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Peyman SHARIFI [1]

BIPLOT ANALYSIS OF SEED YIELD OF FABA BEAN GENOTYPES AT DIFFERENT PLANTING DATES

SUMMARY

A split plot experiment was carried out during 2012-13 in Iran to appraise the effects of genotypes and planting dates, as well as their interactions on seed yield in faba bean, based on randomized complete block design with three replications. The dates of planting and six genotypes were arranged in main and split plots, respectively. Analysis of variance revealed significant effects of genotype for all of the traits except plant height. The interaction effects of two factors were significant on seed yield, number of pods per plant and pod length. The polygon view of treatment by trait (TT) biplot indicated the autochthonous landrace from north of Iran (G1) were as a genotype with high mean productivity, but their stability in four planting date is low. This genotype was also the best for first, second and forth sowing dates. The breeding variety (France) was as a more stable variety in all of the planting times. The polygon view of TT biplot is also indicated the best genotypes with respect to each of planting date. The results of present study can help to planning a crosses program for achieving the heterosis, since heterosis only can occur between genetically divergent germplasms.

Keywords: Graphic Analysis, Faba bean, Sowing Date, Seed yield

INTRODUCTION

Faba bean (*V*icia *faba* L.; 2n = 12), which used as a food for its high nutrient components in seeds, is a major legume (Duc, 1997). It is consumer in the Middle East, Mediterranean, China and Ethiopia as a vegetable green or fresh seed (FAO, 2016). Faba bean is divided to four botanical varieties including *paucijuga*, *major*, *equine* and *minor* according to their differences in some of the seed characters such as shape, weight and size (Duc, 1997).

Planting date is crucial in faba bean, because early or late sowing expose the crop to drought, adverse temperature, pests and diseases attack. Some of researchers indicated that sowing date significantly influenced the seed yield and growing traits in faba bean and late sowing increased the severity of insect and disease attack and reduced days to flowering, green pod length, seeds per pod and seed yield (Yusufali *et al.*, 2007; Kawochar *et al.*, 2010; Khalil *et al.*, 2010). Abdelmula and Abuanja (2007) used three sowing dates to evaluate the heat stress on faba bean genotypes and indicated the high temperature stress

[1] Peyman Sharifi *(corresponding author: sharifi@iaurasht.ac.ir), Department of Agronomy and Plant Breeding, Rasht Branch, Islamic Azad University, Rasht, IRAN.

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significantly reduced seed yield and most of the studied traits. They were also indicated significant differences between genotypes. Alghamdi (2007) were also indicated the significant differences between studied genotypes for yield and yield components. Crossing system in faba bean is intermediate between autogamy and allogamy, and therefore the genetic variability of this crop is very large (Hanelt and Mettin 1989). Knowledge of the extent of genetic variability for quantitative and quality traits in faba bean would facilitate the breeding improvement of faba bean.

Genotype main effects and genotype × environment interaction (GGE) biplot analysis were proposed for graphic interpretation of the genotype × environment interactions (Yan *et al.*, 2000). Although agronomic traits represent the combined effects of genotype (G), environment (E), and genotype × environment (GxE) interaction, the GGE Biplot analysis considers that only the G and G×E effects are relevant and they need to be considered simultaneously when evaluating cultivars.

The graphic axes of biplot are the first two principal components of multivariate analysis and identify the superior cultivars, classify the environments in mega-environments and determined the superior genotype in any of environments (Yan *et al.*, 2000). Balalić *et al*. (2010) used biplot method to assess the effects of hybrids and planting dates as well as their interaction on oil yield in sunflower and indicated the higher values of oil yield in earlier planting dates in comparison to laters. They also facilitate the choice of stable hybrids and planting dates for desired characters in sunflower by graphical presentation of biplot. Genotype by trait (GT) biplot were also used in rye (Yari et al., 2017), Spinach (Sabaghnia et al., 2016), rice (Sharifi and Ebadi. 2016). Sabaghnia and Janmohammadi (2014) used treatment by trait (TT) biplot for studying the various nano-silicon dioxide treatments on seed germination of lentil under various NaCl concentrations.

The aim of this study was to appraise the effects of genotypes and planting dates, as well as their interaction on yield in faba bean by biplot graphic method.

MATERIALS AND METHODS

Experimental field area

This study was carried out during 2012-13 in Shanderman, Guilan province, Iran (longitude, 49° 55´ E; latitude, 37° 27´ N; altitude, 71 m above sea level; climate, wet). The experiment comprised of 24 treatment combinations, consisting of six genotypes (Table 1) and four date of sowing (1 December 2012, 22 December 2012, 5 January 2013 and 2 March 2013). The experiment was laid out in a split plot design with three replications based on randomized complete block design. The dates of planting and genotypes were arranged in main and split plots, respectively. Each plot consisted of four rows with 6 m long and distance between rows was 50 cm. The seeding rate was 15 plants per m^2. Routine cultural operations were attended to keep the plots free from weeds.

Table 1. Information of studied faba bean genotypes.

Genotype	Genotype name	Origin	Breedng status	Seed structure
1	-	North of Iran (Guilan)	Autochthonous Landrace	Large
2	Barrakat	Iran/ Gurgaon	Breeding variety	Large
3	France	France	Breeding variety	Intermediate
4	-	Lorestan (Borujerd1)	autochthonous Landrace	Small
5	FILIP3	Syria	Breeding variety	Small
6	FILIP5	Syria	Breeding variety	Small

Estimated characters

The characters containing pod length (PL), seeds per pod (NSP), stems per plant (NStPl), pods per plant (NPoPl), hundred seed weight (HSW) and dry seed length (LS) and width (SW) were measured on fifteen plants of each plot. Seed yield per plot was measured after removal of the marginal effect and reported as dry seed yield per m^2 (SY) and used for treatment by trait (TT) biplot analysis.

Statistical analysis

The statistical model was adopted for this experimental design is: $Y_{ijk} = \mu + \rho_k + (\alpha\rho)_{ik} + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk}$

Where,

μ: general mean; α_i: effect of i^{th} factor, genotype, (i = 1, 2, ..., 6); β_j: effect of j^{th} factor, sowing date, (j = 1, 2); ρ_k: effect of k^{th} replication (k = 1, 2, 3); $(\alpha\rho)_{ik}$: main plot error; $\alpha\beta_{ij}$: the interaction effect of i^{th} genotype with j^{th} sowing date; e_{ijk}: experimental error.

Genotype × planting date interaction was evaluated according to Gauch and Zobel (1996). GGE biplot software according to Yan (2001) was used for plotting the biplot.

RESULTS AND DISCUSSION

Analysis of variances

Analysis of variance indicated significant effects of genotype on all of the traits except of plant height. These results are in agreement with the findings of Alghamdi (2007) which revealed the faba bean genotypes were significantly differed for yield and yield components. The results were also indicated the significant effect of planting date on all of the studied traits. In agreement to this result, many of researchers revealed that sowing date had significant effect on

yield and yield components and late sowing reduced the number of days to flowering, green pod length, number of seeds per pod and seed yield (Abdelmula and Abuanja, 2007; Yusufali *et al.*, 2007; Kawochar *et al.*, 2010; Khalil *et al.*, 2010). The interaction effect of planting date and genotype were significant on seed yield, number of pods per plant and pod length. The magnitude of interaction indicates the influence of planting date on adaptability and stability, which is a desired character only when it is connected with yield above average (Yan and Hunt, 2003). Therefore, the genotype × planting date interactions were studied on seed yield by biplot method.

Table 2. Analysis of variance for some of yield and yield components of faba bean genotypes

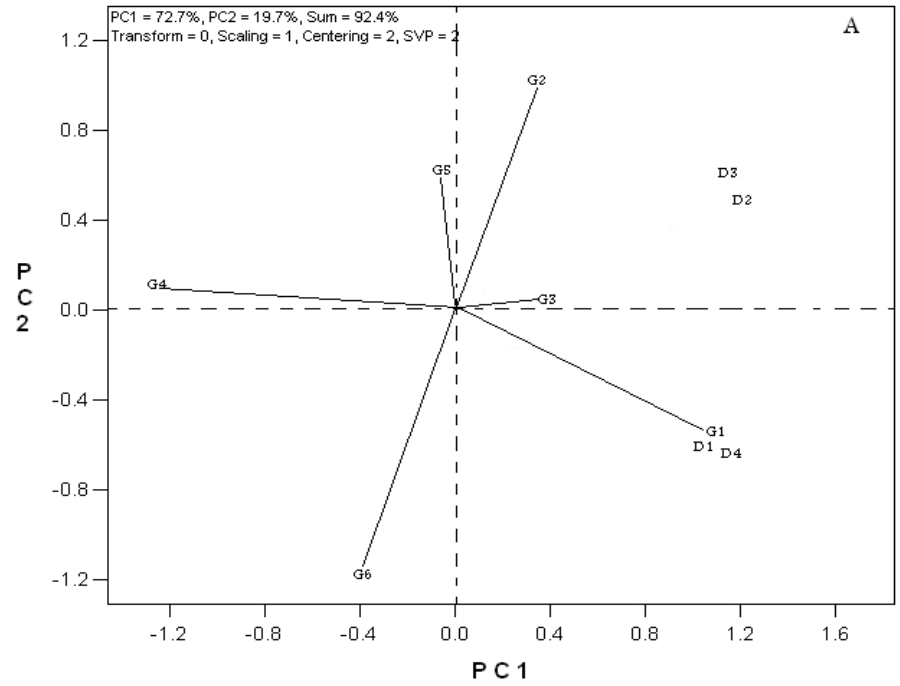
Source	df	Mean Square						
		SY	HSW	NStPl	NPoPl	PL	NSePo	PH
Replication	2	126349.81*	921	0.71**	0.37	4.24	0.55*	1857.79**
Planting date	1	46991710.5**	16469.44**	21**	601.06**	93.18**	3.61**	26292.62**
Genotype	5	704319**	39327.73**	0.39*	46.07**	79.34**	4.03**	142.92
Planting date * Genotype	5	295130.82**	576.71	0.22	26.16**	5.12*	0.27	153.55
Error	22	26673.46	369.69	0.11	2.09	1.36	0.12	167.62
CV		11.22	17.19	17.19	21.64	13.00	10.15	13.73

ns, not significant; * and **, significant at the 0.05 and 0.01 probability level, respectively.
PL: pod length, NSP: number of seeds per pod, NStPl: number of stems per plant, NPoPl: number of pods per plant, LS: dry seed length, SW: dry seed width, HSW: hundred seed, SY: seed yield.

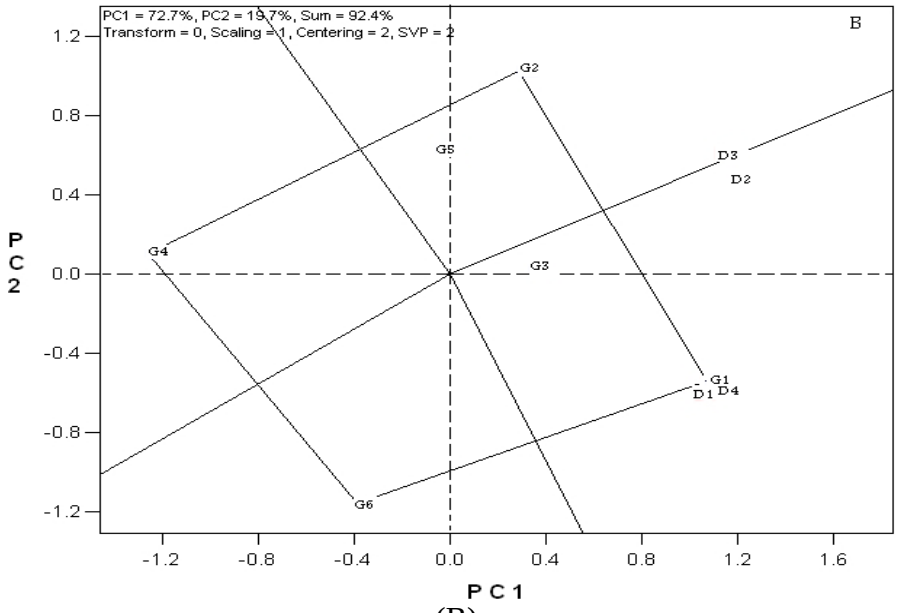
Treatment by trait (TT) Biplot analysis

The graphic TT biplot analysis of six genotypes in four planting date indicated in Figure 1 A. The genotypes farthest from the biplot origin give most to increase the genotype × planting date interaction, such as G1, G2, G4 and G6. Whereas, G3 and G5 that were closer to the center of origin of the axes, contributed least to the genotype × planting date interaction.

In the biplot method, the small angles between the genotype vectors within the same quadrant indicated the similarity of the genotypes. According this view of biplot the genotypes such as G2 and G3 and G4 and G5 had similarity behavior. These results are logical, since Barrakat (G2) and France (G3) are breeding varieties that were selected in the same environment, while small seed genotype from Lorestan (G4) and FILIP3 (G4) are genotypes that have similar agronomic performance.



(A)



(B)

Figure 1. Graphic analysis of vector (A) and polygon (B) view of biplot of faba bean genotypes in four planting date: 1 December 2012 (D1), 22 December 2012 (D2), 5 January 2013 (D3) and 2 March 2013 (D4).

The Autochthonous landrace from north of Iran (G1) is an adapted genotype in Guilan, the region that there were carried out this experiment. The places of the genotype in contrasting quadrants indicate their dissimilar genetic performance, as can be observed for G1 and G5, G1 and G4, G3 and G6, G2 and G6, and G1 and G2. These results can help to planning a diallelic crosses for achieving to heterosis, since heterosis only can occur between genetically divergent germplasm.

Since the second principal component (PC2) score play a significant role (19.7%) in explaining the genotype × environment (planting date) interactions (GEI), the first principal component (PC1) score were plotted against PC2 score, to further explore adaptation (Figure 1 B.). The polygon view of biplot of the six faba bean genotypes in four planting date is displayed in Figure 1 B. The first two principal components explained 92.4% of the total variability. In the graphic analysis, PC1 and PC2 represent genotype productivity and stability, respectively (Yan *et al.*, 2000). However, Burgueño *et al*. (2000) stated that such properties tend to occur when the cultivars' PC1 is highly correlated with cultivar effects.

The TT Biplot indicated that the ideal genotype must have a high PC1 value (high mean productivity) and a PC2 value next to zero (more stable). Thus, based on the graphic interpretation, the genotypes with the highest PC1 values were G1, G3 and G2, respectively. The most stable genotypes were G3 and G4. It was not possible to identify the ideal genotype by measuring just productivity and stability. According to this polygon view of biplot, the autochthonous landrace from north of Iran (G1) were as a genotype with high mean productivity, but their stability in four planting date is low. The breeding variety (France) was as a more stable variety in all of the planting time and intermediate productivity.

The polygon is formed by joining the markers of the genotypes that are furthest away from the biplot origin such that all other genotypes are contain in the polygon. The vertex genotypes (G1, G2, G4 and G6) have the longest vectors, in their respective direction, which is a measure of responsiveness to planting time. The vertex genotypes are, therefore, among the most responsive genotypes; all others are less responsive in their respective direction. These genotypes that located in the vertex are an unstable. Genotypes located near the plot origin (G3 and G5) were less responsive than the vertex genotypes. G3 is closer to the center of biplot, showing to be more stable (Purchase, 2000).

The polygon view biplot is also indicated the best genotypes with respect to each of planting date (Yan and Hunt, 2003). The Autochthonous landrace from north of Iran (G1) were the best for first, second and forth date of faba bean sowing. Barrakat (a breeding variety) was the best genotype for third planting date.

CONCLUSION

On the basis of the obtained results can be concluded all main effects (genotype, planting date), as well as interaction showed highly significant values

for seed yield. Biplot analysis showed that both PC axes (PC1 and PC2) were highly significant. The major part of variation belonged to PC1 (72.7%). G3 did not differ in the mean values for seed yield, which were above the general average and indicated high stability for seed yield response to four planting date. Seed yield was higher in earlier planting dates than in later planting dates. Graphical performance of TT biplot could promote the choice of stable genotypes and planting dates for desired traits in faba bean.

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