from Russian)

The following report is on the research conducted in Kazakhstan to examine genetic variation in melons from Central Asia.

1. field trial - two field trials were conducted in 1995, the first at the research station at Turkistan (southern Kazakhstan)and the second at the research station at Kazladah (near the Aral Sea). Over fifty accessions or primitive varieties from Kazakhstan, Israel and Turkmenistan were sown in both localities. The agromanagement techniques were those commonly used in each region.
Each accession/variety was examined for an array of traits. These included germination rate, initial growth rate, time to flowering, days to harvest, number of fruit per plant, yield per plant, fruit weight, fruit shape (length, width and diameter), fruit color (both skin and flesh) and TSS. The data is still being analyzed and will be presented in a later report.

2. biochemical genetic variation. When Usken Batilova returned to Kazakhstan, he continued the isozyme variation study in melons. The results will be presented in the next report.

C. Scientific Impact of Collaboration

As is evident from section IB and IID (see below), considerable collaboration has occurred between the P.I.s of this program. In addition, collaboration has occurred with other scientists, principally junior scientists from C.A.R. and Israel. The planning of all collecting trips were conducted by the P.I.s from all three countries with the P.I.s from C.A.R. learning the techniques developed by the Israelis. Most collecting trips had participants from one of the C.A.R. countries and at least one Israeli. The research conducted in Israel was performed by scientists from all participating countries, often with several scientists working together on the same project.
The specific role of each P.I. in the project was:
(a) Dr. Mendlinger- He developed the collection strategies for barley and melons as well as participating in most of the collection trips for them. He is responsible for the research programs in melons and barley in Israel. Several Kazakh and one Turkmen scientists obtained training in electrophoretic and field trial protocols and statistical analysis of data in his laboratory.
(b) Dr. Kamenetsky - She is responsible for formulating the collecting strategy for wild onions and for the onion program in Israel.
(c) Dr. Orlovsky- He has overall responsibility for the program in Turkmenistan. He organized all of the Turkmenian collecting trips and has responsibility for seed maintenance and storage.
(d) Dr. Durikov- He was responsible for and went on each collecting trip in Turkmenistan. He will also be responsible for the field evaluation studies that are planned.

(e) Dr. Sarsenbaev- He has full responsibility for the program in Kazakhstan. This includes collecting, evaluation and genetic characterization.

D. Description of Project Impact

The collecting strategies developed and the electrophoretic and field trial protocols used have been incorporated into the research programs of the C.A.R. scientists. For example, a trainee in this program in the first year, Dr. Turuspekov, has begun a program on determining the effect of radiation pollution on plant communities in Kazakhstan and is collecting his populations according to the principals of this program.

E. Strengthening of Developing Countries Institutions

Only at the end of the first year was funds made available for purchasing equipment and material; therefore their research programs only began in the second year. However, training of scientists from C.A.R. began immediately with a funding advance given by BGU. One junior scientist from Turkmenistan spend two periods of six months in Israel learning how to conduct, and conducting, field trials in barley and melons as well as being introduced to electrophoretic techniques. Four junior scientists from Kazakhstan learned electrophoretic techniques and examined genetic variation in wild barley and melons and/or were involved in field trials. Two was taught how to evaluate and determine fruit quality and fruit constituents (sugars, TSS, acidity, pH, etc.) in melons. Appropriate collection strategies were taught to and employed by the Kazakh and Turkmen P.I.s as well as by Dr. Turuspekov when he returned to Kazakhstan.

Both C.A.R. Institutions have obtained important and necessary equipment.

F. Future Work

Most of the objectives for the first two years were accomplished. There had been a delay in purchasing equipment for C.A.R., but this was due to administrative problem and not due to the program itself.

SECTION II.

A. Managerial Issues

The basic problem of the first year between the Kazakh P.I. and the P.I.s of Israel and Turkmenistan in which the former attempted to unilaterally change the project as well as having made unsubstantiated comments against some of the other P.I.s was settled. All P.I.s have reaffirmed their acceptance of the original program. The Kazakh P.I. admitted that his comments were indeed wrong and apologized for making them and in the second year worked in complete harmony with the other P.I.s.

B. Budget

No major changes were made to the budget in the second year. However, the Turkmen P.I.s have stated that they may wish to increase the proportion for training and take the money from other parts of their budget.

C. Special Concerns

Not relevant in this program.

D. Collaboration, Travel, Training and Publications

Section I.C., covered the collaboration between the P.I.s. Since the last progress report, the P.I.s have traveled to:

(a) Dr. Orlovsky- in October, 1994 he went to Kazakhstan for the general meeting of all P.I.s; in November 1995 went to Israel for the general meeting of all of the P.I.s and began a one year sabbatical in Israel working on the project.

(b) Dr. Kaminitsky- in October, 1994 went to Kazakhstan for a general meeting of all P.I.s; in July, 1995 visited Kazakhstan to collect Onions and examine the program there.

(c) Dr. Durikov - spent 8 weeks in December 1994- February 1995 in Israel working on the project and attending an international course in desert agriculture which was sponsored by Ben Gurion University.

(d) Dr. Sarsenbaev - visited Israel in November 1995 for the general meeting of all P.I.s

(e) Dr. Mendlinger - visited Kazakhstan in October 1994 for the general meeting of all P.I.s; visited Kazakhstan in August 1995 to see the melon field trials and to participate in the collecting trip for melons; visited Turkmenistan in December 1995.

In the second year, most of the training activities were associated with junior scientists and students from the three countries. The trainees were:

(a) Azat Nourenbyev-Turkmenistan-spent six months in Israel learning electrophoretic and field trial protocols- ;

(b) Usken Batilova-Kazakhstan-spent eight months in Israel learning electrophoretic protocols for determining genetic variation in plants and field trials protocols;

(c) Umuzat Bertova - Kazakhstan - field trials of Central Asian melons;

(d) Sergei Volis-Israel- electrophoretic variation in barley, field trials in barley, stress physiology.

Publications -

(a) Turuspekov, E.K., S.I. Abugalieva, S. Mendlinger and S. Volis. 1996. Polymorphism in populations of wild barley from Turkmenistan. Genetica (in Russian, in press).

(b) Volis, S., S. Mendlinger, U. Safriel, L. Olsvig-Whittaker and N. Orlovsky. Conservancy implications of phenotypic variation and stress persistence in core and peripheral populations of *Hordeum spontenaum*. Biological Conservation (submitted).

(c) Mendlinger, S., Y. Ventura and S. Abugalieva. Genetic variation in melons from Central Asia. (in preparation).

(d) Y. Ventura, S. Abugalieva and S. Mendlinger. Fruit quality of Central Asian melons. (in preparation).

E. Request for A.I.D. or Bostid Actions

From our experience and problems associated with the Kazakh P.I., we highly recommend that officials in Washington contact all P.I.s if a problem occurs before coming to any conclusions or taking actions.

Table 1. Ecogeographical data for 18 populations of *H. spontaneum* sampled in Turkmenistan and Israel in 1992-1993 and used in a field trial at Sede Boqer (1993/1994)

Station	Population position	Geomorphology	Soil type	Habitat	Altitude (m)	January temperature (t°C)	Annual temperature (t°C)	Annual rainfall (mm)
Turkmenistan								
1	core	Kopet-Dag mountain range	mountain grey soil	defile	600	0.7	15.4	383
8	core	Kopet-Dag mountain range	mountain grey soil	wadi	500	0.0	14.4	295
12	core	Kopet-Dag mountain range	mountain grey soil	mountain pass	1130	1.0	12.9	457
13	core	Kopet-Dag mountain range	mountain grey soil	wadi	340	3.2	16.0	238
14	periphery	Krasnovodsk plateau	basalt	shallow wadi	100	1.7	14.2	150
Lake ruderal	core	Kopet-Dag foot-hill plain	grey brown desert soil	roadside	150	0.9	16.1	220
35 km	core	Kopet-Dag foot-hill plain	grey brown desert soil	roadside	150	0.9	16.1	220
19	core	Kopet-Dag foot-hill plain	grey brown desert soil	plain and wadi	170	1.4	16.3	245
21	core	South-East Karakum Desert	sand	ravine	200	1.8	16.7	205
22	core	South-East Karakum Desert	takyr	abandoned field	300	3.0	16.6	225
23	core	Badhyz plateau	grey soil	plain	160	2.4	14.5	290
24	core	Badhyz plateau	mountain grey soil	east slope	880	2.4	14.5	285
Israel								
Yavne	core	Meditterranean coast	sandy loam	roadside	0	14.0	21.0	400
Dimona	periphery	Negev Desert	loess	roadside	400	10.0	21.0	100
Sede Boqer	periphery	Negev Desert	loess	roadside	400	10.0	21.0	90
Yeruham	periphery	Negev Desert	loess	wadi	300	10.0	21.0	105
Jeriho	periphery	Judean Desert	alluvium	roadside	-300	14.0	23.0	150
Dead Sea	periphery	Judean Desert	alluvium	wadi	-300	14.0	23.0	100

Table 2 . Variance components (in %) between population groups segregated by different criterion, between populations within a group and within populations for total genetic diversity as revealed by gel electrophoresis in populations of *H. spontaneum*.

Diversity component	Regions (Israel-Turkmen.)			Species range (core-periphery)			Geomorphologic areas		
Loci	With. pop.	Betw. pop.	Betw. groups	With. pop.	Betw. pop.	Betw. groups	With. pop.	Betw. pop.	Betw. groups
Est-1	60	40	0	42	41	17	66	0	34
Est-3	44	47	9	45	53	2	38	19	43
Est-4	65	35	0	55	37	8	48	15	37
Cat	37	36	27	45	55	0	31	16	53
G.P.	57	29	14	65	32	3	69	16	15
Gdh	64	36	0	29	35	36	65	23	12
Pgm	34	47	19	34	48	18	19	20	61
Pgi-1	36	34	30	53	46	1	53	16	31
Pgi-2	48	28	24	54	30	16	30	12	58
6 Pgd-1	66	22	12	74	24	2	66	9	25
6 Pgd-2	53	28	19	70	30	0	70	30	0
Mdh-1	39	37	24	46	49	5	34	18	48
Mdh-2	68	32	0	45	38	17	65	17	18
Mean	51	35	14	50	40	10	50	16	34
St. deviation	13	7	11	13	10	11	18	7	19

Table 3. Allele frequencies in 8 Turkmenian and 6 Israeli populations of Hordeum spontaneum collected in 1994

Loci	Alleles	Populations													
		27	28	29	32	36	37	38	40	BG	JR	SH	BS	KG	YK
Est-1	a	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.075	0.000	0.100	0.000	0.050	0.000
	b	0.500	0.425	0.750	0.800	1.000	1.000	1.000	1.000	0.575	0.640	0.650	1.000	0.900	1.000
	c	0.500	0.575	0.250	0.000	0.000	0.000	0.000	0.000	0.350	0.360	0.250	0.000	0.050	0.000
Est-3	a	0.000	0.050	0.200	0.200	0.075	0.000	0.075	0.300	0.075	0.150	0.000	0.000	0.050	0.000
	b	0.700	0.775	0.750	0.800	0.675	0.650	0.125	0.550	0.875	0.750	0.950	0.800	0.725	0.750
	c	0.300	0.175	0.050	0.000	0.000	0.250	0.550	0.000	0.050	0.050	0.050	0.200	0.225	0.250
	d	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000
	e	0.000	0.000	0.000	0.000	0.250	0.100	0.250	0.150	0.000	0.000	0.000	0.000	0.000	0.000
Est-4	a	0.000	0.000	0.000	0.050	0.250	0.150	0.500	0.150	0.000	0.000	0.000	0.000	0.250	0.325
	b	1.000	1.000	1.000	0.950	0.600	0.775	0.100	0.850	0.825	0.950	0.900	0.900	0.725	0.675
	c	0.000	0.000	0.000	0.000	0.075	0.025	0.000	0.000	0.125	0.000	0.050	0.100	0.025	0.000
	d	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.050	0.000	0.000	0.000
	e	0.000	0.000	0.000	0.000	0.075	0.050	0.400	0.000	0.000	0.050	0.000	0.000	0.000	0.000
Cat	b	1.000	1.000	1.000	0.800	1.000	0.950	0.900	0.950	1.000	1.000	1.000	0.975	0.900	0.950
	c	0.000	0.000	0.000	0.200	0.000	0.050	0.100	0.050	0.000	0.000	0.000	0.025	0.100	0.050
Gdh-1	b	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.950
	c	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050
Gdh-2	a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000
	b	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000
GP	a	0.000	0.000	0.050	0.025	0.000	0.000	0.000	0.000	0.025	0.050	0.000	0.000	0.000	0.000
	b	1.000	1.000	0.950	0.975	1.000	1.000	1.000	1.000	0.975	0.950	1.000	1.000	1.000	1.000
Pgm	b	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Pgi-1	b	1.000	1.000	0.975	0.925	1.000	0.950	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	c	0.000	0.000	0.025	0.075	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pgi-2	b	1.000	1.000	1.000	1.000	0.925	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	c	0.000	0.000	0.000	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mdh-1	a	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.025	0.050	0.000	0.050	0.000	0.000
	b	1.000	1.000	1.000	0.650	0.875	0.725	0.500	1.000	0.975	0.950	1.000	0.950	1.000	1.000
	c	0.000	0.000	0.000	0.300	0.125	0.275	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mdh-2	a	0.000	0.050	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.200	0.000	0.000
	b	0.850	0.900	0.900	0.800	1.000	0.950	1.000	0.975	0.700	0.850	0.700	0.800	0.750	0.850
	c	0.150	0.050	0.000	0.200	0.000	0.050	0.000	0.025	0.300	0.150	0.150	0.000	0.250	0.150
	d	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000
6-pgd-1	a	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000
	b	1.000	1.000	1.000	1.000	0.950	0.975	1.000	0.950	1.000	1.000	1.000	1.000	1.000	0.950
	c	0.000	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050
6-pgd-2	a	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	b	1.000	1.000	1.000	1.000	0.950	1.000	1.000	0.975	0.975	1.000	1.000	1.000	1.000	1.000
	c	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.025	0.000	0.000	0.000	0.000	0.000
G-6pdh	a	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	b	1.000	1.000	1.000	1.000	0.975	1.000	1.000	1.000	1.000	1.000	1.000	0.950	1.000	1.000
	c	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000

Table 4. **A**, the mean number of alleles per locus, **P**, the proportion of loci polymorphic, and **He**, the expected proportion of heterozygotes in 14 populatiopns of *Hordeum spontaneum*, 8 from Turkmenistan and 6 from Israel.

Population	A	P	He
Turkmenistan			
27	1.20	0.20	0.045
28	1.33	.020	0.069
29	1.40	0.33	0.075
32	1.60	0.53	0.140
36	1.66	0.46	0.105
37	1.66	0.47	0.107
38	1.47	0.27	0.125
40	1.47	0.40	0.072
Israel			
Bet Guvrin	1.73	0.53	0.134
Jerusalem	1.53	0.40	0.090
Shoresh	1.53	0.27	0.084
Bet Shemesh	1.40	0.40	0.070
Kiryat Gat	1.53	0.33	0.105
Yokneam	1.40	0.40	0.093

Table 5. The mean number of alleles per locus, A, the proportion of loci polymorphic, P, and the proportion of heterogugotes (He) in 44 melon varieties from Turkmenistan (T) and Kazakhstan (K). n=3.

Variety	A	P	He	Variety	A	P	He
T-10	1.38	0.38	0.146	K13	1.06	0.06	0.021
T-13	1.13	0.06	0.042	T-66	1.00	0	0
T-20	1.13	0.13	0.042	T-95	1.31	0.25	0.063
T-18	1.19	0.19	0.063	T-65	1.19	0.19	0.063
T-1	1.19	0.19	0.083	T-72	1.25	0.25	0.083
T-15	1.31	0.31	0.125	T-67	1.00	0	0
T-17	1.44	0.44	0.167	T-81	1.06	0.06	0.021
T-25	1.00	0	0	K-20	1.00	0	0
T-11	1.06	0.06	0.021	K-9	1.00	0	0
T-7	1.19	0.19	0.063	K-21	1.00	0	0
T-12	1.06	0.06	0	K-16	1.25	0.25	0
T-19	1.25	0.19	0.042	T-82	1.00	0	0
K-4	1.13	0.13	0.083	T-63	1.13	0.13	0
K-11	1.31	0.31	0.125	T-74	1.13	0.13	0
T-72	1.19	0.19	0.063	T-74	1.06	0.06	0
T-66.7	1.31	0.31	0.167	K-19	1.19	0.19	0.063
T-60	1.06	0.06	0.021	K-22	1.00	0	0
T-69	1.06	0.06	0.021	K-7	1.13	0.13	0.063
T-19	1.00	0	0	T-18.1	1.06	0.06	0.021
T-18.2	1.06	0.06	0.063	T-16	1.13	0.13	0.083
T-7	1.25	0.25	0.042	T-4	1.00	0	0
T-76	1.00	0	0	T-61	1.06	0.06	0.021