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Some Grain Yield Parameters of Multi-environmental Trials in Faba Bean (*Vicia faba*) Genotypes

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ABSTRACT

The objective of this research was to determinate genotype x environment (GE) interaction and also to determine stable faba bean (*Vicia faba* L.) cultivar(s) for grain yield in Turkey. The study was carried out during two years at six different locations around South Anatolian Region. According to stability analysis results, cultivar 1 (Eresen, 87) was the most stable for grain yield. Among the cultivars, the highest grain yield was obtained from cultivar Eresen 87 (3.21 t ha^{-1}) across environments. This genotype had regression coefficient (b_i =1) around unity and deviations from regression values (δ_{ij} =0) around zero. This suggested that both these attributes were responsive to changing environments and could be recommended for favorable environments.

Key Words: Faba bean; *Vicia faba*; Grain yield; Stability

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the oldest cultivated crops and was grown in farming villages of Turkey. Faba bean is a grain legume and grown for its high protein content (25.4%) in the seed (Özdemir, 2002). It is grown during spring (at Central & East Regions) or winter (at South & West Regions) in Turkey (Anonymous, 2008). Genetic variation among trials is important for breeding and in selection of desirable types. Arshad *et al.* (2002) explained low heritability percentage coupled to primary and secondary branches and indicated that these traits were greatly influenced by environments. New cultivars are tested for their yield performance in the different locations. The success of a new faba bean variety depends on its yield and adaptation potential in those locations. Evaluation of stability performance and range of adaptation has become increasingly important in breeding programs (Akçura *et al.,* 2006).

Genotype x Environment interactions (GEI) are of major importance, because they provide inforation about the effects of different environments on cultivar performance and play a key role for assessment of performance stability of the breeding materials (Moldovan *et al.,* 2000). Stable genotypes have the same reactions with high yield or performance (Björnsson, 2002). Increasing genetic gains in yield are possible in part from narrowing the adaptation of cultivars (Ayçiçek & Yıldırım, 2006). Thus maximizing yield in particular areas are explained by GEI (Peterson *et al.*, 1989). GEI is the differential responce of genotypes evaluated under different environmental conditions. It is a complex phenomenon as it involves environmental (agro-ecolgical, climate & agronomic) conditions and all physiological and genetic factors that determine the plant growth and development (Kaya *et al.*, 2006).

Eberhart and Russel (1966) proposed a model to test the stability of different environments. They indicated a stable variety as having unit regression over the environments ($b_i = 1.0$) and minimum deviation from the regression ($\delta^2_{di} = 0$). Therefore a variety with a high mean yield over the environments, unit regreesion coefficient ($b_i = 1.0$) and deviation from regression as smal as possible ($\delta^2_{di} = 0$), will be a better choise as a stable variety. GEI was studied by different researchers in various crops such as chickpea, wheat, mung bean, oat and maize (Singh *et al.*, 1987; Ashraf *et al.*, 2001; Zubair & Ghafoor, 2001; Genç *et al.*, 2005; Akçura *et al.*, 2006; Javed *et al.*, 2006; Kaya *et al.,* 2006).

The stability parameters have also been studied in the grain legumes for measuring phenotypic stability (Khan *et al.*, 1987; Sharif *et al.*, 1998; Özdemir *et al.,* 1999). However still very little information about the faba bean cultivars and environmental interactions. In this study, we aimed to evaluate the grain yield performance of faba bean

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genotypes in different environment and to determine their stability parameters.

MATERIALS AND METHODS

Four faba bean cultivars and two lines were evaluated during 2001-2003 growing seasons at six locations (Namely, Hatay/Kırıkhan, Hatay/Serinyol, Adana/Ceyhan, Adana/Center, Kahramanmaraş/Türkoğlu & Kahramanmaraş/Beyoğlu) under rainfed conditions in the South Anatolian Regions. Cultivars were analyzed by a randomized complete block design (RCBD) with four replications. The names of used genotypes were Eresen 87, Filiz 99, Seville and Giza 1, while names of lines were 69V1, 69V2. Each genotype was sown on four rows per plot (5 m long & 0.5 m apart). The central two rows were used for agronomic observations. A combined three factor analysis of variance was performed on data collected for all locations and years using the statistical model (Demidenko, 2004):

$$Y_{ijkl} = \mu + g_i + p_j + t_k + (gp)_{ij} + (gt)_{ik} + (tp)_{ik} + (gpt)_{ijk} + e_{ijkl}$$

Where Y_{ijkl} is the i^{th} observation on the l^{th} cultivar in j^{th} location in the k^{th} year. The first four terms are the mean and main effects of cultivar, location and years. The next three terms are the first order interaction and finally the micro environmental deviation within locations and years. It is usually assumed that cultivars and locations are fixed effects and years random effects, so that the model is mixed effects model.

Data were analyzed across all locations and years using pooled data. To characterize genotypic stability the following linear regression model was also used (Eberhart & Russell, 1966):

$$Y_{ij} = \mu + b_i L_j + \delta_{ij} + \varepsilon_{ij}$$

Where Y_{ij} the mean for the genotypes *i* at location *j*.

μ ; The general mean for genotype.

b_i ; The regression coefficient for the i^{th} genotype at a given location index, which measures the responce of a given genotype to varying location.

L_j ; The environmental index, which is defined as the mean deviation for all genotypes at a given location from the overall mean.

δ_{ij} ; The deviation from regression for the i^{th} genotype at the j^{th} location.

ε_{ij} ; The mean for experimental error.

Two stability parameters were calculated based on the regression coefficient. Regression performance of each genotype in different locations calculating means over all the genotypes. The regression coefficient (b_i) and mean square deviation (δ_{ij}) were estimated. The significance of the regression coefficients was determinated using the 't test' and coefficient of determination (R^2)were computed by individual linear regression analysis (Pinthus, 1973). All statistical analysis was performed using the SAS program (SAS Institute, 1999).

RESULTS AND DISCUSSION

Mean grain yield varied among environments and ranged from 3.99 t ha^{-1} for environments 3 to 4.55 t ha^{-1} for environment 1 (Table I). Pooled analysis of variance showed higly significant difference the genotypes and environments for grain yield (Table II).

Table I: The range of grain yield (t ha^{-1}) in environments

Code	Growing season	Locations	Mean (t ha^{-1})	Maximum grain yield (t ha^{-1})	Minimum grain yield (t ha^{-1})	Range (t ha^{-1})
E1	2001-2002	Hatay/Kırıkhan	2.83	4.55	2.67	1.88
E2	"	Adana/Ceyhan	2.56	4.21	1.36	2.85
E3	"	Kahramanmaraş/Türkoğlu	2.45	3.99	1.66	2.33
E4	2002-2003	Hatay/Serinyol	2.62	4.28	1.83	2.45
E5	"	Adana/Center	2.60	4.15	2.18	1.97
E6	"	Kahramanmaraş/Beyoğlu	2.42	4.04	1.97	2.07

Table II: Analysis of variance, among 6 faba bean genotype

Source of variation	df	Sum of square	Mean square	F values
Year (Y)	1	1269287	1269287	6.38*
Location (L)	5	12829315	2565863	12.90**
Year x Location (YxL)	5	121251105	24250221	121.91**
Rep. (Location xYear)	24	31269074	1302878	6.55
Genotype (G)	5	14167265	2833453	14.24**
Year x Genotype (YxG)	5	4784466	956893	4.81**
Location x Genotype (LxG)	25	220048063	8801923	44.25*
Year x Location x Genotype (YxLxG)	25	9343392	373736	1.88*
Error	120	23869987	198917	
Total	215	438831954		

Significant at 0.05, ** Significant at 0.01 probability level, Unmarked is non-significant

Table III: Estimates of stability and adaptability parameters of grain yield (t ha^{-1}) for six faba bean cultivars at 6 environments

Genotypes	Mean grain yield (t ha^{-1})	b_i (t ha^{-1})	δ_{ij} (t ha^{-1})	R^2 (%)
Eresen 87	3.21	0.97**	0.186	88
Filiz 99	2.65	1.08*	0.124	90
Seville	2.52	0.57	0.321	89
Giza 1	2.86	0.89**	0.246	86
69V1	2.76	1.22*	0.261	86
69V2	2.58	0.62	0.272	85

Significant at 0.05, ** significant at 0.01 probability level

The location, year x location, genotype and year x genotype were highly significant (P<0.01), whereas year location x genotype and year x location x genotype were significant (P<0.05).

The presence of genotype x year's interaction indicated that particular genotypes tended to rank differently for grain yield over years, while the small genotype x location interaction indicated small effects of the location on the relative productivity. The mean yield of six faba bean genotypes ranged from 2.52 to 3.21 t ha^{-1} (Table III). The highest yield was obtained from Eresen 87 (3.21 t ha^{-1}). It was emphasized that both linear (b_i) and non-linear (δ_{ij}) components of GE interactions are necessary for judging the stability of a genotype (Eberhard & Russel, 1966). A regression coefficient (b_i) approximately 1.0 coupled with an δ_{ij} of zero indicated average stability (Eberhart & Russell, 1966). Regression values above 1.0 describe genotypes with higher sensitivity to environmental change (below average stability) and greater specifity of adaptability to high yielding environments. A regression coefficient below 1.0 provides a measurement of greater resistance to environmental change (above average stability) and this increases the specificity to adaptability to low yielding environments (Wachira *et al.*, 2002). Finlay and Wilkinson (1963) found that linear response is the positively associated with mean performance. Eberhart and Russel (1966) emphasized that both linear (b_i) and nonlinear (δ_{ij}) components of G × E interaction should be considered in judging the phenotypic stability of a particular genotype and their responses were independent from each other.

Linear regression for the average grain yield of a single genotype on the average yield of all genotypes in each environments resulted in regression coefficient (b_i values) ranging from 0.57 to 1.22 for grain yield (Table III). This large variation in regression coefficient explains different responses of genotypes to environmental changes (Akçura *et al.,* 2005). The regression coefficients of Eresen 87 for grain yield was non-significant (b_i =1.0) and had a small deviation from regression (δ_{ij}) and this possessed fair stability. Genotypes with high mean yield, a regression coefficient equal to the unity (b_i =1.0) and small deviation from regressin (δ_{ij} =0) are considered stable (Finlay & Wilkinson, 1963; Eberhard & Russel, 1966).

Higher values of δ_{ij} explained to us that there is high sensivity to environmental changes. These varieties gave quite good yield when environmental conditions were conducive (Arshad *et al.*, 2003). Eresen 87 was the most stable for the grain yield. Because its regression coefficient was close to unity and they had low deviation from regression. R^2 values varied between 85% and 90%, conforming their stability.

CONCLUSION

Among these genotypes, genotype 1 could be considered the most stable ones. Genotype 3,4 and 6 are sensitive to environmental changes and have adapted to the poor environments. The stable genotype should be recommended for a wide range of environments, while the genotype, which proved to be suitable for high yielding or low yielding environments, should be recommended for the respective areas.

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