EFFICIENCY OF STABILITY PARAMETERS APPLIED TO FABA BEAN GENOTYPES

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ABSTRACT

Fifteen varieties of faba bean (Vicia faba L.) were evaluated in a randomized complete block experiment with three replications over nine environments, representing three seeding dates in three winter seasons (2000 / 2001, 2001 / 2002 and 2003) at Alexandria University Farm, Egypt.

All genotypes were statistically analyzed for their stability by using four various stability parameters; namely b_i, $S^2_{d_i}$ W^2 and C.V.%.A highly significant linear genotype x environment interaction was detected for seed yield. Such result indicated of that the genotypes reacted differently in their linear response to the change of the environments. The comparison among the four stability parameters would suggest that faba bean breeders would depend upon regression coefficient (b_i), in addition to one statistics derived from the variance; i.e, $S^2_{d_i}$ or W^2_i. No significant relationship was found between seed yield and the various parameters, however, there was a significant positive relationship between regression coefficient (b) and covalence (W^2_i) (r= 0.56). The results further illustrated that the four local improved equine varieties, Giza 461, Giza 402, Giza 643 and Giza 716, showed the best combination of stability and mean yield and could be grown in North Egypt. Future research on stability should depend on a large number of genotypes tested over a relatively large number of diverse environments. On the other hand, it was recommend that attention should be taken to stability for yield components, such as 100-seed weight and maturity in order to facilitate breeding for stable genotypes of faba bean.

INTRODUCTION

Vicia faba L. is considered the major food legume crop in Egypt. Most of the crop is consumed as cooked dry seeds for human food. Increasing seed yield and improving yield stability are the main objectives of many breeding programs.

Several methods have been proposed to describe and interpret the response of genotypes to environmental variation. Some of them are based on the analysis of variance and others use regression analysis. Yates and Cochran (1938) were the first to point out that the regression of yield on environmental index could be used to measure stability. Later, Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Carlos and Kranowski (2003) developed and modified this method. Comstock and Moll (1963) and Rao *et al* (2002) developed the analysis of variance approach to estimate genotype x environment interaction, while Wricke (1962) proposed the term " ecovalence " as a measure of stability of characters in different environments. Lin *et al* (1986) summarized the different stability methods. They classified them in four groups in addition to the cluster analysis.

On the other hand, Gauch (1994) proposed AMMI method to analyze multiplication trials. Although there are numerous papers on stability estimations for different field crops, only a few are available for faba bean, such as Dantuma *et al* (1983), Ibrahim and Ruckenbauer (1987), Kang and Magari (1996) and Kang (1998).

The main objective of the present work was to estimate yield potential and yield stability in a collection of faba bean genotypes grown in different seeding dates in three winter seasons, consequently, the most promising genotypes could be utilized for production and / or as parents of crosses. A second objective was to determine the relationship between seed yield and various stability parameters, for these genotypes.

MATERIALS AND METHODS

The data from several faba bean trials, using fifteen different varieties; namely, fourteen local genotypes belonging to equine type (Giza 3, Giza 343, Giza 714, Giza 717, Giza 461, Giza 674, Giza 716, Giza429, Giza 2, Giza H. 843, Giza 429, Giza 402, Giza 643 and Giza Planka; large seed size), in addition to Diana small seed size from Germany, were used in this investigation.

The field experiments were grown in a randomized complete block design, with three replications, under three seeding dates; viz, D_1 (Nov. 1st), D_2 (Nov.15th) and D_3 (Dec.1st), at the Agricultural Experiment Station of Alexandria University, Egypt for three winter growing seasons (2000 / 2001 till 2002 / 2003). Soil of the experimental site in the three seasons was clay loam, mixed with shells, with a pH value of 8.2. Plot size was 18.0 m^2, consisting of six ridges, 5.0 m long and 60 cm apart. The plant density was forty plants/m^2.Cultural practices were applied, according to the recommendations for faba bean production in Alexandria region.

Data for seed yield were collected on the four central ridges of each plot and converted to tons/ha. The analysis of variance was performed on the data at each seeding date for each season, as well as combined over the nine environments of the three dates of planting across the three seasons. The experimental data were analyzed, using Proc ANOVA (SAS software, 1997), according to Steel and Torrie, (1980).

Four stability parameters for seed yield across the nine environments were computed as follows :

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(i) b = Linear regression coefficient (Eberhart and Russell,1966).

(ii) S^2_d = Mean square of deviation from regression (Eberhart and Russell, 1966).

(iii) W^2_i = Ecovalence (Wricke,1962). The GXE interaction effect of genotype i, squared and summed across all environments, was the stability measure for genotype i.

(iv) ($C.V_i$) = Coefficient of variability for each genotype as stability measure (Francis and Kannenberg, 1978).

RESULTS AND DISCUSSION

The combined analysis of variance for seed yield data of the fifteen faba bean varieties in the nine environments showed a highly significant interaction of varieties (V) x Environments (E) (Table 1). This means that the seed yield of varieties highly significantly varied across different environments. The trend of these results was similar to the previous faba bean studies by Dantuma *et al* (1983) and Ibrahim and Ruckenbauer (1987). Furthermore, partitioning the sum of squares of V x E to linear and non-linear components indicated significant linear genotype x environment interaction, showing that the genotypes differently rected in their linear response to the change in environments. This trend of linearity agreed with previous results of Dantuma *et al* (1983).

Mean seed yield (ton / ha.) and the values of stability parameters for the fifteen varieties differed in rank for most stability parameters (Table 2). The results indicated that there were significant differences among varieties in seed yield over seasons. In general, Giza Rena Planka variety had significantly the highest seed yield (6.98 t/ha.) over seasons. Such results were expected, where Giza Planka belonged to the major type, however, it is less acceptable by consumers due to the variation in seed size and thickness of seed coat. Also, the present results further indicated that the varieties Giza 3, Giza 2 and Giza 343 the lowest seed yields over seasons (4.10, 3.80) and 3.89 t/ha, respectively produced. Meanwhile, the improved equine varieties, Giza 402, Giza 461, Giza 643 and Giza 716, were of moderate seed yields over seasons (ranging from 4.42 to 4.72 t/ha.).

Table 1. Combined analysis of variance for seed yield (ton/ha) of fifteen faba bean varieties over nine environments.

Source of variance	DF	Mean squares
Environments (E)	8	33.910**
Rep./ environ.	18	5.188**
Varieties (V)	14	16.034**
V x E	112	0.589**
Due to. reg. varieties (linear)	14	5.350**
Deviation from regression	106	0.298
Error	252	0.373

** Significant at p = 0.01

The general trend of results in Table 2 showed that the values of the four stability parameters for the fifteen varieties differed in rank, however, some of then had similar ranks with different stability parameters.

Regression analysis, according to Eberhart and Russell model (1966), identifyied a widely adapted cultivar was that having high values of mean yield (x_i) and a regression coefficient (b_i) close to 1.0 and the mean square for deviation from regression S^2_{di} = 0.0. The regression coefficient models of Finlay and Wilkinson (1963) and Eberhart and Russell (1966) were most valid for a large number of entries tested over a relatively large number of diverse environments. The regression coefficient (b), in Table 2, showed that the values ranged between 0.69 for Giza 717 to 1.37 for Hybrid 843. The varieties, Giza 461, Giza 402, Giza 716, Giza Planka and Giza 643, had regression coefficients around 1.0, which would be considered as stable varieties. However, the other varieties were less responsive to the change in productivity environmental conditions.

The results in Table 2 further illustrated that the S^2_d values ranged between 0.068 for Giza Planka to 0.652 for Giza 343. Generally, the ranks of S^2_d values differed from the order of the b values for the fifteen genotypes. Lin *et al* (1986) indicated that the b value was an indicator of the response of variety for the predictable or macro-environmental features, while the S^2_d value was an indicator of the unpredictable variations or micro-changes in the environment, Hence, the identification of a stable cultivar might the based on both statistics.

As for the other stability parameters in Table 2, the magnitude of the coefficient of variability (C.V.%) was, generally, high for the fifteen genotypes (ranging between 15.4 to 28.2%). Such values might be ascribed, to the fluctuations in ecological factors over seasons. The C.V.% values can not statistically be compared, because it is a ratio between standard deviation and the mean. The values of ecovalence in Table 2 showed that they were similar in rank to b values for few genotypes.

Linear regression values of seed yield for the promising four stable genotypes (Giza 643, Giza 461, Giza 402 and Giza 716), across the nine environments, are summarized in Fig. 1. It is obvious that the four genotypes were characterized by high seed yield and its stability.

Results in Table 3 showed that there was an insignificant relation ship between mean yield and various stability parameters. However, a significant positive correlation coefficient (r), between the regression coefficient (b) and W^2_i, being 0.56 detected was.

The comparison among the four stability parameters would suggest, in conclusion, that faba bean breeders might depend upon the regression coefficient, in addition to one statistics derived from

Table 2. Stability for seed yield (ton/ha.) over nine environments (combined data).

Varieties	Mean ($\overline{X}$)		Regression coefficient		Sum of squared deviation regression		Coefficient of variability		Ecovalence	
	(ton / ha.)	Rank	(b)	Rank	S^2_d	Rank	(C.V.%)*	Rank	(W^2_i)	Rank
Giza Rena Planka	6.98	1	1.09	5	0.068	2	25.8	14	6.390	15
Diana	5.02	2	1.10	6	0.398	13	20.7	11	1.001	8
Giza 643	4.72	3	1.01	1	0.296	8	20.2	7	0.696	3
Hybrid 843	4.52	4	1.37	15	0.375	11	28.2	15	1.753	10
Giza 402	4.51	5	0.94	3	0.144	4	20.2	8	0.335	2
Giza 429	4.51	6	1.15	8	0.244	5	23.6	13	0.711	4
Giza 716	4.45	7	0.93	4	0.368	10	20.2	9	0.882	6
Giza 461	4.42	8	1.02	2	0.078	1	21.0	12	0.175	1
Giza 429	4.33	9	0.90	7	0.393	12	20.3	10	0.964	7
Giza 717	4.20	10	0.69	14	0.128	3	15.4	1	0.818	5
Giza 714	4.16	11	0.71	12	0.511	14	18.4	3	2.730	14
Giza 3	4.10	12	0.76	9	0.257	6	18.1	2	1.467	11
Giza 343	3.89	13	0.71	13	0.652	15	19.1	5	2.059	13
Giza 2	3.80	14	0.75	10	0.304	9	19.3	6	1.132	9
Giza 674	4.02	15	0.74	11	0.267	7	18.6	4	1.526	12
L.S.D. (0.05)	0.33									

* C.V. = SE. 100 / mean.

the variance (S^2_d, W^2_i or C.V$_i$%). Similar conclusions were obtained by Beacker (1981), Lin *et al* (1986) and Shehata *et al* (2005). The results further indicated that the four improved equine genotypes, Giza 461, Giza 402, Giza 643 and Giza 716, showed the best combinations of stability and mean seed yields and could be grown in the North Delta Region of Egypt.

The present results on stability parameters and their rank correlations were almost similar to other authors., probably because the studied materials covered only a small number of genotypes (fifteen) and a limited number of environments (nine). Future research on stability should depend on a large number of genotypes that should be tested over a relatively large number of diverse environments. On the other hand, it was recommended that more attention should be taken to stability of seed yield components, such as 100-seed weight and maturity, in order to facilitate breed for stable genotypes of faba bean.

Table 3. Rank correlation coefficients between mean yield ($\bar{X}$) and stability parameters for seed yield (ton/ha.)

Stability parameters	b	S^2_d	W^2_i	C.V%.
Mean ($\bar{X}$)	0.50	0.20	0.20	-0.70
b		0.41	0.56*	-0.28
S^2_d			0.47	-0.17
W^2_i				-0.11
C.V%.				-

* Significant at P = 0.05.

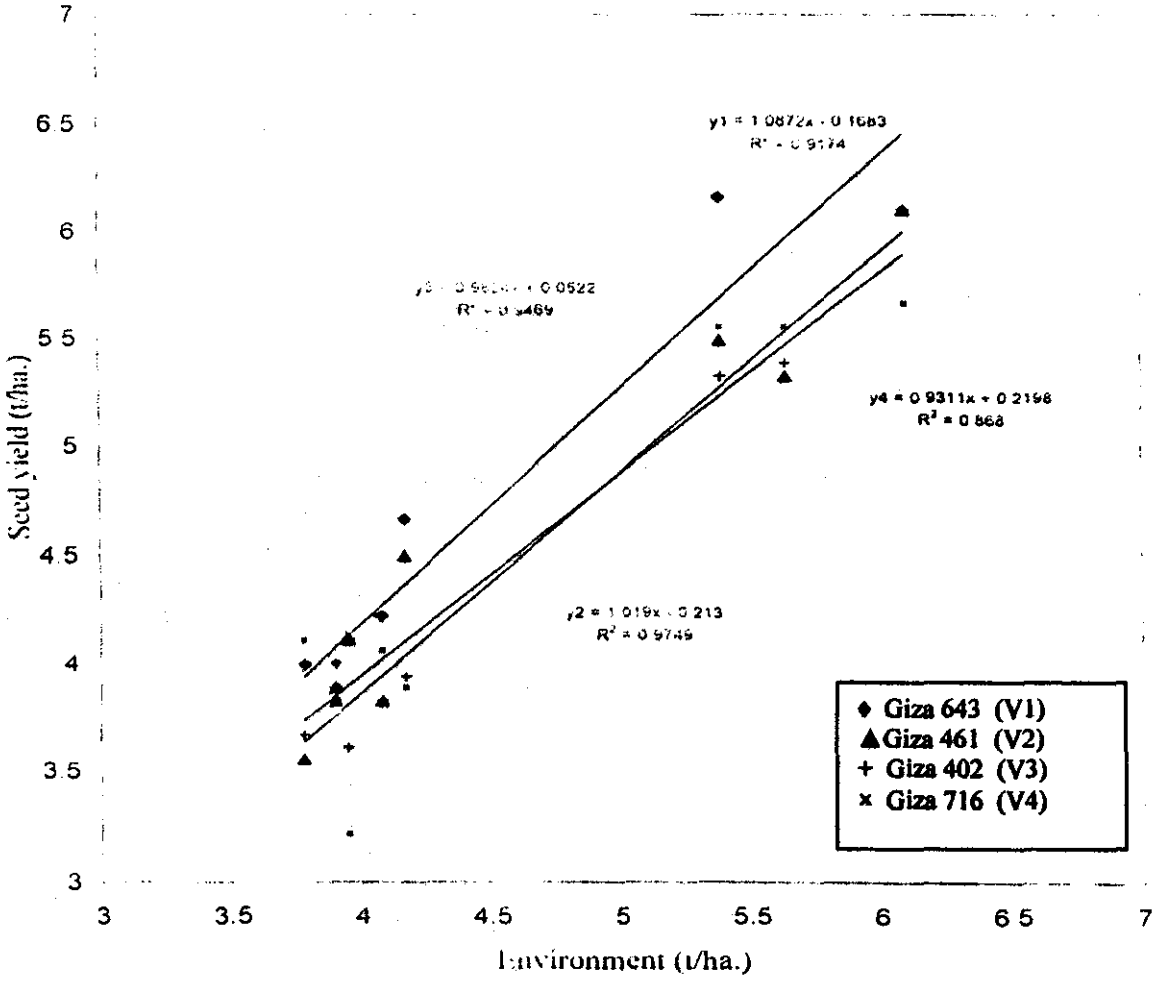

Fig 1 : Linear regression of seed yield of V1, V2, V3 and V4 environmental means in nine environments of faba bean trials

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الملخص العربي

كفاءة مقاييس تقدير الثبات تطبيقا علي التراكيب الوراثية للفول البلدي

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تم تقويم خمسة عشر صنفا من الفول البلدي في تجربة قطاعات عشوائية كاملة في ثلاث مكررات في تسع بيئات تمثل ثلاثة مواعيد زراعة في ثلاثة مواسم شتوية (٢٠٠٠ / ٢٠٠١ و ٢٠٠٢/ ٢٠٠٣) زرعت بمزرعة جامعة الإسكندرية بمصر. قدر ثبات جميع الأصناف إحصائيا بتقدير أربعة مقاييس للثبات وهي: b_i و S^2_{di} و W^2_i و C.V% . وقد بينت النتائج تفاعلا عاليا المعنوية بين الأصناف والبيئات في صفة محصول البذور، بما يدل علي اختلاف استجابة الأصناف مع تغير ظروف بيئة الزراعة. وقد أظهرت المقارنة بين مقاييس الثبات الأربعة أنه يجب علي مربي الفول البلدي الاعتماد علي تقدير معامل الارتداد (b_i) بالإضافة إلي مقياس إحصائي يشتق من التباين مثل S^2_{di} أو W^2_i وقد كانت العلاقة بين محصول البذرة ومقاييس الثبات غير معنوية فيما عدا العلاقة بين معامل الارتداد (b) ودليل التساوي (W^2_i) والتي كانت معنوية (r = 0.56). وقد أوضحت النتائج أيضا أن الأصناف المحلية صغيرة البذور المحسنة "جيزة ٤٦١ وجيزة ٤٠٢ وجيزة ٦٤٣ وجيزة ٧١٦" أتسمت بأفضل توليفة من الثبات ومتوسط محصول البذور وبذلك فهي مناسبة للزراعة في منطقة شمال مصر. ويفضل أن تعتمد الأبحاث المستقبلية علي أعداد أكبر من الأصناف والبيئات من تلك المستخدمة في الدراسة الحالية بالإضافة إلي الاهتمام بقياس ثبات صفات مكونات المحصول كوزن المائة بذرة والتبكير في النضج وذلك بهدف تسهيل تربية أصناف من الفول البلدي لها صفة ثبات الإنتاجية.