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DETERMINING RELATIONSHIPS AMONG PLANT CHARACTERISTICS RELATED TO PLANT SEED YIELD OF BROAD BEAN (*VICIA FABA* L.) SOWN IN WINTER AND SUMMER SEASONS IN TRANSITIONAL CLIMATE AREAS OF TURKEY

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Abstract

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The aims of the study were to investigate growing possibilities of broad bean sown in winter and summer seasons in transitional climate areas and determine the relationship between yield and other plant characteristics of broad bean. The experiments were carried out under Tokat-Turkey ecological conditions for two years during (2002-2003). Field experiments were utilized a randomized complete blocks design with three replications. Sowing dates (November 9th 2001 and November 7th 2002 for winter sowing; March 2nd 2002-2003 for summer sowings) were placed to main plots whereas varieties were located in sub-plots. Three certified varieties (Filiz, Eresen and Sevilla) and six local populations (Niksar, Erbaa, Tokat, Çanakkale, Aydın and Turgutlu) were used. Plant height, first pod height, number of pods per plant, pod length, number of seeds per pod, seed yield per plant and harvest index characteristics were investigated. A statistically significant difference was obtained for seed yield per plant between sowing dates. Seed yield per plant was higher in winter sowing than summer sowing. Correlations among plant characteristics affecting the seed yield per plant of broad bean sown in winter and summer were investigated. Statistically significant and positive correlations were obtained between plant seed yield and harvest index, number of seed per pod, and pod length.

Key words: broad bean, correlation analysis, seed yield, sowing date

Introduction

Broad bean (*Vicia faba* L.) is one of the earliest domesticated food legumes in the world (Ladizinsky et al., 1988). The Mediterranean origin of the crop imparts a special significance to broad bean in the agriculture of the Mediterranean basin, where it has multiple functions in the traditional farming systems. It is a source of protein for human diet and contributes to feed and fodder supply for livestock, and affects positively the soil productivity for the cereal crops grown in rotation (Saxena, 1991).

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Broad bean requires 20-25°C average daily temperatures for a proper growth and higher temperatures leads to fall of flowers and fruits (Sehirali, 1988; Akcin, 1988). Broad bean is a cool-season grain legume, and can resist to certain levels of low temperatures. Low temperature tolerance levels are between -6°C and -12°C (Lawes et al., 1983). Several local landraces from Syria and Lebanon survived repeated sub-zero temperatures, including exposure to one night at -11°C (Saxena, 1982).

Resistance to inhibiting or damaging temperatures is commonly divided into responses to heat, chilling and freezing. Cool season legumes may be limited by cold or freezing conditions in the winter and early spring or by hot weather in early and midsummer (Buddenhagen and Richards, 1988).

Temperature, especially low temperature, plays important role in determining sowing date of broad bean. It is advised that broad bean could be sown as winter crop in temperate zones and as early summer crop in cold regions (Sepetoglu, 1994). Literature review shows that broad bean seed yields decline rapidly when sowing is delayed, especially in low rainfall regions (Baldwin, 1980; Marcellos and Constable, 1986; Loss and Siddique, 1996; Loss and Siddique, 1997; Loss et al., 1997). Decreasing biological yield limits broad bean formation as a response to day lengths (Loss et al., 1997). Broad bean flowers under long day conditions (Vural et al., 2000). Especially traditional cultivars of broad bean produce between two and ten flower buds on each axillaries raceme. However, only between five and fifteen percent of those flower buds form mature pods (Erskine et al., 1988).

Various plant characteristics have different effects on yield. This issue is also valid for broad bean. For example, there are significant and positive correlations between number of main branch and number of flower and fruit. There are also either positive or negative correlations between number of main branch and number of pod per plant as depending on environmental conditions (Kitiki and Acikgoz, 1994; Vural et al., 2000). Responses of plant to changing environmental conditions are different. This helps formation of various plant characteristics. Therefore, there is a need for selection and development of proper plant varieties for changing conditions.

The aims of the study were to i) investigate growing possibilities of broad bean sown in winter and summer seasons in transitional climate areas, ii) determine the type of broad bean having the highest yield, and the relationship between plant seed yield and other plant characteristics.

Material and Methods

This study was carried out under Tokat-Turkey ecological conditions in 2002 and 2003. Three certified varieties (Filiz, Eresen and Sevilla) and six local populations (Niksar, Erbaa, Tokat, Çanakkale, Aydin and Turgutlu) were used.

Climatic data for research years are given in Table 1. Second year of the study was cooler and drier than the first year. The lowest temperature was recorded as –22.9 °C in December of the year 2002. Amount of precipitation was higher in the first year (399.0 mm) than the second year (225.0 mm).

Soil characteristics of research area were as follows: total salt 0.067%, pH 7.79, lime 11.6%, available phosphorous 112.2 kg P_2O_5 ha^{-1}, potassium 347.2 kg K_2O ha^{-1} and organic material 1.00%.

Experimental design was a randomized complete blocks design with three replications. Each genotype was sown in two rows of 5 m length in each replication and planted with 10 cm intra-row spacing. Row distance was 40 cm. The sowing was made on November 9th 2001 and November 7th 2002 for winter sowing and on March 2nd 2002 and March 2nd 2003 for summer sowings. Before sowing, 30 kg ha^{-1} N and 70 kg ha^{-1} P_2O_5 fertilizers were applied. Harvest was carried out when the seeds were ripened. Fifty cm parts of rows were excluded on both ends, and investigated characteristics were measured in an area of 3.2 m^2 in each

Table 1
Some climate characteristics for research years

	Years	October	December	January	February	March	April	May	June	July
Minimum temperature, °C	2001-2002	-9.0	-10.6	-18.8	-6.4	-5.0	-3.0	0.0	5.8	9.3
	2002-2003	-1.6	-22.9	-5.2	-7.3	-9.0	-3.0	0.3	4.0	5.6
	L.T.A.	12.8	-28.0	-26.5	31.6	-27.1	-6.1	-2.9	0.5	4.5
Mean montly temperature, °C	2001-2002	2.7	1.3	-7.2	-4.1	3.1	4.5	6.6	11.7	23.2
	2002-2003	2.3	-6.1	1.0	-1.8	-1.4	4.5	7.8	9.2	21.7
	L.T.A.	7.0	3.2	1.3	2.8	6.9	12.5	16.2	19.5	22.1
Monthly rainfall, mm	2001-2002	73.4	50.5	45.1	20.4	29.2	68.4	16.8	57.6	37.6
	2002-2003	33.8	25.0	27.8	21.8	16.4	75.6	11.8	11.4	1.4
		46.7	45.9	39.5	34.7	38.2	62.4	59.5	38.6	10.4
Relative humidity, %	2001-2002	79.6	77.2	90.6	76.7	63.8	76.6	65.1	76.4	70.4
	2002-2003	86.5	86.1	82.2	73.7	75.0	70.2	64.6	66.8	64.6
	L.T.A.	69.6	71.4	68.9	63.9	59.8	59.5	60.2	57.8	55.0

L.T.A. : Long Term Avarage

plot (4.0 m x 0.4 m x 2 rows = 3.2 m^2).

Plant height (cm), the first pod height (cm), number of pods per plant (number $plant^{-1}$), pod length (cm), number of seeds per pod (number pod^{-1}), seed yield per plant (g $plant^{-1}$) and harvest index (%) characteristics were recorded according to methods explained by Akcin (1988), Sehirali (1988). Values belonging to characteristics were merged and average of two years. Analysis of variance was conducted. Duncan's Multiple Range Test was applied to evaluate the significance of differences among means (Yurtsever, 1984; Duzgunes et al., 1987). All statistical analyses were carried out according to Williams et al. (1990) and Yucel (2004).

Results

The effects of sowing date and genotype were significant on plant height particularly in the first year whereas only genotypic affect was evident in the second year for character. Average plant height for the first year was higher in winter sowing (73.33 cm) than in summer sowing (61.28 cm). The highest and shortest plants were obtained from Erbaa (77.15 cm) and Sevilla (59.91 cm), respectively. In the second year, Eresen had the highest plant height values. The shortest plants were observed in Aydin and Sevilla genotypes. Significant sowing date x genotype interaction was found for plant height in the first year. For example, in winter sowing, Tokat and Erbaa had higher values but in summer sowing Eresen had higher value than Tokat and Erbaa.

The effect of sowing date and genotype were significant on the first pod height particularly in the first year whereas only genotypic affect was evident in the second year for character. Average the first pod height for the first year was higher in summer sowing than in winter sowing. While Eresen had the highest first pod height value, Niksar had the lowest value among genotypes. In the second year, the highest and the lowest first pod height belonged to Sevilla and Tokat, respectively. Reactions of genotypes to sowing dates were different in the first year. The significant interactions (sowing date x genotype) of the parameters for first pod height were determined in the first year. When

Table 2

Annual averages for plant height (cm), the first pod height (cm), number of pod per plant (number plant^{-1}) for winter sown and summer sown broad bean genotypes for both years

Varieties	2002			2003		
	Winter sowing	Summer Sowing	Mean	Winter sowing	Summer Sowing	Mean
Plant height, cm						
Niksar	71.63 bcd[1]	61.03 ab	66.33 c	46.60	40.33	43.46 abcd
Filiz	72.33 bc	59.16 ab	66.75 c	43.13	47.10	45.11 abc
Eresen	80.56 ab	68.36 a	74.46 b	47.86	48.86	48.36 a
Erbaa	86.96 a	67.33 a	77.15 a	43.06	47.66	45.36 abc
Tokat	87.53 a	63.40 ab	75.46 b	46.40	47.66	47.03 ab
Canakkale	69.60 cd	61.80 ab	65.70 c	42.20	40.86	41.53 bcd
Sevilla	63.90 cd	55.93 b	59.91 c	36.00	40.66	38.33 d
Aydin	61.96 d	59.76 ab	60.86 c	37.00	41.66	39.33 d
Turgutlu	65.50 cd	54.80 b	60.15 c	41.00	41.66	41.33 cd
Mean	73.33 a	61.28 b		42.58	44.06	
LSD	SD: 8.908*	G: 6.291**	SD x G: 8.897**	SD: ns	G: 5.078**	SD x G: ns
The first pod height, cm						
Niksar	12.56 a	19.76 cd	16.16 c	16.33	18.06	17.20 abc
Filiz	13.20 a	22.43 bcd	17.81 bc	16.00	21.80	18.90 ab
Eresen	15.46 a	28.53 a	22.00 a	15.60	22.10	18.85 ab
Erbaa	15.23 a	21.40 cd	18.31 abc	12.66	18.80	15.73 bc
Tokat	16.20 a	17.00 d	16.60 bc	12.00	15.73	13.86 c
Canakkale	13.53 a	27.56 ab	20.55 ab	16.86	18.93	17.90 abc
Sevilla	13.90 a	24.03 abc	18.96 abc	19.33	22.73	21.03 a
Aydin	13.03 a	24.96 abc	19.00 abc	12.93	21.86	17.40 abc
Turgutlu	13.93 a	22.63 bcd	18.28 abc	14.46	22.13	18.30 ab
Mean	14.11 b	23.14 a		15.13	20.24	
LSD	SD: 5.316*	G: 3.767**	SD x G: 5.327**	SD:ns	G:3.628*	SDxG:ns
Number of pod per plant, number plant^{-1}						
Niksar	6.66	7.50	7.08 a	4.96	2.53	3.75 a
Filiz	5.16	6.63	5.90 ab	3.26	1.66	2.46 bc
Eresen	5.93	6.46	6.20 ab	3.30	2.00	2.65 abc
Erbaa	7.76	7.36	7.56 a	4.60	2.53	3.56 ab
Tokat	8.36	6.60	7.48 a	4.60	2.93	3.76 a
Canakkale	6.10	4.80	5.45 abc	3.13	2.06	2.60 abc
Sevilla	4.20	3.10	3.65 c	2.40	2.13	2.26 c
Aydin	4.76	4.26	4.51 bc	3.46	2.26	2.86 abc
Turgutlu	5.10	6.53	5.81 abc	2.33	2.06	2.20 c
Mean	6.00	5.91		3.56 a	2.24 b	
LSD	SD:ns	G:1.92**	SDxG:ns	SD:0.617*	G:1.060*	SDxG: ns

SD:Sowing Date, G: Genotype, *:0.05 Significance level, ** 0.01Significance level, ns:not significancant

[1]: Avarages indicated with the same letter fall into same statistical group

the interactions were taken into consideration, the highest first pod height was observed in Tokat but the lowest value was obtained from Aydin and Niksar genotypes in winter sowing. For summer sowing, genotypes such as Eresen, Canakkale, Sevilla, Aydin, Turgutlu, and Niksar had first pod heights in summer sowing about twice of the first pod heights in winter sowing (Table 2).

While number of pod per plant was significantly affected by genotype in the first year, both sowing date and genotype influenced this character in the second year. In the first year, average number of pod per plant of genotypes varied from 3.65 (for Sevilla) to 7.56 (for Erbaa). In the second year, number of pods per plant was higher in winter sowing than in summer sowing. Averages of genotypes ranged from 2.20 to 3.76. The highest number of pods per plant was observed in Tokat and Niksar but the lowest was observed in Sevilla and Turgutlu genotypes (Table 2).

Length of pods exhibited statistically significant differences in terms of sowing dates and genotypes in both years. Longer pods were observed in winter sowing than summer sowing in both years. As far as genotypes were concerned, pod lengths varied from 8.51 (Niksar) to 13.70 (Sevilla) in the first year, and from 6.50 (Tokat) to 10.03 (Turgutlu) in the second year. There was significantly sowing date x genotype interaction in the first year. For example, Tokat had an average of 8.66 cm pod length in winter sowing, but 8.80 cm in summer sowing. While some genotypes ranked low in statistical groups in winter sowing, they ranked in high statistical groups in summer sowing (Table 3).

The effect of sowing date and genotype were significant on number of seed per pod in the first year. There was no significant effect of factors on this character in the second year. For the first year, average number of seed per pod was higher in winter sowing than in summer sowing. Genotypes of Sevilla and Turgutlu had the highest value and Tokat had the lowest one. Significant sowing date x genotype interaction was found on the number of seed per pod only for the first year. Genotypes of Erbaa and Tokat showed high increase in the number of seed per pod from winter sowing to summer sowing in terms of statistical groups (Table 3).

Genotype significantly affected seed yield per plant, and sowing date x genotype interaction was significant only in the first year. Winter sowing had higher seed yield than summer sowing. Result of comparison of winter sowing with summer sowing shows that a dramatic decrease in seed yield per plant was observed especially in Canakkale genotype. The same trends were observed for Niksar, Turgutlu, Aydin, and Sevilla genotypes. On the other hand, Erbaa genotype had nearly same yield level in both sowing date (Table 3).

Harvest index exhibited statistically significant changes with regard to genotypes. Sowing date x genotype interaction was significant only for the first year. There was no significant effect of factors on this character in the second year. Among the genotypes, the highest values were obtained from Sevilla (59.27%) and Filiz (58.27%), followed by Turgutlu, Niksar, Aydin and Canakkale. On the other hand, the lowest value was observed highest number of pods per plant was observed in Tokat and Niksar but the lowest was observed in Sevilla and Turgutlu genotypes (Table 3).

Length of pods exhibited statistically significant differences in terms of sowing dates and genotypes in both years. The longest pods were observed in winter sowing than summer sowing in both years. As far as genotypes were concerned, pod lengths varied between 8.51 (for Niksar) and 13.70 (for Sevilla) in the first year, and between 6.50 (for Tokat) and 10.03 (for Turgutlu) in the second year. There was significantly sowing date x genotype interaction in the first year. For example, Tokat had average 8.66 cm pod length in winter sowing, but it was 8.80 cm in summer sowing. While some genotypes were at low statistical groups in winter sowing, they were at high statistical groups in summer sowing (Table 3).

The effect of sowing date and genotype were significant on number of seed per pod in the first year. There was no significant effect of factors

Table 3
Averages for pod length (cm), number of seed per pod (number pod^{-1}), seed yield per plant (g plant^{-1}) and harvest index (%) for winter and summer sown broad bean genotypes for both years

Varieties	2002			2003		
	Winter sowing	Summer Sowing	Mean	Winter sowing	Summer Sowing	Mean
Pod length, cm						
Niksar	9.13 e[1]	7.90 b	8.51 d	8.51 d	6.66	8.03 ab
Filiz	11.00 cde	9.30 ab	10.15 cd	10.15 cd	6.46	7.46 ab
Eresen	11.66 cd	9.30 ab	10.48 c	10.48 c	7.80	8.10 ab
Erbaa	10.16 de	9.23 ab	9.70 cd	9.70 cd	6.73	7.76 ab
Tokat	8.66 e	8.80 b	8.73 d	8.73 d	6.60	6.50 b
Canakkale	12.30 bcd	9.20 ab	10.75 bc	10.75 bc	9.53	8.83 ab
Sevilla	15.96 a	11.43 a	13.70 a	13.70 a	9.73	9.76 a
Aydin	13.20 bc	9.50 ab	11.35 bc	11.35 bc	7.83	8.18 ab
Turgutlu	14.26 ab	10.10 ab	12.18 b	12.18 b	9.66	10.03 a
Mean	11.81 a	9.41 b			7.89 b	
LSD	SD: 1.142*	G: 1.516**	SD x G: 2.144**	SD: 0.642*	G: 2.299**	SD x G: ns
Number of seed per pod, number pod^{-1}						
Niksar	2.56 c	2.43 a	2.50 c	2.66	1.73	2.20
Filiz	2.96 bc	2.80 a	2.88 abc	2.20	1.46	1.83
Eresen	2.90 bc	2.53 a	2.71 bc	1.80	1.80	1.80
Erbaa	2.43 c	2.50 a	2.46 c	2.53	1.66	2.10
Tokat	2.16 c	2.26 a	2.21 c	1.66	1.86	1.76
Canakkale	3.80 ab	2.56 a	3.18 ab	2.40	2.13	2.26
Sevilla	4.03 a	2.80 a	3.41 a	1.93	2.13	2.03
Aydin	4.00 a	2.53 a	3.26 ab	2.46	1.46	1.96
Turgutlu	3.80 ab	3.03 a	3.41 a	2.73	2.26	2.50
Mean	3.18 a	2.60 b		2.26	1.83	
LSD	SD: 0.371*	G: 0.606**	SD x G: 0.857**	SD: ns	G: ns	SDxG: ns
Seed yield per plant, g plant^{-1}						
Niksar	30.93 ab	15.97 bc	23.54	7.93	10.20	9.07
Filiz	25.70 ab	18.03 abc	21.67	6.83	7.97	7.40
Eresen	24.97 b	16.93 abc	20.95	6.07	6.23	6.15
Erbaa	24.90 b	24.27 a	24.58	5.00	4.80	4.90
Tokat	25.33 ab	21.07 ab	23.20	7.57	6.30	6.93
Canakkale	29.47 ab	11.50 b	20.48	8.53	8.07	8.30
Sevilla	25.87 ab	15.07 bc	20.47	8.90	5.57	7.23
Aydin	24.53 b	13.73 bc	19.13	8.17	7.43	7.80
Turgutlu	33.17 a	21.53 ab	27.35	7.70	8.90	8.30
Mean	27.16 a	17.57 b		741	7.27	
LSD	SD: 7.377*	G: ns	SDxG: 7.069*	SD:ns	G: ns	SDxG: ns

(continued)

Table 3 (continued)

Harvest index, %												
Niksar	51.27	bc	50.40	a	50.83 abc	39.46	51.07	45.26
Filiz	60.73	ab	55.82	a	58.27 a	34.13	39.76	36.95
Eresen	52.42	bc	43.40	a	46.91 bc	33.58	30.98	32.28
Erbaa	35.06	c	53.59	a	44.33 c	25.02	23.92	24.47
Tokat	40.51	bc	51.14	a	45.82 bc	37.86	31.40	34.63
Canakkale	55.24	abc	41.15	a	48.19 abc	42.56	40.32	41.44
Sevilla	72.95	a	45.58	a	59.27 a	44.50	28.20	36.35
Aydin	52.31	bc	45.63	a	48.97 abc	40.83	37.11	38.97
Turgutlu	59.28	ab	55.03	a	57.16 ab	38.59	44.58	41.58
Mean	53.08		49.08			37.39	36.37	
LSD	SD: ns		G: 9.934*		SD x G: 8.873**	SD: ns	G: ns	SD x G: ns

SD:Sowing Date, G: Genotype, *:0.05 Significance level, ** 0.01Significance level, ns: not significancant

[1]: Avarages indicated with the same letter fall into same statistical group

on this character in the second year. For the first year, average number of seed per pod was higher in winter sowing than summer sowing. Genotypes of Sevilla and Turgutlu had the highest value but Tokat had the lowest value. Significant sowing date x genotype interaction was determined on the Erbaa (44.33%). With regard to interactions, Niksar had similar harvest index values at both sowing dates and averages. While Tokat and Erbaa genotypes exhibited high harvest index values in summer sowing, other genotypes had high values in winter sowing. For example, Sevilla yielded twofold harvest index values in winter sowing, compared to summer sowing. On the other hand, Erbaa had high harvest index value in summer sowing but low value in winter sowing (Table 3).

Results of correlations among plant characteristics are given in Table 4. Harvest index was the most significant parameter affecting the seed yield per plant in positive way in each year and average (0.445**, 0.988**, 0.687**, respectively). According to the year 2002 and average of both years, there were statically significant and positive correlations between seed yield per plant and number of seed per pod (0.401** and 0.581**), and between seed yield per plant and pod length (0.369** and 0.535**). The effects of plant height on seed yield per plant were positive and significant in the year 2002 and average of both years but negative and significant effect in the year 2003. There was a positive and significant correlations between seed yield per plant and number of pod per plant only in average of both years (0.665**). There were negative and strong relationships between seed yield per plant and sowing dates in the year 2002 (-0.674**) and average of both year (-0.819**).

Discussion

Sowing dates had important roles on primary seed yield per plant and other characteristics, except for harvest index. Only first pod height had high values in summer sowing, compared to winter sowing. On the contrary, other plant characters showed high means in winter sowing. For example, in the year 2002, high values were observed in the winter sowing for characteristics such as seed yield per plant, plant height, and number of seed per pod. In both years, pod length had higher values in winter sowing than summer sowing. Although broad bean has a deep root system, it is not much resistant to drought. Water stress has significant effects on all plant characteristics and especially on seed yield (Akcin, 1988). Table 1 show that there were a high amount rainfall with a good distribution over

Table 4
Correlations among plant characteristics

		2	3	4	5	6	7	8
	2002	-0.603**	0.808**	-0.025ns	-0.533**	-0.433**	-0.178ns	-0.674**
1	2003	0.139ns	0.590**	-0.555**	-0.224ns	-0.335*	-0.047ns	-0.031ns
	2002-2003	-0.832**	-0.094ns	-0.709**	-0.494**	-0.542**	-0.539**	-0.819**
	2002	1 000	-0.388**	0.428**	-0.033ns	-0207ns	-0.355**	0.336*
2	2003	1 000	0.162ns	0.143ns	-0.280*	0.106ns	-0272*	-0.318*
	2002-2003	1 000	-0.045ns	0.727**	0.360**	0.374**	0.302**	0.758**
	2002		1 000	-0.215ns	-0.391**	-0.371**	0.344*	-0.736**
3	2003		1 000	-0.580**	-0.065ns	-0.314*	-0.105ns	-0.090ns
	2002-2003		1 000	-0.170ns	-0.184ns	-0.237*	-0.150ns	-0.230**
	2002			1 000	-0.450**	-0.335*	-0.205ns	0.248ns
4	2003			1 000	0.042ns	0.261ns	0.066ns	0.061ns
	2002-2003			1 000	0.180ns	0.325**	0.325**	0.665**
	2002				1 000	0.828**	0.439**	0.369**
5	2003				1 000	0.652**	-0.059ns	-0.069ns
	2002-2003				1 000	0.814**	0.427**	0.535**
	2002					1 000	0.545**	0.401**
6	2003					1 000	0.059ns	0.045ns
	2002-2003					1 000	0.512**	0.581**
	2002						1 000	0.445**
7	2003						1 000	0.988**
	2002-2003						1 000	0.687**
	2002							1 000
8	2003							1 000
	2002-2003							1 000

1: Sowing dates, 2: Plant Height, 3: The first pod height, 4: Number of pod per plant, 5: Pod lenght, 6: Number of seed per pod, 7: Harvest Index, 8: Seed yield per plant

the months in winter sowing, compared to summer sowing in both years. Therefore, broad bean sown in summer has faced to water stress. It leads to having low plant values. Literature review shows that broad bean seed yields decline dramatically with delays in sowing in South Australia (Baldwin, 1980; Adisarwanto, 1988), in New South Wales and Australia (Marcellos and Constable, 1986), in Southern Italy (Santonoceto and Anastasi, 1995), in South Western Australia (Loss and Siddique, 1997). Some studies carried out in Turkey showed that broad bean and chickpea sown in winter had twofold seed yield, compared to those sown in summer (Akdag, 2001; Ece et al., 2004).

Genotypes used in the experiment had significant effects on some of the investigated characteristics. Pod length, number of pod per plant, first pod height, and plant height in both years were affected by genotypes. In general, certified genotypes showed advantage in plant height, first

pod height, pod length, and number of seed per pod, compared to local populations. This situation is possibly a result of the fact that certified varieties have more stable genotypic structure than populations.

As far as correlations between seed yield per plant and first pod height are concerned, results of the study are similar to those in literature. For example, Peksen (2007) stated that there were positive and significant relationships between seed yield and harvest index, pod length, number of seeds per pod and biological yield. Loss and Siddique (1997) found that seed yield was correlated with harvest index. In another study, a positive and significant correlation was found between green pod yield per plant and plant height. Green pod yield per plant was positively and significantly correlated with the number of pods per plant, pod length and thickness (Peksen et al., 2006).

Conclusions

Broad bean seed yields per plant declined to nearly half with delayed sowing (from 27.16 g plant^{-1} in winter sowing to 17.57 g plant^{-1} in summer sowing).

Genotypes had some effects on different plant characteristics. Local populations had high performance in terms of seed yield per plant while certified genotypes showed advantage in plant height, first pod height, pod length, and number of seed per pod.

Seed yield per plant was strongly positively correlated with harvest index, number of seed per pod, pod length, and plant height. On the other hand, there were negative and strong relationships between seed yield per plant and sowing dates.

Cultivation of broad bean can be advised for the same transitional climatic conditions under which the experiment was carried out. Genotypes which are suitable for winter sowing should have long plant height, high number of pod per plant, high number of seed per pod, and high harvest index value while genotypes sown in summer should have the characteristics such as long plant height, high number of pod per plant, long pod length, high number of seed per pod, and high harvest index. These characteristics should be used as primary criteria during the selection of high yielding broad bean genotypes which are suitable for winter and summer sowing.

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