ON MERCİMEK RECOMBİNANT INBRED HAT POPULASYONUNUN TÜRKIYE'NİN YÜKSEK BÖLGELERİNE ADAPTASYONU İÇİN KIŞA DAYANIMLARINA GÖRE SEÇİMİ VE DEĞERLENDİRMESİ

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ÖZET

Türkiye'nin yüksek yerlerinde mercimeğin kışlık olarak yetiştirilmesindeki ana sınırlayıcı factor düşük sıcaklıktır. Çiftçiler, mercimeği kışa dayanımının yetersizliği nedeniyle yazlık eker. Bu çalışmanın amacı, yüksek bölgelere adapte olabilen kışa dayanıklı hatların seçimi ve değerlendirilmesidir. Çalışma için kışa dayanıklı ve kışa hassas ebeveynlerin melezlenmesi ile oluşa 10 rekombinant inberd hat popülasyonu (RIL) kullanılmıştır. F6' dan farklaştırılan on adet RIL popülasyonu (her bir popülasyonda 100 adet üzerinde hat) tesadüf blokları deneme deseninde üç tekerrürlü olarak ekildi. Denemeler 1997/98 ve 1998/99 kışında Haymana, Türkiye ve Pullman, ABD'de kuruldu. Bütün RIL popülasyonları kış canlılığı ve ilk çiçeklenme gün sayıları için değerlendirildi.

10 RIL popülasyonundan elde edilen 200 hat değerlendirilerek 1999–2004 yılları arasında Bölge Verim Denemsine kadar ilerletildi. En yüksek ortalama kış canlılık oranı Pullman'da dayanıklı x dayanıklı, Haymana'da dayanıklı x orta dayanıklı melezinde elde edilirken kış canlılık oranı en düşük değere her iki lokasyonda da hassas x dayanıklı popülasyonlarında görüldü. Haymana'da en geç ortalama ilk çiçeklenme gün sayısı dayanıklı x dayanıklı melezlerinde olurken en erkenciler hassas x orta dayanıklı melezlerde oldu. Genelde, kışa dayanıklı ebeveynlerin dölleri geç çiçeklendi. En yüksek verimler de orta dayanıklı x orta dayanıklı melezlerinde elde edildi. Sonuç da şunu söyleyebiliriz ki, yüksek alanlarda kışlık yetiştirmede yüksek verim için hatlar, sadece kışa dayanıklık değil aynı zamanda erken ilk çiçeklenme gibi özellikleri de taşımalıdır.

Anahtar Kelimeler: *Mercimek,Recombinant Inbred Hat, Populasyon, Kişa Dayaniklik, Yüksek Alanlar, Kış Canlılık Oranı, Ilk Çiçeklenme Tarihi, Seleksiyon*

EVALUATION AND SELECTION FOR WINTER HARDINESS IN 10 LENTIL RECOMBINANT INBRED LINE POPULATIONS FOR ADAPTATION TO HIGH ELEVATION REGIONS OF TURKEY

ABSTRACT

Low winter temperature is a major limiting factor for productivity of lentil (*Lens culinaris* Medik.) as a winter crop in high elevation regions of Turkey. Due to insufficient winter hardiness, farmers plant lentil in spring. The goal of this study was to evaluate and select winter hardy lentil germplasm that was well adapted to high elevation regions. For the study, we used 10 lentil recombinant inbred line populations (RIL) developed from crosses of winter-hardy and winter susceptible parents. The ten F_6 derived RIL populations (with over 100 RILs per population) were planted in the fall in a randomized complete block design with three replications. The experiments were established at Haymana, Turkey and Pullman, WA, USA in the winters of 1997/98 and 1998/99. All RIL populations were evaluated for winter survival and days to first flower.

From that initial evaluation 200 RILs from the 10 RIL populations were advanced to Regional Yield Trials and evaluated during 1999-2004 in Turkey. Survival at both locations was the lowest for the non-winter hardy x winter hardy populations, while mean survival was highest for the hardy x intermediate hardy crosses at Haymana and the hardy x hardy crosses at Pullman. Days to first flower average was the latest for the hardy x hardy crosses and earliest for the winter susceptible x intermediate hardy crosses at Haymana. In general, the hardy parents had the latest flowering dates. The highest yields were obtained from the intermediate hardy x intermediate hardy crosses. In conclusion, one can say that higher yields could be obtained not only from winter

hardy lines but also lines with acceptable developmental adaptive traits such as an early first flowering date, in high elevation winter growing zones.

Key Words: Lentil, Recombinant Inbred Line, Population, Survival, First Flowering Date, High Elevation Regions, First Flowering Date, Selection

Introduction

Lentil is a traditionally grown and consumed crop in Turkey. The amount of plant origin protein consumption in Turkey is 74.2 g /day. Out of this figure, approximately 10.5 % (7.8g) is from legume crops 76% (5.9 g) being from chickpea and lentil.

Lentil consumption in Turkey is well above the world average. During the 1995-2002 years, World lentil consumption average is 0.5 kg per person while it was 5.78 kg/person in Turkey in the same period.

In 2003, total lentil acreage was 442 000 ha and production was 540 000 ton in Turkey. These figures were corresponding to 12% of worlds' lentil production areas and 17.4 % of over all production. Two types of lentil, orange and yellow cotyledon, are produced in Turkey. The yellow cotyledon lentil (*Lens culinaris* var. *macrosperma*) accounts for 10 % (about 55 000 tons) while the orange cotyledon lentil (*Lens culinaris* var. *microsperma*) accounts for 90 % (about 485 000 tons) of total lentil production. Production of the orange cotyledon lentil changes from year to year while yellow cotyledon lentil has decreased steadily since 1987 (1). Red cotyledon lentil is mainly grown in areas with altitude lower than 800 m (particularly in south east Anatolia) and is grown as a winter crop whereas the yellow cotyledon is grown in areas altitudes with higher than 800 m elevations (particularly in central Anatolia) and is grown as a spring crop.

In lowlands, the 10 year (1994-2003**)** average yield of red lentil was 1024 kg/ha while in highlands, the average yield of yellow cotyledon lentil was 847 kg/ha (2). In highlands, lentil is grown as spring crop and is planted late due to very low temperatures in winter. When lentil crop is late planted, vegetative growth of the crop faces drought and this reduces the yield. When the crop is fall sown, temperatures are mild and there is availability of enough water compared to spring sown lentil (3). Fall sown crop grows faster due to enough water at late winter early spring and therefore the crop flowers and matures early (4).Fall sown lentil have more vegetative growth and this support generative period; therefore, fall sown lentil have 20-60% higher yield than spring sown lentil (5). Another study showed that when winter hardy lentil cultivars were fall sown, yields were 50 to 100% higher than spring sown lentils (6).

For producing lentil in highlands, there is a need to develop winter hardy lentil cultivars (7). However, use of winter hardy cultivars do not warrant high yields. To shift from spring planting to winter planting, cultivars should have appropriate phenology in addition to winter hardiness. This ensure**s** higher yield. Therefore, to be able to grow winter hardy lentils in highlands, cultivars should have phenology adaptive traits (8). Because, phenology is a key factor for a well adaptation in a macro-geographic scale (9). Major phonologic events such as germination, flowering and maturity should take place in optimum conditions with no high rainfall and extreme temperatures (10). In Turkey, studies on development of winter hardy lentils were based on screening the existing germplasm.. Studies carried out in Italy (12) showed that some lentil germplasm originated from Turkey survived at -20 $^{\mathbf{0}}$C in central Italy. Recently 3 lentil cultivars, Kafkas, Ozbek and Çiftçi were selected from local landraces and released as winter hardy cultivars for highland regions (13).

In this study, genetics and inheritance of winter hardiness in lentil were investigated in details using ten sets of recombinant inbreed lines (14, 15). By creating large genetic variation for winter hardiness, it was possible to develop new lentil cultivars with winter hardiness. Recently, new lentil cultivar with high winter hardiness and other acceptable quality and phenological characters was released from these RILs (16). The aim of this study was; 1) to select lentil lines from RIL populations based on first flowering dates in addition to high winter hardiness and 2) to determine and release high yielding, winter hardy lentil cultivars that are adapted to highlands of Turkey.

MATERIALS AND METHODS

Materials

Two winter hardy (WA 8649041, WA 8649090), two intermediate hardy (ILL-669, ILL-1878) and one non hardy lentil germplasm (Precoz) were used as parents to make crosses in a half diallel design in 1992. F2 seeds (total 1085) from these crosses were advanced by single seed descent method to obtain 10 sets of F6 derived recombinant inbred line populations (Table 1). Ten sets of RIL's were planted for evaluation and selection of winter hardiness in two years, 1997/98 and 1998/99 seasons, respectively, at two locations, Haymana, Ankara, Turkey and Pullman, WA, USA, respectively.

Table 1. Population numbers, crosses and Crossing Groups.

Populations	Cross	Crossing Groups		
Pop 1	Precoz/ILL 669	Nonhard	x	Intermediate hardy
Pop 2	ILL 669/ILL 1878	İntermediate hardy	x	Intermediate hardy
Pop 3	WA 8649090/ILL669	Hardy	x	Intermediate hardy
Pop 4	WA8649041/ILL 669	Hardy	x	Intermediate hardy
Pop 5	Precoz/ILL 1878	Nonhardy	x	Intermediate hardy
Pop 6	WA 8649090/Precoz	Hardy	x	Nonhardy
Pop 7	Precoz/WA8649041	Nonhardy	x	Hardy
Pop 8	WA8649090/ILL 1878	Hardy	x	Intermediate hardy
Pop 9	WA8649040/ILL 1878	Hardy	x	Intermediate hardy
Pop 10	WA8649090/WA 8649041	Hardy	x	Hardy

Source :Kahraman et al. (2004)

In addition to RILs, Turkish lentil cultivars (Kafkas, Özbek, Çiftçi, Malazgirt 89 and Erzurum 89) were used as controls in selections in experiments carried out between 1999-2004 years. **Basic** characteristics of these cultivars are given in Table 2.

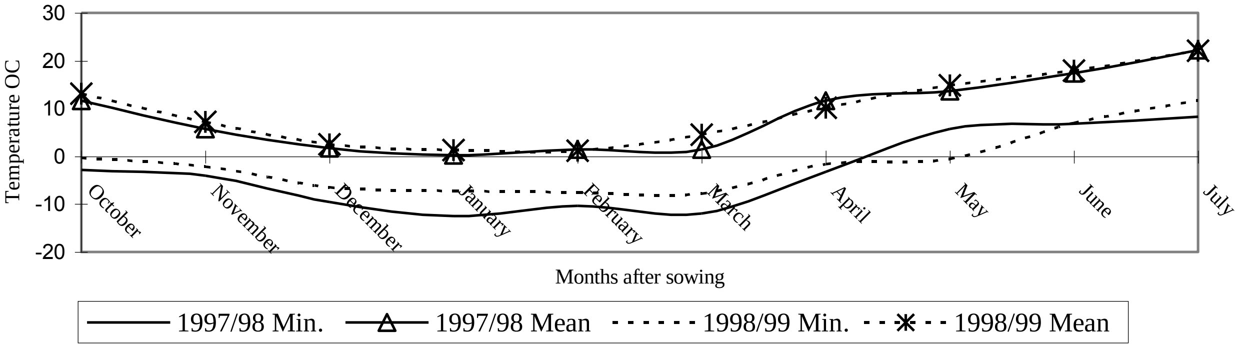
Table 2. Basic characteristics of cultivars used as control in selection experiments between 1999–2004 years

Cultivar/Control	Malazgirt 89	Erzurum 89	Fırat 87	Kafkas	Özbek	Çiftçi
Winter hardiness	nonhardy	nonhardy	Intermediate hardy	Hardy	Hardy	Hardy
Days to 50 % Flowering	223	224	227	214	214	216
Cotyledon color	Red	Yellow	Red	Red	Red	Red
100-seed weigh	2.86	5.40	3.86	3.78	3.52	3.92
Origin	ICARDA	ICARDA	ICARDA	Turkey	Turkey	Turkey
Growth type	Spring	Spring	Winter	Winter	Winter	Winter

Climate

Climatic data for Haymana Research Farm where selections were carried out are shown in Figure 1.The lowest temperatures in 1997/98 and 1998/99 growing seasons were recorded as -12.5^{O}**C** in January -8^{O}C in March respectively. Between 2000 and 2004 years, the lowest temperatures were -17.2 ^{O}C in January of 2000, -11.2 ^{O}C in February of 2001, -16.9 ^{O}C in January of 2002, -15.3 ^{O}C in February of 2003 and -16.9 ^{O}C in January of 2004.

Fig. 1. Min. and mean monthly air temperature at Haymana, Turkey ,in 1997/98 and 1998/99



Methods

During 1997/98 and 1998/99 seasons, winter hardiness and first flowering date of the population were determined. The populations were sown for this at Pullman, USA and Haymana, Turkey. Sowing dates for Haymana location was 25 October in 1997 and 18 October in 1998 respectively and for Pullman location was 5 October in 1998. Ten populations and parental lines were sown in 1 m length with 0.3 m width in Randomized Complete Block Design (RCBD) with 3 replications. Susceptible check, Brewer and **r**esistant check, WA 8649090 were repeated at every 20 plots.

The difference between emergence before winter and after winter was calculated as winter survival. First flowering date was also calculated from sowing to first flowering day. 200 RIL selected from10 populations were advanced up to Regional Yield Trials. Preliminary, Yield and Regional Yield Trials were conducted in RCBD (Table 3). Cold damage (1: resistant, 9: susceptible) (17), 50 % flowering time, weight of 100 seeds, yield and plant height were recorded on the lines used in the trials.

Table 3. Experiments conducted at Haymana, Turkey in 1999-2004

Cropping Season	RIL/Check	Trial Names	Plot Size and Rep.	Sowing date
1999/00	200 + 2	Screening Nursery	2 m x 1row x 2 rep	8 Oct. 1999
2000/01	21+2	Screening Nursery	2m x 2 rows x 2 rep	4 Oct. 2000
2001/02	6+2	Preliminary Yield Trial	5m x 4 rows x 2 rep	5 Oct. 2001
2002/03	5+4	Yield Trial	5m x 4 rows x 3 rep	1 Oct. 2002
2003/04	4+5	Regional Yield Trial	5m x 4 rows x 4 rep x 2 locations	2 and 8 Oct. 2003 in Haymana and Esenboga

Evaluation of winter survival and frequency distribution of every population was calculated based on Haymana (1997/1998) and Pullman (1998/1999) data by **means of** SAS software in Pullman, WA, USA. Winter survival rate of populations was **classified** by Least Significant Differences (LSD) test. Data of first flowering date of 10 populations based on 1998/1999 in Haymana, Turkey and Trials conducted in 2001-2004 seasons were evaluated by **means of** MSTAT –C software 2.10 (1988) (18). Frequency distributions of the RIL's for first flowering date were determined.

Results and Discussion

Evaluation of RIL's for Winter Survival

Mean winter survival of five parental lines ranged from 37 % to 95% at Haymana and 0 % and 76% in Pullman. Mean winter survival among the parental lines was the highest in winter hardy line WA 8649041 and the lowest in susceptible line Precoz (Table 4)

Table 4. Mean winter survival (%) of parental lines at Haymana, Turkey during the winter of 1997-98 and at Pullman, WA, U.S.A. during the winter of 1998-99

Parents	Winter hardiness	Haymana 1997-1998		Pulman 1998-1999	
		Mean	Range	Mean	Range
Precoz	nonhardy	37.0	25.0-54.2	0.0	0-0
ILL-669	Intermediate hardy	66.2	38.7-73.1	10.4	8.9-13.4
ILL-1878	Intermediate hardy	73.6	42.4-85.2	18.2	4.0-37.1
WA 8649090	Hardy	77.5	61.5-86.3	26.0	17.0-33.5
WA 8649041	Hardy	95.0	76.7-98.7	74.5	69.1-85.6

Source: Kahraman et al (2004**) (14)**

Mean survival of 10 populations **ranged** from 47.2 to 86 % at Haymana and 0.9 to 63.9 % at Pullman. Survival at both locations was the lowest for the nonhardy x intermediate hardy (Pop 5 and 1) and winter hardy x nonhardy crosses (Pop 6). Average survival at both locations was the highest for the hardy x intermediate hardy crosses (Pop 9) at Haymana and hardy x hardy crosses (Pop 10) at Pullman. Average survival in crosses (Pop 4,7,9 and 10) with the hardiest parent (WA 8649041) at both locations was always higher than mean survival of the other crosses.

Mean survival of selected lines **ranged** from 46 % to 84 %. The highest number of lines selected for winter survival among the crosses was from Pop 2 (intermediate hardy x intermediate hardy) with 75 lines while the lowest selection with 5 lines **were** made from Pop 8 (hardy x intermediate hardy) (Table 5).

Table 5. The Mean, Range and selected lines winter survival (%) of recombinant inbred line populations at Haymana, Turkey, in 1997/1998 and at Pullman, WA, USA, in 1998/1999

		*Winter survival (%) of RIL Populations				Selected lines		
		Haymana 1997-1998		Pulman 1998-1999		Winter survival (%)		Selected lines
RIL Populations	Crossing Groups	Mean	Range	Mean	Range	Mean	Range	
1.Precoz /ILL -669	Nonhardy x İntermediate hardy	50.7 d	4.8-100	0.9 e	0-27.6	48	11-98	26
2. ILL-669/ILL-1878	İnter. hardy x İnter. hardy	70.2 bc	12.3-100	10.8 de	0-88.5	70	11-100	74
3.WA 8649090/ILL-669	Hardy x İntermediate hardy	65.5 bc	15.7-100	18.3 cd	0-96.0	68	16-100	25
4.WA8649041/ILL-669	Hardy x İntermediate hardy	70.3 bc	16.8-100	47.1 b	0-93.1	69	14-100	10
5.Precoz /ILL-1878	Nonhardy x İntermediate hardy	47.2 d	0.1-99.1	3.9 e	0-55.1	46	9-81	23
6. WA 8649090/ Precoz	Hardy x Nonhardy	49.6 d	7.4-93.6	5.2 e	0-62.1	48	6-85	7
7. Precoz/ WA8649041	Nonhardy x hardy	72.5 bc	12.4-100	27.6 c	0-96.4	71	20-100	8
8. WA 8649090/ ILL-1878	Hardy x İntermediate hardy	71.9 bc	18.4-100	21.6 c	0-51.7	84	69-98	5
9. WA8649041/ ILL-1878	Hardy x İntermediate hardy	86.0 a	7.7-100	63.9 a	0-100	84	16-100	14
10. WA 8649090/ WA8649041	Hardy x Hardy	72.6 b	19.5-100	55.7a	0-92.5	69	60-80	8
General Mean		65.7		25.5		65.7		
Total								200

Means within locations fllowed by the same letter are not significantly different from each other as detemined by a LSD at the 0.05 probability level
* Source : Kahraman et al. (2004) (14)

Winter survival range for selected lines was the highest for Pop 2 (11-100) whereas it was the lowest for Pop 10 (60-80). Mean winter survival of the selected lines from 10 Pop. was the same as that of Haymana location (65.7 %).

Evaluation of RIL's for days to first flower

Days to first flower of parental lines ranged from 211 days to 230 days. First flowering time among the parent lines was the earliest with 211 days to first flower in nonhardy line (Precoz), flowed by ILL 1878, ILL 669, WA 8649090. Winter hardy line (WA 8649041) was the latest flowering parent with 230 days to first flower.

Analysis of variance indicated that days to first flower were not significant among replication for all populations, while differences among the populations were significant at the 0.01 probability level at Haymana location. Mean, days to first flower among the populations ranged from 234.3 days to 214.3 days. This was the latest with 234.3 days for hardy x hardy crosses (Pop 10) while it was earliest with 214.3 days for nonhardy x intermediate hardy (Pop 5). Days to first flower of nonhardy parents' (Precoz) crosses (Pop 1, 5, 6 and 7) was always shorter than winter hardy parents' (WA 8649041) crosses (Pop 4, 7, 9 and 10) (Table 6). It was also determined at both locations that higher the winter survival rate (Pop 9 and 10) longer the days to first flower.

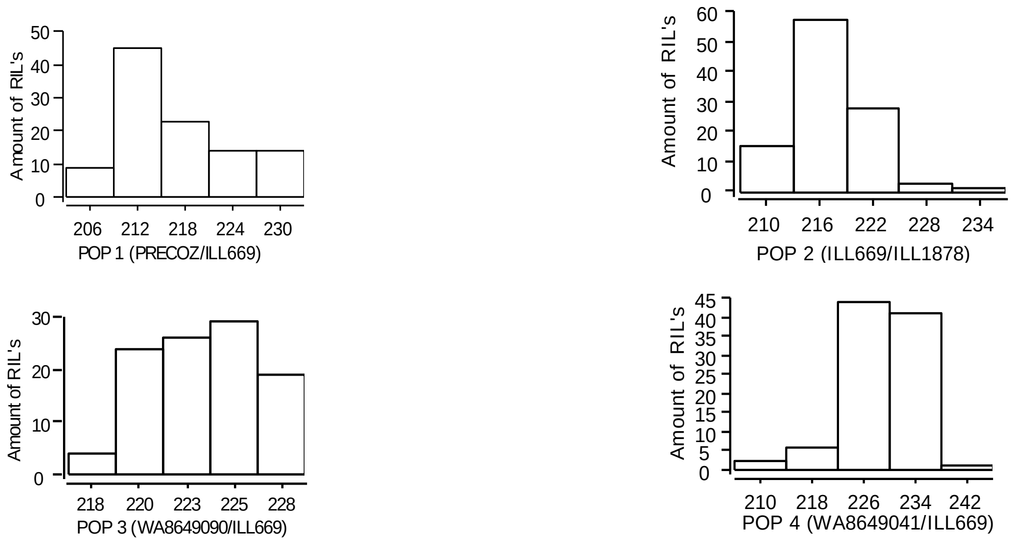
Table 6. The range and mean number of days to first flower (%) of recombinant inbred line populations at Haymana, Turkey, in 1998-1999

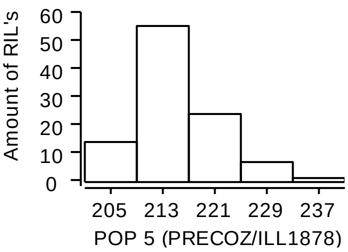
RIL Populations	**Number of days to first flower of RIL Population**			**Number of days to first flower of Selected lines**	
	Mean**	Range	Rank	Mean	Range
Pop 1 (Nonhardy x Intermediate hardy)	216.3 g	206-233	9	216	206-229
Pop 2 (Intermediate hardy x Intermediate Hardy)	216.7 fg	211-241	8	217	211-227
Pop 3 (Hardy x Intermediate hardy)	224.0 d	212-220	4	223	217-227
Pop 4 (Hardy x Intermediate hardy)	228.3 b	212-241	2	226	217-232
Pop 5 (Nonhardy x Intermediate hardy)	214.3 h	190-235	10	214	206-225
Pop 6 (Hardy x Nonhardy)	217.3 f	192-236	7	216	211-228
Pop 7 (Nonhardy x hardy)	221.0 e	209-237	5	226	213-234
Pop 8 (Hardy x Intermediate hardy)	220.3 e	211-241	6	220	215-225
Pop 9 (Hardy x Intermediate hardy)	225.0 c	211-237	3	226	217-236
Pop 10 (Hardy x Hardy)	234.3 a	212-255	1	230	224-242

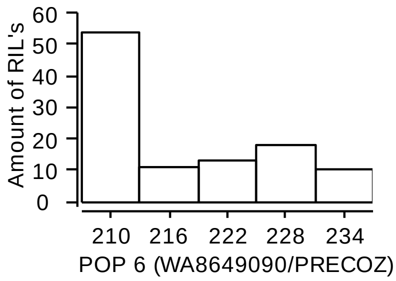
** P: 0.01

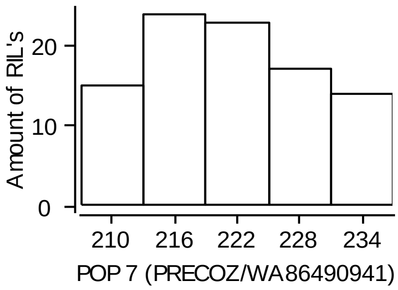
It seemed that there was a great variation among the lines in each population for frequency distributions of days to first flower. Frequency distributions over the categories of days to first flower were flat in Populations 7 and 9 and also closer to flat in Populations 3 and 8 (Fig. 2) while the greater differences was observed for number of RIL's over categories of days to first flower in Pop. 10 (hardy x hardy) of which parents had also very late first flowering time and the largest frequency distribution was observed in Pop 5 (190-235 days). Frequency distribution of nonhardy x intermediate hardy (Pop 1 and 5) and intermediate hardy x intermediate hardy (Pop 2) crosses were very close to their mean days to first flower.

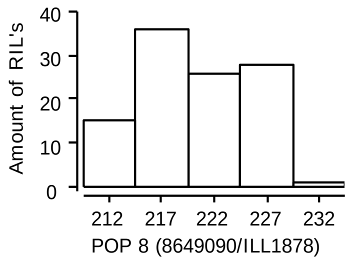
Fig. 2. Frequency distributions for days to first flower of 10 RIL lentil populations at Haymana, Turkey in 1998/1999

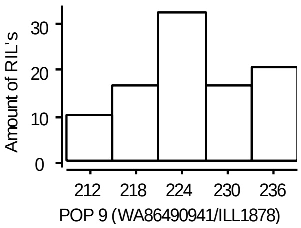


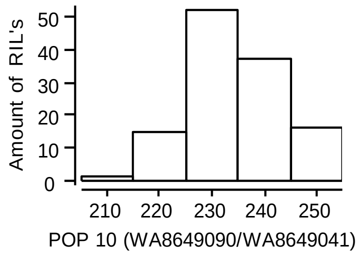












Mean days to flower of the selected lines were 206-224 days while they were 206- 225 days for the 10 lentil RIL populations. Mean days to first flower for Pop 2 in which the highest number of lines was selected was 217 days and range of selected lines for the trait changed from 211 to 227 days in 1999. On the contrary, mean of days to first flower for Pop 8 in which the lowest selection was made was 220 days and range of selected lines for the trait changed from 215 to 225 days.

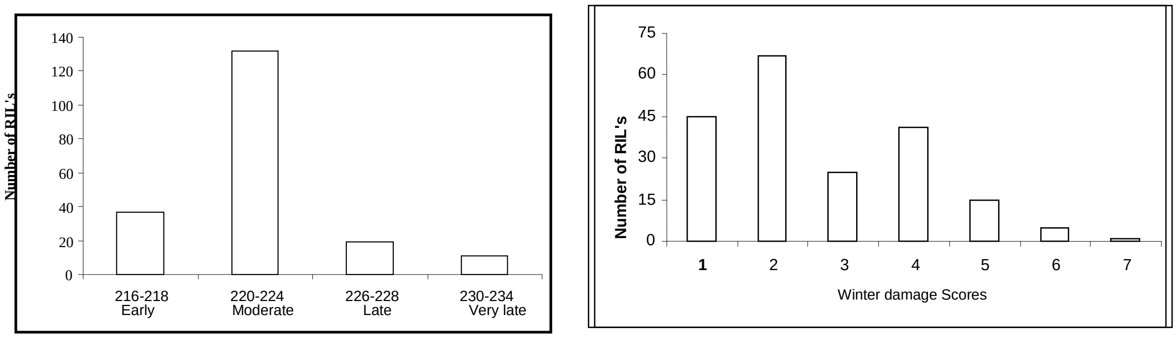
Observation Nurseries

200 RIL's were evaluated in the Observation Nurseries in 1999/2000 cropping season. Turkish cultivars Kafkas (hardy) and Erzurum 89 (susceptible) were used as checks. Based on 50 % flowering time, 37 lines were early (216-218 days), 137 lines were moderate (220-224 days), 19 lines were late (226-228 days) and 11 lines identified as very late as (230-234) (Fig 3A).

Number of days to first flower was 219 day for winter hardy check (Kafkas) and 222 days for susceptible check (Erzurum 89). 200 lines were tested for winter damage and 45 lines were determined as resistant to winter, 133 lines as moderate and 21 lines as susceptible. Only one line was completely killed. Winter damage score for Kafkas and Erzurum 89 varieties were 2 and 6 respectively on the 1-9 scale (Fig. 3B).

Fig 3. 50 % flowering time (A) and winter damage scores (B) of selected 200 lines from RIL's at Haymana in 1999/2000

A B



In total, 21 lines 3 with yellow and 18 red cotyledon color were selected from 200 lines selecting those with 218-223 flowering days and 1-4 winter damage scores. These 21 lines were taken in to the observation nursery in order to multiply their seeds and re-evaluate them in morphologically. Winter damage score was 1 for 9 lines, 2 for 5 liners, 3 for 4 lines and 5 for 3 lines in the observation nursery. 50 % flowering time was 220 days or below for 15 lines and 220 days for 6 lines. Their 100 seeds weight ranged from 2.54 g to 4.61 g and plant height from 20 cm to 25 cm (Table 7). 6 lines with 1-3 winter damage score, 215-226 (50 %) flowering days, 2.89-3.40 g 100 seeds weight and 21-23 plant height were selected and advanced to the Preliminary Yield Trials in 2001-2002 cropping season.

Table 7. Some characteristics of RIL's and checks conducted trail as observation nursery at Haymana in 2000/2001

	RIL's			Checks	
Characters	Means	Min.	Max.	Malazgirt 89	Fırat 87
Winter damage score	2	2	5	3	3
Days to 50% Flowering	219	209	226	216	217
Plant Hight (cm)	22	20	25	23	22
100 Seeds weight (g)	3.26	2.54	4.61	2.67	3.73

Yield Trials

Totally 6 lines from Pop 10 (hardy x hardy), Pop 1 (nonhardy x intermediate hardy), Pop 3 (hardy x intermediate hardy) and Pop 2 (intermediate hardy x intermediate hardy) were evaluated in Preliminary Yield trial. The highest yield in this trial was 137 kg/da for the check Özbek and 129 kg/da for line 112 from Pop 10. Other cultivars and lines were in the same group below 100 kg/da or less yield. All cultivars and RIL lines excluding cultivar Malazgirt -89 and line 75 from pop 1 gave yields higher than 100 kg/da in yield trial of 2002-2003 season. Line 44 from Pop 2 outyielded all lines and checks with 155.7 kg/da in the Yield Trial. Winter damage score for susceptible check (Erzurum 89) was 7 while it was 2 for line 44 from Pop 2 in this trial. 50 % flowering time of the lines used in the trial ranged from 224 to 226 days and it was determined for the cultivar Kafkas and Özbek as 223 days (Table 8).

Yield difference among the locations was not significant while it was significant for all genotypes at 0.01 probability level for the checks in Regional Yield Trial. The highest yield level was obtained from line Pop 2/81 (215.6 kg/da), cultivar Çiftçi (208.1 kg/da) and line Pop 2/44 (202.8 kg/da). Mean yield of line Pop 2/81 outyielded all lines and cultivars with 140.4 kg/da during the last three seasons. Mean yield level (126.9 kg/da) of the lines was lower than mean yield (162.2 kg/da) of winter hardy Turkish cultivar Kafkas, Özbek and Çiftçi.

Table 8.Winter damage score, 50 % flowering time, 100 seed weight and yield of RIL's and Checks in conducted trials in 2002 – 2004

Preliminary Yield Trial (2001-2002)					Yield Trial (2002-2003)					Regional Yield Trials (2003-2004)		Mean of RIL's (2001-2004)
Pop/ Entry No	Yield Kg/da	w.d.s.	50% f.d.	100 s.w.	Pop/ Entry No	Yield Kg/da	w.d.s.	50% f.t.	100 S.W	Pop/ Entry No	Yield (Kg/da)	
Pop-2/81	87 b	4	225	3.90	Pop-2/81	118.7 b	3	226	3.41	**Pop-2/81**	**215.6 a**	**140.4**
Pop-3/107	76 b	4	227	3.79	Pop-3/107	127.3 b	2	226	2.96	Pop-3/107	152.6 b	118.6
Pop-10/112	**129 a**	**2**	**222**	**3.82**	Pop-10/112	127.3 b	3	224	3.36	Pop-10/112	155.9 b	137.4
Pop-1/75	73 b	5	223	3.57	Pop-1/75	77.33 c	4	225	3.47	**Pop-2/44**	**202.8 a**	111.1
Pop-2/44	78 b	3	224	3.91	**Pop-2/44**	**155.7 a**	**2**	**225**	**3.67**	**Checks**	**Mean of RIL's**	**126.9**
Pop-2/42	76 b	4	227	3.38	**Checks**					Kafkas	160.1 b	141.4
Checks					Kafkas	121.7 b	2	223	3.47	Fırat 87	166.4 b	120.5
Fırat 87	75 b	4	227	4.13	Özbek	132 ab	3	223	3.08	Özbek	142.6 b	137.2
Özbek	**137 a**	**3**	**221**	**3.88**	Fırat 87	120 b	4	227	3.69	Malazgirt 89	107.5 c	76.1
					Malazgirt 89	44.67 d	7	227	3.37	**Çiftci**	**208.1 a**	**208.1**
% CV	10.75					12.75					20.22	**Mean of Checks 136,6**
LSD	23.20					24.78					34.15	
P	**					**					**	

****** P: 0.01, w.i.s: Winter demage score, f.d: Flowering time, s.w: seed weight

As a result, there was a significant relationship between days to first flower and winter survival rates of populations. When days to first flower are short, winter survival percentages were also low. This was obvious in pop 10 because of extreme genetic variation between parents. From these results we can conclude that there is a negative correlation between flowering date and winter hardiness, that is when days to flower is late winter survival is high or vice versa. Negative correlations between winter hardiness and flowering date were also reported in lentil (19). Therefore, developing winter hardy lentil cultivars for highlands, flowering date should be taken into account for selection of improved high yielding lentil lines.

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