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PARTITIONING OF GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY FOR GRAIN YIELD AND PROTEIN CONTENT IN BREAD WHEAT (*Triticum aestivum* L.)

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ABSTRACT: Fifteen local and introduced bread wheat genotypes were evaluated for grain yield/m^2, grain yield/main spike, spike length and grain protein content under eighteen diverse environments which were the combinations between two seasons x three sowing dates x three locations. Stability was assessed, using regression coefficient (b_i) and mean square of deviation from regression (S^2d_i), coefficient of variability (C.V.$_i$%) and the index of production response (R_1). The most important results are summarized as follows:

1. Pooled analyses of variance indicated highly significant differences among wheat genotypes(G), seasons(S), locations (L) and sowing dates (D), as well as their first-order interactions between genotypes and the environmental factors, in most cases, and only second-order (GxLxD) interaction for grain protein content.

2. It was evident that location effect accounted for most part of the total variation on the studied characters, followed by seasonal and the genotype effects, however, sowing dates had little effect in this respect, since the contribution of these items were 50.59% for locations, 25.80% for seasons, 12.24% for genotypes and 11.37% for sowing dates from the total variance of wheat grain yield/m^2.

3. Stability analysis revealed highly significant genotype x environment(GxE) - "linear" interaction for all studied characters. The (GxE)-"linear" interaction, also, was significant when tested against pooled deviation in all characters.

4. The most adapted genotypes to be grown under favorable conditions were the new Egyptian cultivars, Gemmeiza 5, Gemmeiza 9 and the exotic one ACSAD 941 for grain yield/m^2; Gemmeiza 5, Gemmeiza 9 and Sids 6 for grain yield/main spike and Sakha 69, Gemmeiza 9, ACSAD 925, ACSAD 935 and ACSAD 949 for grain protein content. Whereas, Sakha 8 and Tsi/Vee 'S' performed well under less favorable environments for grain yield/m^2 and grain protein content. Hereby, it could be useful for growing under Khattara or East Bitter Lakes (Sinai) as stress environment.

5. Based on all stability parameters, the most desirable and stable genotypes were Gemmeiza 7, followed by ACSAD 903 and Sakha 69 for grain yield/m^2; Gemmeiza 7 for grain yield/main spike; Gemmeiza 5 and Sahel 1 for spike length, as well as Giza 168 and Gemmeiza 5 for grain protein content. Therefore, these genotypes may be suggested to be included in wheat breeding programs for improving wheat grain yield and protein content stability.

INTRODUCTION

Genotype x environment (GxE)-interactions are of notable importance in the development and evaluation of wheat cultivars. Although, (GxE)-interactions represent a major challenge to plant breeders, significant advances have been made in the parameters to understand the nature of these interactions and determine the most stable genotypes with the minimum values of (GxE). In this respect, it has been recorded that the contribution of the (GxE)-interaction to the total variation was substantial. It is of importance for the breeder to estimate and quantify such components of (GxE)-interaction in order to minimize it to obtain reliable estimates of genotypic expression. Many investigators reported significant (GxE)-interactions in bread wheat and they partitioning the total variance to its components, since high significant genotype x location, genotype x season and genotype x location x season interactions were recorded for wheat grain yield, spike grain weight and spike length (Hassan, 1997, Abd EL-Moneim, 1998 and Salem *et al.*, 2000) ; genotypes x seasons, genotypes x locations, genotypes x sowing dates for grain yield (EL-Morshidy *et al.*,2001) and for grain yield/fed. and spike grain weight (Sharaan *et al.*,2001),and genotypes x sowing dates x nitrogen-levels for grain yield and protein content (EL-Marakby *et al.*, 2002).

Many investigators recorded an appreciable amount of variation due to the various items of (GxE); i.e., locations contributed 65.58% for grain yield/fed. , 67.86% for spike grain weight and 45.85% for spike length, however, the genotype effect was 10.10% for grain yield/plant and 39.30% for spike length and the seasonal changes had a little effect (Hassan, 1997). Also, Sharaan *et al.* (2001) revealed that, an appreciable amount of the total variation in grain weight/spike and grain yield/fed. was due to location effect, followed by planting dates and/or varieties, while the seasonal changes had a little effect.

Yield stability is a trait of special interest for plant breeders. Stability of yield, defined as the ability of genotypes to avoid substantial fluctuations over a range of environments. This breeding objective is difficult to achieve. Since the causes of yield stability or instability are often unclear, while physiological, morphological and phenological mechanisms, that impart stability, are diverse. The inconsistency of differences among genotypes for grain yield, from one environment to another, may arise from two reasons, one being the differences in response of the same set of genes to different environments, and the other being the expression of different sets of genes in various environments (Cocherham, 1963). If the same set of genes is expressed, then, the differences in response may be regarded as heterogeneity of genetic or error variances (or both) across environments. Mechanisms of yield stability fall into four general categories; i.e., genetic heterogeneity, yield components compensation, tolerance and capacity to recover rapidly from stress (Heinrich *et al.*, 1983).

The "phenotypic stability" is often used to refer to fluctuation in the phenotypic expression of yield, while the genetic composition of the varieties or populations remains stable (Becker and Leon, 1988).

Numerous methods have been proposed to estimate stability to provide further information on the real response of phenotype to environment; i.e., Eberhart and Russell (1966) , Francis and Kannenberg (1978) and Langer *et al.* (1979). Many investigators have assessed the phenotypic stability of yield performance in wheat genotypes (Sharma *et al.*, 1984; Keser *et al.*, 1996 and EL-Marakby *et al.*, 2002). They reported significant differences among genotypes, environments and their interactions for grain yield and some agronomic characters.

In the present investigation, partitioning of variance and stability parameters were estimated for fifteen bread wheat genotypes, grown under three sowing dates over three locations and two seasons.

MATERIALS AND METHODS

To assess the phenotypic stability, fifteen bread wheat genotypes (Table 1) were evaluated under eighteen different environments, which were the combinations of three locations; i.e., Experimental Farm of Faculty of Agriculture, Zagazig University, representing clay soil, Khattara Farm, representing sandy soil and East Bitter Lakes Farm (Sinai) of Faculty of Agriculture, Suez Canal University,representing sandy loam soil (Table 2), on three different dates; viz., November 4th and 25th and December 15th during two successive seasons of 1999/2000 and 2000/2001, using a randomized complete block design with three replicates. The experimental plot consisted of six rows, 3m long and 20 cm. apart. Wheat grains were manually drilled at a rate of 300 grains/m^2 for each genotype. The recommended cultural practices for wheat production were applied in each location.

Table (1): Name, origin and pedigree of the studied fifteen bread wheat genotypes.

No.	Name	Origin	Pedigree
1	Sakha 8	Egypt	Indus 66/ Norteno "S"- Pk3418-6s-1SW-OS
2	Sakha 69	Egypt	Inia/ RL 4220// 7c/ Yr "S" CM 15430-25-65-0s-0s
3	Giza 168	Egypt	MIL/BUC//Seri: CM93046-8M-OY-OM-2Y-OB
4	Gemmeiza 5	Egypt	Vee "S"/SWM6525 CGM4017-1GM-6GM-3GM-OGM.
5	Gemmeiza 7	Egypt	CMH74 A.630/5 x //Seri:82/3 Agent CGM4611-2GM-3GM-1GM-0GM
6	Gemmeiza 9	Egypt	Ald "S" / Huac "S"// CMH74A.630/5x CGM4583-5GM-1GM-OGM
7	Sahel 1	Egypt	N.S.732/Pim//Veery "S" Sd735-4sd-1 sd-Osd.
8	Sids 6	Egypt	Maya "S"/ Mon "S"//CMH74 A.592/3/Sakha8*2SD10002-4sd-3sd-1sd-Osd
9	Tsi/ Vee 'S'	Mex/Syr	CM 64335-3AP-1Ap- OAP
10	ACSAD 903	Syria	ACSAD529/4/C182.24/C168.3/3/Cno*2/7c//Cc/Tob Acs-W-8024-20 IZ-3IZ-4IZ-0IZ
11	ACSAD 925	Syria	GEN/3/GOV/AZ//MUS "s"/4/Sannine/Ald'sACS-W-9174-10IZ-5IZ-3IZ- 0IZ
12	ACSAD 935	Syria	ACSAD 529// Yr/Sprw "s" ACS-W-8023- 1IZ-2IZ- 2IZ-0IZ
13	ACSAD 939	Syria	Maya "S"/ON//1160.147/3/BB/GLL/4/CHAT "s"/S/Vee "s"/NacACS-W-8163-2IZ-3IZ-5IZ- 0IZ
14	ACSAD 941	Syria	GEN/3/Gov/AZ//MUS"S"/4/Sannine/Aids "s" ACS-W-8174-10 IZ-2IZ-5IZ-0IZ
15	ACSAD 949	Syria	Snb "s"/ ACSAD 305ACS-W-8083-3IZ-5IZ-3IZ-0IZ

Data recorded for grain yield/m^2, grain yield/main spike and spike length. Grain protein content also was determined by using the micro Kjeldahal Apparatus, as described in the A. O.A.C (1995).

Table (2).: Particle size distribution of the surface samples*.

Location	Particle size distribution %			Texture class
	Sand	Silt	Clay	
Zagazig	13.3	32.1	54.6	Clay
Khattara	95.40	2.46	2.14	Sandy
Sinai	74.0	9.0	17.0	Sandy loam

*Samples of the soil were obtained from 25 cm. Soil surface.

Regular analysis of variance was computed for each environment. Combined analysis of variance over environments was again conducted as outlined by Allard (1960). Stability parameters assessed were as follows:

1. The linear regression coefficient (b_i) and the mean square of deviation from regression (S^2d_i) for each genotype of the model described by Eberhart and Russell (1966).

2. Coefficient of variability (C.V.$_i$%), given by Francis and Kannenberg (1978).

3. The index of production response (R1) according to Langer *et al.* (1979). It means the differences between the minimum and maximum yields of a genotype in a series of environments.

RESULTS AND DISCUSSION

Components of genotype x environment interaction:

Pooled analyses of variance for bread wheat genotypes over environments (Table 3) provided evidence for highly significant environmental effects on the studied characters.

The effects of environmental components of seasons (S), locations (L) and sowing dates (D), as well as their interactions, revealed that they were highly significant on all studied characters, except for (SxL) for grain yield/main spike and grain protein content; (SxD) for all characters and (SxLxD) for most studied characters, which were insignificant. The insignificant effect of these items indicated that the combinations of environmental components (S), (L) and (D) were sufficient to obtain reliable information about the studied genotypes for those characters.

Highly significant differences were obtained for genotypes (G), regarding the studied characters overall environments. Also, highly significant first-order interaction (GxS) for grain yield/main spike, spike length and grain protein content; (GxL) and (GxD) for all characters, as well as the second-order interaction (GxLxD) for grain protein content, implying different response of genotypes over seasons, locations and sowing dates. Whereas, the remaining interactions between genotypes and the environmental items were insignificant (Table 3).

In this connection, many investigators recorded significant (GxS), (GxL) and (GxSxL)-interactions for wheat grain yield, spike grain weight and spike length (Hassan, 1997; Abd EL-Moneim, 1998 and Salem *et al.*,2000), as well as (GxD) and (GxDxN-levels)-interactions for grain yield and grain protein content(EL-Marakby *et al.*, 2002). However, insignificant effects of environmental item(S),interactions (SxD) and (LxD) were recorded for spike grain weight and grain yield/fed., as well as between (GxSxD) and (GxSxLxD) for grain yield/fed. (Sharaan *et al.*, 2001).

Partitioning of (GxE):

Partitioning the total variance to its components; i.e., seasons (S), locations (L), sowing dates (D) and genotypes (G) for each character, was estimated and given in Table (3). It was evident that the location effect accounted for most part of the total variation for grain yield/m^2 , grain yield/main spike and grain protein content, however, seasons exerted the highest effect on spike length. The contribution percentage attributed to (L) factor was 50.59% for grain yield/m^2;71.38%for grain yield/ main spike;15.09% for spike length and 64.25%for grain protein content. The relative contribution of (S) effect was 25.80% for grain yield/m^2;12.13%for grain yield/ main spike; 63.32% for spike length and 14.05% for protein content. The percentage of variation. caused. by genotypic effect, was 12.24% for grain yield/m^2; 12.98% for grain yield/main spike; 11.55% for spike length and 14.37% for grain protein content. Whereas, the sowing date effect (D) had a little effect with values of 11.37% for grain yield/m^2; 3.51% for grain yield/main spike; 10.04% for spike length, as well as 7.33% for grain protein content (Table 3). The significant effect of

Table (3): Pooled analyses and partitioning of variance for grain yield/m^2, grain yield/main spike, spike length and grain protein content of fifteen wheat genotypes under three sowing dates during two seasons in three locations.

S.O.V.	d.f	Grain yield/m^2 (k.g.)	Grain yield/main spike (g.)	Spike length (cm)	Grain protein content(%)
Seasons (S)	1	0.3324**	2.068**	100.337**	8.954**
Locations (L)	2	0.6402**	15.333**	17.786**	47.963**
S x L	2	0.0195*	0.046	10.507**	0.108
Reps in (S x L) combined	12	0.0390	1.954	0.605	1.762
Sowing dates (D)	2	0.1217**	0.352**	13.453**	1.848*
S x D	4	0.0040	0.148	0.685	1.056
L x D	4	0.0350**	0.106	1.004	1.673*
S x L x D	4	0.0032	0.212	2.308*	0.123
Genotypes (G)	14	0.138**	1.878**	13.784**	5.884**
G x S	14	0.0026	0.829**	4.855**	2.879**
G x L	28	0.0265**	0.679**	2.586**	2.928**
G x D	28	0.0177**	0.298**	3.502**	4.423**
G x S x L	28	0.0044	0.087	0.492	0.055
G x S x D	28	0.0023	0.039	0.574	0.088
G x L x D	56	0.0041	0.172	0.726	0.797*
G x S x L x D	56	0.0028	0.055	0.527	0.059
Error	528	0.0054	0.159	0.886	0.537
Contribution of the factors (%)					
Seasons		25.80	12.13	63.32	14.05
Locations		50.59	71.38	15.09	64.25
Sowing dates		11.37	3.51	10.04	7.33
Genotypes		12.24	12.98	11.55	14.37

*,** denote significant at 5% and 1% levels of probability, respectively.

environmental factors, along with the genotypic effect, have been reported on grain yield/fed., grain weight/spike and spike length by Krenzer *et al.*(1992);Awaad (1997) and Hassan (1997) and grain yield/plant and protein content by EL-Marakby *et al.* (2002).

Stability analysis:

Stability analysis of variance for wheat grain yield/m^2, grain yield/main spike, spike length and grain protein content are presented in Table (4). The results indicate highly significant mean squares of wheat genotypes for all studied characters, indicating that wheat genotypes were genetically different for genes controlling these characters. Highly significant environment + (genotype x environment) component and environment "linear" mean squares were recorded for all characters, indicating that the studied characters were highly influenced by the combination of environmental components (seasons, locations and sowing dates).

Table (4): Mean squares of stability analysis for grain yield/m^2, grain yield/main spike, spike length and grain protein content.

S.O.V	d.f	Grain yield/m^2	Grain yield/main spike	Spike length	Grain protein content
Genotypes	14	0.1860**	1.8718**	12.7662**	4.0840**
Environment+(Genotype x environment)	255	0.0133**	0.3543**	4.2337**	0.7253**
Environment (Linear)	1	2.2718**	64.7489**	956.9573**	86.8452**
Genotype x environment (Linear)	14	0.0126**	0.2772**	1.1558**	0.9077**
Pooled deviation	240	0.0039**	0.0905**	0.4435**	0.3558**
Pooled error	504	0.0003	0.0284	0.1541	0.0494

***,** denote significant at 5% and 1% levels of probability, respectively.**

Highly significant genotype x environment "linear" interactions were shown for all characters, suggesting that wheat genotypes differed in their responses to the environmental variation. The genotype x environment "linear" was highly significant when tested against the pooled deviation for the studied characters, 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 the foregoing characters. Previous reports of Keser *et al.* (1996), Salem *et al.* (2000), El-Morshidy *et al.* (2001) and El-Marakby *et al.* (2002) detected significant (GxE)-interaction effects on wheat grain yield /fed., grain weight/spike and spike length and Ismail *et al.* (2000) for grain protein content. Meanwhile, Rasmusson and Glas (1967) emphasized that (GxE)-interaction should be considered one of the most important strategies for any breeding program to improve and develop new barley varieties. However, (GxE)-interaction variance components for yielding ability, was as of much less importance than genotypic components, were detected in small number of environments (Cox *et al.*, 1985).

The analysis of variance (Tables 3 and 4) provided information about the existence of (GxE)-interaction, but failed to provide information about the individual response of the genotype to specific environment, hereby, mean performance and stability parameters for each genotype were performed and given in Table (5).

Mean performance

Data presented in Table (5) showed the mean performance of wheat grain yield/m^2, grain yield/main spike, spike length and grain protein content for the tested fifteen bread wheat genotypes across environments. The results revealed significant differences among the wheat genotypes, regarding the studied characters, suggesting varietal differences in genes responsible of the above mentioned characters.

For grain yield/m^2, it was evident that Gemmeiza 5 ranked the first one, followed by Gemmeiza 7, ACSAD 941 and Gemmeiza 9. They, also, almost surpassed the other studied genotypes for grain yield/main spike, spike length and grain protein content, except for ACSAD 941 which had low value of spike length and grain protein content, compared to the grand mean. ACSAD 903, Sakha 69, Sahel 1 and Giza 168 were moderately high in grain yield/m^2. The remaining wheat genotypes exhibited low values of grain yield/m^2. These results suggest that Gemmeiza 5, Gemmeiza 7, ACSAD 941 and Gemmeiza 9 were the promising ones to be employed in breeding or selection programs for improving grain yield potentialities with high protein content. Awaad (2001) and EL-Marakby *et al.* (2002) reported high degree of genetic variability among wheat genotypes for wheat grain yield.

Grain yield/main spike displayed a high genetic variability. Gemmeiza 5 ranked the first one followed by Gemmeiza 7, ACSAD 941, ACSAD 939, Gemmeiza 9, Sids 6, Sahel 1 and Giza 168. They produced the heaviest grain weights/spike, in comparison with the grand mean ($\bar{X}$=2.023g). However, ACSAD 949 was the lightest one (1.621g). The other wheat genotypes exhibited moderate values among them. In this respect, genetic differences among bread wheat genotypes existed for spike grain weight (Hassan , 1997 and Sharaan *et al.*, 2001).

With respect to spike length, Gemmeiza 7 ranked the first one, followed by Sids 6, Gemmeiza 5, Sahel 1, Gemmeiza 9 and Giza 168, which gave long spikes more than 10.5cm. and surpassed the grand mean(10.212cm.). However, the other wheat genotypes were the shortest ones in that respect. In this connection, Abd EL-Moneim (1998) recorded high significant differences among wheat genotypes for spike length.

For grain protein content, it was evident from Table (5) that the new wheat cultivar, Giza 168, ranked the first while, the old Egyptian wheat cultivar, Sakha 69, was the second, as well as Gemmeiza 9 in the third order, whereas, the exotic genotype, ACSAD 903, was the lowest one (10.478%). The other wheat genotypes exhibited different values of protein content. In this respect, significant genetic differences among wheat genotypes for grain protein content have been reported by Ismail *et al.* (2000) and EL-Marakby *et al.* (2002).

Stability parameters:

Four stability parameters were used for measuring stability for the studied characters, regarding the fifteen bread wheat genotypes across various environments.

According to Eberhart and Russell (1966) method, the stable genotype is the one having high mean values($\bar{X}$)over environments, with a (b_i) value approaches near unity and a deviation from regression as low as possible (S^2d_i=0).

Also, Breese (1969), Samuel *et al.* (1970) and Jatasra and Paroda (1979) emphasized that the linear regression "b_i" could be simply be regarded as a measure of response of a particular genotype, whereas, the deviation around the regression line "S^2d_i" was the most suitable measure of stability, where, the genotype with the lowest "S^2d_i" value being the most stable and vice versa. Meanwhile, Breese (1969) reported that genotypes with regression coefficients, greater than one, would be adapted to more favorable environments, while those with coefficients less than one would be relatively better adapted to less favorable growing conditions. In the present study, the regression coefficients (Table 5)deviated significantly from unity (b_i>1)in the genotypes, Gemmeiza 5, Gemmeiza 9 and ACSAD 941 for grain yield/m^2; Gemmeiza 5, Gemmeiza 9 and Sids 6 for grain yield/main spike; Giza 168 for spike length, as well as Sakha 69, Gemmeiza 9, ACSAD 925, ACSAD 935 and ACSAD 949 for grain protein content (Figs. 1-4).

These results indicated that these genotypes were highly adapted to improved environments and could be grown under Zagazig region. Whereas, the "b_i" values significantly were less than unity in the genotypes Sakha 8, Tsi/Vee'S' and ACSAD 949 for grain yield/m^2; Sahel 1, Tsi/Vee'S' and ACSAD 935 for grain yield/main spike; Sakha 8 and ACSAD 939 for spike length,as well as Sakha 8, Gemmeiza 7, Sids 6, Tsi/Vee 'S', ACSAD 903 and ACSAD 941 for grain protein content, which appeared to be more adapted to be grown under Khattara or East Bitter Lakes (Sinai) as less favorable environment. In this respect, Hayward and Lawrence (1970) stated that the response to environment, as measured by the regression parameter, was found to be highly heritable and controlled by genes with additive effects.

In the case of insignificant "b_i" value, the deviation from regression "S^2d_i" is considered the most appropriate criterion for measuring phenotypic stability in an agronomic sense, because this statistic measures the predictability of genotypic reaction to various environments(Becker *et al*., 1982).

Considering the deviation from linear regression "S^2d_i", it was very small and not significantly deviated from zero in Sakha 69 Gemmeiza 7,Gemmeiza 9 and ACSAD 903 for grain yield/m^2; Sakha 8, Sakha 69, Gemmeiza 5, Gemmeiza 7, Sids 6, ACSAD 925, ACSAD 935 and ACSAD 949 for grain yield/main spike; Sakha 8, Sakha 69,Gemmeiza 5, Sahel 1, Tsi/Vee 'S', ACSAD 903, ACSAD 935, ACSAD 939, ACSAD 941 and ACSAD 949 for spike length, as well as Sakha 8, Giza 168, Gemmeiza 5, Gemmeiza 7, ACSAD 903,ACSAD 925,ACSAD 935, ACSAD 939 and ACSAD 941 for grain protein content. In this connection, Guilan Yue *et al*., (1990) reported that the deviation from regression seemed to be very important for estimating the stability. However, the remaining genotypes were sensitive ones.

Regarding the coefficient of variability (C.V.$_i$%), proposed by Francis and Kannenberg (1978), the genotype with a low value of C.V.$_i$% is considered stable. Accordingly, the most stable wheat genotypes for grain yield/m^2 were ACSAD 903, followed by Tsi/Vee 'S', ACSAD 935, ACSAD 941, Sakha 69, Sakha 8 and Gemmeiza 7 for grain yield/m^2; ACSAD 935, followed by ACSAD 903,ACSAD 949, Gemmeiza 7 and Sakha 69 for grain yield/main spike; ACSAD 941, followed by ACSAD 949, ACSAD 939, ACSAD 903, Sakha 8, Tsi/Vee 'S' and Gemmeiza 5 for spike length, as well as ACSAD 941, followed by Gemmeiza 7, Sakha 8, Tsi/Vee 'S', ACSAD

Table (5): Mean performance and stability parameters for grain yield/m², grain yield/main spike, spike length and grain protein content of fifteen wheat genotypes over eighteen environments.

No.	Character / Parameter / Genotype	Grain yield/m² (k.g.)					Grain yield/main spike (g.)					Spike length (cm.)					Grain protein content (%)				
		$\overline{X}_i$	b_i	S^2d_i	C.V.$_i$%	R_i	$\overline{X}_i$	b_i	S^2d_i	C.V.$_i$%	R_i	$\overline{X}_i$	b_i	S^2d_i	C.V.$_i$%	R_i	$\overline{X}_i$	b_i	S^2d_i	C.V.$_i$%	R_i
1	Sakha 8	0.438	0.801*	0.00299**	16.552	0.381	1.927	0.972	0.0505	23.717	2.01	10.137	0.807*	0.177	16.978	4.4	10.752	0.467**	0.134	5.225	2.32
2	Sakha 69	0.485	0.961	0.00154	16.312	0.398	1.955	1.083	0.0054	20.850	2.29	10.579	1.015	0.131	20.377	5.0	11.865	1.811**	0.603**	11.125	4.83
3	Giza 168	0.479	0.963	0.00257*	18.504	0.473	2.098	0.865	0.0586*	23.664	2.61	10.713	1.206*	0.416*	23.099	6.5	12.138	0.926	0.104	7.169	2.59
4	Gemmeiza 5	0.533	1.312*	0.00420**	21.078	0.620	2.212	1.245*	0.0524	28.034	3.88	11.248	1.056	0.063	17.609	4.5	11.459	0.948	0.017	7.291	2.48
5	Gemmeiza 7	0.512	1.118	0.00219	17.976	0.391	2.160	1.125	0.0501	20.046	2.26	11.383	1.142	0.496**	20.883	5.3	11.190	0.612*	0.028	4.879	2.49
6	Gemmeiza 9	0.503	1.337*	0.00208	20.818	0.464	2.110	1.305*	0.1174**	31.855	3.13	10.781	1.165	0.431*	22.475	6.0	11.564	1.445*	0.494**	9.777	4.67
7	Sahel 1	0.480	0.920	0.00357**	18.700	0.502	2.107	0.714*	0.0901**	28.511	1.86	10.889	1.153	0.194	20.777	4.3	11.546	1.131	0.495**	9.049	4.22
8	Sids 6	0.446	1.157	0.00482**	23.901	0.649	2.110	1.533**	0.0099	35.356	2.81	11.365	1.031	0.681**	21.792	7.6	11.470	0.549*	0.386**	6.509	3.33
9	Tsi/Vee 'S'	0.415	0.256**	0.00642**	15.431	0.364	1.951	0.608**	0.0644*	29.412	2.32	10.136	0.924	0.218	17.485	4.5	11.080	0.689*	0.308*	6.151	1.92
10	ACSAD 903	0.487	0.922	0.00078	14.753	0.395	2.021	0.856	0.0753**	19.340	2.92	9.632	1.045	0.334	16.188	5.5	10.478	0.691*	0.282	6.157	3.34
11	ACSAD 925	0.453	1.149	0.00293**	21.865	0.461	1.985	0.913	0.0431	23.928	2.26	9.417	0.890	0.435*	18.452	4.0	10.945	1.312*	0.103	6.602	4.28
12	ACSAD 935	0.465	1.097	0.00432**	15.598	0.368	1.789	0.674*	0.0072	18.129	1.48	9.200	0.994	0.045	18.500	4.9	10.870	1.377*	0.164	8.436	3.08
13	ACSAD 939	0.455	0.845	0.00258*	21.122	0.572	2.138	1.081	0.0686*	24.796	2.96	9.304	0.730**	0.206	15.960	5.0	11.071	1.194	0.097	7.563	3.32
14	ACSAD 941	0.509	1.425**	0.00751**	15.609	0.447	2.154	0.865	0.203**	23.826	2.60	9.627	0.900	0.342	12.822	3.1	10.842	0.611*	0.043	4.736	2.23
15	ACSAD 949	0.374	0.835*	0.00301**	29.967	0.579	1.621	1.157	0.0394	19.819	2.55	9.625	0.901	0.172	15.412	5.5	11.169	1.236*	0.431**	9.117	4.13
	Grand mean	0.469					2.023					10.269					11.229				
	L.S.D 0.05	0.004					0.167					0.437					0.329				

*,** denote significant at 5% and 1% levels of probability, respectively.

No.	Genotype
1	Sakha 8
2	Sakha 69
3	Giza 168
4	Gemmeiza 5
5	Gemmeiza 7
6	Gemmeiza 9
7	Sahel 1
8	Sids 6
9	Tsi/Vee "S"
10	ACSAD 903
11	ACSAD 925
12	ACSAD 935
13	ACSAD 939
14	ACSAD 941
15	ACSAD 949

Graphical illustration of stability parameter (bi) and mean performance ($\bar{X}$) of individual genotypes for the studied characters (Figs. 1-4)

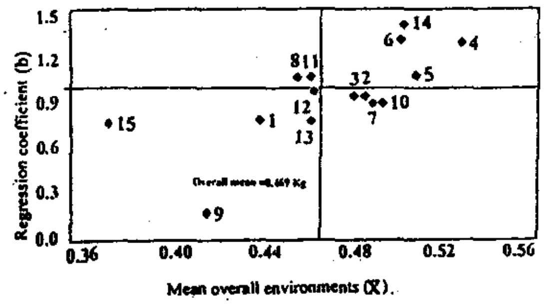

Fig.(1): Grain yield/m^2.

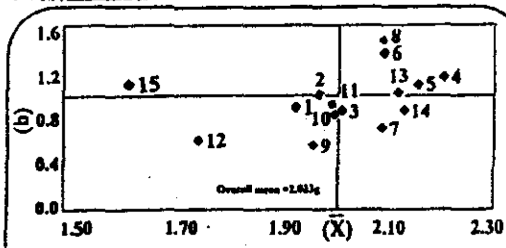

Fig.(2): Grain yield/main spike.

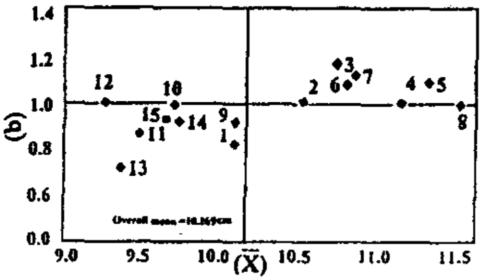

Fig.(3): Spike length.

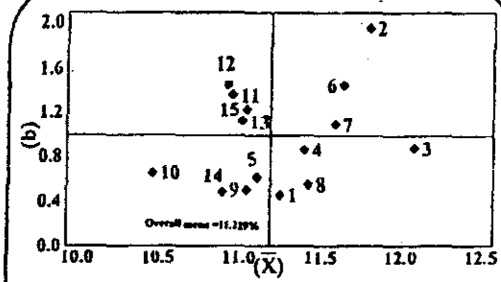

Fig.(4): Grain protein content.

903, ACSAD 925, Giza 168 and Gemmeiza 5 for grain protein content. In this connection, Becker and Leon (1988) stated that, if the ($C.V._i\%$) was small, the genotype was described as stable. Whereas, the other studied genotypes were unstable.

The index of production response (R_l), proposed by Langer *et al*. (1979), who reported that, for practical breeding purposes, it would be desirable to have a more simple method than regression for evaluating the response of genotypes to the environmental conditions in preliminary trials. As a simpler method than the regression, was the range (R_l), which was defined as the extreme yields for a variety in all environments. Small range (R_l) values indicate stability and vice versa. Thus, it can be seen that the bread wheat genotypes, Tsi/Vee 'S', ACSAD 935, Sakha 8, Gemmeiza 7, ACSAD 903 and Sakha 69 showed low values of R_l for grain yield/m^2; ACSAD 935, Sahel 1, Sakha 8, Gemmeiza 7 and ACSAD 925 for grain yield/main spike; ACSAD 941, ACSAD 925, Sahel 1, Sakha 8, Gemmeiza 5 and Tsi/vee 'S' for spike length, as well as Tsi/Vee 'S', ACSAD 941, Sakha 8, Gemmeiza 5, Gemmeiza 7 and Giza 168 for grain protein content. Therefore, these genotypes are stable. However, the remaining genotypes were sensitive to the environmental changes. In this respect, Langer *et al*. (1979) stated that the parameter (R_l) seemed to provide a more accurate estimation of production response.

When the four stability parameters (b_i, S^2d_i, $C.V._i\%$ and R_l) are considered together with mean performance ($\bar{X}_i$), it is important to mention that the most desirable and stable wheat genotypes were; Gemmeiza 7, followed by ACSAD 903 and Sakha 69 for grain yield/m^2; Gemmeiza 7 for grain yield/main spike; Gemmeiza 5 and Sahel 1 for spike length, as well as Giza 168 and Gemmeiza 5 for grain protein content.

Generally, there were great similarities between b_i, S^2d_i, $C.V._i\%$ and R_l in the wheat genotypes, Sakha 69 and Gemmeiza 7 for grain yield/main spike; Gemmeiza 5, Sahel 1, Tsi/Vee 'S' and ACSAD 941 for spike length, as well as Giza 168, Gemmeiza 5 and ACSAD 939 for grain protein content. This result suggest, that any one of these parameters is sufficient for determining phenotypic stability and, particularly, $C.V._i$ or R_l as ease in computation and useful in the preliminary stages of a breeding program when the breeder has to deal with a large number of genotypes. Similar interpretation has been reported by Duarte and Zimmermann (1995).

A high degree of similarities have been observed among the stability parameters; b_i , S^2d_i and R_1, for measuring stability in the genotypes; Sakha 69, Gemmeiza 7 and ACSAD 903 for grain yield/m^2; Sakha 8, Sakha 69, Gemmeiza 7, ACSAD 925 and ACSAD 949 for grain yield/main spike; Gemmeiza 5, Sahel 1, Tsi/Vee 'S' and ACSAD 941 for spike length, as well as Giza 168 and Gemmeiza 5 for grain protein content. A similar trend has been reported between b_i, S^2d_i and R_1 in Kav2 bread wheat genotype for spike length and grain yield by Abd EL-Moneim (1998).

The stability parameters, S^2d_i, C.V.$_i$% and R_1 showed exact similarity in Sakha 69,Gemmeiza 7, and ACSAD 903 for grain yield/m^2; Sakha 69, Gemmeiza 7and ACSAD 935 for grain yield/main spike; Sakha 8, Gemmeiza 5, Sahel 1, Tsi/Vee 'S' and ACSAD 941 for spike length, as well as Sakha 8, Giza 168, Gemmeiza 5, Gemmeiza 7 and ACSAD 941 for grain protein content, indicating that any of them could be a satisfactory parameter for measuring stability.

Coefficient of variability (C.V.$_i$%) showed a similar trend with R_1, when used in measuring stability in the wheat genotypes, Sakha 8, Sakha 69, Gemmeiza 7, Tsi/Vee 'S', ACSAD 903 and ACSAD 935 for grain yield/m^2; Sakha 69, Gemmeiza 7 and ACSAD 935 for grain yield/main spike;Sakha 8,Gemmeiza 5 and ACSAD 941 for spike length, as well as Sakha 8, Giza 168, Gemmeiza 5, Gemmeiza 7, Tsi/Vee 'S' and ACSAD 941 for grain protein content, hereby, could be used as simple parameters for describing stability.

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تجزئة تفاعل التركيب الوراثي والبيئة وثبات محصول الحبوب ومحتوي البروتين في قمح الخبز (*Triticum aestivum* L.)

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أجريــت هــذه الدراسة بهدف تحليل تفاعل التركيب الوراثي مع البيئة وتقدير الثبات لخمسة عشر صنفا من قمح الخبز، ثمانية منها محلية (سخا ٨، سخا ٦٩، جيزة ١٦٨، جميزة ٥، جميزة ٧،

جميزة ٩، ساحل ١ و سدس ٦) وسبعة تراكيب وراثية أجنبية (Tsi/Vee 'S' ، أكساد ٩٠٣، أكساد ٩٢٥، أكساد ٩٣٥، أكساد ٩٣٩، أكساد ٩٤١ وأكساد ٩٤٩) وذلك لصفات محصول الحبوب للمتر المربع ، محصول حبوب سنبلة الساق الرئيسي، طول السنبلة ومحتوي الحبوب من البروتين ، قيمت تحت ثماني عشر بيئة مختلفة (موسمان زراعيان × ثلاثة مواعيد زراعة× ثلاثة مواقع). وتم حساب قيم الثبات المظهري مستخدماً أربعة مقاييس مختلفة [معامل الإنحدار (b_i) و مجموع مربع الإنحرافات عن الإنحدار (S^2d_i) و معامل الإختلاف ($C.V._i\%$) و دليل إستجابة الحاصل (R_i)]. ويمكن تلخيص أهم النتائج فيما يلي:

١- أظهرت نتائج التحليل التجميعي للبيانات إلي وجود إختلافات عالية المعنوية بين التراكيب الوراثية و المواسم و المواقع ومواعيد الزراعة والتفاعل من الدرجة الأولي بين التركيب الوراثي والبيئات المدروسة في معظم الحالات، وكذلك التفاعل من الدرجة الثانية بين التراكيب الوراثي × المواقع × مواعيد الزراعة لمحتوي الحبوب من البروتين.

٢-أشارت النتائج إلي إرتفاع قيم التباين الراجع إلي تأثير الموقع بالنسبة للتباين الكلي، يليه التباين الراجع إلي موسم الزراعة، ثم تباين التركيب الوراثي ، في حين كانت مساهمة التباين الراجع إلي تأثير ميعاد الزراعة هو الأقل. وكانت نسبة مساهمة العوامل تحت الدراسة إلي التباين الكلي لمحصول الحبوب للمتر المربع ٥٠,٥٩% (للمواقع) و ٢٥,٨٠% (للمواسم) و ١٢,٢٤% (للتراكيب الوراثية) و ١١,٣٧% لمواعيد الزراعة.

٣-أظهرت نتائج تحليل الثبات إلي أن التفاعل الخطي بين التركيب الوراثي × البيئة كان عالي المعنوية للصفات المدروسة، كما كانت قيم التفاعل الخطي بين التركيب الوراثي × البيئة معنوية عند اختبارها أمام قيم الانحرافات عن خط الإنحدار لجميع الصفات ، مشيراً إلي أن الإنحدار الخطي والإنحرافات عن خط الإنحدار يمكن إستخدامها كمقاييس لوصف ثبات التراكيب الوراثية.

٤-أشارت معالم الثبات المظهري إلي تميز الصنفين المحليين "جميزة ٥ وجميزة ٩" والأجنبي "أكساد ٩٤١" بدرجة عالية من الأقلمة تحت ظروف البيئات الملائمة لصفة محصول الحبوب للمتر المربع ؛ وجميزة ٥ وجميزة ٩ وسدس ٦ لمحصول حبوب السنبلة الرئيسية و سخا ٦٩ وجميزة ٩ وأكساد ٩٢٥ و أكساد ٩٣٥ وأكساد ٩٤٩ لصفة محتوي الحبوب من البروتين. بينما يمكن أقتراح زراعة الصنف المحلي "سخا ٨" والصنف الأجنبي" Tsi/Vee 'S' تحت ظروف منطقة الخطارة أو شرق البحيرات (سيناء) كبيئات أقل ملاءمة لصفتي محصول الحبوب ومحتوي البروتين.

٥-كانت أكثر الأصناف قبولاً وثباتاً تحت مدي واسع من البيئات المتباينة، علي أساس جميع المقاييس المدروسة، هي جميزة ٧ يليه أكساد ٩٠٣ وسخا ٦٩ لمحصول الحبوب للمتر المربع والصنف "جميزة ٧" لمحصول حبوب السنبلة الرئيسية وجميزة ٥ وساحل ١ لطول السنبلة وجيزة ١٦٨ وجميزة ٥ لمحتوي بروتين الحبة، مقترحاً أهمية هذه التراكيب الوراثية في برامج تربية القمح لتحسين ثبات محصول الحبوب ومحتوي البروتين.