Bull. Fac.Agric.,Cairo Univ., 62:457 -467. (2011)

STABILITY ANALYSIS AND GENOTYPE X ENVIRONMENT INTERACTION FOR GRAIN YIELD IN BREAD WHEAT

(Received:28.9.2011)

By
R. M. Koumber, E. F. El-Hashash* and S. A. Seleem

Wheat Research Department, Field Crops Research Institute, Agriculture Research Center and
********Agronomy Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.*

ABSTRACT

The objective of this study was to determine stability and genotype X environment interaction of some wheat genotypes, and the effect of different environments on grain yield to understand their adaptation to varying environments. Forty wheat genotypes were evaluated at three locations (Gemmieza, Nubaria and Mallawy) in Egypt during 2008/2009 and 2009/2010 seasons. Genotypes generally showed variation in their response to changing environment. Combined analysis of variance revealed highly significant variances ($P < 0.01$) due to genotypes (G), locations (L), years (Y), the first order interactions (G x L, G x Y and Y x L) and the second order interaction (G x L x Y) for grain yield. Maximum grain yield was produced in Gemmieza followed by Mallawy and Nubaria locations. Pooled analysis of variance and stability analysis were performed. The variances due to genotypes (G), environments (E), E + (G x E), G x E, E (linear), G x E (linear) and pooled deviation were highly significant ($P < 0.01$). The partitioning of G x E interaction variance into linear and non-linear components indicated that both predictable and unpredictable components shared the interaction. Wide range of stability statistics was observed among genotypes for all the stability parameters. Maximum grain yield of 21.16 (ardab/feddan) was produced by the promising line 32 followed by the promising 33, 28, 23, Sakha 93 and Gemmieza 9. The large variation in mean grain yield, phenotypic variance (σ^2_P), coefficient of variation (C.V. %), regression coefficient (bi) and deviation from regression (S^2_d) indicates different responses of genotypes to environmental changes. Genotypes Sakha 93 and the promising lines 23, 31 and 32 showed high grain yield, low deviation from regression and their regression coefficient values were close to unity and could be classified as stable genotypes. Stable performance was expressed by the promising line 32 (Gemmieza 9 / Sids 8) because of higher grain yield ($\bar{x}$ = 21.16 ardab/feddan), regression coefficient close to unity (b_i = 1.06) and low deviation from regression (S^2_d = -0.53). Regression coefficient of each genotype was highly significant positive correlated with mean, phenotypic variance and coefficient of variation. However, the phenotypic variance had significant and highly significant positive correlation with mean and coefficient of variation, respectively.

Key words: *correlation, genotype x environment interaction ,grain yield, stability parameters, wheat.*

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the leading human food crop in Egypt. The total national consumption from wheat was about 13 million tons whereas; the national wheat production was about 8 million tons during the last five years. Increasing total wheat grain production is a national goal to meat the increase in wheat consumption resulted from increasing population. The total wheat production could be increased, horizontally, by extending wheat area to the new cultivated land and vertically, *via* growing high yielding cultivars and supplementing the recommended cultural practices. However, stable wheat cultivars that are tolerant to different environmental stresses are the ultimate goal of the national wheat research program. The environmental effect along with genotype X environment interaction (GEI) make it difficult to verify and give general recommendations for a particular variety. However, several attempts have been made to specify, estimate and correct GEI. The ideal wheat genotype should be high yielding under different environmental conditions, but as genetic effects are not independent of environmental effects, most genotypes do not perform satisfactorily in all environments (Carvalho *et al*., 1983). When interaction between genotype and environment occurs, the relative ranking of cultivars for yield often differs when genotypes are compared across a series of environments and/or years. This poses a serious problem for selecting genotypes significantly superior in grain yield (Stafford, 1982). GEI are of major importance, because they provide information about the effect of different environments on cultivar performance and have a key role for assessment of performance stability of the breeding materials (Moldovan *et al*., 2000). Stable genotypes have the same reactions across the environments. Most favourable stability occurs with high yield or performance (Björnsson, 2002). Increasing genetic gains in yield is possible in part from narrowing the adaptation of cultivars, thus maximizing yield in particular areas by exploiting GEI. The genotypes response to environment is multivariate, yet the parametric approach tries to transform it to univariate problem *via* stability characters. This represents shifts from ranking stability by a quantitative measure to assigning genotypes into qualitatively homogeneous stability subset (Lin *et al.*, 1986). The stability was defined as adaptation of varieties to unpredictable and transient environmental conditions and the technique has been used to select stable genotypes unaffected by environmental changes (Allard and Bradshaw, 1964). Various statistical techniques have been developed to identify systematic variation in individual genotypic responses. Among these, Eberhart and Russell (1966) model has been widely used in studies of adaptability and stability of plant materials. Therefore, the choice of an adequate model to measure the stability of different genotypes is a question to be resolved by researchers. The regression coefficient (b_i) and the average departure from regression line (S^2_d) are two mathematical indices for the assessment of stability (Eberhart and Russell, 1966). A genotype with a high bi and S^2_d reacts readily to changes in the environment and possesses considerable variability, whereas cultivars with a bi < 1.0 and S^2_d near to 0.00 react weakly to changes in growing conditions and are considered to be stable in yield (Shindin and Lokteva, 2000). Finlay and Wilkinson (1963) regarded those genotypes with a b_i near 1.0 and high mean yield as being well adapted to all environments. The objectives of this study were to evaluate grain yield magnitude and stability; find quality differences between the genotypes and years; find influence of environment and genotype; identify most stable genotypes and locations; grouping of the genotypes by quality and finding out correlations between the stability parameters.

2. MATERIALS AND METHODS

2.1. Plant material and environments

Six field experiments were carried out during 2008/2009 and 2009/2010 growing seasons. The experiments were evaluated at three different locations in Egypt (El-Gemmieza, Nubaria and Mallawy). Forty wheat genotypes (Table 1) were grown in a randomized complete block design with three replications at six environments (3 locations X 2 years). The experimental plot consisted of 6 rows, 4 m. long and 20 cm. width and distance between plants within row was 10 cm with two plants per hill. Grain yield was obtained from the three interior rows in each plot. Plots were hand harvested, then grains were cleaned and weighed to determine grain yield.

2.2. Statistical analyses

Stability parameters were estimated by the method described by Eberhart and Russell (1966). Analysis of variance procedure was adopted to test the significance of location, year, genotype, and first and second order interactions assuming the year and location effects as random and genotype effect as fixed (Comstock and Moll, 1963).

The stability analysis of variance and stability parameters: phenotypic variance, coefficient of variation (CV %), linear regression coefficient (b_i) and deviation from regression (S^2_d) of genotype means across environments index were computed as suggested by Eberhart and Russell (1966). For the regression analysis of variance, the residuals from the combined analysis of variance were used as a pooled error to test the S^2_d values. A significant F value would indicate that the S^2_d was significantly different from zero. The hypothesis that each regression coefficient equaled unity was tested by t test using the standard error of the corresponding b value. Correlation analysis was used to study the relationship between mean yield *per se* and stability parameters, as well as between studied stability parameters. Correlation coefficients were compared against table r-values given by Fisher and Yates (1953) at (n-2) degrees of freedom at the probability levels of 0.05 and 0.01 to test their significance.

3. RESULTS AND DISCUSSION

3.1. Combined analysis

The values of variances for genotype, location, year, and their interactions are presented

Table (1): Pedigree of the forty bread wheat genotypes under six environments.

No.	Cultivar / Line	Pedigree
1	Sakha 93	SAKHA 92/TR810328 S8871-IS-2S-IS-0S
2	Sakha 94	OPATA/RAYON//KAUZ.CMBW 90Y3180-OTOM-3Y-010M-010Y-10M-015Y-0Y-0AP-0S.
3	Giza 168	MRL/BUC//SERICM 93046-8 M-OY-OM-2Y-OB-OGZ.
4	Sids 1	HD2172/2/PAVON//1158.57/MAYA74SD46 -45D-15D-05D
5	Gemmieza 7	CMH74A.630/SX//SERI82/AGENTCGM 4611-2GM-3GM-1GM-OGM
6	Gemmieza 9	Ald“s”/HUAC//CMH74 .630/SxCGM 4583 -5GM- 1GM- OGM
7	Gemmieza 10	MAYA74 "S" / On // 1160-147BB/ GALL141CHAT"S" 151 CROW"S".
8	Promising line 1	GEMMIEZA 27 / MILAN
9	Promising line 2	PREW / SAKHA 93
10	Promising line 3	SIDS 7/ MILAN
11	Promising line 4	GIZA 168/ SIDS 7
12	Promising line 5	GIZA 168 / GEMMIEZA 7
13	Promising line 6	GIZA168/CHIL//SLMI 75
14	Promising line 7	GHZA168/MAYA//NAC
15	Promising line 8	GEMMIEZA9/SIDS 6
16	Promising line 9	GEMMIEZA9/SIDS 4
17	Promising line 10	BUC"S"/DOVE"S"//TSI/3/GEMMIEZA 9
18	Promising line 11	KAUZ*/YACO//KAUZ/3/GEMMIEZA 7
19	Promising line 12	PARENTSK-47-A-1/SAKHA 61
20	Promising line 13	IRENA/WEAVER//GEM. 5
21	Promising line 14	ASKHA206/GEM.LINE 27
22	Promising line 15	KAUKO/CMH82-493//GEM 7
23	Promising line 16	KAUKO/CMH82-493//GEM 9
24	Promising line 17	KAUKO/CMH82-493//GEM 10
25	Promising line 18	KAUKO/CMH82-493//GEM 5
26	Promising line 19	KAUKO/CMH82-493//GEM 3
27	Promising line 20	GIZA168/SAKHA 61
28	Promising line 21	GIZA168/SIDS 6
29	Promising line 22	GIZA168/GEM.3
30	Promising line 23	GIZA168/GEM.10
31	Promising line 24	GIZA168/GEM.7
32	Promising line 25	GIZA168/CHIL//SLM 175
33	Promising line 26	SAKHA 61/SIDS 6
34	Promising line 27	SAKHA 93/SIDS 4
35	Promising line 28	SAKHA 61/GIZA164//SAKHA 61
36	Promising line 29	SAKHA 61/GIZA164//SAKHA 69
37	Promising line 30	GEMMIEZA 7/GEMMIEZA 9
38	Promising line 31	GEMMIEZA 9/SIDS 6
39	Promising line 32	GEMMIEZA 9/SIDS 8
40	Promising line 33	GEMMIEZA 9/SIDS 1

in Table (2). The mean squares due to genotypes (G), locations (L), years (Y), the first order interactions (G x L, G x Y and Y x L) and the second order interaction (G x L x Y) were highly significant (*P < 0.01*) for grain yield. However, the mean squares due to replications (Y x L) were not significant for grain yield. These results indicated that the studied genotypes responded differently to the various environmental conditions, suggesting the importance of the assessment of genotypes under different environments in order to identify the best genetic make up for a particular environment. The presence of GEI indicates that particular genotypes tended to rank differently in grain yields at different locations, while the small GEI

Table (2): Combined analysis of variance for grain yield based on two year data from three locations in Egypt.

S.O.V	d.f	Mean Squares
Years (Y)	1	662.78**
Locations (L)	2	3930.82**
Y x L	2	98.90**
Replications (YxL)	12	4.41^{NS}
Genotypes (G)	39	49.17**
G x Y	39	5.50**
G x L	78	22.02**
G x L x Y	78	4.91**
Error	468	2.93

***, ** = Significant at 5 and 1% probability level, respectively. NS = Not-Significant.**

indicates a small effect of the years on relative productivity.

The significance of variances due to genotypes, environments and their interactions was attributed to variations in different climatic and edaphic conditions at different locations, indicating the necessity of testing at multiple locations over time for accurate characterization of genotypic performance across divergent regions (Afzal Arain, *et al*., 2001). Ülker *et al.* (2006) reported that, the results indicated that there were significant variances due to interactions among genotypes, locations and years. Khan *et al*. (2007) mentioned that, the GEI mean squares were highly significant for grain yield. Combined analysis of variance revealed significant differences among locations, years, genotype x year and location × year interactions for grain yield (Parveen *et al.*, 2010). Hristov *et al*. (2011) using analysis of variance showed that all sources of variation were highly significant for grain yield mean squares.

3.2. Yield performance of the genotypes

Means of grain yield of wheat cultivars averaged across two years and three locations are given in Table (3). The average grain yield performances of locations and years across varieties were different. Mean grain yield for the 6 environments ranged from 8.87 to 28.47 (ard/fed.). Mean values in grain yields ranged from 16.87 to 28.47 (ard/fed.) and from 14.57 to 25.07 (ard/fed.) in Gemmieza location, from 10.07 to 17.40 (ard/fed.) and from 8.87 to 17.50 (ard/fed.) in Nubaria location, and from 12.93 to 25.73 (ard/fed.) and from 13.83 to 22.33 (ard/fed.) in Mallawy location during 2008/2009 and 2009/2010 seasons, respectively. Grand mean grain yield of the genotypes was 21.11, 13.26 and 18.89 (ard/fed.) in Gemmieza, Nubaria and Mallawy regions, respectively. However, it was 18.71 and 16.79 (ard/fed.) during 2008/2009 and 2009/2010 seasons, respectively. There were a relatively large variation in grain yields, the variation in yields between genotypes was notably higher as compared to that between in locations and years. Values of environmental index varied between -4.75 to 4.87 in six environments, which were the highest for Gemmieza. Location Gemmieza gave the highest mean grain yield in both years, which has been the best environment for wheat production. Ülker *et al*. (2006) also found differences in grain yields of different wheat genotypes in response to different environmental conditions.

3.3. Stability analysis

3.3.1. Analysis of variance

Pooled analysis of variance also exhibited highly significant mean squares ($P < 0.01$) due to the genotypes, environments and genotype × environment for grain yield (Table 4), revealing the presence of variability among genotypes as well as environments under which the experiments were conducted. The results of the combined analysis of stability are given in Table (5). An analysis of variance for stability revealed highly significant differences ($P < 0.01$) for grain yield among genotypes and environment + (G x E). This reveals that not only the amount of variability existed among environments but also the presence of genetic variability among the genotypes. The sum of squares due to environments and genotype x environment are partitioned into environments (linear), genotype x environment (linear) and pooled deviation (nonlinear) from the regression model. The highly significance ($P < 0.01$) of these components showed that both predictable and unpredictable components shared GEI. The G × E (linear) interaction was highly significant (tested against pooled deviation) which demonstrated that genotypes respond differently to variation in environmental conditions and indicating existence

Table (3): Means, ranges and values of environmental index (E.I.) of the various locations for grain yield (ard/fed.) of 40 wheat genotypes in Egypt during 2008/2009 – 2009/2010 seasons.

Locations	Gemmieza		Nubaria		Mallawy	
Seasons / Genotypes	2008/2009	2009/2010	2008/2009	2009/2010	2008/2009	2009/2010
Sakha 93	25.25	23.83	17.13	14.63	21.33	18.80
Sakha 94	26.03	20.40	16.33	14.10	23.48	19.47
Giza 168	22.77	21.37	13.70	14.67	21.55	20.03
Sids 1	19.40	18.60	13.73	12.87	25.73	22.33
Gemmieza 7	21.70	20.30	16.57	15.90	18.42	16.73
Gemmieza 9	28.47	24.83	12.87	13.30	20.88	19.73
Gemmieza 10	24.87	20.77	12.60	13.77	19.18	15.67
Promising 1	21.67	18.00	12.87	11.80	15.02	18.13
Promising 2	26.07	23.67	10.07	13.77	18.57	15.60
Promising 3	23.00	19.97	12.63	14.77	18.80	16.50
Promising 4	26.60	25.07	12.13	11.00	23.45	21.23
Promising 5	24.27	18.80	11.50	11.67	17.93	15.87
Promising 6	24.90	21.63	12.80	11.00	18.77	17.93
Promising 7	21.77	17.13	14.30	15.43	20.85	17.13
Promising 8	26.23	21.30	11.70	12.17	19.87	17.10
Promising 9	20.57	16.67	11.60	9.67	19.87	19.30
Promising 10	20.12	16.87	12.07	10.07	22.30	20.20
Promising 11	20.37	17.10	12.03	11.93	18.90	15.57
Promising 12	19.87	16.87	13.20	10.00	20.47	18.67
Promising 13	22.77	20.67	12.23	10.67	18.32	17.27
Promising 14	18.10	15.47	11.80	11.77	17.70	16.03
Promising 15	20.70	17.23	11.33	8.87	21.17	17.70
Promising 16	19.77	18.17	12.30	14.40	20.12	15.63
Promising 17	21.67	17.80	10.60	9.60	21.85	19.20
Promising 18	22.87	20.67	12.87	13.80	12.93	16.77
Promising 19	19.97	17.10	11.93	12.50	17.60	16.77
Promising 20	20.63	18.03	15.20	14.93	19.98	15.33
Promising 21	17.70	14.57	12.23	15.27	18.73	16.93
Promising 22	21.07	19.67	12.33	11.90	21.63	19.05
Promising 23	25.77	22.63	15.53	13.87	23.83	21.13
Promising 24	16.87	15.17	12.53	15.07	14.65	14.53
Promising 25	24.77	22.80	12.93	15.10	23.00	16.80
Promising 26	20.40	16.93	11.80	10.70	18.37	16.27
Promising 27	18.70	21.10	15.57	12.80	15.63	13.83
Promising 28	25.97	23.07	16.10	14.33	23.33	20.10
Promising 29	22.70	18.40	16.93	11.27	19.73	16.57
Promising 30	23.93	18.60	16.87	14.57	17.23	18.27
Promising 31	22.27	18.63	15.73	11.77	23.73	17.23
Promising 32	26.87	22.13	16.37	16.70	23.90	21.00
Promising 33	27.40	21.50	17.40	17.50	20.93	18.90
Mean	22.62	19.59	13.51	13.00	19.99	17.78
Range	11.60	10.50	7.33	8.63	12.80	8.50
E.I.	4.87	-4.24	2.25	1.84	-4.75	0.03

Table (4): Pooled analysis of variance of grain yield in 40 wheat genotypes grown in 6 locations in Egypt.

S.O.V	d.f	Mean squares	F
Genotypes (G)	39	49.17**	16.52
Environments (E)	5	1744.45**	586.26
G x E	195	11.88**	3.99
Error	480	2.98	

**** = Significant at 1% probability level.**

Table (5). Stability analysis of grain yield of 40 wheat genotypes grown in 6 locations in Egypt.

Source of variation	d.f	Mean squares
Genotypes (G)	39	16.39**
Environment + (G X E)	200	18.40**
Environment (Linear)	1	2907.42**
G X E (linear)	39	7.05**
Pooled Deviation	160	3.11**
Pooled error	480	0.99

**** = Significant at 1% probability level.**

of differences among the regression coefficients. The pooled deviations were highly significant against pooled error, showing that the differences in stability were due to deviation from linear regression only. Further, the variation in stability of different cultivars performances was mainly due to genotypes by environment interaction. Afzal Arain *et al*. (2001) detected pooled analysis of variance overall environments, indicating that the genotype, environment and GEI mean squares were highly significant for grain yield. Therefore, an understanding of GEI provides valid insights into the selection of new stable genotypes in the diversified environmental conditions prevailing in a region. The mean squares due to G x E (linear) were non-significant, depicting lack of genetic differences among genotypes for linear response to varying environments, while the mean squares due to pooled deviations were highly significant, reflecting considerable differences among genotypes for non - linear response (Rasul *et al*., 2006).

Anwar *et al*. (2007) analyzed stability of variance for grain yield and reported highly significant variances due to environments and environment (linear), while non-significant variance was obtained for genotype. Genotypes, environments and GEI variances were significant at P < 0.01 (Akçura *et al*. 2009). Hristov *et al.* (2011) using the analysis of stability parameters denoted that the stability of grain yield per plant was existed.

3.3.2. Stability parameters

Calculated stability parameters for grain yield are presented in Table (6). Average grain yield, phenotypic variance (σ^2_P), coefficient of variation (C.V. %), regression coefficient (b_i) and deviation from regression (S^2_d) for the 40 genotypes ranged from 14.80 (promising line 24) to 21.16 (promising line 32), from 9.71 (promising line 24) to 225.49 (promising line 4), from 21.05 (promising line 24) to 75.57 (promising line 2), from 0.43 (promising line 21) to 1.72 (promising line 4) and from -0.74 (promising line 26) to 13.60 (Sids 1), respectively (Table 6). The large variation in mean grain yield, σ^2_P, C.V. %, bi and S^2_d indicated different responses of genotypes to environmental changes (Akçura *et al*., 2005). Grand mean of grain yield, σ^2_P, C.V. %, b_i and S^2_d were 17.75, 91.98, 52.07, 1.00 and 2.11, respectively. Nineteen genotypes in mean grain yield, σ^2_P and C.V. %, 20 genotypes in b_i and 16 genotypes in S^2_d gave higher values than the grand means for these corresponding stability parameters.

Genotype promising line 32, promising line 33, promising line 23, Sakha 93 and Gemmieza 9 had the highest grain yield across all locations. However, the genotype promising 24 gave the poorest performance across all the environments. The performance of all other genotypes was moderately well in all environments. According to Eberhart and Russell (1966), an ideal cultivar would have both a high average performance over a wide range of environments plus stability. The highest values of phenotypic variance across environments were recorded for promising line 4, Gemmieza 9 and promising line 2, although some genotypes with very close average yield had different phenotypic variances. This closer magnitude suggested that the greater role of variability is due to the environment conditions.

Table (6): Estimates of stability and adaptability parameters of grain yield (ard/fed) for 40 bread wheat genotypes across 6 environments.

No.	Cultivars/ Line	Mean Grain Yield (ardab/feddan)	Phenotypic Variance σ^2_P	Coefficient of variation C.V.%	Regression coefficient (b_i)	Deviation from regression (S^2_d)
1	Sakha 93	20.16	82.33	45.00	1.01	1.15
2	Sakha 94	19.97	97.23	49.38	1.12	0.47
3	Giza 168	19.01	74.23	45.31	0.98	-0.02
4	Sids 1	18.78	121.83	58.78	0.93	13.60
5	Gemmieza 7	18.27	26.79	28.33	0.54	0.42
6	Gemmieza 9	20.01	191.67	69.17	1.57	2.10
7	Gemmieza 10	17.81	108.51	58.49	1.16	1.80
8	Promising 1	16.25	68.72	51.02	0.86	2.80
9	Promising 2	17.96	184.11	75.57	1.44	7.38
10	Promising 3	17.61	70.11	47.54	0.93	0.71
11	Promising 4	19.91	225.49	75.41	1.72	1.33
12	Promising 5	16.67	116.25	64.67	1.23	0.57
13	Promising 6	17.84	137.29	65.68	1.34	0.76
14	Promising 7	17.77	43.77	37.23	0.70	1.01
15	Promising 8	18.06	156.67	69.30	1.44	0.44
16	Promising 9	16.28	106.15	63.29	1.11	2.98
17	Promising 10	16.94	120.45	64.80	1.11	6.67
18	Promising 11	15.98	61.15	48.92	0.91	-0.65
19	Promising 12	16.51	85.04	55.85	0.98	2.97
20	Promising 13	16.99	111.33	62.12	1.21	0.15
21	Promising 14	15.14	38.75	41.11	0.70	-0.24
22	Promising 15	16.17	125.69	69.35	1.24	2.27
23	Promising 16	16.73	49.01	41.84	0.75	0.92
24	Promising 17	16.79	146.23	72.04	1.34	2.90
25	Promising 18	16.65	91.04	57.31	0.81	9.84
26	Promising 19	15.98	48.88	43.76	0.81	-0.68
27	Promising 20	17.35	32.71	32.96	0.60	0.62
28	Promising 21	15.91	27.96	33.24	0.43	2.64
29	Promising 22	17.61	94.89	55.32	1.09	1.16
30	Promising 23	20.46	112.46	51.83	1.23	-0.52
31	Promising 24	14.80	9.71	21.05	0.26	0.23
32	Promising 25	19.23	120.22	57.01	1.21	2.29
33	Promising 26	15.74	71.24	53.61	0.98	-0.74
34	Promising 27	16.27	48.11	42.63	0.53	5.89
35	Promising 28	20.48	102.05	49.32	1.18	-0.71
36	Promising 29	17.60	72.82	48.49	0.88	3.13
37	Promising 30	18.24	48.94	38.34	0.68	2.85
38	Promising 31	18.23	95.75	53.68	1.02	4.10
39	Promising 32	21.16	83.91	43.29	1.06	-0.53
40	Promising 33	20.61	69.90	40.57	0.88	2.50
Mean		17.75	91.98	52.07	1.00	2.11

Promising lines 2, 4 and 17 differed from the other genotypes by higher C.V. % values, but the promising line 24 and Gemmieza 7 had lower C.V. %. Ortiz *et al*. (2001) suggested that it may be possible to select simultaneously for high and stable grain yield by selecting outyielders that exhibit a low C.V. %.

The coefficient of variation for the dough stability time ranged from 24.29 to 49.60% across different varieties, locations, and years (Ji-Chun *et* *al.*, 2007). Mustăţea1 *et al.*, (2009) stated that, plotting C.V.'s against average yield proved to be the most useful tool in identifying cultivars with high and stable yield.

The variations in regression coefficient (b_i) values suggested that the forty genotypes responded differently to the different environments. Variability among environments is an important factor and mostly determines the usefulness of b values (Ülker *et al*., 2006).

The regression coefficient (b_i) values of the forty genotypes used in this study exhibited no genotype with b-values equal to 1.00. The regression coefficient values of Sakha 93, promising lines 31, 32, 12 and Giza 168 genotypes were close to unity. Hence, these genotypes may be considered as stable genotypes. Twenty out of forty genotypes had regression coefficients above unity, while other genotypes expressed b values below unity. Regression values above 1.00 describe genotypes with higher sensitivity to environmental change (below average stability) and greater specificity of adaptability to high yielding environments. Promising line 32, promising line 33, promising line 23, Sakha 93 and Gemmieza 9 had regression coefficient values of 1.06, 0.88, 1.23, 1.01 and 1.57, respectively, with high grain yield (Table 6).

Promising line 4 had the highest (1.72) regression coefficient, followed by Gemmieza 9 (1.57), promising line 2 (1.44) and promising line 8 (1.44). The yields of these lines were significantly affected by varying environmental conditions and yields increased when the conditions were adequate and decreased to below average when the conditions were inadequate.

Baker (1988) considered deviation from regression (S^2_d) to be the most appropriate criterion for measuring phenotypic stability in an agronomic sense, because this parameter measures the predictability of genotypic reaction to environment; with high and desirable *per se* performance of a variety across environments is also a positive point to rate the variety as a better and highly stable genotype. The genotypes displayed a wide range of values for S^2_d for grain yield. The genotypes; promising line 13, promising line 24, Gemmieza 7 and Giza 168 gave low S^2_d values which show better stability and specific adaptation to favourable environments. Five genotypes; Sids 1, promising line 18, promising line 2, promising line 10 and promising line 27 had high S^2_d, indicating less stability and indicating sensitivity to environmental changes. Due to the high values of S^2_d, these genotypes are expected to give good yield under favorable environmental conditions. Deviation from regression as small as possible is the measure of genotypic stability across a set of environments (Abdul Majid *et al*., 2007).

Accordingly, the promising line 32 ($\bar{x}$ = 21.16, b_i = 1.06 and S^2_d = -0.53), Sakha 93 ($\bar{x}$ = 20.16, b_i = 1.01 and S^2_d = 1.15) and Giza 168 ($\bar{x}$ = 19.01, b_i = 0.98 and S^2_d = -0.02) were the most stable for grain yield because their regression coefficients were the highest, b_i value almost near unity and they had lower deviations from regression; these would be recommended for environmental conditions of Gemmieza, Nubaria and Mallawy locations. Genotypes with high mean yield, a regression coefficient equal to the unity (b_i = 1) and small deviations from regression (S^2_d = 0) are considered stable (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966). Parveen *et al*. (2010) noticed some cultivars as stable on the basis of overall mean yields and stability parameters *viz*., regression coefficients and minimum deviations from regression. Özgen (1994), Ülker *et al.* (2006), Abdul Majid *et al*. (2007), Akçura *et al*. (2009), Feiziasl, *et al*. (2010) and Hristov *et al*. (2011) considered that a desirable genotype with stability and above average grain yield should have a regression line with a positive intercept and slope equal to 1.0 and lower deviation from regression.

3.3.3. Correlations

The correlation coefficients among the mean grain yield and stability parameters are presented in Table (7). The regression coefficient (b_i) displayed highly significantly positive correlation with mean grain yield (0.45), phenotypic variance (0.95) and coefficient of variation (0.90). Moreover, the phenotypic variance displayed significant and highly significant positive correlation with mean grain yield (0.40) and coefficient of variation (0.92), respectively. In contrast, the deviations from regression demonstrated insignificant correlation with mean grain yield (-.06), phenotypic variance (0.23), coefficient of variation (0.28) and regression coefficient (-0.02). Despite existence of several highly significant correlations, it is obvious that each stability parameter and especially those belonging to different groups according to Lin *et al*. (1986) and Mustăţea1 *et al*. (2009) describe different aspects of genotypes x environment interaction. Hugo Ferney *et al*. (2006) mentioned that grain yield correlated significantly and

Table (7): Correlation coefficients between mean yield and the studied stability parameters.

Stability parameters	Mean	σ^2_P	C.V.%	b_i	S^2_d
Mean	1.00	0.40*	0.11	0.45**	-0.06
σ^2_P		1.00	0.92**	0.95**	0.23
C.V.%			1.00	0.90**	0.28
b_i				1.00	-0.02
S^2_d					1.00

positively with the stability parameters regression coefficient and deviation from regression. Phenotypic variance and coefficient of variation were significantly correlated with average grain yield regression coefficient and deviation from regression (Mustãţea1 *et al*., 2009).

4. REFERENCES

Abdul Majid S., Asghar, R. and Murtaza, G. (2007). Yield stability analysis conferring adaptation of wheat to pre- and post-anthesis drought conditions. Pak. J. Bot., 39(5): 1623 –1637.

Afzal Arain M., Sial M.A. and Javed M.A. (2001). Stability analysis of wheat genotypes tested in multi-environmental trail (METs) in Sindh Province. Pak. J. Bot., 33: 761 – 765.

Akçura M., Kaya Y. and Taner S. (2005). Genotype-environment interaction and phenotypic stability analysis for grain yield of durum wheat in the Central Anatolian Region. Turk. J Agric., 29: 369 – 375.

Akçura M., Kaya Y. and Taner S. (2009). Evaluation of durum wheat genotypes using parametric and nonparametric stability statistics. Turk. J. of Field Crops, 14(2): 111 – 122.

Allard R.W. and Bradshaw A.D. (1964). Implications of genotype environmental interactions in applied plant breeding. Crop Sci., 4: 503 – 507.

Anwar J., Khan S.B., Rasul I., Zulkiffal M. and Hussain M. (2007). Effect of sowing dates on yield and yield components in wheat using stability analysis. Inter. J. of Agric. and Biol., 1: 129–132.

Baker R.J. (1988). Test for crossover genotype-environmental interaction. Canadian J. Pl. Sci., 68: 405–10

Björnsson I. (2002). Stability analysis towards understanding genotype x environment interaction. Plant Agriculture Department of University of Guelph,Ontario, Canada. www.genfys.slue.se/staff/deg/nova02.

Carvalho F.I.F., Federizzi L.C. and Nodari R.O. (1983). Comparison among stability models in evaluating genotypes. Rev. Bras. Genet., 6(4): 667 – 691.

Comstock R.E. and Moll R.H. (1963). Genotype-environment interactions. In: Statistical Genetics and Plant Breeding, (Ed: W.D. Hanson and H.F. Robinson). Proc. Natl. Acad. Sci.-NRC Pub. no. 982, pp. 164 –196.

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

Feiziasl V., Jafarzadeh J. Amri A., Ansari Y., Mousavi S.B. and Chenar M.A. (2010). Analysis of yield stability of wheat genotypes using new crop properties balance index (cpbi) method. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38(1), 228 – 233.

Finlay W. and Wilkinson G.N.R. (1963). The analysis of adaptation in a plant breeding programme. Aust. J. Ag. Res., 14: 742–754.

Fisher, R.A and Yates, F. (1953). Statistical Tables for Biological, Agricultural, and Medical Research. Olive and Boyd, Edinbugh, p.94.

Hristov N., Mladenov N., Kondic-Špika A., Marjanovic-Jeromela A., Jockovic B. and Jacimovic G. (2011). Effect of environmental and genetic factors on the correlation and stability of grain yield components in wheat. Genetika, 43(1): 141-152.

Hugo Ferney G.B., Alexei M. and Aigul A. (2006). Evaluation of grain yield stability, reliability and cultivar recommendations in spring wheat (*Triticum aestivum* L.) from Kazakhstan and Siberia. J. of Central European Agric., 7(4): 649 – 659.

Ji-Chun T., Rui-Bo H.U., Zhi-Ying D. and Yan-Xun W. (2007). The variation and stability analysis of wheat dough stability time. Agric. Sci., in China, 6(2): 143-149.

Khan A.G., Ali A., Azam F.I. and Tariq M. (2007). Grain yield stability analysis of wheat genotypes from NWFP of Pakistan. Pakistan J. Agric. Res., 20(3-4): 105 – 109.

Lin C.S., Binns M.R. and Lefkovitch L.P. (1986). Stability analysis: Where do we stand. Crop Sci. 26: 894–900.

Moldovan V., Moldovan M. and Kadar R. (2000). Item from Romania. S.C.A. Agricultural Research Station. Turda, 3350, str. Agriculturii 27 Jud Chuj, Romania.

Mustăţea1 P., Saulescu N.N., Ittu1 G., Paunescu G.,Voinea L., Stere I., Mîrlogeanu S., Constantinescu E. and Nastase D. (2009). Grain yield and yield stability of winter wheat cultivars in contrasting weather conditions. Romanian Agric. Res. 26: 1 – 8.

Ortiz R., Wagoire W. W., Hill J., Chandra S., Madsen S. and Stølen O. (2001). Heritability of and correlations among genotype-by-environment stability statistics for grain yield in bread wheat. Theor. Appl. Genet., 103: 469 – 474.

Özgen M. (1994). Analysis of adaptation and stability in yield and yield component of winter barley under Central Anatolia conditions. Turkish J. of Agric. and Forestry, 18: 169 –177.

Parveen L., Khalil I.H. and Khalil S.K. (2010). Stability parameters for tillers, grain weight and yield of wheat cultivars in north-west of Pakistan. Pak. J. Bot., 42(3): 1613 – 1617.

Rasul I., Zulkiffal M., Anwar J., Khan S.B., Hussain M. and Riaz U.D. (2006). Grain yield stability of wheat genotypes under different environments in Punjab. J. of Agric. and Soc. Sci., 4:222–224.

Shindin I.M. and Lokteva O.V. (2000). Evaluation of spring wheat varieties at Primorskey for ecological plasticity. Ann. Wheat. Newslet., 46: 105 – 106.

Stafford R.E. (1982). Yield stability of guar breeding lines and cultivars. Crop. Sci., 2(5): 1009 –1011.

Ülker M., Sönmez F., Çiftçi V., Yilmaz N. and Apak R. (2006). Adaptation and stability analysis in the selected lines of tir wheat. Pak. J. Bot., 38(4): 1177–1183.

تحليل الثبات والتفاعل التركيب x البيئة لمحصول الحبوب في قمح الخبز

رضا محمد قمبر- عصام فتحى الحشاش* - صبرى أحمد سليم

قسم بحوث القمح – معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية.
*قسم المحاصيل – كلية الزراعة – جامعة الأزهر - القاهرة – مصر.

ملخص

تهدف هذه الدراسة الى دراسة الثبات الوراثى وتفاعل التركيب مع البيئة فى بعض التراكيب الوراثية من القمح وتأثير بعض البيئات المختلفة على محصول الحبوب لفهم عملية التكيف مع البيئات المختلفة. تم فى هذه الدراسة استخدام 40 تركيب وراثى من القمح لتقييمها فى ثلاثة مواقع (الجميزة – النوبارية – مالاوى) خلال موسمى النمو 2009/2008 ، 2010/2009 فى مصر.

وكانت أهم النتائج المتحصل عليها كالتالى:-

1 - أظهرت التراكيب الوراثية المستخدمة فى الدراسة إختلاف فى أستجابتها للبيئة المتغيرة.
2 - كشف تحليل التباين التجميعى وجود فروق عالية المعنوية بين التراكيب الوراثية و المناطق و السنوات و التفاعلات من الدرجة الاولى (التركيب الوراثى x المناطق و التركيب الوراثى x السنوات و السنوات x المناطق) و التفاعل من الدرجة الثانية (التركيب الوراثى x المناطق x السنوات).
3 - تم الحصول على أعلى محصول من القمح بمنطقة الجميزة يتبعها منطقتى مالاوى والنوبارية.
4 - أظهرتحليل التباين المجمع وتحليل التباين للثبات أن التركيب الوراثى و البيئات و البيئى + (التركيب الوراثى x البيئى) و التركيب الوراثى x البيئى و البيئى (الخطى) و التركيب الوراثى x البيئى (الخطى) و الانحراف التجميعى كانت عالية المعنوية. وتجزئة تفاعل التركيب الوراثى x البيئى الى المكونات الخطية وغير الخطية تشير الى أنه هناك مكونات يمكن التنبؤ بها ومكونات لا يمكن التنبؤ بها على حد سواء تشارك فى التفاعل المشترك.
5 - كما لوحظ وجود مدى واسع للثبات بين التراكيب الوراثية لكل مقاييس الثبات.
6 - أوضحت النتائج الى أن أعلى محصول حبوب من القمح (21.16 أردب/فدان) نتج من السلالة المبشرة 33 يليها المبشرة 34 و المبشرة 29 و المبشرة 24 و سخا 93 و جميزة 10.
7 - أشارت النتائج الى وجود تباين كبير فى متوسط محصول الحبوب و التباين الظاهرى و معامل الأختلاف و ومعامل الانحدار والانحراف عن الانحدار والتى تشير الى الاستجابات المختلفة من التراكيب الوراثية للتغيرات البيئية.

8 - أظهرت التراكيب الوراثية سخا 93 و المبشرة 24 و المبشرة 32 و المبشرة 33 محصول حبوب عالى و انحراف عن الانحدار منخفض و قيم معامل الانحدار قريبة من الواحد وبالتالى تصنف بانها تراكيب وراثية ثابتة.

9 - يعتبر التركيب الوراثى المبشرة 33 ذو أداء ثابت وراثياً وذلك لارتفاع محصول الحبوب (21.16 أردب/فدان) و معامل إنحدار يقترب من الواحد (b_i = 1.06) و انحراف من الانحدار منخفض (S^2_d = -0.53).

10 -أوضح معامل الارتباط بين مقاييس الثبات الى أن ارتباط معامل الانحدار كان عالى المعنوية وموجب مع كل من المتوسط و التباين الظاهرى و معامل الاختلاف. بينما كان ارتباط التباين الظاهرى معنوى وموجب مع المتوسط وعالى المعنوية وموجب مع معامل الاختلاف.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (62) العدد الرابع (أكتوبر2011): 457-467.