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GENOTYPE X ENVIRONMENT INTERACTION AND INTERRELATIONSHIP AMONG SOME STABILITY STATISTICS IN SESAME (*Sesamum indicum* L.)

Awaad, H. A. * and A. A. Aly**
***Agron. Dept., Fac. Agric., Zagazig Univ., Zagazig, Egypt.**
****Agron. Dept., Fac. Agric., Suez Canal Univ., Ismailia, Egypt.**

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ABSTRACT: Twelve sesame genotypes were evaluated for seed yield/fed., seed oil content, fruiting zone length, number of branches/plant, number of capsules/ plant, number of seeds/ capsule and 1000-seed weight under twelve different environments i.e. three plant population densities (84000, 112000 and 168000 plants/fed.), two diverse locations i.e. Zagazig region (clay soil) and Khattara region (sandy soil) and two successive seasons (1999 and 2000). Stability was assessed using regression coefficient (bi), mean squares of deviation from regression (S^2di), ecovalence (Wi) and coefficient of determination (r^2i). Pooled analyses of variance showed that the factors under study contributed 62.25 % for plant population densities(D), 13.11% genotypes(G), 12.64% locations(L) and 11.72% for years(Y) from the total variance of sesame seed yield. There were highly significant differences among sesame genotypes, years, locations and plant population densities as well as first, second and third order interactions for all studied characters, except (L), (Y x D) and (L x D) for seed oil content as well as (Yx L) and (L x D) for 1000-seed weight which were insignificant.

Stability analysis indicated that, genotype x environment (GxE) "linear" was significant for the studied characters. G x E "linear" was also significant when tested against pooled deviation in all characters, except number of seeds /capsule.

It was evident that Giza 25, Mutant 48 and B-11 were adapted for favorable environments for seed yield/fed., whereas Local Sharkia could be grown under the less favorable environment of Khattara region.

The most desired and stable genotypes were; Giza 32 for seed yield/fed., fruiting zone length and 1000-seed weight; Mutant 8 for seed yield/fed. and number of capsules/plant ; Mutant 48 for seed oil content and number of seeds/ capsule and F5 generation for 1000-seed weight.

Positive and significant relationship was recorded between the mean ($\bar{X}$) number of seeds/capsule and (r^2i). The same association was detected between (S^2di) and (Wi) for fruiting zone length, number of branches/plant, number of capsules/plant and number of seeds/capsule, suggesting that any of them should be a satisfactory parameter for measuring stability.

Negative and significant correlation was recorded between $(\bar{X}i)$ and each of; (Wi) for seed yield/fed., number of capsules/plant and 1000-seed weight and with (S^2di) for number of capsules/plant, indicating that the high performing genotypes tend to be classed as less stable and vice versa, but no association was observed between the mean yield and each of (bi), (S^2di) and (r^2i), suggesting that selection for high yield and phenotypic stability was possible and could be done separately. The statistic (r^2i) was negatively correlated with each of; (S^2di) and (Wi) for number of capsules/plant and /or number of seeds/capsule and 1000-seed weight, showing inverse relationship of (r^2i) rather than (S^2di) and (Wi) in measuring stability.

INTRODUCTION

Breeding for high yielding and stable varieties has always been an important objective of all plant breeding programs. Seed yield is a complex character and sensitive to environmental changes. Plant breeder aim to produce high yielding and stable varieties. Genotype-environment interactions are often described as inconsistent differences among genotypes from one environment to another, especially when varieties are compared over a number of environments. The relative ranking of genotype usually differs as a result of edaphic and climatic variation between locations, and large G x E interactions led to reduce progress from selection (Comstock and Moll, 1963). The analysis of variance procedure is useful for estimating the magnitude of G x E interaction, but fails to provide information on the contribution of individual genotypes to environment. To obtain reliable estimates concerning the response of individual genotypes across a range of environments, several methods of stability analyses have been developed as shown by Wricke (1962), Eberhart and Russell (1966) and Pinthus (1973).

Phenotypic stability of yield performance and some attributes of sesame genotypes have been assessed by many investigators. In this respect, significant G x E interaction between genotype x location and genotype x sowing methods were detected for seed yield and its components by El-Serogy *et al.* (1997). Also highly significant interaction between varieties x row or hill spacing (Basha, 1998) and genotype x plant population density (Awaad and Basha, 2000) were recorded for seed and oil yields/fed. and some attributes.

Moreover, significant differences due to environments (E), genotypes (G) and their interactions with years (Y), locations (L) and (G x Y x L) with a major importance of the linear component for seed yield, its components and oil percentage have been reported by Mahdy *et al.* (1988), Suresh *et al.* (1991) , Ragab *et al.* (1995) and Ragab and Kassem (2002).

The present investigation was conducted to evaluate seed yield potential and some related characters of twelve sesame genotypes under twelve environments (3 plant population densities x 2 locations x 2 years) and determine the nature of G x E interaction as well as to assess the phenotypic stability of the tested genotypes.

MATERIALS AND METHODS

Two repeated field experiments were carried out to evaluate twelve local and introduced sesame genotypes (Table 1) under twelve environments. These environments are the combinations between two locations, i.e. Experimental Farm of Zagazig region representing clay soil and Khattara Farm representing sandy soil under three plant population densities i.e., 50 x 20cm (84000 plants/fed.), 50 x 15 cm (112000 plants/fed.) and 50 x 10 cm (168000 plants/fed.) during two successive summer seasons of 1999 and 2000. A randomized complete block design with three replications was used. The materials were sown on May 2o and 21 in Zagazig and Khattara in the first season and May 25 and 26 in the second, respectively. Plot area was 9 m^2 and included 6 rows of 3 m long and 50 cm apart. After full emergence the seedlings were thinned to secure two plants/hill. The recommended cultural practices for sesame production under each location were applied. At maturity, a sample of 10 random guarded plants was taken from each plot to determine, fruiting zone length, number of branches/plant, number of capsules/plant and number of seeds/ capsule. Seed yield/fed. was recorded on plot mean basis and 1000-seed weight was estimated. Seed oil content was determined using Soxhlet technique according to A.O.A.C(1984). The obtained data were subjected to the conventional analysis of variance according to Snedecor and Cochran(1967). The combined analyses of variance over environments were conducted as outlined by Allard (1960). Stability statistics used were Wi of Wricke (1962), $\bar{X}$, bi and S^2di of Eberhart and Russell (1966) and coefficient of determination (r^2i) of Pinthus (1973).

Table (1): Name and source of the studied sesame genotypes.

No.	Genotype	Source
1	**Giza 25**	Agric. Res. Center., Giza, Egypt.
2	**Giza 32**	Agric. Res. Center., Giza, Egypt.
3	**Local Sharkia**	Belbies, Sharkia Province, Egypt.
4	**Mutant 8**	Fac. of Agric., Cairo Univ., Egypt.
5	**Mutant 48**	Fac. of Agric., Cairo Univ., Egypt.
6	**B-10**	Oil Crop Res. Sec., F.C.R.I., ARC.
7	**B-11**	Oil Crop Res. Sec., F.C.R.I., ARC.
8	**B-35**	Oil Crop Res. Sec., F.C.R.I., ARC.
9	**Line 5/91**	Agric. Res. Center., Giza, Egypt.
10	**F5 generation**	Oil Crop Res. Sec., A.R.C., Giza, Egypt.
11	**Adnan hybrid**	Agric. Res. Center., Giza, Egypt.
12	**Venezuela 7**	Introduced from Venezuela.

RESULTS AND DISCUSSION

Components of genotype-environment interaction:

Pooled analyses of variance for sesame genotypes over environments (Table 2) provide evidence for highly significant environmental effects on the studied characters. Partitioning the environmental effects into years (Y), locations (L) and plant population densities (D), and their interactions, revealed that they were significant in all the studied characters, except(L), (Y x D) and (L x D) for seed oil content as well as (Y x L) and (LxD) for 1000-seed weight which were insignificant. The insignificant effect of these items, revealed that the combination of environmental components (Y),(L) and (D) were sufficient to obtain reliable information about the studied genotypes regarding seed oil content and 1000-seed weight. The factors under study accounted, generally for 62.25% (plant population densities), 13.11% (genotypes); 12.64% (locations) and 11.72% (years) from the total variance of sesame seed yield. The significant effects of environments on yield and its contributing characters obtained herein are in

Table (2): Pooled analyses of variance for seed yield and its contributing characters of 12 sesame genotypes grown under 3 plant population densities in two seasons and two locations.

Source of variance	d.f	Seed yield (ard./fad)	Seed oil content (%)	Fruiting zone length	No. of branches /plant	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight
Years (Y)	1	0.871**	7.857*	14489.823**	2.654*	16088.266**	1657.690**	0.921**
Locations (L)	1	1.271**	0.704	1721.925**	106.446**	98684.927**	2504.570**	0.553**
Year x Location (YxL)	1	12.040**	15.618**	833.000**	43.092**	12706.762**	1640.185**	0.004
Reps in (YxL) combined	8	0.014	1.021	4.938	0.424	13.890*	15.591**	0.013
Plant population density (D)	2	45.380**	10.413**	6599.887**	48.259**	21600.494**	5314.034**	15.684**
YxD	2	0.092*	1.714	2530.931**	11.0411**	1283.385**	1029.519**	0.079*
LxD	2	0.065*	0.148	184.004**	2.316**	305.643**	268.894**	0.038
Y X L X D	2	2.360**	3.667**	214.955**	2.534**	1136.226**	799.025**	0.149**
Genotypes (G)	11	7.320**	89.878**	879.767**	9.391**	988.903**	431.073**	1.764**
G X Y	11	0.873**	13.799**	1780.998**	3.112**	1544.238**	130.169**	0.146**
G X L	11	1.894**	6.706**	308.412**	6.205**	1201.394**	205.837**	0.135**
G X D	22	0.725**	17.838**	381.589**	1.285**	257.259**	51.736**	0.399**
G X Y X L	11	0.574**	3.987**	501.201**	6.096**	1150.757**	145.034**	0.486**
G X Y X D	22	1.031**	2.245**	429.693**	1.369**	444.486**	36.692**	0.112**
G X L X D	22	0.433**	2.739**	47.424**	1.568**	404.389**	78.404**	0.107**
G X Y X L X D	22	0.663**	2.096**	69.528**	1.058**	539.903**	32.575**	0.132**
Error	280	0.016	0.587	3.052	0.228	5.894	1.405	0.023

*,**Significant at the 5% and 1% probability levels, respectively.

agreement with those detected by El-Serogy *et al.* (1997), Basha (1998) and Awaad and Basha (2000).

Significant differences were obtained for genotypes (G) respecting the studied characters overall environments. A similar finding was obtained by Ragab and Kassem (2002).

With respect to first order interactions of genotypes with each of years, locations and plant population densities, the results indicated that they were significant in all characters. Also, highly significant second (G x Y x L), (G x Y x D) and (G x L x D) as well as third (G x Y x L x D) order interactions were noticed for sesame seed yield and its contributing characters, implying different response of genotypes over year, location and plant population density combinations, also providing evidence for the necessity of testing genotypes in multiple environments. A similar conclusion was reported by Ragab *et al.* (1995) and Awaad and Basha (2000).

Stability analysis:

Stability analysis of variance of seed yield and its contributing characters (Table 3), provides evidence for highly significant mean squares of genotypes for all studied characters, suggesting that sesame genotypes were genetically different for genes controlling these characters. Highly significant environment + (genotype x environment) component was recorded for all characters. Also, highly significant effect of environments (linear) was reported, indicating that the studied characters were highly influenced by the combination of environmental components (years, locations and plant population densities).

Genotype x environment (linear) item was highly significant for the studied characters, suggesting that the tested sesame genotypes differed in their response to environments. The significance of the linear component gave the chance to continue the estimation of the stability parameters. In addition to the significance of the mean squares of G x E interaction (linear), the pooled deviation item was also highly significant, suggesting differential response of genotypes to the various environments. Significant G x E interaction (linear) against the pooled deviation was observed for the studied characters, except

Table (3): Mean squares of stability analysis of seed yield and its contributing characters in sesame.

Source	Mean squares							
	d.f	Seed yield/ fed.	Seed oil content (%)	Fruiting zone length	No. of branches/ plant	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight
Genotypes	11	7.320**	89.878**	879.767**	9.391**	988.903**	431.073**	1.764**
Environment +(genotype x environment)	132	0.554**	2.206**	215.823**	1.439**	1235.304**	76.662**	0.725**
Environment (linear)	1	44.624**	18.630**	12151.120**	94.452**	81364.359**	6884.820**	10.393**
Genotype x environment (linear)	11	0.584**	3.693**	296.939**	2.012**	2489.942**	32.814**	1.271**
Pooled deviation	120	0.184*	1.933**	108.927**	0.612*	452.554**	23.946**	0.595**
Pooled error	264	0.014	0.768	3.223	0.336	6.820	1.704	0.019

number of seeds/capsule, suggesting that differences in linear response among genotypes across environments had occurred, and the linear regression and the deviation from linearity were the main components for differences in stability for most studied characters among genotypes. In this respect, G x E interaction was found to be highly significant for seed yield and some related characters (Mahdy *et al.*, 1988; Suresh *et al.*, 1991; Ragab *et al.*, 1995 and John *et al.*, 2001).

The main objective of the majority of sesame breeding programs is to select genotypes, which perform consistently over a wide range of environments or specific environment. It is of importance for the breeder to quantify and estimate the G x E component and to characterize each genotype according to its environmental response. The analysis of variance provide information about the existence of G x E interaction, but fails to provide information about the individual response of the genotype to certain environment, therefore the stability parameters for each genotype were performed and given in Table (4).

According to Eberhart and Russell (1966) method, the stable genotype is the one having high mean values over environments, with (b) value equal 1 and deviation from regression as low as possible ($S^2d = 0$).

Also, Breese (1969) and Samuel *et al.* (1970), Paroda and Hays (1971) and Jatasra and Paroda (1979) emphasized that linear regression "b" could simply be regarded as a measure of response of a particular genotype, whereas the deviation around the regression line "S^2d" is the most suitable measure of stability, genotype with a lowest "S^2d" being the most stable and vice versa. As well Breese (1969) reported that genotypes with regression coefficients greater than one would be adapted to more favorable environment, while those with coefficients less than one would be relatively better adapted to less favorable growing condition. In the present study, the regression coefficients (Table 4) varied from 0.429 (Venezuela 7) to 1.639 (Mutant 48) for seed yield/ fed.;-2.084 (Venezuela 7) to 3.478 (Line 5/91) for seed oil content; 0.031 (Line 5/91) to 1.780 (B-10) for fruiting zone length; 0.133(B-35) to 2.286(Venezuela 7) for number of branches/plant; 0.380 (Giza 32) to 2.770 (Giza 25) for number of capsules/plant; 0.487 (Venezuela 7) to 1.368 (Adnan hybrid) for number of seeds/capsule as well as from 0.312 (Venezuela 7) to 4.637 (Mutant 8) for 1000-seed weight.

It is evident that "b" value deviated significantly from unity (b>1) in genotypes Giza 25, Mutant 48 and B-11 for seed yield/fed.; Giza 32, B-35 and Line 5/91 for seed oil content; B-10 for fruiting zone length; Venezuela 7 for number of branches/plant; Giza 25 for number of capsules/plant; Adnan hybrid for number of seeds/capsule as well as Mutant 8 for 1000-seed weight (Figs. 1-7), indicating that these genotypes were highly adapted to favorable environments. Otherwise, the "b" value deviated significantly from unity and was less than one (b<1) in genotypes, Local Sharkia and Venezuela 7 (seed yield/fed.); Giza 25 and Line 5/91 (fruiting zone length); B-35 (number of branches/plant) ; Giza 32 (number of capsules/plant) as well as Venezuela 7 for number of seeds/capsule and 1000-seed weight, which appeared to be more adapted to unfavorable environments. The negative "b" values have been recorded in Local Sharkia, Adnan hybrid and Venezuela 7 for seed oil content, provide evidence that these genotypes may be grown under poor environments (Singh and Chaudhary, 1985).

The response to environments as measured by the regression technique was found to be highly heritable and controlled by genes which are predominantly additive in action (Hayward and Lawrence, 1970 and Samuel *et al.*, 1970). In the case of the insignificant "b" value, the deviation from regression "S^2d" is considered the most appropriate criterion for measuring phenotypic stability in an agronomic sense, because this statistic measures predictability of genotypic reaction to various environments (Becker *et al.*, 1982).

Considering the deviation from regression "S^2d" (Table 4), it can be seen that out of the studied twelve sesame genotypes, seven (No. 2, 4, 6, 7, 9, 10 and 12) showed stability for seed yield/fed.; four (No.3, 5, 10 and 12) for seed oil content; five genotypes (No. 2, 3, 4, 5 and 7) for fruiting zone length; five (No. 1,3,6,7 and 11) for number of branches/plant; nine (No. 1, 2, 4, 5, 6, 7, 10, 11 and 12) for number of capsules/plant; two (No. 5 and 6) for number of seeds/capsule as well as all genotypes, except No. 4 for 1000-seed weight. Since their "S^2d" values were very small and not deviated significantly from zero. However, the remaining genotypes were sensitive to the environmental changes. In this regard, Guilan Yue *et al.* (1990) reported that the deviation from regression seemed to be very important for estimating the stability.

Stability parameter, termed ecovalence (Wi) was proposed by Wricke (1962) which measures the contribution of a genotype to the GxE interactions; a genotype with Wi=0 is regarded as stable. , and consequently stars corresponding to (Wi) indicate significant unstable performance across environments (Becker and Leon, 1988). Thus, the most stable sesame genotypes were Giza 32, Local Sharkia, Mutant 8, Mutant 48, B-10 and Line 5/91 for seed yield/fed.; Giza 25, Local Sharkia, Mutant 48, B-10, B-35 and F5 generation for seed oil content; Giza 32, Local Sharkia and Mutant 8 for fruiting zone length; Local Sharkia, Mutant 8, B-10, Line 5/91, F5 generation and Adnan hybrid for number of branches/plant; Mutant 8, B-10, Adnan hybrid and Venezuela 7 for number of capsules/plant; Mutant 48, B-10 and Line 5/91 for number of seeds/capsule as well as all genotypes, except Giza 25 , Mutant 8, Adnan hybrid and Venezuela 7 for 1000-seed weight (Table 4).

The coefficient of determination (r^2i) as a measure of the predictability of the estimated

Table (4): Stability parameters for seed yield and its contributing characters of 12 sesame genotypes grown under 12 environments.

Character	Seed yield (ard. /fed.)					Seed oil content (%)					Fruiting zone length (cm)					No. of branches/plant				
Genotype	$\bar{X}i$	bi	$S^{2}di$	Wi	r^2	$\bar{X}i$	bi	$S^{2}di$	Wi	r^2	$\bar{X}i$	bi	$S^{2}di$	Wi	r^2	$\bar{X}i$	bi	$S^{2}di$	Wi	r^2
1) Giza 25	2.987	1.606*	2.641*	0.674*	0.504*	48.376	0.509	1.185**	0.771	0.338	73.719	0.234*	89.422**	41.430**	0.450	3.219	0.974	0.243	0.464*	0.663**
2) Giza 32	3.124	0.998	0.439	0.201	0.664*	51.533	2.207*	1.840**	8.173*	0.513*	86.514	1.029	4.247	2.650	0.644*	2.886	0.924	0.552**	2.232**	0.135
3) Local Sharkia	3.076	0.575*	2.189**	0.138	0.403	49.005	-0.526	0.982	0.001	0.891**	74.931	1.438	3.403	1.809	0.432	3.728	0.923	0.054	0.083	0.844**
4) Mutant 8	3.652	0.684	0.594	0.024	0.788**	52.290	0.839	2.278**	3.466*	0.230	83.781	0.673	3.742	0.172	0.069	3.133	1.207	0.480**	0.299	0.333
5) Mutant 48	3.349	1.639**	1.517**	0.102	0.685*	50.103	0.711	0.056	0.223	0.800**	78.083	1.001	3.137	5.841*	0.983**	3.389	0.881	0.495**	0.408*	0.521*
6) B-10	2.733	0.738	0.312	0.008	0.925**	49.568	1.796	1.629**	0.196	0.633*	77.630	1.780*	24.317**	10.014**	0.712*	3.369	1.066	0.010	0.121	0.836**
7) B-11	2.984	1.508*	0.471	0.731*	0.736**	47.473	1.269	1.962**	1.852*	0.387	80.183	1.224	4.267	6.047*	0.809*	2.600	0.658	0.212	0.537*	0.668**
8) B-35	2.670	1.070	1.801**	0.458*	0.460	49.245	2.761*	2.844**	0.189	0.573*	83.939	0.649	124.671**	11.813**	0.428	2.511	0.133**	0.715**	0.773*	0.264
9) Line 5/91	2.919	1.014	0.052	0.099	0.483*	49.123	3.478**	3.841**	4.002*	0.619*	64.892	0.031**	9.470**	4.104*	0.535	3.531	1.359	1.296**	1.085	0.691**
10) F5 generation	3.159	1.018	0.531	0.572*	0.775**	48.943	1.510	0.720	0.078	0.983**	71.256	1.170	9.763**	21.860**	0.568*	4.019	0.773	0.317*	0.040	0.634**
11) Adnan hybrid	2.169	0.658	1.341**	1.501**	0.793**	46.476	-0.490	1.899**	6.492*	0.230	76.769	0.866	5.013*	6.937*	0.839**	3.878	0.815	0.293	0.021	0.856**
12) Venezuela 7	2.033	0.429*	0.223	0.511*	0.667*	46.068	-2.084	0.483	3.334*	0.678*	79.244	1.204	8.155**	7.034*	0.314	4.600	2.286**	1.281**	4.326**	0.613*
Grand mean	2.905					49.017					77.578					3.405				
L.S.D.	0.572					1.126					8.452					0.633				

Sesame ardab=120 kg.
$P^{*}= 0.05$
$P^{**}= 0.01$

Table: (4) continue

Character	No. of capsules/plant					No. of seeds/capsule					1000-seed weight (g)				
Genotype	$\bar{X}i$	bi	S^2di	Wi	r^2_i	$\bar{X}i$	bi	S^2di	Wi	r^2_i	$\bar{X}i$	bi	S^2di	Wi	r^2_i
1) Giza 25	84.794	2.770**	4.285	9.512*	0.654*	42.922	0.807	7.658**	7.817*	0.779*	3.513	0.433	0.527	0.288*	0.641*
2) Giza 32	77.194*	0.380**	7.042	8.502*	0.889**	37.867	0.953	40.731**	9.269*	0.225	4.299	0.939	-0.607	0.001	0.757**
3) Local Sharkia	72.653	1.047	13.258**	37.627**	0.458*	40.526	0.824	3.199**	8.270*	0.410*	3.752	0.628	0.544	0.015	0.880**
4) Mutant 8	80.906	0.745	1.120	6.290	0.668*	46.609	0.968	6.568**	6.843*	0.628*	4.356	4.637**	5.204**	0.128*	0.403
5) Mutant 48	81.444	1.223	12.019	17.488*	0.487*	45.658	1.039	0.514	0.536	0.852**	3.888	1.769	0.455	0.015	0.955**
6) B-10	73.139	0.665	4.021	8.103	0.783**	42.803	1.019	0.508	2.987	0.862**	3.870	0.343	0.574	0.096	0.973**
7) B-11	63.933	0.5s99	7.015	18.183*	0.433	41.903	1.057	17.301**	15.453*	0.721*	4.148	0.843	-0.536	0.026	0.811**
8) B-35	63.617	0.749	115.468*	49.319**	0.194	44.989	1.078	31.919**	26.443**	0.452*	3.967	0.686	0.566	0.013	0.832**
9) Line 5/91	72.069	0.744	37.336**	8.483*	0.686*	41.592	1.357	3.947**	0.273	0.651*	3.758	0.551	0.621	0.019	0.825**
10) F5 generation	76.536	1.009	7.079	23.660**	0.891**	44.975	0.932	21.629**	16.164**	0.306	4.150	0.636	-0.545	0.0009	0.635*
11) Adnan hybrid	84.016	1.066	0.078	1.716	0.899**	42.783	1.368*	12.891**	5.987*	0.754*	3.223	0.749	0.595	0.757**	0.425
12) Venezuela 7	75.728	0.999	12.084	5.992	0.985**	34.350	0.487*	13.283**	7.795*	0.074	3.997	0.312*	-0.518	0.171*	0.703**
Grand mean	75.502					42.248					3.910				
L.S.D.	17.228					3.962					0.624				

$P^{*} = 0.05$
$P^{**} = 0.01$

(Figs. 1-7): Diagrams of phenotypic stability for the studied characters.

No.	Genotype
1	Giza 25
2	Giza 32
3	Local Sharkia
4	Mutation 8
5	Mutant 48
6	B-10
7	B-11
8	B-35
9	Line 5/91
10	F5 generation
11	Adnan hybrid
12	Venezuela 7

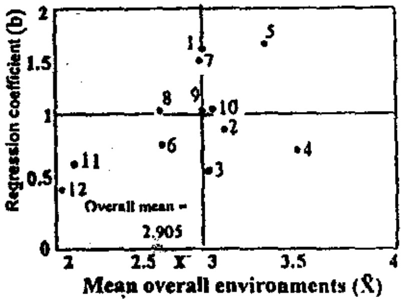

Fig.(1): Seed yield/fed.

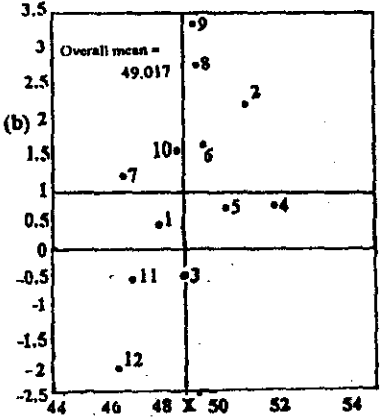

Fig.(2): Seed oil content.

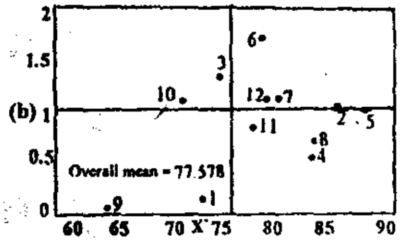

Fig.(3): Fruiting zone length.

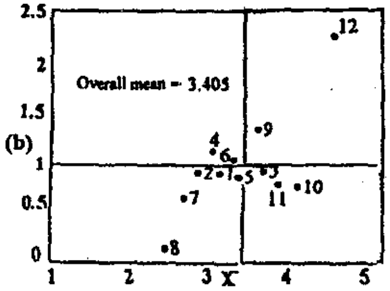

Fig.(4): No. of branches/plant.

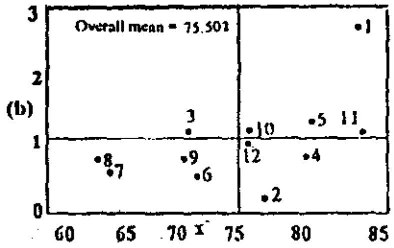

Fig.(5): No. of capsules/plant.

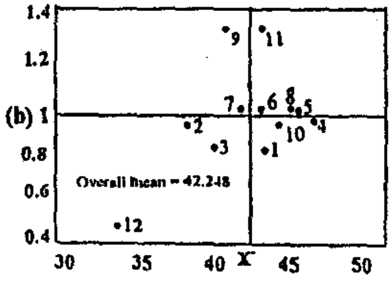

Fig.(6): No. of seeds/capsule.

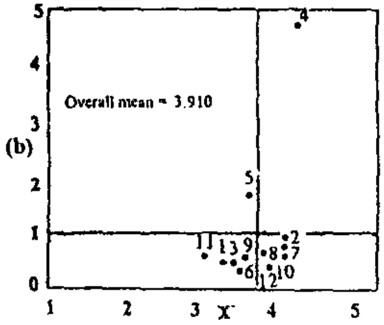

Fig.(7): 1000-seed weight.

Horizontal axis =Mean overall environments (X̄)
Vertical axis =Regression coefficient (b)

response (stability) was proposed by Pinthus (1973) as a best measure of phenotypic stability because its value lies between zero and one, and is strongly related to S^2di (Becker, 1981). As presented in Table (4), among the studied sesame genotypes, "r^2" values accounted for 40.3 to 92.5% of the variation in seed yield/fed.. Significant values have been recorded in ten genotypes (No. 1, 2, 4, 5, 6, 7, 9, 10, 11, and 12) for seed yield/fed.; eight (No. 2, 3, 5, 6, 8, 9, 10 and 12) for seed oil content; six (No. 2, 5, 6, 7, 10 and 11) for fruiting zone length; nine (No. 1, 3, 5, 6, 7, 9, 10, 11 and 12) for number of branches/plant; ten(No. 1, 2, 3, 4, 5, 6, 9, 10, 11 and 12) for number of capsules/plant; nine (No. 1, 3, 4, 5, 6, 7, 8, 9, and 11) for number of seeds/capsule as well as ten (No. 1, 2, 3, 5, 6, 7, 8, 9, 10 and 12) for 1000-seed weight, indicating high degree of stability. In this connection, Langer *et al.* (1979) and Ragab *et al.* (1995) found that the linear regression accounted for 70 to 99% of the variations in yields of oats and sesame, respectively.

In conclusion, there were great similarities between (bi), (S^2di), (Wi) and (r^2i) in sesame genotypes; Giza 32 and Line 5/91 for seed yield/fed. and 1000-seed weight with specific superiority for high yield potentiality. Meanwhile, F5 generation was the same for stability statistics but exhibited low oil contant.

Full uniformity was also observed between (bi), (S^2di) and (r^2i) in genotype F5 generation for seed yield/fed. and between (bi) and (r^2i) in Adnan hybrid for seed yield/fed., fruiting zone length, number of branches/plant and number of capsules/plant, indicating high stability and good adaptability to a wide range of environments.

The stability parameters; (S^2di),(Wi) and(r^2i) showed exactly similar in Mutant 8 and B-10 for seed yield/fed. and number of capsules/plant as well as (S^2di) and (r^2i) in Venezuela 7 for seed yield/fed., seed oil content, number of capsules/plant and 1000-seed weight. These results agree with Duarte and Zimmermann (1995), suggesting that one of both parameters (S^2di) and (r^2i) is sufficient to determine phenotypic stability.

Considering the four stability parameters (bi, S^2di, Wi and r^2i) accompanised with mean performance ($\bar{X}$i), it is important to mention that the most desired and stable sesame genotypes were; Mutant 8, Giza 32 and Line 5/91 for seed yield/fed.; Mutant 48 for seed oil content; Giza 32 for fruiting zone length; Adnan hybrid and Local Sharkia for number of branches/plant; Adnan hybrid, Mutant 8 and the exotic one Venezuela 7 for number of capsules/plant;Mutant 48 and B-10 for number of seeds/capsule as well as Giza 32, F5 generation, B-11 and B-35 for 1000-seed weight (Figs. 1-7).

Correlation among stability statistics:

A range of stability statistics has been developed. The most reliable is the one ease of computaion and gave unbiased estimation of yield stability. Therefore, simple correlation coefficient between pairs of estimated statistics was computed (Table 5). It could be seen that, positive and significant correlation between mean performance ($\bar{X}i$) and the regression coefficient (bi) (r=0.708**) has been reported for number of branches/plant. Thus, genes controlling greater number of branches/plant are likely to be associated with those controlling adaptability measured by the "b" value. Therefore, the most adapted genotypes could be identified on the basis of ($\bar{X}$). The same association was detected between ($\bar{X}i$) and (r^2i) for number of seeds/capsule, hereby sesame genotypes having greater number of seeds/capsule tend to have high (r^2i) values.

Positive and significant relationship was detected between (S^2di) and (Wi) for fruiting zone length, number of branches/plant, number of capsules/plant and number of seeds/capsule; (bi) and (S^2di) for seed oil content and 1000-seed weight; (bi) and (Wi) for seed oil content and number of branches/plant as well as between (bi) and (r^2_i) for number of seeds/capsule. In this connection, (r^2_i), (S^2di) and (Wi) were highly and significantly correlated with one another which indicates that any of them should be a satisfactory parameter for measuring stability (Langer *et al.*, 1979 and Silva and Barreto, 1985).

Negative and significant correlation was recorded between ($\bar{X}i$) and each of; (Wi) for seed yield/fed., number of capsules /plant and 1000-seed weight and with (S^2di) for number of capsules/plant. Hereby, the high performing genotypes tend to be classed as less stable and vice versa. Virk *et al.* (1985) found that the mean ($\bar{X}$) and (S^2d) were repeatable for measuring stability in oat.

Negative and significant association was recorded between (S^2di) and (r^2_i) for number of capsules /plant and number of seeds/capsule and between (Wi) and (r^2_i) for number of capsules/plant and 1000-seed weight. In this respect, Becker and Leon (1988) reported that the high (r^2_i) values and the low estimates of both (S^2di) and (Wi) are regarded as being desirable.

However, the insignificant correlation between ($\bar{X}i$) and each of; (bi), (S^2di) and (r^2i) for seed yield and one or more of its attributes may indicate the independent genetic control of mean performance and stability parameters, providing the breeder a chance for developing high yield and stable genotypes (Duarte and Zimmermann, 1995). The lack of correlations which have been recorded between the other pairs of statistics for seed yield/fed. and one or more of its attributes, showing that each of (bi), (S^2di) and (r^2_i) was independent and has its own characteristic and using any one of them depends upon its ease of computaion, since all of them give reliable estimates for stability.

Table (5): Correlation coefficients between pairs of different stability statistics for the studied sesame characters.

Statistics correlated	Seed yield /fed.	Seed oil content (%)	Fruiting zone length	No. of branches/ plant	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight
$\bar{X}_i$ – bi	0.413	0.520	0.313	0.708**	0.543	0.510	0.438
$\bar{X}_i$ - S^2di	0.075	0.188	0.130	0.273	-0.609*	-0.222	0.177
$\bar{X}_i$ – Wi	-0.588*	0.055	-0.306	0.350	-0.615*	0.125	-0.729**
$\bar{X}_i$ - r^2i	-0.023	-0.004	-0.113	0.509	0.554	0.622*	0.086
b_i - S^2di	0.318	0.682*	-0.378	0.547	-0.169	-0.039	0.896**
b_i – Wi	0.021	0.602*	-0.302	0.706*	-0.089	-0.130	-0.041
b_i - r^2i	-0.145	0.013	0.260	0.189	-0.016	0.570*	-0.482
S^2di – Wi	0.218	0.327	0.586*	0.719**	0.721**	0.693*	0.101
S^2di - r^2i	-0.547	-0.434	-0.221	-0.302	-0.637*	-0.586*	-0.484
Wi - r^2i	0.130	-0.510	-0.034	-0.313	-0.759**	-0.389	-0.633*

REFERENCES

Allard, R.W. (1960). Principles of Plant Breeding. New York, London, John Wiley and Sons, Inc.

A.O.A.C. (1984). Association of Official Agricultural Chemists. "*Official Methods of Analysis*". Washington 25, D.C., USA.

Awaad, H.A. and H. A. Basha (2000). Yield potentiality and yield analysis of some sesame genotypes grown under two plant population densities in newly reclaimed sandy soils. Zagazig J. Agric. Res. , 27:239-253.

Basha, H.A. (1998). Response of some sesame varieties to different row and hill spacing in newly cultivated sandy soil. Zagazig J. Agric. Res., 25 : 385-397.

Becker, H.C. (1981). Biometrical and empirical relations between different concepts of phenotypic stability. In Gallais, A. (ed.), Quantitative Genetics and Breeding Methods, 307-317. Versailles: I.N.R.A.

- - - - - - - and J. Leon (1988). Stability analysis in plant breeding. Plant Breeding, 101: 1-23.

- - - - - - -; H.H. Geiger and K. Morgen Stern (1982). Performance and phenotypic stability of different hybrid types in winter rye. Crop Sci., 22: 340-344.

Breese, E. L. (1969). The measurement and significance of genotype-environment interactions in grasses. Heredity, 24 : 27-44.

Comstock, R.E. and R.H. Moll (1963). Genotype-environment interaction. Statistical Genetics and Plant Breeding. National Research Council Publication, 982, p. 164-196.

Duarte, J.B. and M.J.de O.Zimmermann (1995). Correlation among yield stability parameters in common bean. Crop Sci., 35: 905-912.

Eberhart, S.A. and W.A. Russell (1966). Stability parameters for comparing varieties. Crop Sci., 6 : 36-40.

El-Serogy, S.T.; M.A. El-Emam and W.A.I. Sorour (1997). The performance of two sesame varieties under different sowing methods in two locations. Annals Agric. Sci., Ain Shams Univ., Cairo, 42 : 355-364.

Guilan Yue; S.K. Perng; T.L. Walter; C.E. Wassom and G.H. Liang (1990). Stability analysis of yield in maize, wheat and sorghum and its implications in breeding programs. Plant Breeding, 104 : 72-80.

Hayward, M.D. and T. Lawrence (1970). The genetic control of variation in selected population of *Lolium perenne* L. Can. J. Cytol., 12: 806-815.

Jatasra, D.S. and R.S. Paroda (1979). Stability for synchrony traits in wheat. Ind. J. Genet. and Pl. Breed., 39 : 378-383.

John, A. ; N. Subbaraman and S. Jebbaraj (2001). Genotype by environment interaction in sesame (*Sesamum indicum* L) Sesame and Safflower Newsletter, No. 16:13-15.

Länger. S.; K.J. Frey and T. Bailey (1979). Associations among productive, production and stability indexes in oat varieties. Euphytica, 28: 17-24.

Mahdy, E.E.; B.R. Bakheit; M.Z. El-Hifny and A. El-Shimy (1988). Genotypic stability analysis of yield and several traits of sesame, *Sesamum indicum*, L. Assuit J. Agric. Sci., 19: 19-34.

Paroda, R.S. and J.D. Hayes (1971). Investigation of genotype-environment interactions for rate of ear emergence in spring barley. Heredity, 26 : 157-176.

Pinthus, M.J. (1973). Estimate of genotypic value: A proposed method. Euphytica, 22: 121-123.

Ragab, A.I. and M. Kassem (2002). New varieties of sesame Taka 1, Taka 2 and Taka 3. 2- Estimates of variety-environment interaction, phenotypic and genotypic stability and adaptation. Egypt. J. Appl. Sci., 17: 117-128.

------ ; A.A. Hoballah and M. Kassem (1995). Genotypes x environment interaction effect for seed yield and oil content of sesame (*Sesamum indicum*, L.). Zagazig J. Agric. Res., 22:963-974.

Samuel, C.J.A.; J. Hill; E.L. Breese and Alison Davies (1970). Assessing and predicting environmental response in *Lolium perenne*. J. Agric. Sci. Comb., 75: 1-9.

Silva, J.G.C.da, and J.N Barreto (1985). Aplicäo de regressäo lineär segmentädä em estudos dä interäcäo genotipo ämbiente. P.49-50. In Fund. Cärigill (ed.) Simposio de est ätisticä äplicädä ä experimentäcäo ägronomicä, 22-26/07/1985 Cämpinäs, Brazil.

Singh, S.K. and B.D. Chaudhary (1985). Biometrical methods in quantitative genetic analysis. Kalyani Pub. New Delhi Ludhiana pp. 318.

Snedecor, G.W. and W.G. Cochran (1967). "Statistical Methods" 6th ed. Iowa State Univ., Press Ames. Iwoa, USA.

Suresh, M.; A. Narayanan; S. Thangavelu and S.R. Sree Rangasamy (1991). Genotype x environment interaction for seed yield in sesame 1) irrigated conditions. Sesame and Safflower Newsletter, No. 6: 11-12.

Virk, D.S.; S.S. Chahal and H.S. Pooni (1985). Repeatability of stability estimators for downy mildew incidence in pearl millet. Theor. Appl. Genet., 70: 102-106.

Wricke, G. (1962). Über eine Methode zur Erfassung der ökologischen Streubreite in Feldversuchen. Z. Pflanzenzüchtung , 47: 92-96.

تفاعل التركيب الوراثي والبيئة والعلاقة بين بعض إحصاءات الثبات في السمسم

حسن عوده عواد* و عبد الرحيم أحمد على مصطفى**

***قسم المحاصيل-كلية الزراعة- جامعة الزقازيق**

****قسم المحاصيل -كلية الزراعة- جامعة قناة السويس**

أجريت هذه الدراسة بهدف تحليل تفاعل التركيب الوراثي مع البيئة وتقدير الثبات المظهري لأثنى عشر تركيب وراثي من السمسم هي جيزة ٢٥، جيزة ٣٢، شرقية محلى، طفرة ٨، طفرة ٤٨ ، B-10، B-11، B-35، سلالة ٩١/٥، الجيل الخامس، هجين عدنان وفنزويلا ٧. حيث تم تقييم صفات المحصول ومساهماته ونسبة الزيت لهذه التراكيب الوراثية تحت إثنى عشر بيئة مختلفة تمثل التوافيق بين نوعين من التربة، طينية (مزرعة كلية الزراعة بالزقازيق)، ورملية (مزرعة كلية الزراعة بالخطارة) وثلاث كثافات زراعية (٨٤٠٠٠، ١١٢٠٠٠و ١٦٨٠٠٠ نبات/فدان) خلال الموسم الصيفي لاعوام ١٩٩٩ و ٢٠٠٠، مستخدماً أربعة مقاييس مختلفة للثبات هي معامل الانحدار (bi) ، مجموع مربع الانحرافات عن الانحدار (S^2di)، المكافئ البيني (Wi) و معامل التقدير(r^2i).

أشارت نتائج تحليل التباين التجميعي، أن نسبة مساهمة العوامل تحت الدراسة إلى التباين الكلى لصفة محصول بذور الفدان كانت ٦٢,٢٥% (للكثافة النباتية) ، ١٣,١١% (للتراكيب الوراثية) ، ١٢,٦٤% (للمواقع) ، فى حين كان تأثير السنوات ١١,٧٢% . وقد أوضحت النتائج وجود

اختلافات معنوية بين التراكيب الوراثية والبيئات المدروسة وكذلك تفاعلاتها لجميع الصفات عدا تأثير المواقع ،السنوات × الكثافة النباتية والمواقع × الكثافة النباتية لصفة محتوى البذور من الزيت ، والسنوات × المواقع والمواقع × الكثافة النباتية لصفة وزن الالف بذرة .

وقد أظهر تحليل الثبات المظهرى، أن التفاعل الخطي بين التركيب الوراثى × البيئة كان معنوياً للصفات تحت الدراسة ، موضحاً أختلاف التراكيب الوراثية فى استجابتها للتغيرات البيئية . كما كانت قيم التفاعل الخطي بين التركيب الوراثى × البيئة معنوية عند اختبارها امام قيم الانحرافات الكلية لجميع الصفات عدا عدد بذور الكبسولة ، مشيراً الى ان الانحدار الخطى والانحرافات عن خط الانحدار يمكن أستخدامهما كمقاييس لوصف ثبات التراكيب الوراثية لمعظم الصفات .

أظهرت الأصناف جيزة ٢٥ ، طفرة ٤٨ و B-11 درجة عالية من الأقلمة تحت ظروف البيئات الملائمة لصفة محصول بذور/الفدان . فى حين كان الصنف شرقية محلى أكثر ملاءمة لظروف البيئات القاسية ، ومن ثم يمكن التوصية بزراعته تحت ظروف منطقة الخطارة كبيئة أقل ملاءمة .

وأظهرت النتائج أن اكثر الأصناف قبولاً وثباتاً تحت مدى واسع من البيئات المتباينة كان الصنف المحلى جيزة ٣٢ لصفات محصول بذور الفدان ، طول المنطقة الثمرية ووزن الألف بذرة ؛ الطفرة ٨ لمحصول بذور الفدان و عدد الكبسولات للنبات ؛ الطفرة ٤٨ لمحتوى البذور من الزيت وعدد بذور الكبسولة والتركيب الوراثي الجيل الخامس لصفة وزن الألف بذرة.

أشارت نتائج الارتباط بين إحصاءات الثبات إلى وجود أرتباط موجب ومعنوي بين متوسط $(\bar{X}i)$ عدد بذور الكبسولة والمقياس (r^2i) ، وكذلك بين (S^2di) و (Wi) لصفات طول المنطقة الثمرية ، عدد الأفرع للنبات ، عدد الكبسولات للنبات وعدد بذور الكبسولة ، مشيراً إلى وجود درجة من التشابه بين كل زوج من هذه المقاييس، ومن ثم إمكانية استخدمها بثقة في قياس الثبات.

في حين كان هناك ارتباط سالب ومعنوي بين المتوسط الحسابي $(\bar{X}i)$ وكل من؛ المكافئ البيئي (Wi) لصفات محصول بذور الفدان ، عدد الكبسولات للنبات ووزن الألف بذرة ، ومع الانحراف عن خط الانحدار(S^2di) لصفة عدد الكبسولات للنبات ، مشيراً إلى أن التراكيب الوراثية عالية المحصول تميل إلى أن تكون أقل ثباتا والعكس صحيح. بينما، لم يوجد أرتباط بين متوسط $(\bar{X}i)$ محصول البذور وكل من؛ (bi)،(S^2di) ومعامل التحديد(r^2i) ، في دلالة على إمكانية الانتخاب للمحصول العالي والثبات المظهري كلٌ على حده.

ويشير الارتباط السالب والمعنوي بين المقياس (r^2i) وكل من ؛ (S^2di) و (Wi) لصفات عدد الكبسولات للنبات و / أو عدد بذور الكبسولة ووزن الألف بذرة إلى العلاقة العكسية بين دلالة المقياس (r^2i) مقارنة بالمقياسين (S^2di) و (Wi) في تقدير الثبات.