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STATISTICS OF REGRESSION AND CORRELATION AS STABILITY ESTIMATES OF NINETEEN FABA BEAN GENOTYPES

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ABSTRACT

Nineteen faba bean genetic resources were evaluated in two dates (15 October and 15 November) at Nubaria Research Station in 2004/5, 2005/6 and 2006/7 seasons. Combined analysis was performed to test the difference among varieties, seasons, dates and their interactions in order to apply statistics of Eberhart and Russell, Tai's as well as regression and correlation model. Results cleared highly significant environment (linear) mean squares indicating that environments differ in their effect on different genotypes. Highest yield/fed. was given by genotype 1557/992/2001 being 11.22 ard./fed. followed by genotypes 1378/1157/99, 1423/653/2000, 1617/817/2002, 943/1151/93, and 1557/930/2001 that produced 10.42, 10.22, 9.392, 9.386 and 9.313 ard./fed., respectively. Eberhart and Russell method, showed that genotypes 943/1151/93, 1426/711/2000, 1556/914/2001, 1233/848/99, 1557/992/2001, 1423/653/2000, 1378/1157/99, 1033/738/96, 1569/600/2002, 1617/817/2002 and 1557/930/2001 had phenotypic stability and stable performance in the environments. Tai's, parameters α_i and λ_i showed that genotypes Giza 3, 943/1151/93, 1426/711/2000, 1033/738/96 and 1617/817/2002 exhibited above average stability ($\alpha < 0$ and $\lambda = 1$). Genotypes 1005/654/95 and 1475/1162/2000 had a degree of below average stability ($\alpha > 0$ and $\lambda = 1$). Estimates of simple regression and correlation model scored insignificant and low values of r and R^2 and high values of stability percentage ($1-R^2$ %) for genotypes Giza 3, 943/1151/93, 1426/711/2000, 1556/914/2001, 1557/992/2001, 1423/653/2000, 1033/738/96, 1569/600/2002, 1617/817/2002 and 1557/930/2001 indicating poor of response to changing environments recording a stability percentage of 90.6, 94.2, 89.0, 98.5, 88.3, 99.7, 91.3, 99.5, 89.6 and 99.6%, respectively. Generally, results cleared that regression and correlation model, Eberhart and Russell and Tai's showed that 10, 11 and 8 genotypes out of nineteen revealed yield stability. Regression and correlation model were in agreement of stable genotypes with Eberhart and Russell and Tai's for genotypes 943/1151/93, 1426/711/2000, 1557/992/2001, 1033/738/96, and 1617/817/2002, respectively. On the other hand, it differs with Eberhart and Russell for Giza 3 variety. Also, results differ with Tai's method for 1556/914/2001, 1423/653/2000, 1569/600/2002 and 1557/930/2001 genotypes. Results indicated that regression and correlation model included all stable genotypes in the other two methods in addition to the simplicity of this model. The result of Chi square test for evaluating the studied methods was not significant with P value of 0.612 indicating that the three methods are similar in their results.

Key words: *Faba bean, Vicia faba, Environments, Stability statistics, Regression, Correlation.*

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important legume crops in Egypt. Research activities were more directed to develop high yielding varieties with improved level of resistance to biotic and abiotic stresses under different agroclimatic conditions. The average cultivated area devoted to faba bean represented 200,000 feddan during the last three years with average seed yield 9.2 ardab/feddan. About 85% of the total area is located in North Delta, where foliar diseases prevailed and severely attacked the crop with an average of 39.7% yield losses, particularly during wet seasons (Mohamed 1982).

The development of varieties, which can be adapted to a wide range of diverse environment, may be the ultimate goal of plant breeders in a crop improvement program. Genotype x environment interaction is of major importance for the faba bean breeder because phenotypic response to a change in the environment is different among genotypes. Several techniques have been proposed to characterize the stability of yield performance when the genotypes are tested at a number of environments.

Several studies were carried out to estimate stability parameters to compare the genotypes of legume crops. Nassib *et al* (1986) noticed highly significant interaction between genotypes and environments in Middle Egypt region in their studies on faba bean genotypes. Genotype x environment interaction and deviation from the linear response were studied by Abo El-Zahab *et al* (1986) for estimating the genotypic stability of soybean genotypes. Abdalla *et al* (1998) studied the stability of 12 faba bean genotypes under *Orobanche* infestation at Giza, Fayoum and Sids locations. Data of genotype ranking, genotype x environment interaction, coefficient of vriability and ecovalence indicated that genotypes varied in stability and two genotypes (Cairo 241 and Line 101) were the most stable stocks. Darwish *et al* (1999) analyzed the stability performance of ten faba bean varieties across 20 environments under old and newly reclaimed lands using five stability parameters (C.V.%, W_i, b_i, S^2d and R^2). These estimates showed great variability among tested genotypes which varied due to old or newly reclaimed environments the ranking of stability in performance of faba bean varieties differs between old land environments and newly reclaimed ones. Omar *et al* (1999) cleared that combined analysis revealed significance of pooled deviation of genotypes, environments and this interaction. The influence of the genotype x environment interaction in the phenotypic performance has been reported by Redden *et al* (2000) and Truberg and Hühn (2000). They reported that plant breeding is not carried out only to obtain high yield capacity in the genotypes, but also requires productive performance stability over many environmental conditions. Heavy infestation with parasitic weed broomrape (*Orobanche crenata*) is currently a major constrant of faba bean production in Egypt and caused serious yield damage as review by Abdalla and Darwish (2002). Corte *et al* (2002) mentioned that some cultivars and lines exhibit generally of adaptability and phenotypic stability in different environments. Darwish *et al* (2003) studied the stability of 15 faba bean genotype across difference salinity levels at Giza and Nubaria locations. Environments, genotypes and their interactions were highly significant sources of variation for all traits studied and there were more differences in ranking among genotypes across environments. Stability parameters indicated seven stable genotypes for seed yield. Four genotypes were recommended for poor environments and three for highly favorable invironments. El-Hosary *et al* (2006) in their study on faba bean reported that genotype, environment and genotype x environment interaction mean squares were highly significant. Attia *et al* (2007) evaluated some faba bean genotypes by using some stability statistics methods and recommended five genotypes as the most stable one.

The current study aimed to explore the reliability and simplicity statistics of regression and correlation model as stability parameters for evaluating nineteen faba bean genotypes grown in different environments compared with two famous stability methods namely: phenotypic (Eberhart and Russell, 1966) and genotypic (Tai 1971). Also, to use the available information from these estimates for obtaining stable genotypes to be released as experimental lines to be incorporated in a breeding program aiming at selecting stable high yielding varieties.

MATERIALS AND METHODS

Nineteen faba bean genotypes were evaluated during three successive seasons of 2004/05, 2005/06 and 2006/07 in two dates (15 October and 15 November) at Nubaria Research Station.The design used was randomized complete blocks with four replications, (six experiments = 3 years x 2 dates). Code number and pedigrees of the studied genotypes are presented in Table (1).

The experimental plot consisted of six ridges, 60 cm apart and 3 meters long (10.8 m^2 size). Seeds were planted on both sides of the ridge, in double seeded hills, 25 cm apart. All cultural practices were done as recommended for faba bean yield trial packages. Three central ridges of each plot (5.4 m^2) were harvested to estimate seed yield (ard./fed.).

Table 1. Code and pedigree of the studied faba bean genotypes.

No.	Genotypes	Pedigree
1	Giza 3	Giza 1x (Dutch introduction N A 29)
2	943/1151/93	Giza3 x 461/837/A83
3	1426/711/2000	S40/93 x Nubaria1
4	1556/914/2001	S40/93 x X- 843
5	1233/848/99	985/1415/90 x 900/668/89
6	1195/961/99	990/1530/90/ x 899/614/89
7	1557/992/2001	X-908 x Nubaria1
8	1423/653/2000	749/954/90 x Nubaria1
9	1378/1157/99	123A/45/76 x 716/10361/89
10	836/1121/92	561/2082/85 Sakha x (1LB938 x 249/801/80)
11	1033/738/96	667/153/87 x composite66/1882/87
12	1557/1015/2001	X-908 x Nubaria1
13	1564/530/2002	Giza 402 x 1LB 4370
14	1569/600/2002	Giza 461 x X-1001
15	1617/817/2002	Comp. 60/1175/88 x 711/778/90
16	1557/930/2001	X-908 x Nubaria1
17	1557/920/2001	X-908 x Nubaria1
18	1005/654/95	716/724/88 x S83385-6-1 Ethyopia
19	1475/1162/2000	ICARDA 2544/86 x X-905

Analysis of variance

Regular analysis of variance of RCBD as outlined by Gomez and Gomez (1984) was applied on each individual environment. The Bartelett's test of homogeneity adopted indicating validity of applying combined analysis of variance for the six environments.

The genotypes and environments (Ei) were considered as fixed and random variables, respectively. To detect the differences among genotypes over all the studied environments (Ei), least significance difference test (LSD) was used. Confidence intervals (C.I.) at 5% and 1% were calculated to compare each genotype mean and the grand mean of all genotypes over all environments.

Stability analysis

Regression and correlation statistics

When yield of a genotype (dependent) is regressed on the environments as a dummy variable (independent), R^2 is the contribution of the independent variable in the total variation of the dependent variable (yield of the genotype) as reported by Draper and Smith (1987). It equals the environmental variance and it could be used as indicator of the instability of the genotype. Correlation coefficient (r) measures the power of the relation between the yield of the genotype and environment. Then, significance of (r) or (R^2) means that genotype yield is more affected by the environmental conditions indicating instability of the genotype. Since the total variance equals the unity, so, value of $1-R^2$ is the rest of the total variation which is due to genetic effect of the genotype in yield .Therefore $1-R^2$ value indicates the stability of the genotype (G.V.). Regression and correlation coefficient was computed as outlined by Snedecor and Cochran (1989).

Phenotypic stability (Eberhart and Russell 1966)

The performance of individual genotype is regressed on an environmental index (deviation of the mean yield at that environment from the overall mean yield of all environments) in the analysis of phenotypic stability of Eberhart and Russell (1966). Linear regression coefficient, b, (performance response index) and the deviation from regression mean square, S^2d, (stability index) were provided by the analysis.

Genotypic stability (Tai 1971)

Concerning genotypic stability, genotype x environment interaction effect was partitioned into two statistics for each genotype. The first statistic is α_i that measures the linear response to environmental effects and the second is λ_i that measures deviation from linear response in terms of magnitude of the error variance.

Genotypes of perfect stability would not change its performance from one environment to another. This is equivalent to stating that $\alpha = -1$ and $\lambda = 1$ because perfectly stable genotypes probably do not exist. Plant breeders will have to be satisfied with the obtainable levels of stability *i.e* average stability ($\alpha = 0$ and $\lambda = 1$), whereas the values ($\alpha > 0$ and $\lambda =1$) will be as below average stability, however, the values ($\alpha < 0$ and $\lambda = 1$) will be referred as above average stability.

Statistical performance evaluation criterion

Chi square test was used to discover the similarity of performance for simple regression and correlation model as stability parameters with Eberhart and Russell and Tai`s methods. The non significance of the test indicates that the three methods are similar for detecting stable genotypes and there is no difference among them.

RESULTS AND DISCUSSION

Results of combined analysis of variance for testing the significance of varieties, seasons, dates and their interactions showed highly significant differences among all sources which validate using the statistics of Eberhart and Russell, Tai`s and regression and correlation model (Table 2).

The analysis of variance for stability estimates Eberhart and Russell and regression analysis was used to analyze faba bean yield character and results are presented in Table (3).

Table 2. Combined analysis among varieties, seasons, dates and their interactions.

Sources	d.f.	S S	Ms	Probability of sign.
Seasons	2	101.713	50.856	0.0000
Reps x seasons	6	0.289	0.048	
Varieties	18	568.976	31.610	0.0000
Seasons x varieties	36	223.869	6.219	0.0000
Dates	1	1.251	1.251	0.0301
Seasons x dates	2	4.926	2.463	0.0002
Varieties x dates	18	31.577	1.754	0.0000
Seasons x varieties x dates	36	58.764	1.632	0.0000
Error	222	61.132	0.276	

Genotypes mean squares were highly significant. Highly significant environment (linear) mean squares were found indicating that environments differ in their effect on different genotypes when tested with pooled deviation. Significant genotype x environment (linear) mean squares also, was found meaning that genotypes differ genetically in their response to different environments when tested with pooled deviation.

Environment + (genotype x environment) interaction was partitioned into environment (linear), genotype x environment (linear) interaction (sum of squares due to regression, b_i) and unexplained deviation from regression (pooled deviation mean squares, S^2d) for all genotypes. Highly significant mean squares were found due to genotypes 1556/914/2001, 1233/848/99, 1195/961/99, 1423/653/2000, 1378/1157/99, 836/1121/92, 1557/1015/2001, 1564/530/2002, 1569/600/2002, 1557/930/2001 and 1557/920/2001. The significant residual of genotypes cleared that the non-linear components were also significant.

Table 3. Analysis of variance for stability estimated of Eberhart and Russell method for nineteen faba bean genotypes of yield character.

Sources	d.f.	Mean Square
TOTAL	113	2.949
Genotypes (G)	18	10.587**
Env + (G x Env.)	95	1.502**
Environment Linear)	1	36.293**
G X Env. (Linear)	18	3.820**
Poold Deviation	76	0.495
Giza 3	4	0.0179
943/1151/93	4	0.0879
1426/711/2000	4	0.142
1556/914/2001	4	0.356**
1233/848/99	4	0.427**
1195/961/99	4	0.487**
1557/992/2001	4	0.041
1423/653/2000	4	0.250**
1378/1157/99	4	2.678**
836/1121/92	4	0.521**
1033/738/96	4	0.111
1557/1015/2001	4	0.279**
1564/530/2002	4	1.163**
1569/600/2002	4	0.495**
1617/817/2002	4	0.133
1557/930/2001	4	0.854**
1557/920/2001	4	0.642**
1005/654/95	4	0.066
1475/1162/2000	4	0.155
Pooled error	228	0.0913

** Indicate significant mean square at 1%

Nassib *et al* (1986), Abo El-Zahab *et al* (1986), Abdalla *et al* (1998), Darwish *et al* (1999), Omar *et al* (1999), Redden *et al* (2000), Truberg and Hühn (2000), Abdalla and Darwish (2002), Darwish *et al* (2003), El-Hosary *et al*, (2006) and Attia *et al* (2007) found that non-linear components were significant . Therefore, it could be concluded that it is essential to determine the stability degree of each genotype. Table (4) indicated that yield was significantly affected by genotypes. The highest yield/fed. was given by

Table 4. Mean performance and Eberhart and Russell parameters for yield of studied faba bean genotypes.

Genotypes	Means	Eberhart and Russell parameter (Phenotypic stability)			
		$b_{vi.}$	S^2d_{vi}	T_{bvi}=0	T_{bvi}=1
Giza 3	7.380*	*0.155*	*-.073*	*1.597*	*-10.2*
943/1151/93	*9.386**	*0.143*	*0.003*	*0.665*	*-4.51*
1426/711/2000	*10.90***	*0.401*	*0.051*	*1.468*	*-3.26*
1556/914/2001	*8.493**	*-.651*	*0.264*	*-.845*	*-6.23*
1233/848/99	6.697	*-1.41*	*0.835*	*-2.86*	*-9.07*
1195/961/99	7.424*	*1.585*	*0.396*	*3.138**	*1.158*
1557/992/2001	*11.22***	*0.159*	*-.050*	*1.081*	*-6.64*
1423/653/2000	*10.20***	*0.359*	*0.158*	*0.992*	*-2.40*
1378/1157/99	*10.42***	*1.184*	*2.587*	*0.999*	*0.339*
836/1121/92	7.822*	3.849*	0.429	7.374**	1.933
1033/738/96	*8.783**	*-.162*	*0.019*	*-.672*	*-2.37*
1557/1015/2001	7.879*	2.949*	0.188	7.719**	0.331
1564/530/2002	*8.761**	*2.792**	*1.072*	*3.579**	*1.509*
1569/600/2002	*8.644**	*0.029*	*0.404*	*.057*	*-1.93*
1617/817/2002	*9.392***	*-.035*	*0.042*	*-.076*	*-5.75*
1557/930/2001	*9.313***	*0.607*	*0.762*	*0.907*	*-.887*
1557/920/2001	7.711*	2.366	0.551	4.086*	0.638
1005/654/95	7.219*	2.373	-.025	12.75**	-3.00
1475/1162/2000	7.286*	2.337	0.063	8.228**	-1.18

Shadow cells that bold face and italic line the genotypes have phenotypic stability.

L.S.D. for genotypes = 0.464 and 0.627 at 5% and 1%, respectively.

*** Confidence Interval. (5%) 7.172 < 8.681 <10.192. ** Confidence Interval. (1%) 6.609 < 8.681 < 10.753.**

genotype 1557/992/2001 being 11.22 ard./fed. followed by genotypes 1378/1157/99, 1423/653/2000, 1617/817/2002, 943/1151/93, and 1557/930/2001 that produced 10.42, 10.22, 9.392, 9.386 and 9.313 ard./fed., respectively. On the other side, the lowest yield/fed. was given by genotypes 1233/848/99, 1005/654/95, 1475/1162/2000, Giza 3 and 1195/961/99 recording 6.697, 7.219, 7.286, 7.380 and 7.424 ard./fed., respectively.

Phenotypic stability

All genotypes exhibited degree of stability according to Eberhart and Russell parameters, the regression coefficient values did not significantly differ from unity (b close to 1) and deviation from regression (S^2d) was not significantly different from zero except Giza 3, 1195/961/99, 836/1121/92, 1557/1015/2001, 1564/530//2002, 1557/920/2001, 1005/654/95 and 1475/1162/2000 (Table 4). Actually b measures the reaction of the genotype to the environmental effects, and then it is considered as a parameter of response, while S^2d exhibits the degree of stability. Mean performance of yield of genotypes 1557/992/2001, 1426/711/2000, 1378/1157/99 and 1423/653/2000 were significantly greater than that of all genotypes. It is evident that these genotypes have regression coefficients and deviations from regression that did not significantly differ from one and zero, respectively.

Moreover, it had mean performance significantly greater than the mean of all genotypes. Therefore, genotypes 943/1151/93, 1426/711/2000, 1556/914/2001, 1233/848/99, 1557/992/2001, 1423/653/2000, 1378/1157/99, 1033/738/96, 1569/600/2002, 1617/817/2002 and 1557/930/2001 met all the stability characteristics of the stable genotypes as described by Eberhart and Russell (1966) and could be recommended as stable genotypes for faba bean yield. These results are similar to those obtained by Nassib *et al* (1986), Abo El-Zahab *et al* (1986), Abdalla *et al* (1998), Darwish *et al* (1999), Omar *et al* (1999), Redden *et al* (2000), Truberg and Hühn (2000), Abdalla and Darwish (2002), Darwish *et al* (2003), El-Hosary *et al* (2006) and Attia *et al* (2007) who reported that adaptability and phenotypic stability estimates showed that there was generally wide adaptability and stable performance of the cultivars and lines in the environments.

Genotypic stability

Data of Tai's parameters α_i that measures the linear response to environmental effects and λ_i that measures deviation from linear response in terms of magnitude of the error variance are presented in Table (5). Results in Table (5) and Fig (1) showed that genotypes Giza 3, 943/1151/93, 1426/711/2000, 1033/738/96 and 1617/817/2002 will be referred as above average stability ($\alpha < 0$ and $\lambda = 1$). Genotypes 1005/654/95 and 1475/1162/2000 will be as below average stability ($\alpha > 0$ and $\lambda = 1$). Negative and significantly differed from zero distribution of α statistic was found for genotypes Giza 3, 943/1151/93, 1426/711/2000, 1426/711/2000, 1033/738/96 and 1617/817/2002 indicating that these genotypes were responsive to poor environment.

On the other hand, genotypes 1556/914/2001, 1233/848/99, 1195/961/99, 1423/653/2000, 1378/1157/99, 836/1121/92, 1557/1015/2001, 1564/530/2002, 1569/600/2002, 1557/930/2001 and 1557/920/2001 had distribution of statistic greater than unity (Fig. 1) indicating the importance of the unpredictable component of GE interaction and these genotypes were of unstable yield. These findings are in agreement with those reported by Omar *et al* (1999), El-Hosary *et al* (2006) and Attia *et al* (2007) who cleared significance of pooled deviation of genotypes, environment and their interaction.

Table 5. Mean performance and Tai's parameters for yield of studied faba bean genotypes.

Genotypes	Means	Tai's parameter (Genotypic stability) and Stability degrees			
		α_v	λ_{vi}	95%	99%
Giza 3	7.380*	*-.85*	*.123*	+++	+++
943/1151/93	*9.386**	*-.87*	*.771*	+++	+++
1426/711/2000	*10.90***	*-.61*	*1.29*	++	++
1556/914/2001	*8.493**	-1.6	3.23		
1233/848/99	6.697	-2.4	8.25		
1195/961/99	7.424*	.566	4.50		
1557/992/2001	*11.22***	*-.85*	*.340*	+++	+++
1423/653/2000	*10.20***	*-.65*	2.29		
1378/1157/99	*10.42***	.186	4.87		
836/1121/92	7.822*	2.89	4.34		
1033/738/96	*8.783**	-1.2	*.949*	+++	+++
1557/1015/2001	7.879*	1.98	2.36		
1564/530/2002	*8.761**	1.82	4.60		
1569/600/2002	*8.644**	.98	4.54		
1617/817/2002	*9.392***	-1.1	*1.17*	++	
1557/930/2001	*9.313***	-.39	7.92		
1557/920/2001	7.711*	1.38	5.85		
1005/654/95	7.219*	1.39	*.501*	++	
1475/1162/2000	7.286*	1.36	*1.33*	+	

Shadow cells that bold face and italic line the genotypes that had different degree of genotypic stability where: + Below average stability. + + Average stability. +++ Above average stability.
* Confidence Interval. (5%) 7.172 < 8.681 <10.192. ** Confidence Interval. (1%) 6.609 < 8.681 < 10.753.

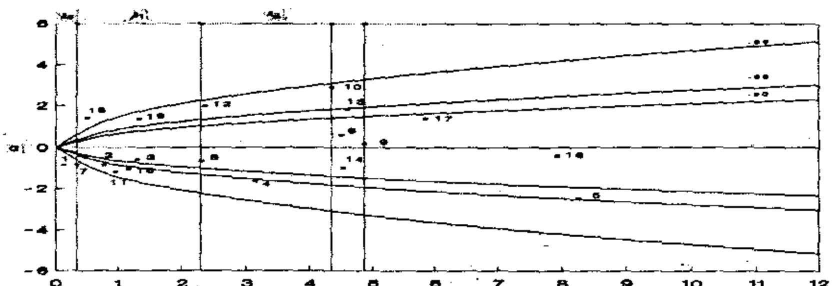

Fig 1:Stability distribution for all genotypes according to Tai's parameters.

Regression and correlation model

Estimates of correlation coefficient r in Table (6) scored low values being 0.307, 0.242, 0.332, 0.121, 0.334, 0.057, 0.294, 0.070, 0.323 and 0.067 for genotypes Giza 3, 943/1151/93, 1426/711/2000, 1556/914/2001, 1557/992/2001, 1423/653/2000, 1033/738/96, 1569/600/2002, 1617/817/2002 and 1557/930/2001, respectively. These insignificant values indicate that yields of these genotypes are not affected by changing environments and this relation is not strong. Also, this result clears that these genotypes were of poor response to the change of environmental conditions and consequently have a degree of stability. Table (6) also showed that the contribution of environments in each of the previous genotypes were 9.4%, 5.8%, 11%, 1.5%, 11.7%, 0.03%, 8.7%, 0.05%, 10.4% and 0.04%, with stability percentage equal to 90.6, 94.2, 89.0, 98.5, 88.3, 99.7, 91.3, 99.5, 89.6 and 99.6%, respectively. Lower estimates of R^2 and higher values of stability percentage ($1- R^2$) clear that contribution of the independent variable (environments) in the total variation of the dependent variable (genotypes yield) is not important indicating that the yield of the genotype is not affected by the environment. On the other hand, the contribution of environments in genotypes 1233/848/99, 1195/961/99, 1378/1157/99, 836/1121/92, 1557/1015/2001, 1564/530//2002, 1557/920/2001, 1005/654/95 and 1475/1162/2000 were 55.9%, 80.9%, 28.4%, 69.5%, 52.3%, 70%, 43.2%, 33.9% and 73%, respectively. Also, higher values of r corresponds to these genotypes were 0.748, 0.900, 0.533, 0.834, 0.723, 0.836, 0.657, 0.582 and 0.855, respectively, Table (6). This result shows that environmental conditions had a great effect on these genotypes and, in turn they are not stable. When R^2 value is insignificant the regression line represents the changing of yield according to changing of environments close to be parallel to the x-axis, indicating the stability of the genotype yield. Fig (2) clears that yield of genotypes had regression line close to be parallel to the x-axis (environments) indicating that these genotypes had stable yield. The average yield of each genotype did not significantly differ from the regression line with insignificant values of R^2 showing that regression line seems to be parallel to x-axis, indicating stability of the studied genotypes. On the other hand, Fig. (3) shows that the yield of each genotype changed according to changing environments of regression line and had significant value of R^2. Also the average yield of each genotype was significantly different through the regression line, which did not seem to be parallel to x-axis, indicating instability of studied genotypes.

Table 6. Mean performance, correlation coefficient (r), coefficient of determination (R^2%) and stability percentage (1-R^2%) as stability parameters for yield of studied faba bean genotypes.

Genotypes	Means	Statistics of regression model as stability parameters			
		r.	R^2 %	% Stability (1- R^2)	P - value.
Giza 3	7.380*	*.307 ns*	*.094 ns*	*90.6*	*.215*
943/1151/93	*9.386**	*.242 ns*	*.058 ns*	*94.2*	*.334*
1426/711/2000	*10.90***	*.332 ns*	*.110 ns*	*89.0*	*.179*
1556/914/2001	*8.493**	*.121 ns*	*.015 ns*	*98.5*	*.631*
1233/848/99	6.697	.748 s	.559 s	44.1	0.000
1195/961/99	7.424*	.900 s	.809 s	19.1	0.000
1557/992/2001	*11.22***	*.343 ns*	*.117 ns*	*88.3*	*.164*
1423/653/2000	*10.20***	*.057 ns*	*.003 ns*	*99.7*	*.823*
1378/1157/99	*10.42***	.533 s	.284 s	71.6	.023
836/1121/92	7.822*	.834 s	.695 s	30.5	.000
1033/738/96	*8.783**	*.294 ns*	*.087 ns*	*91.3*	*.236*
1557/1015/2001	7.879*	.723 s	.523 s	47.7	0.001
1564/530/2002	*8.761**	.836 s	.700 s	30.0	0.000
1569/600/2002	*8.644**	*.070 ns*	*.005 ns*	*99.5*	*.781*
1617/817/2002	*9.392***	*.323 ns*	*.104 ns*	*89.6*	*.191*
1557/930/2001	*9.313***	*.067 ns*	*.004 ns*	*99.6*	*.792*
1557/920/2001	7.711*	.657 s	.432 s	56.8	.003
1005/654/95	7.219*	.582 s	.339 s	66.1	.011
1475/1162/2000	7.286*	.855 s	.730 s	27.0	.000

Shadowy cells that bold face and italic line meaning that genotypes had stability percentage.

L.S.D. for genotypes = 0.464 and 0.627 at 5% and 1%, respectively.

*** Confidence Interval. (5%) 7.172 < 8.681 <10.192. ** Confidence Interval. (1%) 6.609 < 8.681 < 10.753.**

Significance of r or R^2 (s= significant, ns= not significant) means instability of genotype because its contribution of environments in genotype

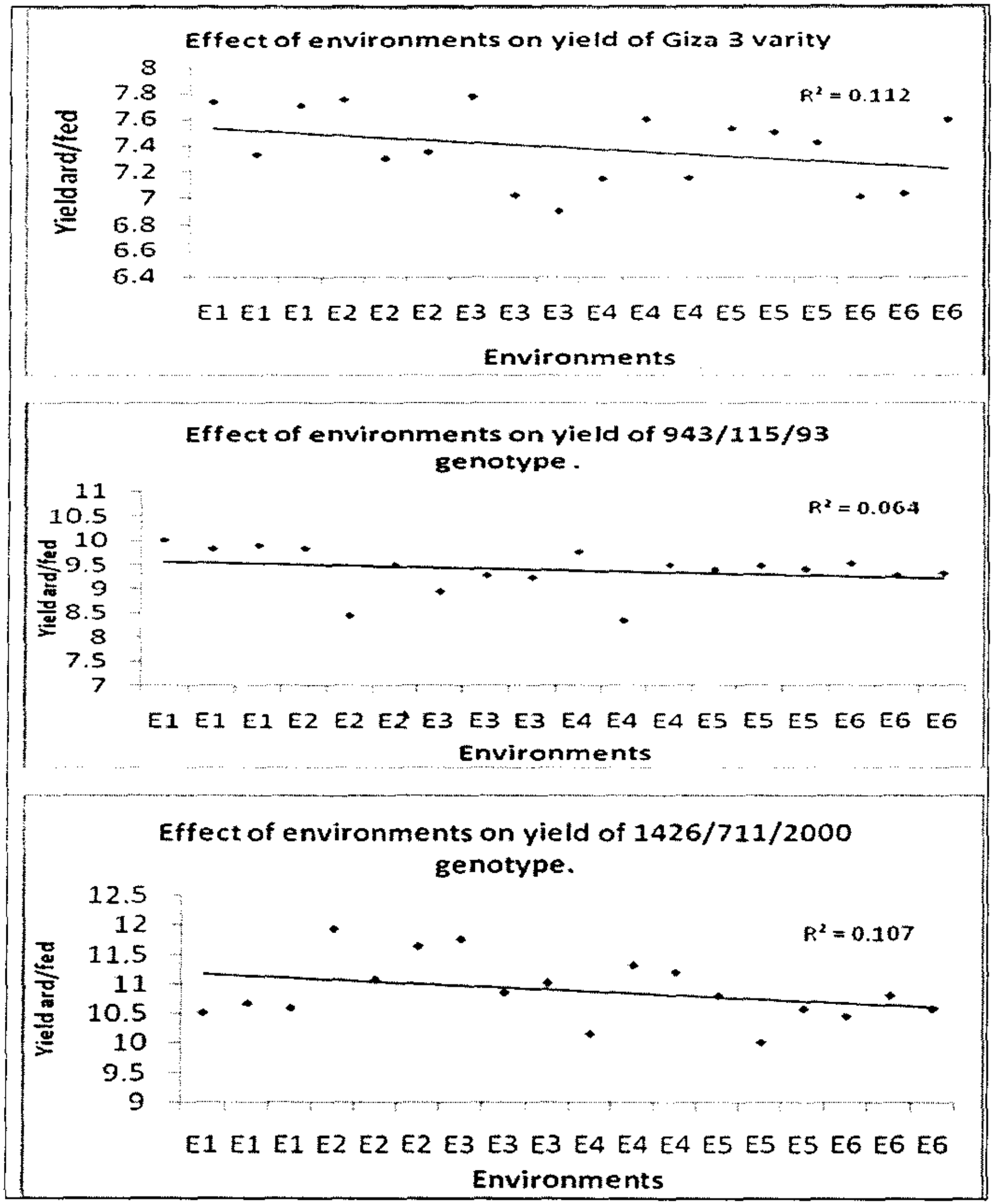

Fig. 2 a. Relation between yield of stable genotypes and six environments (Ei).

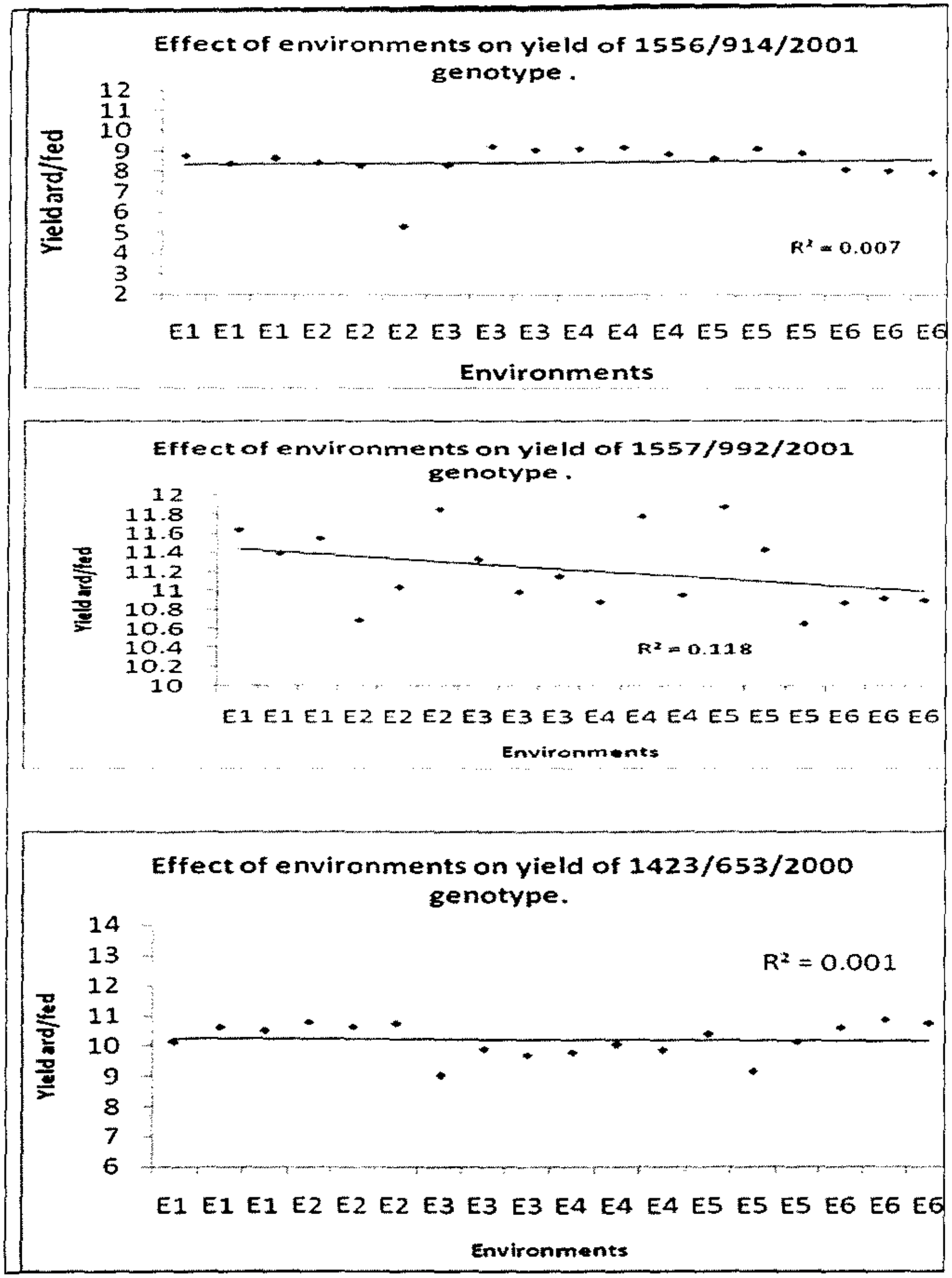

Fig. 2b. Relation between yield of stable genotypes and six environments (Ei).

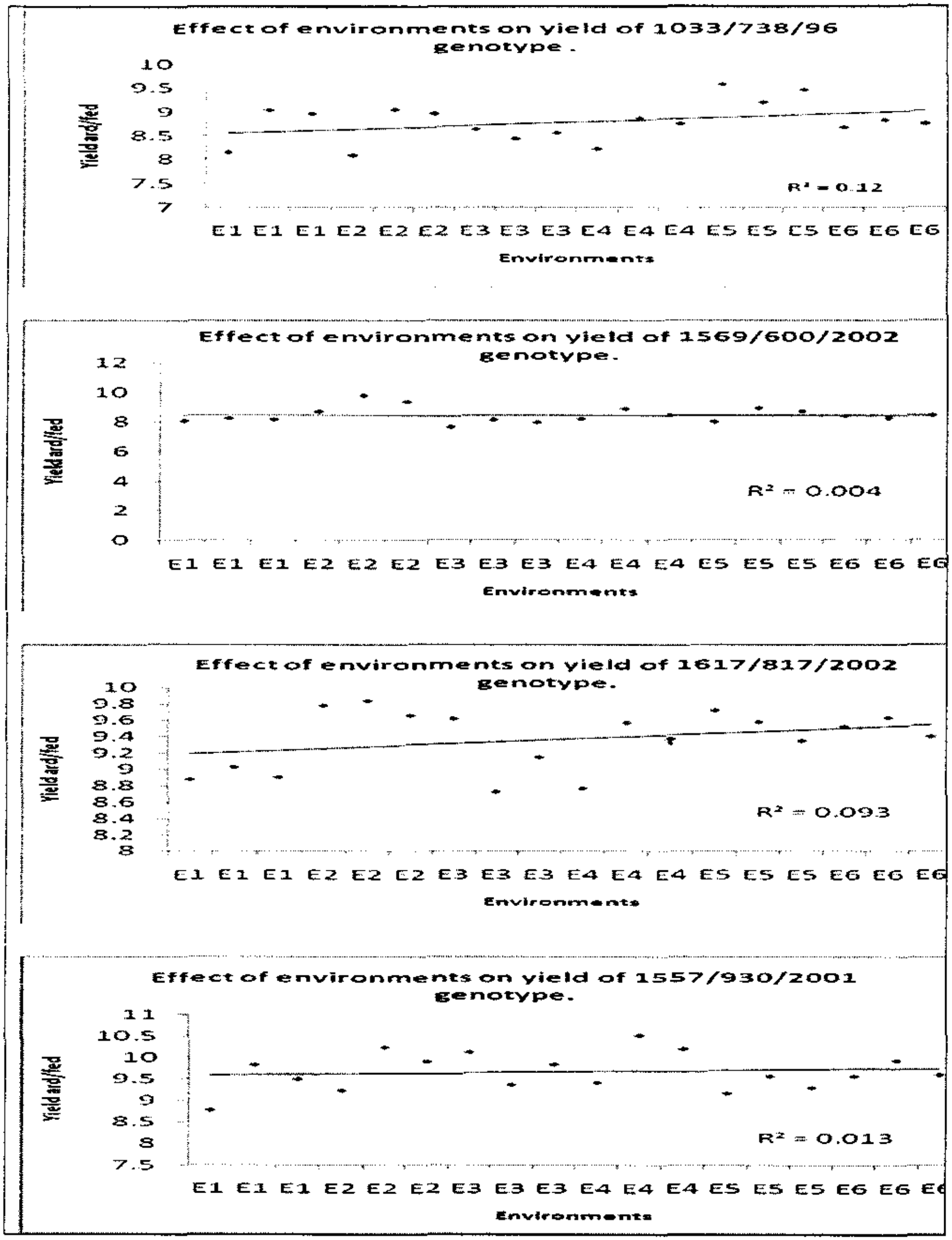

Fig. 2c. Relation between yield of stable genotypes and six environments (Ei).

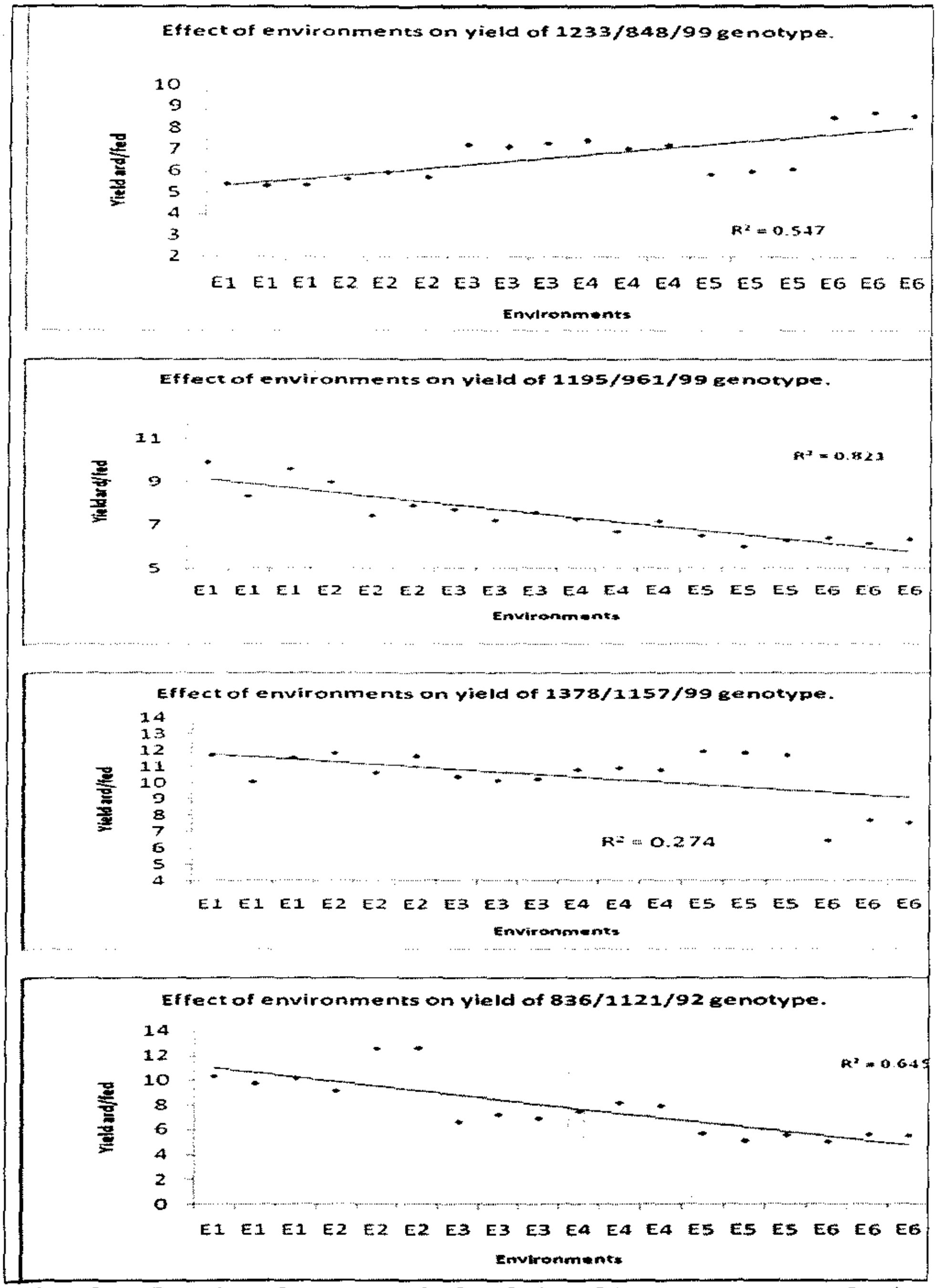

Fig. 3a. Relation between yield of instable genotypes and six environments (Ei).

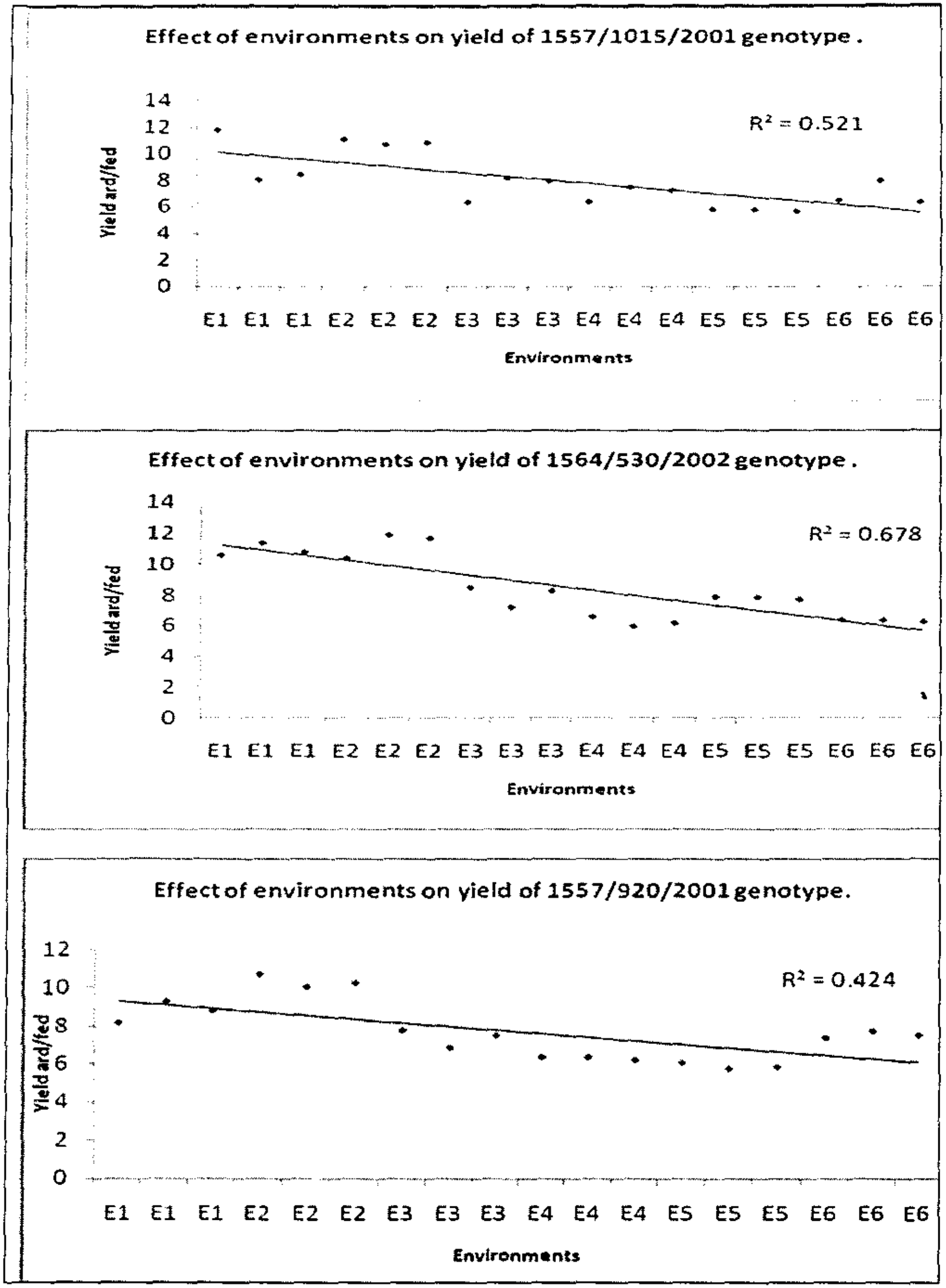

Fig. 3b. Relation between yield of instable genotypes and six environments (Ei).

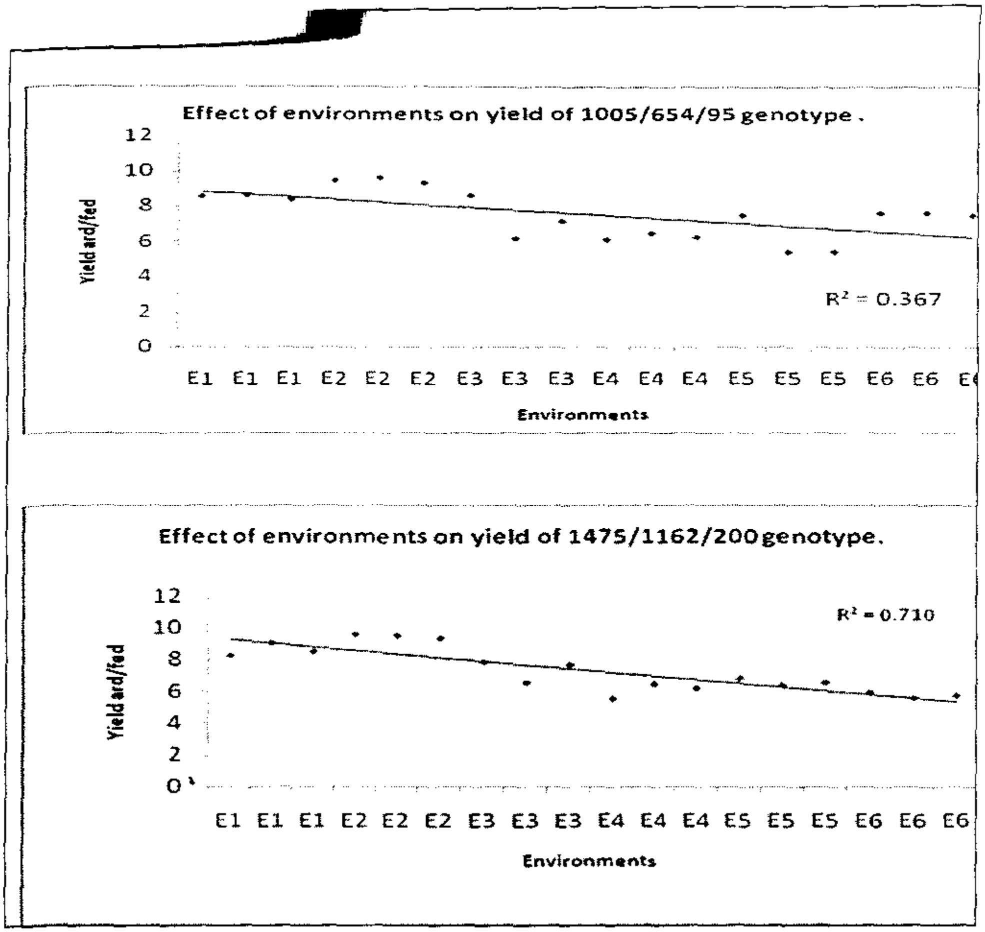

Fig. 3c. Relation between yield of instable genotypes and six environments (Ei).

Generally, results showed that genotypes 11, 8 and 10 had stable yield according to statistics of Eberhart and Russell, Tai`s and regression and correlation model, respectively. Genotypes 943/1151/93, 1426/711/2000, 1557/992/2001, 1033/738/96, and 1617/817/2002 showed yield stability using above mentioned stability methods.

Therefore, the five mentioned genotypes could be recommended to be as commercial stable of high yielding cultivars and /or incorporated to be as breeding stocks in any future breeding program aiming for producing high yielding lines for seed yield of faba bean.

Results cleared that simple regression method exhibited the genotypes of stable yield according to the other two methods, in addition to the simplicity of calculations of its parameters compared with Eberhart and Russell and Tai`s methods.

Statistical performance evaluation criterion

Results of Chi square test for comparison between simple regression and correlation model as stability parameters with Eberhart and Russell and Tai's methods are presented in Table (7). The results showed clearly that there was similar trend of the studied methods. Already, this agreement between the studied methods lends additional support to the validity of these methods and to use them in the variety trials of faba been and other crops especially when these trials faced hard conditions. The results of Chi square test between the studied methods were not significant with P value of 0.612. This means that the three methods are similar in their results.

Table 7. Results of Chi square test between the studied methods

Methods	Sources	Stability cases	
	Genotypes %	Stable	Unstable
Eberhart & Ru.	Count	11	8
	% of row	57.89%	42.11%
	% of column	37.93%	28.57%
Simple reg. & Cor.	Count	10	9
	% of row	52.63%	47.37%
	% of column	34.48%	32.14%
Tai	Count	8	11
	% of row	42.11%	57.89%
	% of column	27.59%	39.29%
Over all methods	Count	29	28
	Total percentage	50.83%	42.12%
Total percentage %		100%	100%

Chi-Square = 0.983 DF = 2 P value = 0.612

The previous results showed clearly the simplicity of simple regression and correlation model in calculating stability statistics in addition to estimation of the degree of stability as a percentage using the value of $1-R^2$. Also, this method could be used to estimate the stability even for one genotype unlike the other two methods.

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أحصاءات نموذج الانحدار والارتباط لتقدير الثبات الوراثى لتسعة عشر تركيبا وراثيا من الفول البلدى

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لتحسين صفة المحصول العالي للاصناف وتحسين المقاومة الحيوية والتحمل للظروف المناخية والبيئية المتباينة ولزيادة تاقلم التراكيب الوراثية التى من الممكن ان تنجح زراعتها فى نطاق مناخي واسع وللحكم الدقيق على الثبات الوراثى لتلك التراكيب والمفاضلة بينها وللكشف عن سهولة وبساطة استخدام المعالم الاحصائية لنموذج الانحدار والارتباط للدلالة على ثبات تلك التراكيب الوراثية على اعتبار البيئات متغيرا وصفيا وذلك خلافا لما يتم فى طريقتى Eberhart and Russell (1966) لحساب الثبات المظهرى وطريقة Tai (1971) لحساب الثبات الوراثى وذلك بهدف استخدام المعلومات المتحصل عليها من هذه التقديرات لتوجيه برامج التربية وقد تم مقارنة النتائج المتحصل عليها لطرق الثبات تحت الدراسة باستخدا اختبار مربع كاى.

ولتحقيق الاهداف السابقة تم اجراء هذه الدراسة فى منطقة النوبارية كمنطقة مازالت تعتبر من الاراضى الجديدة نظرا لاستمرار عمليات استصلاح الاراضى فيها ومن حولها لتكون منطقة رئيسية لزراعة الفول البلدى حيث تم زراعة ١٩ تركيبا وراثيا فى ميعادين هما ١٥ اكتوبر ، ١٥ نوفمبر وذلك خلال ثلاث سنوات متتالية هى ٢٠٠٤/٢٠٠٥ ، ٢٠٠٥/٢٠٠٦ ، ٢٠٠٦/٢٠٠٧ وذلك فى تصميم القطاعات الكاملة العشوائية فى اربع مكررات حيث اشتملت التجربة على ٦ بيئات وكانت مساحة القطعة التجريبية ١٠,٨ م^2 بزراعة ٦ خطوط وتم تطبيق كل التوصيات الخاصة بمحصول الفول البلدى وعند تمام النضج تم تقدير صفة المحصول بالاردب من الخطوط الثلاث الداخلية لكل قطعة وقد لخصت النتائج كما يلى:

١ – قوة معنوية العلاقة الخطية للتاثير البيئى تشير الى ان تاثير البيئات على التراكيب الوراثية والذى يختلف من تركيب الى اخر وانعكس ذلك على متوسطات تلك التراكيب حيث كانت اعلى المتوسطات هى ١١,٢٢ ،١٠,٤٢، ١٠,٢٢ ، ٩,٣٩٢ ، ٩,٣٨٦ ، ٩,٣١٣ اردب للفدان وذلك لكل من التراكيب الوراثية 1557/992/2001 ، 1378/1157/99 ، 1423/653/200 ، 1617/817/2002 ، 943/1151/93 ، 1557/930/2001 على التوالى.

٢- باستخدام طريقة قياس الثبات المظهرى Eberhart and Russell حققت التراكيب الوراثية 943/1151/93 ، 1426/711/2000 ، 1556/914/2001 ، 1233/848/99 ، 1557/992/2001 ، 1423/653/2000 ، 1378/1157/99 ، 1033/738/96 ، 1569/600/2002 ، 1617/817/2002 ، 1557/930/2001 ثباتا مظهريا من خلال قياسات الثبات المظهرى خلال البيئات المختبرة.

٣- باستخدام طريقة الثبات الوراثى Tai`s حققت التراكيب الوراثية Giza 3 ، 943/1151/93 ، 1426/711/2000 ، 1426/711/2000 ، 1033/738/96 ، 1005/654/95 ، 1617/817/2002 ثباتا وراثيا اعلى من المتوسط ($\alpha < 0$ and $\lambda = 1$) على الترتيب كما حقق التركيبان 1005/654/95 ، 1475/1162/2000 ثباتا وراثيا اقل من المتوسط ($\alpha > 0$ and $\lambda = 1$) .

٤- باستخدام معالم نموذج الانحدار والارتباط ونتيجة لعدم معنوية وانخفاض قيمة معامل الارتباط (r) وانخفاض قيمة المساهمة النسبية (r^2) للعامل المستقل (البيئات) فى العامل المتاثر (المحصول) وكذلك عند حساب النسبة المئوية للثبات لكل تركيب وراثى ($1- r^2$ %) تبين ان التراكيب Giza 3 ، 943/1151/93 ، 1426/711/2000 ، 1556/914/2001 ، 1557/992/2001 ، 1423/653/2000 ، 1033/738/96 ، 1569/600/2002 ، 1617/817/2002 ، 1557/930/2001 لها استجابة ضئيلة جدا للتغيرات البيئية والمناخية وانها كانت تتمتع بنسب ثبات ٩٦,٦ ، ٩٤,٢ ، ٨٩,٠ ، ٩٨,٥ ، ٨٨,٣ ، ٩٩,٧ ، ٩١,٣ ، ٩٩,٥ ، ٨٩,٦ ، ٩٩,٦ % على التوالى مما يوضح قدرة عالية على الثبات لهذة التراكيب.

وبصفة عامة اوضحت النتائج ان الطرق الثلاثة:

Eberhart and Russell, regression and correlation model and Tai اكدت ثبات ١٠ ، ١١ ، ٨ تركيبا وراثيا على الترتيب من مجموع ١٩ تركيبا وراثيا مختبرا وان المعالم الاحصائية لنموذج الانحدار والارتباط قد تطابقت نتائجها مع الطريقتين الاخريين فى اظهار ثبات التراكيب 943/1151/93 ، 1426/711/2000 ، 1557/992/2001 ، 1033/738/96 ، 1617/817/2002 وقد اختلفت طريق الانحدار مع طريقة Eberhart and Russell فى اظهار ثبات الصنف Giza 3 كما اختلفت مع طريقة Tai`s فى اظهار ثبات التراكيب 1556/914/2001 ، 1423/653/2000 ، 1569/600/2002 ، 1557/930/2001

وقد تم تقييم نتائج طريقة الانحدار والارتباط بمقارنة نتائجتها مع نتائج طريقتى Eberhart and Russell and Tai باستخدام اختبار مربع كاى وقد وافقت نتائجها نتائج الطريقتين دون اى اختلاف معنوى معهما اتضح من النتائج ان الثلاث طرق تكاد تكون نتائجها متماثلة ومما سبق يتاكد بساطة وسهولة استخدام المعالم الاحصائية لنموذج الانحدار والارتباط للحكم على ثبات التراكيب الوراثية علاوة على معرفة نسبة اسهام البينا ت والنسبة المئوية للثبات لاى من التراكيب الوراثية المختبرة.