African Journal of Agricultural Research Vol. 7(34), pp. 4838-4844, 4 September, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.477
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Stability analysis of selected wheat genotypes under different environment conditions in upper Egypt

Tharwat El Ameen

Department of Genetics, Faculty of Agriculture, South Valley University, Egypt.

Accepted 9 August, 2012

The experiment was conducted during winter 2010 and 2011 to assess heat tolerance of 17 genotypes under four environments (two sowing dates with two years). The combined analysis of variance showed that the differences between genotypes as well as GXE were highly significant for grain yield, 1000 grain weight, number of kernel/spike and spike length. The genotypes No. 1, 2, 3 and 7 gave high mean grain yield, regression coefficient "b" not significantly from unit and considered more stable. Meanwhile, genotypes No. 1, 2, 4, 15 and Giza-168 showed below average stability (b=1.92, 1.72, 2.24 and 1.6). Also, genotypes No. 1, 2, 3 and 7 were relatively heat resistance (HSI values <1), while local variety Giza-168, Sids-12 genotypes No. 13, 14 and 12 were relatively susceptible to heat stress. In general, in drought environments, grain yield of genotypes No. 1, 2 and 3 were the highest.

Key words: Environment, genotype, genotype by environment interaction, grain yield, heat stress.

INTRODUCTION

Wheat (*Triticum aestivum* autharuty) is one of the most important crops and is a stable food for large parts of the world population including Egypt. Information about phenotypic stability is useful for selection of crop varieties in a breeding program. Plant breeders encounter genotype × environment interaction (G × E) when testing varieties across a number of environments. The magnitude of the interaction or the differential genotypic responses to environments differs greatly across environments (Kaya et al., 2002).

Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels was investigated by Hamam and Abdel-Sabour (2009). Their results revealed that the differences between genotypes were significant for grain yield, spike length and 1000 grain weight.

The stability analysis showed that four and three genotypes were high, intermediate yielding and stable for yield across different environments.

Continuous high temperature stress for wheat was considered when the mean average temperature of the coolest month is greater than 17.5°C (Fisher and Byerkee, 1991). Terminal heat stress largely refers to a rise in temperature at the time of grain growth. Reduction up to a 23% in grain yield has been reported from as little as 4 days exposure to very high temperature (Randoll and Mass, 1994; Stone and Nicolas, 1994).

There are currently around 9 millions hectares of wheat in tropical or subtropical areas that experience yield losses due to high temperature (lillemo et al., 2005). Many researchers studied the differences between genotypes regarding the response under high stress environments. Fisher and Maurer (1978) described yield potential to be associated with high stress environments. Blum et al. (1988) reported that stability in grain yield for each genotype could be estimated by the drought susceptibility index derived from yield differences between stressed and non stressed environments. Drought stress at the grain filling period dramatically reduces grain yield (Ehdaie and Shakiba, 1996).

Performance of yield and stability of wheat genotypes under high stress environments of the central region of Saudi Arabia was analyzed by Soleman Al -Otayk (2010). The results showed highly significant G × E and genotype differences for all characters studied. The stability

*Corresponding author. E-mail: Tharwat_ameen@yahoo.com.

Abbreviations: b, Regression coefficient; **HIS,** heat susceptibility index; **GE,** genotype by environment interaction; **S^2d,** sums of squares due to deviation from regression; **Bi,** deviation from regression.

analysis revealed that genotypes YR-19 and YR-20 showed high and stable yielding. Also, the genotype, YR-20 and YR-19 were relatively heat resistant HSI<1.

The relative yield performance of genotypes in drought stressed and more favorable environment seems to be a common starting point in the selection of genotypes for use in breeding for dry environment (Clarke et al., 1992). Heat stress is one of the major environmental stress affecting plant growth and productivity in wheat (Akherdiew et al., 2000). Terminal heat stress is a major resistance environmental factor in many population areas. The aim of this study was to screen wheat genotypes with high yield potential and stability under heat stress conditions.

MATERIALS AND METHODS

Field trials

The experiments included two wheat cultivars, Giza-168 and Sids-12 and the 15 advanced lines (labeled from 1 to 15) with highest yield were selected at F_5 generation of cross between long-spike-35 × Sakha-69. Field experiments were conducted at the experimental farm of South Valley University, Egypt during 2009/2010 and 2010/2011 winter seasons. The 17 genotypes were sown in two sowing dates in both seasons, namely the normal sowing dates 25th November, where the sowing condition are favorable and the late sowing 10th January which allow the plants to be subjected to the heat stress resulting from the rise of temperature late in the growing season.

Layout and experimental design

Each of the 17 genotypes were represented in each block by an row of 15 plants spaced 20 cm apart within rows set apart 30 cm from each other. A randomized complete block design (RCBD) with three replications was used in each environment. Normal agriculture practices were followed.

Yield and other measurements

At harvesting time, grain yield, 1000 grain weight, number of kernel/ spike and spike length were recorded for individual plant.

Heat susceptibility index (HSI)

The heat susceptibility index (HSI) was used as a measure of heat tolerance in terms of the reduction in yield caused by unfavorable versus favorable environments. HSI was calculated for each genotype according to the formula of Fisher and Muarer (1978). This is expressed as:

$$HSI = 1 - \frac{\bar{yh}}{\bar{yp}}$$

Where $\bar{yh}$ = mean yield of all genotypes under heat, $\bar{yp}$ = mean of all genotypes under favorable conditions, H= heat stress intensity. Thus:

$$HSI = \frac{YP - Yh}{Yp.\ HSI}$$

Where yp = mean yield of individual genotype under favorable, yh= mean yield of individual genotype under heat stress.

Genotype with average susceptibility or resistant to heat (drought) will have an HSI value of 1.0. Values less than 1.0 indicate less susceptibility and greater resistance to drought. Meanwhile, a values of HSI=0 indicate maximum possible heat tolerance (no effect of heat on yield).

Correlation analysis

Genotypic and phenotypic correlations were estimated according to Miller et al. (1959).

Stability analysis

Stability parameters for grain yield and yield components of the 17 genotypes were calculated according to the model of Eberhart and Russel (1966).

Data analysis

Analysis of variance (ANOVA) was calculated for environment one factor and combined over sowing dates following Gomes and Gomez (1984).

RESULTS AND DISCUSSION

Genotype by environment interaction and stability

Grain yield

The means of grain yield and 1000 grain weight of the 17 genotypes at each of the four environments with the stability parameter are given in Table 2. The analysis of variance (Table 1) revealed highly significant differences between environments and genotypes. In the study of Taw Felis (2006), significant variation in yield and yield component among wheat genotypes were under favorable and late planting averaged over 17 genotypes and the environmental mean ranged from 0.72 to 2.24 g for grain yield indicating that a wide range of variation. Delaying the sowing date resulted in a substantial reduction in grain yield by 63.34%. Blum (1988) reported that drought stress at the grain filling period reduced grain yield. Reduction in grain yield reached 23% from as little as 4 days exposure to very high temperature that was reported by Randoll and Mass (1990).

The joint regression analysis (Table 1) revealed that the G × E interaction Ms was highly significant indicating the differential performance of the 17 genotypes in the array of environments used. The heterogeneity regression and the remainder from regression were highly significant. Highly significant GE interaction for

Table 1. The joint regression analysis of variance for the characters studied.

Item	df	Grain yield	1000 grain	Number of kernel/spike	Spike length
Environment	3	33.71**	1567.03**	14408.28**	247.80**
Error (a)	8	0.26	30.08	126.62	3.28
Genotype	16	1.34**	83.69**	746.90**	11.00**
GXE	48	0.58**	53.43**	246.68**	5.91**
Heterogeneity	16	0.42**	27.69	158.86**	1.58
Remainder	32	0.65**	66.29**	290.58**	8.07**
Pooled error	128	0.10	19.46	52.04	1.06

* $p < 0.05$, ** $p < 0.01$.

many wheat traits were previously reported by Kheialla (2004), Mahmoud (2006) and Soleman Al Otayk (2010).

According to Eberhart and Russel (1966) model, the genotypes No. 7, 3 and 1 gave high mean grain yield and regression coefficient not significant from the unit. On the other hand, genotypes No. 15, 14, 12, 11 and Giza-168 showed below average stability (b=1.16, 2.24, 1.78, 1.92 and 1.14) indicating that these genotypes perform well under favorable conditions whereas their grain yield are reduce markedly under stressed conditions.

1000 grain weight

The data in Table 2 shows the means of 1000 grain weight of the 17 genotypes at each of the four environments. The analysis of variance (Table 1) showed that highly significant differences between genotypes as well as between environments averaged over four environments and the genotypes mean ranged from 32.16 to 40.25 g. The environmental means ranged from 29.42 g to 41.36 g indicating that wide detected range of environment differences.

Late sowing which represented the heat stress resulted in a substantial reduction in 1000 grain weight by 22.22%. Stone and Nicolas (1994) reported that reduction up to 23% from as little as 4 days with high temperature was observed.

The joint regression analysis (Table 1) showed t highly significant GE interaction. The heterogeneity of regression Ms was not significantly against the error, whereas, the remainder from regression Ms was highly significant indicating that non-linear component of GE interaction was operating.

Kaya et al. (2002) reported that there were significant differences between wheat genotypes as well as GE in yield and yield components; a genotype with the lowest or non significant deviation from regression being the most stable.

Three genotypes exhibited small s^2d values and were not significant, namely genotypes No. 13, 16 and 10. On the other hand, genotypes No. 9 and 14 exhibited large values and were significant.

Number of kernel/spike

The Data (Table 3) shows the means of number of kernel/spike of the 17 genotypes at each of the four environments with the stability parameters. The mean of genotypes ranged from 28.62 to 50.62, while the mean of environments ranged from 24.15 to 52.94. The joint regression analysis (Table 1) revealed that the GE interaction was highly significant. The heterogeneity regression Ms and the remainder from regression were highly significant. The heterogeneity constituted of 35% of the interaction, but the remainder from regression constituted 65% of the interaction indicating that a greater portion of the interaction was a non linear function of the environmental values.

Similar results were obtained by El-Morshidy (2001) and Abdel-Majeed (2005). The genotypes, namely No. 7, 3 and 6 had high mean number of kernel/spike and regression coefficient "b" not significant from the unit. In the reverse, genotypes No.12, 14 and 11 showed below average stability (1.98, 1.88 and 1.52) indicating that these genotypes performed well under favorable conditions.

Spike length

The differences between genotypes as well as between environments were highly significant (Table 1) and averaged over four environments with the mean of genotypes ranging from 8.16 cm for genotype No.13 to 11.66 cm for genotype No. 7. The joint regression analysis showed that the GE interaction was highly significant. The heterogeneity regression Ms was not significant, but the deviation from regression was highly significant against Ms error. The heterogeneity constituted 16% of the interaction, but the remainder constituted 84% of the interaction. These results are in agreement with those obtained by Menshawy (2007). The genotypes No. 1, 6, 8, 10 and 12 exhibited small S^2d values and were not significant. On the other hand, genotypes No. 3, 4 and 5 exhibited large values S^2d and were significant.

Table 2. Means of grain yield and 1000 grain weight of 17 genotypes at each of the four environments with the stability parameters.

Genotypes	Environments				Stability parameters				Environments				Stability parameters			
	E_1	E_2	E_3	E_4	Mean	b± SE	Bi	S^2d	E_1	E_2	E_3	E_4	Mean	b± SE	Bi	S^2d
1	2.13	0.72	1.97	1.02	1.46	0.47±0.38	-0.53	1.31	44.37	34.13	40.41	34.98	38.47	0.77±0.29	-0.23	23.0
2	2.66	1.07	2.54	1.17	1.86	1.06±0.27	0.06	0.06	46.59	35.33	39.84	35.44	39.30	0.80±0.36	-0.2	37.40
3	2.48	1.14	2.57	0.83	1.75	1.13±0.29	0.13	0.02	35.66	30.04	38.76	27.89	33.09	0.83±0.25	-0.17	18.6
4	2.05	0.83	2.09	0.64	1.40	0.97±0.29	-0.03	0.002	40.28	37.83	42.79	34.27	38.79	0.61±0.17	-0.39	8.66
5	1.44	1.38	1.82	0.54	1.29	0.51±0.09	-0.49	0.054	38.60	35.93	42.25	31.60	37.09	0.73±0.24	-0.27	16.78
6	1.75	1.15	2.25	1.05	1.55	0.66±0.24	-0.34	0.16	36.23	33.37	40.75	28.84	34.81	0.84±0.30	-0.16	25.00
7	2.86	1.43	2.06	0.83	1.79	0.97±0.18	-0.03	0.70	43.89	37.78	36.12	28.22	36.50	1.0±0.43	0.00	50.75
8	1.96	1.02	1.50	0.22	1.17	0.82±0.08	-0.18	0.53	47.28	33.80	42.54	22.88	36.63	1.94±0.12	0.94	4.51
9	2.32	1.27	1.24	0.48	1.33	0.67±0.37	-0.32	1.29	45.31	43.66	38.39	24.82	38.05	1.30±0.75	0.30	155.04
10	1.43	0.75	1.62	0.74	1.13	0.56±0.29	-0.44	0.02	35.11	32.97	36.34	29.61	33.50	0.51±0.10	-0.49	3.32
11	2.29	0.95	3.34	1.06	1.91	1.32±0.22	0.32	0.79	41.58	42.50	36.92	36.70	39.42	0.16±0.37	-0.84	38.12
12	2.99	0.77	3.41	0.72	1.97	1.78±0.26	0.78	0.11	38.83	31.25	40.63	28.35	34.76	1.03±0.21	0.03	12.85
13	1.76	0.79	1.47	0.84	1.21	0.57±0.27	-0.43	0.09	34.22	32.95	33.34	33.12	33.41	0.07±0.02	-0.93	0.68
14	3.53	0.70	3.96	0.61	2.20	2.24±0.26	1.24	0.11	44.77	32.79	50.70	32.74	40.25	1.40±0.58	0.40	94.23
15	1.92	0.33	1.98	0.35	1.14	1.16±0.29	0.16	0.02	47.02	28.63	42.20	22.89	35.18	2.04±0.25	1.04	18.70
Giza-168	1.83	0.40	2.25	0.50	1.24	1.14±0.25	0.14	0.15	40.72	22.82	40.25	24.85	32.16	1.35±0.09	0.35	2.72
Sids-112	1.88	0.71	1.97	0.65	1.30	0.90±0.29	0.10	0.004	42.70	28.60	36.29	22.88	32.61	1.54±0.24	0.54	16.63
Average	2.19	0.91	2.24	0.72	1.51				41.36	33.79	39.91	29.42	36.12			

Table 3. Means of number of grain/spike and spike length of 17 genotypes at each of the four environments with the stability parameters.

Genotypes	Environments				Stability parameters				Environments				Stability parameters			
	E_1	E_2	E_3	E_4	Mean	B± SE	Bi	S^2d	E_1	E_2	E_3	E_4	Mean	b± SE	Bi	S^2d
1	46.50	21.50	49.33	28.66	36.50	0.77±0.15	-0.23	58.49	10.50	6.50	10.66	7.00	8.66	0.95±0.18	-0.05	1.92
2	57.00	31.50	63.00	33.00	46.12	0.95±0.08	-0.05	18.48	11.00	10.50	11.00	7.66	10.04	0.60±0.28	-0.40	3.97
3	69.50	37.00	66.33	29.66	50.62	1.18±0.14	0.18	51.68	11.00	11.00	13.00	6.66	10.41	1.01±0.47	0.01	10.50
4	51.00	21.00	49.00	19.00	35.00	1.02±0.08	0.02	17.03	10.50	11.00	11.00	5.66	9.54	0.83±0.59	-0.17	15.84
5	37.00	39.00	42.33	17.00	33.83	0.43±0.36	-0.57	346.65	10.00	11.50	10.66	6.00	9.54	0.61±0.63	-0.39	18.40
6	49.00	32.50	55.33	34.66	42.87	0.66±0.11	-0.34	32.32	11.00	8.50	12.00	8.00	9.87	0.86±0.03	-0.14	0.43
7	66.00	38.50	58.33	29.00	47.95	0.97±0.21	-0.03	120.58	11.50	11.50	13.66	10.00	11.66	0.54±0.25	-0.46	3.30
8	41.50	28.00	35.33	9.66	28.62	0.67±0.31	-0.33	257.34	11.50	8.50	10.66	7.33	9.50	0.83±0.13	-0.17	1.27
9	51.50	25.50	33.00	20.00	32.50	0.63±0.34	-0.37	304.84	11.50	7.50	9.33	8.00	9.08	0.63±0.34	-0.37	5.78
10	40.00	23.00	45.00	25.66	33.41	0.62±0.08	-0.38	20.05	11.00	8.00	11.66	8.66	9.83	0.75±0.15	-0.25	1.61
11	54.50	22.50	84.00	29.00	47.50	1.52±0.47	0.52	577.40	12.50	7.00	14.00	7.00	10.12	1.61±0.23	0.61	2.83

Table 3. Contd.

12	77.00	25.00	83.00	25.33	52.58	1.88±0.07	0.88	15.25	11.50	6.00	12.66	5.66	8.95	1.62±0.15	0.62	1.54
13	50.50	24.00	44.33	25.66	36.12	0.76±0.15	-0.24	59.27	10.00	6.00	9.66	7.00	8.16	0.80±0.24	-0.20	3.18
14	78.50	21.50	78.00	19.33	49.33	1.98±0.11	0.98	28.94	13.50	6.00	14.66	6.33	10.12	2.02±0.31	0.37	4.86
15	41.00	11.50	46.66	15.33	28.62	1.04±0.11	0.04	33.57	10.00	5.00	11.00	5.33	7.83	1.34±0.21	-0.03	2.58
Giza-168	45.50	19.00	56.00	21.33	35.45	1.05±0.14	0.05	56.26	10.50	6.50	10.33	6.66	8.50	0.97±0.14	-0.03	1.361
Sids-112	44.00	25.00	54.33	28.33	37.91	0.78±0.16	-0.22	69.30	10.50	6.50	10.00	6.66	8.41	0.93±0.16	-0.07	1.61
Average	52.94	26.23	55.49	24.15	39.70				11.05	8.08	11.52	7.03	9.42			

Table 4. Mean squares from the combined of variance for traits studied of the 17 genotypes tested in favorable and stress environments.

Item	df	Grain yield	1000 grain weight
Environment	3	33.71**	1567.63**
Error (a)	8	0.26	30.08
Genotype	16	1.34**	83.69**
GXE	48	0.58**	53.43**
Error	128	0.10	19.46

* $p < 0.05$, ** $p < 0.01$.

Genotype by environment interaction and heat susceptibility index

Grain yield

The means of grain yield/plant of the 17 genotypes simultaneously grown in favorable and heat stress environments are shown in (Table 5). The analysis revealed highly significant differences between genotypes, environments as well as highly significant GE interaction (Table 4) which indicate differential response of the different genotypes to heat stress. Similar results were obtained by Hamam and Abdel-Sabour (2009) and Abdel Kareem (2001). Accordingly, heat susceptibility index (HSI) was calculated for each of the 17 genotypes tested. The two cultivars, Giza-168 and Sids-12 and genotypes No. 13, 14 and 12 displayed HSI values >1 indicating relative susceptibility to heat stress. Meanwhile, the other genotypes displayed HSI value < 1 with relative resistance to heat stress. The best mean performance over the two environments was displayed by genotypes No. 14, 12, 11, 7 and 3. Drought yield of genotypes No.1, 2 and 3 were highest.

The HSI has sometimes been regarded as providing a measure of genotype yield potential under heat stress conditions (Bruckner and Frogberg, 1987). HSI actually provides a measure of yield stability based on yield loss under stress as compared to non stressed condition rather than on yield level under dry conditions (Clark et al., 1984).

1000 grain weight

Table 5 shows the mean of 1000 grain weight of 17 genotypes in favorable and drought stressed environments. Highly significant differences between genotypes and environments as well as GE interaction were observed (Table 4). The combined analysis of variance revealed the differences between genotypes and GE interaction for grain yield and 100 grain. The six genotypes namely, sids-12, genotypes No.15, 14, 12 and 8 displayed HSI value>1 indicating relative

Table 5. The means of grain yield and 1000 grain weight of 17 genotypes in favorable and stress environments with HIS.

Genotypes	Grain yield				1000 Grain weight			
	Favorable	Stress	Mean	HIS	Favorable	Stress	Mean	HIS
1	2.05	0.87	1.46	0.90	42.35	34.51	38.88	0.88
2	2.60	1.12	1.64	0.89	43.21	35.33	39.27	0.86
3	2.52	0.98	1.75	0.95	37.21	28.96	33.08	1.06
4	2.07	0.73	1.40	1.02	41.53	36.05	38.79	0.62
5	1.63	0.96	1.29	0.64	40.42	33.76	37.09	0.78
6	2.00	1.1	1.55	0.70	38.49	30.83	34.66	0.94
7	2.46	1.13	1.80	0.84	40.01	33.00	34.66	0.83
8	1.73	0.61	1.17	1.03	44.91	28.34	36.51	1.75
9	1.78	0.87	1.33	0.79	41.76	34.24	36.62	0.85
10	1.52	0.74	1.13	0.80	35.72	31.29	38.00	0.59
11	2.81	1.01	1.91	1.01	39.25	38.60	33.51	0.08
12	3.20	0.75	1.97	1.20	39.73	29.80	39.42	1.20
13	1.61	0.81	1.21	0.77	33.78	33.03	34.77	0.10
14	3.73	0.65	2.19	1.29	47.70	32.75	33.41	1.49
15	1.95	0.34	1.14	1.29	44.61	25.76	40.22	2.01
Giza-168	2.04	0.46	1.25	1.21	40.47	28.83	35.18	1.36
Sids-112	1.92	0.68	1.30	1.02	39.49	25.74	34.65	1.65
Average	2.21	0.81			40.62	31.87	32.61	

Table 6. Simple correlation coefficient of HIS and b with grain yield and 1000 grain weight of 17 wheat genotypes.

Parameter	HIS	b
Grain yield	-0.05	0.07
1000 Grain weight	0.398	0.86**

* p< 0.05, ** p< 0.01.

susceptibility to heat stress. Meanwhile, the other genotypes displayed HSI value <1 indicating relative resistance to heat stress, reflecting stable performance over environments. Drought 100 grain weight of genotypes No. 11, 1 and 2 were highest. Heat susceptibility index is a measure of yield stability (Ahmed et al., 2003). Blum (1988) stated that the stability in grain yield for each genotype can be estimated by the drought susceptibility index, derived from the yield differences between stress and non stress environments.

Correlation

Negative and non significant correlation was found between grain yield and heat susceptibility index and weak correlation and non significant with regression coefficient (b) (Table 6). As to the 1000 grain weight, moderate and positive correlation was found with heat susceptibility index, but was significant only with regression coefficient (Table 6). The findings of this study showed that the breeders should choose the indices on the basis of stress severity in the target environment.

Conclusion

In general, it can be concluded that genotypes studied to late – sown environments having heat stress, namely genotypes No. 7, 6, 3, 2 and 1 are useful in the breeding program in developing new wheat varieties with resistance to drought stress conditions.

ACKNOWLEDGEMENT

The author is grateful for the support rendered by the experimental farm and laboratory of South Valley University.

REFERENCES

Allakhverdiew SIA, Sakamato Y, Nishiyama M, Inalba N, Murata (2000). Ionic and osmatic effects of Nacl .Induced in activation of photosystem , I and II in synechococuus sp. Plant physiol. L.123: 1047-56.

Abdel-Majeed SA, Mousa AM, Abd El-Kareem AA (2005). Effect of heat stress on some agronomic of bread wheat [*Triticum aestivum*] genotypes under Upper Egypt conditions. Fayoum J. Agric. Res. Dev. 19(1):4-16.

Ahmed R, Qadir S, Ahmed N, Shah KH (2003). Yield Potential and

stability of nine wheat varieties under water stress conditions, Int. J.Agri. Biol. 5(1):7-9.
Abdel-Kareem AM (2001). Stability analysis for earliness and grain yield in bread wheat the 2 Plant Breed. Comp. October 2, Assiut, Univ. pp. 199-217.
Blum A (1988). Plant breeding for stress environments. CRC press, Florida. p. 212.
Bruckner PL, Frogberg RC (1987). Stress tolerance and adaptation in spring wheat. Crop Sci. 27:31-36.
Clarke JM, Depauw RM, Townly Smith TM (1992). Evaluation of methods for quantification of drought tolerance in wheat. Crop. Sci. 32:732-728.
Clarke JM, Townly-Smith IF, Mccaig TN, Green DG (1984). Growth analysis of spring wheat cultivars of varying drought resistance, Crop Sci. 24:537-541.
Eberhart S, Russel WA (1996). Stability Parameters for comparing varieties, Crop Sci. 6:36-40.
Ehdaie B, Shakiba MR (1996). Relationship of intermode – specific weight and water soluble carbohydrates in wheat. Cereal Res. Commun. 24:61-67.
El-Morshidy MA, Kherialla KA, Abdel-Ghan AM, Abdel –Kareem (2001). Stability analysis for earliness and grain yield in bread wheat the 2 plant Breed .comp. October 2 ,Assiut , University pp.199 -217.
Fisher RA, Byerlee DB (1991). Trends of wheat production in the warmer areas. Major issues and economic considerations. In: wheat for the Natraditional worm areas: Poce. Conf., Iguazu, Brazil. 29 July-3 Aug. 1990. IMMYI, Mexico, DF. pp. 3-27.
Fisher RA, Maurer R (1978). Drought resistance in spring wheat cultivars. I. grain yield, responses, Aust. J. Agric. Res. 29: 8.
Gomes KA Gomez AA (1984). Statistical procedures for agriculture research procedures for agriculture research 2nd, John Wiley & Sons, New York.
Hamam KA, Abdel-Sabour GAK (2009). Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. Aus. J. Basic. Appl. Sci. 3(1):206-217.
Kaya N, Paita C, Taner S (2002). Additive main effects and multiplicative interaction analysis of yield performance in bread wheat genotypes across environment. Turk. J. Agric. 26:275-279.
Lillemo M, Van Ginkei M, Trethowam RM, Hernandez E, Crossa J (2005). Differential adaption of CTMMYI bread wheat to global high temperature environments. Crop. Sci. 45:2443-2453.
Miller PA,Williams JC,Robison HF (1959). Variety X environment interaction in cotton variety tests and their implications on testing method. Agron. J. 51:132-134.
Randoll , Mass (1994). Physiological and morphological traits associated with spring wheat yield under hot, irrigated conditions, Euphytica. 100:85-94.
Soleman AO (2010). Performance of yield and stability of wheat genotypes under high stress environment of the central region of saudi. Arid. Land. Agric. Sci. 21(1):81-92.
Stone PJ, Nicolas ME (1994). Wheat cultivars vary widely in their responses of grain yield and quality to short periods of postanthesis heat stress. Aust. J. Plant Physiol. 21:887-900.
Taw Felis MB (2006) Stability Parameters of some bread wheat genotypes [*Triticum aestivum*] in new and old lands under Egypt, Egypt J. Plant Breed. 10(1):223-246.