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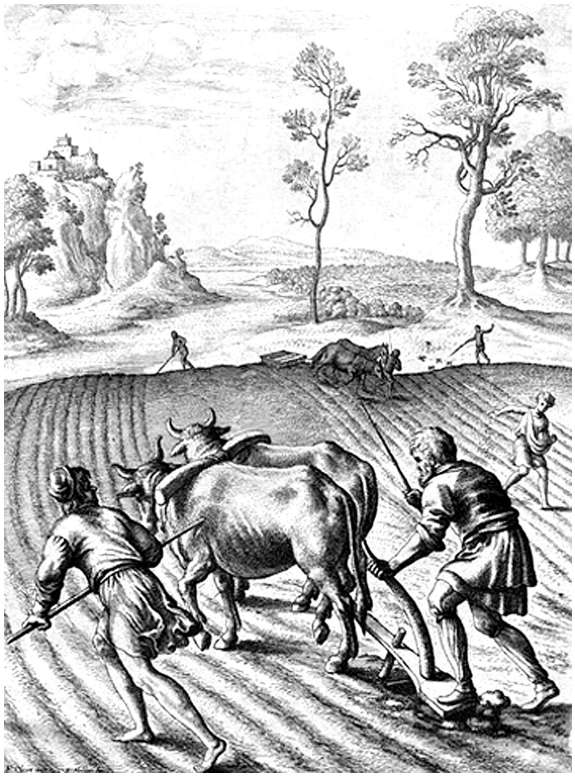

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Evaluation of Heritability and Correlation for Seed Yield and Yield Components in Faba Bean (*Vicia faba* L.)

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Abstract: In this study, heritability and correlation were determined for seed yield and its components by using five faba bean (*Vicia faba* L.) cultivars (Eresen-87, Filiz-99, Sevilla, Kemalpaşa and Tarzan). Correlation analysis between seed yield and yield characteristics indicated that seed yield had significant positive relationship with seeds per pod. Also, significant correlations were found between yield components; pods per plant with plant height and seeds per pod with number of stems. Heritability values of various traits were: 29% for plant height, 17.6% for number of stems, 3% for pods per plant, 47% for seeds per pod, 77% for seed yield, 30% for 1000-seed weight and 33% for hectolitre weight. These results showed that environmental conditions have a greater effect on pods per plant and number of stems than on other characteristics. It is hoped that these findings would be useful for future breeding programmes involving this important crop.

Key words: Faba bean, heritability, correlation analysis, seed yield, yield components

INTRODUCTION

Faba bean is an important source of protein for human and animal nutrition. On the other hand, as other grain legumes, faba bean provides nitrogen fixation so it has a major role in crop rotations in many regions of the world (Geren and Alan, 2005). In case of crop rotation, faba bean legume improves on soil fertility and reduces on weeds, diseases and pests (Mwanamwenge *et al*., 1998). Up to date, faba bean is being cultivated on nearly 24.5 million ha with 18.3 million tones of seed yield in the world (FAO, 2004).

A basic knowledge of interrelationship of certain plant characters with yield and correlation among themselves is an important topic for breeder to improve a complex character such as yield. Seed yield is a final product of several components determined at different growth stages and correlations between yield components indicate mechanisms of yield stabilization under variable environmental conditions (Adams, 1967; Ateş and Tekeli, 2005). In faba bean, the yield components are the number of podding nodes per plant, the number of pods per podding node, the number of seeds per pod and the mean individual seed weight (De Costa *et al*., 1997). Loss and Siddique (1997) reported that plant height, number of stems and pods per plant, 100-seed weight, days to flowering and maturity are the most important characters in faba bean to increase seed yield depend on direct and indirect correlation with seed yield. Similarly, grain yield associated with branches per plant, seeds per pod, pods per plant and 100-seed weight in field pea (Singh and Singh, 1969).

Gene (G) and environment (E) interaction is one of the most important factors to control the yield or productivity, which is related to weather changes year by year. Also, genotype-environment or genotype-year interactions are important to decide a possible breeding method to improve cultivars with adequate adaptation to environments (Fox *et al*., 1997). Therefore, estimation of heritability should be determined as minimal requirement in breeding strategy. Toker (2004) reported that the heritability was affected by the type of genetic material and yield level of environment due to the fact that the plant height, number of stems and pods per plant, seed yield, biological yield, 100-seed weight, days to flowering and maturity of plants are created by the effects of genes and environment.

In the present study, correlation and heritability variance components and genotype×year interactions for seed yield and yield characteristics were determinated on five faba bean cultivars.

MATERIALS AND METHODS

The experiments were performed during 2 years (2002-2004) at the experimental area of Ege University Ödemiş

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Vocational Training School, in the west coast of Turkey. The soil was sandy loam (69% sand; 24% loam; 7% clay) with 1.6% organic matter and pH 7.3. The average maximum and minimum temperatures during the whole growing season were 24 and 5°C. Five faba bean cultivars (Eresen-87, Filiz-99, Sevilla, Kemalpaşa and Tarzan) were used in the study. Cultivars were sown on 21 September in 2002 and on 27 September in 2003. A randomized complete block design with three replicates was used in both years. Seeds were sown 40 cm between rows and 10 cm between plants, in a dept of 4-5 cm with a density of 25 plants m^{-2}. Plants were fertilized with equivalent to 30 kg ha^{-1} N, 70 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} K_2O during growing season.

Plant height (cm), number of stems, pods per plant and seeds per pod measurements were recorded with the average of ten plants randomly selected in the center of rows of the plots prior to maturity. Blackish-brown and dried pods were harvested by hand in late May to early June. Seed yield was determinated in kg per ha^{-1} with total weight of seeds after threshing. The 1000-seed weight (g) and hectoliter weight (kg) were recorded after threshing.

All measurements were statistically analyzed. Correlations between seed yield and yield components were investigated through simple correlation analysis. The form of the analysis of variance and the mean square expectations; the estimates of variance components and the method of determination were used as suggested by Toker (1998) and shown in Table 1 and 2, respectively. The phenotypic variance $\delta^2 p$ was calculated as following:

$$\delta^2 p = \delta^2 g + (\delta^2 gy/y) + (\delta^2 e/ry).$$

Where y, g and r are number of year, genotype and replication, respectively. $\delta^2 g$ and $\delta^2 e$ are components of variance for genotypes and error. Heritability was evaluated as:

$$\text{genotypic variance /phenotypic variance: } h^2 = \delta^2 g / \delta^2 p.$$

Table 1: Form of variance analysis and mean square expectations

Source	Degree of freedom	Mean square*	Mean square expectation
Replication	y (r-1)		
Year	(y-1)		
Genotype	(g-1)	M_3	$\delta^2 e + r\,\delta^2 gy + ry\,\delta^2 g$
Genotype×year	(g-1) (y-1)	M_2	$\delta^2 e + r\,\delta^2 gy$
Error	gy (r-1)	M_1	$\delta^2 e$

* M_1 to M_3 are the observed values of the various mean squares

Table 2: Estimates of variance components and method of determination

Variance components	Method of determination
Genotype ($\delta^2 g$)	M_3-M_2/yr
Genotype×year ($\delta^2 gy$)	M_2-M_1/yr
Error ($\delta^2 e$)	M_1

RESULTS AND DISCUSSION

Eresen-87 had highest seed yield (3677 kg ha^{-1}) while Sevilla had the lowest value (2390 kg ha^{-1}) over two years Table 3. The genotypes were similar in plant height. Number of stems of different faba bean cultivars varied between 6.3 and 8.1. The pods per plant and seeds per pod of different cultivars ranged between 9.8-13.8 and 5.5-4.4, respectively. Eresen-87 had highest thousand seed weight whereas Tarzan had lowest. The genotypes were very similar in hectolitre weight values over year. Inconsistent, seed yield and thousand seed weight means for years and genotypes could be due to the genotypes or environmental fluctuations such as rainfall, drought and diseases. Drought may be occurred during grain filling period. According to the Pilbeam *et al.* (1990) seed yield is influenced by the year×location and by density×cultivar interactions but density has less influence on yield than environmental effects.

There was a significant positive correlation between seed yield and seeds per pod in 2002 and 2003 ($p<0.01$ and $p<0.05$), respectively Table 4. Also, significant correlations were found between yield components. Pods per plant had a significant positive correlation with plant height ($p<0.05$); seeds per pod and number of stems showed significant positive relationship with each other ($p<0.05$). There were no significant negative correlation recorded in this study. These results represented that selection based on seeds per pod increases the seed yield. Pilbeam *et al.* (1991) reported that number of seeds per pod is the component displaying the strongest and most consistent correlation with yield and is arguably the most important determinant of yield. Similar results were also stated that in mung (Malhotra, 1968-unpublished) and in cowpea (Singh and Mehndiratta, 1969).

Significant differences between genotypes were found for all characters at $p<0.01$. The genotype×year interactions were significant for all characters except for hectolitre weight (Table 5). Flores *et al.* (1998) found genotype by environment interactions in faba bean and pea crop (*Pisum sativum* L.). Since genotype×year interactions affected all traits except for hectolitre weight significantly, those traits should be study at multiple years.

As can be seen in Table 5 estimated of broad sense heritability were 29, 17.6,3, 47,77, 30 and 33% for plant height, number of stems, pods per plant, seeds per pod, seed yield, 1000-seed weight and hectolitre weight. These findings seem to agree with results reported in chickpea by Eser (1976) and Singh (1991); in faba bean by Toker (2004). They reported that number of pods per plant was the most affected trait by environmental conditions. On the other hand, same authors stated that 100-seed weight

Table 3: Yield components in faba bean cultivars in 2002 and 2003

Cultivars	Plant height (cm)	No. of stems	Pods per plant	Seeds per pod	Seed yield (kg ha^{-1})	1000-seed weight (g)	Hectolitre weight (kg)
Eresen-87	106.0	6.8	13.2	5.5	3677	1386.8	62.0
Filiz-99	101.5	6.5	13.0	5.2	2990	1221.0	63.6
Sevilla	100.1	7.1	9.8	4.4	2390	1295.9	60.9
K. Paşa	109.0	6.3	12.3	4.5	2445	1226.1	62.4
Tarzan	106.8	8.1	13.8	5.1	3008	1155.2	63.5

Table 4: Correlation analysis between seed yield and its components in 2002 and 2003

	2002						
	Plant height (cm)	No. of stems	Pods per plant	Seeds per pod	Seed yield (kg ha^{-1})	1000-seed weight (g)	Hectolitre weight (kg)
Plant height	-	0.351ns	-0.036ns	-0.149ns	-0.293ns	0.682ns	0.150ns
No. of stems	0.477ns	-	-0.436ns	-0.419ns	-0.426ns	-0.195ns	0.065ns
Pods per plant	0.891*	0.815ns	-	-0.321ns	-0.230ns	-0.640ns	0.702ns
Seeds per pod	0.512ns	0.887*	0.754ns	-	0.979**	0.412ns	-0.067ns
Seed yield	0.541ns	0.847ns	0.734ns	0.893*	-	0.419ns	0.044ns
1000-seed weight	-0.05ns	-0.142ns	-0.153ns	-0.027ns	0.357ns	-	-0.743ns
Hectolitre weight	0.530ns	0.614ns	0.672ns	0.757ns	0.415ns	-0.581ns	-

*Significant at p<0.05, **Significant at p<0.01, ns: Non-significant

Table 5: Results of variance analysis and heritability for some yield characteristics of faba bean

Sources of variation	Plant height (cm)	No. of stems	Pods per plant	Seeds per pod	Seed yield (kg ha^{-1})	1000-seed weight (g)	Hectolitre weight (kg)
Genotype	333.9**	11.9**	57.6**	5.3**	6540701**	185843**	30.6**
Genotype×year	165.5**	17.8**	54.2**	1.7**	837595**	971860**	6.7ns
Error	77.3	3.8	4.8	0.7	20297	10087.9	35.2
Heritability (%)	29	17.6	3	47	77	30	33

*Significant at p<0.05, **Significant at p<0.01, ns: Non-significant

was the least affected trait by environmental conditions but our experiments showed that seed yield was the least affected trait. Lumpkin and Mcclary (1994), concluded from different authors that heritability values in pure lines and segregating materials of adzuki bean (*Vigna ungularis* (Willd.) *Ohwi and Ohashi*s were 84-96% for days to flowering, 26-86% for plant height, 9-87% for pods per plant, 70-99% for seed weight, 44-69% for branches per plant, 99% for days to maturity, 31-50% for seed yield. The highest heritability estimate for seed yield was fallowed by seeds per pod, hectolitre weight. High values for heritability indicated that selection could be practiced in population successfully. The magnitude of heritability was affected by the type of genetic material and yield level of environment due to the fact that the plant height, number of stems and pods per plant, seed yield, biological yield, 100-seed weight, days to flowering and maturity of plants are created by the effects of genes and environment. The most common justification for conducting selection in optimum environments, regardless of the nature of the target environment, was the lower heritability found by Ceccarelli (1994) in low yielding environments. Also, Ceccarelli (1996) reported that the lower heritability expected in low input conditions. In addition, Atlin and Frey (1990) concluded that heritability in low yielding environments in lower than high yielding environments in oat (*Avena sativa* L.).

It can be concluded that seed yield was the least affected characteristic over years. On the other hand, pods per plant and number of stems were the most affected traits by environmental conditions. So, these factors may be considered as practical selection criteria for improving faba bean cultivars. Most of the yield characters did not show significant correlation with yield. However, the significant positive relationship noted between seeds per pod and yield.

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