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USING BIPLOT TECHNIQUE IN WHEAT BREEDING UNDER DIFFERENT ENVIRONMENTAL STRESSES

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ABSTRACT

Biplot technique was used in this study to investigate the genetic behavior and to identify suitable wheat genotypes to be grown under drought and heat stresses. Three field experiments were conducted at the Experimental Farm Kom-ombo Agric. Res. Sta. during two successive seasons 2004/2005 and 2005/2006, to evaluate, correlation and multiple traits selection under different stresses. The average yield of improved cultivars was significantly better than the average of landraces under near optimum as well as drought and heat stress conditions. Wheat genotypes differently responded to different environmental conditions. The results indicated that drought and heat stress reduced number of days to heading, number of days to physiological maturity, grain filling period, plant height, grain filling rate, number of spikes/m^2, number of kernels / spike, 1000-kernel weight, and grain yield in t/ha, by an average of (7.14% and 13.98%), (5.44% and 14.97%), (2.68% and 16.48%),(5.17% and 10.48%), (13.82% and 13.66%), (10.55% and 19.95%), (9.17% and 22.50%), (9.06% and 22.06%) and (16.23% and 27.75%), respectively, compared with the recommended normal planting date and normal irrigation at the depletion of 50% of the available soil moisture.

The biplot visual analysis indicated that the tested cultivars and three landraces (Lr7, Lr11 and Lr14) were inside one sector had cultivar V21 (Sids 1) as its vertex and all tested environment markers in the two seasons and over seasons proving that they were the best productive genotypes in all tested environments. The pattern of genotype x environment interaction in biplot graphs clearly identified tolerant genotypes to heat stress and water stress conditions.

Two genotypes by trait (GT) biplots including 9 and 11 characters explained 76.26% and 68.47% of the total variation of their standardized data, respectively. These GT biplots were enough to graphically illustrate correlations between and among yield, yield components, susceptibility indices to heat and water stress and some agronomic characters. The results indicated that drought and heat stress tolerance were closely correlated. Using GT biplot as a tool for multi-traits selection proved its usefulness for this object.

Key words: ***Wheat genotypes, Triticum aestivum L., Biplot Technique, Evalation, Correlation, Selection, Drought stress, Heat stress and Susceptibility index (DSI & HSI).***

INTRODUCTION

The exposure of world population actualizes considerable demands for food production under limited resources of land, water and capital. One solution to relief the effects of this problem is cultivated marginal lands by cereals including wheat where wheat plants would face water and heat stress. Thus, development of drought and heat tolerant cultivars is an objective in many breeding programs. Unfortunately, (Bruckner and Frohberg 1987) stated the success in this objective has been limited. Finding out resistant genotypes is a result of accumulating many physiological and morphological characters for which effective selection criteria have not yet been developed (Fischer and Maurer 1978). Therefore, grain yield and grain yield components remain the major selection criteria for improved adaptation to stress environment in many breeding programs. But, developing new cultivars with good adaptation to stresses had achieved moderate success (Curtis 1991). Nevertheless, grain yield and its components remain major selection criteria for improved adaptation to stress environments in many breeding programs.

In Upper Egypt terminal heat stress during inflorescence development and grain filling is a recurrent phenomenon that affects wheat production. Moreover, the exposure to hot wind, even for a short time, could drastically reduce spike fertility and grain filling (Fischer and Maurer 1976). Temperatures accelerate organ development in few days without any increase in net photosynthesis and assimilate resulting in smaller biomass (Fischer 1985 and Shpiler and Blum 1986). Yield in stress environments depends upon susceptibility or tolerate level of grown plants. Therefore, the productive genotypes under stress conditions are the most tolerant genotypes for these conditions. Landraces of wheat collected where the environments include drought and high temperature conditions, may have been selectively adapted to perform in a stable manner under stress conditions (Ehdaie *et al.* 1988). In Egypt, wheat has been under cultivation for centuries and the old landraces are still growing in few areas in the country. These progenitors or permissive cultivars are presumed to possess genes for adaptation to harsh environments. These landraces are valuable germplasm resources that can be utilized to increase what productivity under water and heat stresses (Damania 1989 and Abd El Ghani 1999).

Since the different levels of susceptibility or tolerance to abiotic stresses can be distinguished from different responses in multi-environments that impose drought, salinity, heat stresses or good ambient conditions, the statistical methods to study genotype environment interaction can offer a suitable tool to detect tolerate genotypes. The biplot visual analysis displays genotype by environments interaction pattern in a simple manner. In addition, Yan and Rajcan (2002) proposed the GT biplot that can be used to aid genotype selection on the basis of multiple traits.

The objectives of this study were: (1) to explore the potentiality of biplot techniques to evaluate several genotypes under some environments where water and heat stress are common factors, (2) to compare between local landraces and improved cultivars productivity under harsh environmental conditions and (3) to utilize biplot techniques to study the relationships between wheat traits and to select genotypes depending on their performance in multiple-traits.

MATERIALS AND METHODS

Three field experiments were conducted to study the influence of drought and heat stresses on grain yield of some wheat (*Triticum aestivum* L.) genotypes. The experiments were planted in Kom-ombo Agric. Res. Sta. (latitude 24°02; longitude 32°53; altitude 108.30m) of Egypt during 2004/2005 and 2005/2006 growing seasons. This site is clay texture and classified as heat stress region where the temperature raised at anthesis time (late February) from °C 27-29 to around °C 32-36 during grain filling.

The material for this study comprised: a) 16 wheat landraces previously selected from 34 (Tawfelis, 2002) and originally obtained from Genetic Resource Department FCRI who collected them from isolated areas where they were grown for decades; and b) eight improved wheat cultivars, five of them were bred in Egyptian Research Stations (Sahal 1, Sakha 93, Giza 168, Gemmeiza 9 and Sids 1), two Indians (HD 2501and Deberia) and one Sudanese cultivar (El-Nelian).

Twenty-four bread wheat genotypes were tested in both seasons. The genotypes were; (L1-L16) landraces, (V17) Sahal 1, (V18) Sakha 93, (V19) Giza 168, (V20) Gemmeiza 9, (V21) Sids 1, (V22) HD 2501, (V23) El-Nelian and (V24) Deberia.

In 2004/2005 season, the recommended sowing date was 20th November (D1) and the late sowing was 19th December (D2). In 2005/2006 season, the recommended sowing date was 21st November (D1) and the late sowing was 20th December (D2).The three experiments were separate and had the same 24 genotypes with different randomization but each one imposed to different environmental factors; **A)** Near optimum-field conditions (N.O.) normal planting date (D1) and normal irrigation at the depletion of 50% of the available soil moisture, **B)** Drought stress (D.S.): normal planting date (D1) and irrigation regimes (stress irrigation at the depletion of 75% of the available soil moisture and **C)** Heat stress (H.S.) when the sowing was late (D2 = late planting to impose heat stress)

A randomized complete block (RCBD) design with three replications was used in each planting date. Each plot consisted of 6 rows 3.5 long and 20cm apart. Seeds were hand sown in drills. All recommend agricultural practices except the studied inputs were applied. At ripening, 2.80 m^2 from each of the four center rows were harvested.

Data were recorded for seven agronomic characters: days to heading (HD).the number of days from sowing to 50% of the heads appeared beyond the flag leaf sheath; days to physiological maturity (MD), recorded as the number of days from sowing to the date of physiological yellow stage of maturity; plant height (PLH), at harvest measured in cm. of ten main stems taken at random from each experimental plot; number of spikes/m^2 (S/M^2) was evaluated approximately two weeks prior to harvest; number of kernels per spike (K/S), as an average number of kernels from ten main spikes; 1000-kernel weight (1000-KW "g"), and grain yield in ton/ hectare (GY t/ha.), it was estimated on plot basis. Two additional traits were derived from the above measurements (i) grain filling period (GFP), that is days from heading to maturity and grain filling rate (GFR), the grain yield (kg/ha.) divided by grain filling period.

The stress susceptibility index (S) of each of the genotypes was calculated using formula presented by Fischer and Maurer (1978) in which

$$S = (1 - YD/YP)/D,$$

Where YD = mean grain yield in the stress environment, YP = mean grain yield in the nonstress environment = potential yield, and D = environment stress intensity calculated as 1 – (mean YD of all genotypes / mean YP of all genotypes). Stress susceptibility index (S) was used to characterize relative stress tolerance of all genotypes. Low values of the index indicate stress resistance, whereas, high values indicate stress susceptibility.

Statistical analysis

Data were statistically analyzed according to Gomez and Gomez (1984). Combined analysis of variance for the two seasons was undertaken using the appropriate analysis of variance. However, the combined analysis was carried out respecting the homogeneity of variance criterion. Treatment means were compared by least significant difference (L.S.D) at 5% level of probability.

The GGE Biplot

The genotype plus genotype by environment interaction biplot (GGE biplot) method according to Yan and Rajcan (2002) is based on the formula:

$$y_{ij} - y_{i.} = \lambda_1 \varepsilon_{i1} \eta_{j1} + \lambda_2 \varepsilon_{i2} \eta_{j2} + e_{ij} \qquad [1]$$

where y_{ij} is the average yield of genotype i in environment j; $y_{i.}$ is the average yield over all genotypes in environment j; and $\lambda_1 \varepsilon_{i1} \eta_{j1}$ and $\lambda_2 \varepsilon_{i2} \eta_{j2}$ are collectively called the first principal component (PC1) and the second principal component (PC2); λ_1 and λ_2 are the singular values for the first and second principal components, PC1 and PC2, respectively; ε_{i1} and ε_{i2} are the PC1 and PC2 scores, respectively, for genotype i; η_{j1} and η_{j2} are the PC1 and PC2 scores, respectively, for environment j; and e_{ij} is the residual of the model associated with the genotype *i* in environment *j*.

To display the PC1 and PC2 in a biplot, the λ values are absorbed into the genotype and environment scores so that the equation is written as:

$$y_{ij} - y_{i.} = \varepsilon_{i1}^{*} \eta_{j1}^{*} + \varepsilon_{i2}^{*} \eta_{j2}^{*} + e_{ij}$$

Where $\varepsilon_{in}^{*} = \lambda_n^{0.5} \varepsilon_{in}$ and $\eta_{jn}^{*} = \lambda_n^{0.5} \eta_{jn}$ with n=1,2. This scaling method has the advantage that PC1 and PC2 have the same unit (square root of original unit Mg ha^{-1} in terms of yield).

A GGE biplot is generated by plotting ε_{i1}^{*} and ε_{i2}^{*} against η_{j1}^{*} and η_{j2}^{*}, respectively, so that each genotype or environment is represented by a marker in the biplot.

The genotype by trait biplot (GT Biplot)

Yan and Rajcan (2002) stated that to display the genotype by trait two-way data in a biplot, the following formula can be used:

$$\frac{T_{ij}-T_{ij}}{s_j} = \lambda_1\xi_{i1}\tau_{j1} + \lambda_2\xi_{i2}\tau_{j2} + e_{ij} \qquad [2]$$

where *Tij* is the average value of genotype *i* for trait *j*, *Tj* is the average value of trait j over all genotypes, sj is the standard deviation of trait *j* among the genotype averages; ξ_{i1} and $\xi_{i2}$are the PC1 and PC2 scores, respectively, for genotype *i*; τ_{j1} and τ_{j2} are the PC1 and PC2 scores, respectively, for trait *j*; and *εij* is the residual of the model associated with the genotype i in trait j. Equation [2] is a principal component analysis of standardized data with two principal components. Because different traits use different units, the standardization is necessary to remove the units. PC1 and PC2 must be scaled as in Eq. [1] so that the unit values are symmetrically distributed between the genotype scores and the trait scores. A genotype by trait (GT) biplot is constructed by plotting the PC1 scores against the PC2 scores for each genotype and each trait.

All the calculation steps to estimate ε_{i1}^{*}, ε_{i2}^{*}, η_{j1}^{*} and η_{j2}^{*} were done according to steps represented by Saba (2006)

RESULTS AND DISCUSSION

The test of homogeneity showed homogeneous error variance for all studied traits in both seasons, therefore the combined data of both seasons have been discussed.

Mean squares of the combined analysis of variance of the collected data are presented in (Table1). These results showed significant differences between years for days to heading, days to physiological maturity, grain filling period, plant height, number of spikes /m^2, 1000-kernels weight "g" and grain yield /ha. These results reflected the differences in climatic conditions prevailing during the growing seasons. The main effect of environments was highly significant for all studied characters as it would be expected for differences between optimum, drought stress and late sowing dates (heat stress). Also

Table 1 Combined analysis of variance and principal components for some wheat characters of twenty four wheat genotypes under different conditions during 2004/2005 and 2005/2006 growing seasons.

Source of Variance	Mean Squares (MS)									
	df	HD	MD	G.F.P.	PLH	G.F.R.	S/m2	No.K/S	1000-KW	G.Y.
Year (Y)	1	524.481**	125.669**	143.521**	776.021**	160.967	25101.502*	16.803	186.934**	1.360**
R/Y (E a)	4	1.804	2.141	12.192	8.670	54.637	1315.995	2.711	0.470	0.158
Environments (E)	2	5427.704**	16924.481**	3436.593**	5053.720**	9037.475**	355464.725**	4359.914**	3147.021**	83.951**
Y x E	2	33.620**	935.398**	630.333**	126.563**	998.989**	5713.600	99.830**	34.283*	1.006**
Error (b)	8	2.499	1.981	3.657	10.350	36.422	2793.214	4.659	5.269	0.048
Genotypes (G)	23	36.768**	38.746**	28.775**	808.368**	4016.553**	35506.990**	165.201**	81.750**	6.093**
Y x G	23	9.684**	18.679**	28.898**	73.445*	251.258*	3922.937**	12.124*	8.125	0.541*
E x G	46	7.991**	15.991**	23.187**	76.752**	232.726*	2931.927*	10.810**	11.335**	0.492*
Y x E x G	46	5.686*	16.893**	21.217*	62.124*	241.673*	2612.991*	7.129	9.214**	0.303
G+G.E [+]	138	12.301**	20.493**	24.451**	193.261**	869.545**	8419.961**	35.537**	21.832**	1.371**
PC1 [++]	28	32.887**	37.573**	49.566**	716.412**	3360.173*	30032.917**	138.700**	74.295**	5.161**
PC2 [+++]	26	14.199**	32.080**	31.127**	95.049**	372.135**	5131.519**	14.232**	11.926**	0.662**
Remainder	84	4.852	11.214	14.0136	49.275	193.295	2233.492	7.744	7.409	0.326
Error (c)	276	3.779	9.718	13.423	41.087	158.870	1812.298	6.528	5.657	0.306
C.V. %	---	2.38	2.34	7.08	5.98	13.90	9.52	5.87	6.00	11.84

[+] G+GE, genotype plus genotype x environment interaction

[++] PC1, first principal component

[+++] PC2, second principal component

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

highly significant differences among genotypes for all studied characters were observed. The first order interaction between years x environments was significant for all the studied characters except number of spikes/m^2 while the interaction between year x genotypes and environments x genotypes was also significant for all the studied characters except 1000-kernels weight "g" indicating that wheat genotypes responded differently to the different environmental conditions , suggesting the importance of assessment of genotypes under different environments in order to identify the best genotypes for a particular environment. The combined analysis of variance showed significant interactions between years x environments x genotypes for all the studied characters except number of kernels/spike and grain yield. Similar results were obtained by Abd El-Shafi *et al* (2001) and Tawfelis (2006).

To construct the biplots, the principal component analysis was performed and mean squares due to PC1 and PC2 for all studied traits were presented in Table (1). All these mean squares were significant while the mean squares due to remainders were non- significant, indicting that most important variations were loaded in the first two principal components and the resulted biplots could visually illustrate the data.

Morpho- physiological traits

The average number of days to heading over years for the 24 genotypes is presented in Table (2). Results revealed that the studied wheat genotypes significantly differed in days to heading. Average number of days to heading ranged from 85.00 days for genotype no. 18 (Sakha 93) to 92.50 days for genotype no. 20 (Gemmeiza 9) with an average over all genotypes of 87.76 days under favorable environment. Meanwhile the trait ranged from 78.33 days for genotype V23 (El-Nelian) to 84.67 days for genotype V20 (Gemmeiza 9) with an average over all genotypes of 81.49 days under drought conditions. Moreover, the range was from 71.33 days for genotype V22 (HD 2501) to 78.50 days for genotype Lr9 with an average over all genotypes of 75.49 days under heat stress. Generally, it could be seen that drought and heat stress reduced number of days to heading by 7.14% and 13.98% over all genotypes compared with favorable conditions, respectively. Genotypes V23, V18, V22, Lr5 and Lr7 were earlier in number of days to heading with no significant differences among them under favorable environment. Meanwhile under drought conditions, the earlier genotypes in number of days to heading were V23, V22, Lr2, Lr7 and V18 with no significant differences among them on the

Table 2 Average performance of number of days to heading, number of days to physiological maturity and grain filling period (day) for different wheat genotypes under different conditions during 2004/2005 and 2005/2006 growing seasons.

Ent. No.	Days to heading			Days to maturity			Grain filling period (day)		
	NO*	DS**	HS***	NO*	DS**	HS***	NO*	DS**	HS***
1	89.83	82.83	76.50	145.00	139.33	123.33	55.17	56.50	46.83
2	87.50	79.67	75.17	141.83	136.00	121.67	54.33	56.33	46.50
3	90.17	83.50	76.67	149.83	138.83	120.67	59.66	55.33	44.00
4	87.17	81.83	76.00	145.50	136.50	122.17	58.33	54.67	46.17
5	85.50	80.50	76.00	141.00	133.50	120.50	55.50	53.00	44.50
6	88.00	81.83	76.33	143.50	135.33	122.17	55.50	53.50	45.84
7	86.00	79.67	77.17	140.50	135.17	124.50	54.50	55.50	47.33
8	87.00	81.50	74.50	143.67	133.33	119.67	56.67	51.83	45.17
9	87.17	81.67	78.50	144.67	134.83	123.67	57.50	53.16	45.17
10	88.17	83.00	77.00	143.00	134.33	122.50	54.83	51.33	45.50
11	90.00	83.50	74.17	143.00	136.50	122.00	53.00	53.00	47.83
12	88.83	83.00	76.83	143.17	135.00	122.00	54.34	52.00	45.17
13	89.50	80.50	76.83	143.67	136.50	119.50	54.17	56.00	42.67
14	88.00	81.83	74.83	143.83	135.50	122.50	55.33	53.67	47.67
15	87.50	81.67	73.67	142.83	137.17	121.50	55.33	55.50	47.83
16	87.33	82.17	74.67	142.00	134.83	119.83	54.67	52.66	45.16
17	87.67	81.67	76.67	141.33	135.67	121.50	53.66	54.00	44.83
18	85.00	80.00	75.00	141.17	131.83	117.83	56.17	51.83	42.83
19	86.83	80.33	75.17	141.50	133.83	122.17	54.67	53.50	47.00
20	92.50	84.67	77.67	143.67	135.17	128.00	51.17	50.50	50.33
21	88.17	81.67	72.67	142.50	134.00	123.83	54.33	52.33	51.16
22	85.33	78.67	71.33	140.67	134.17	117.17	55.34	55.50	45.84
23	84.00	78.33	73.83	142.50	133.83	121.17	58.50	55.50	47.34
24	89.17	81.67	74.50	142.83	135.33	119.33	53.66	53.66	44.83
Mean	87.76	81.49	75.49	143.05	135.27	121.63	55.26	53.78	46.15
C.V.%	2.38%			2.34%			7.08%		
L.S.D. at 0.05									
Env. (E)	0.43			0.38			0.52		
Gen. (G)	1.27			2.04			2.39		
E x G	2.20			3.53			4.14		
r*	0.988**			0.895**			-0.369		

NO*=Normal planting date and normal irrigation at the depletion of 50% of the available soil moisture.

DS**=Normal planting date and stress irrigation at the depletion of 75% of the available soil moisture.

HS***= Late planting to impose heat stress and normal irrigation at the depletion of 50% of the available soil moisture.

r* =Simple correlation coefficient between average effects of genotype and PC1(first principal component).

average On the other hand, genotypes V22, V21, Lr15, V23 and Lr11 were earlier in number of days to heading with no significant differences among them under heat stress conditions. It is apparent that the ranks of genotypes were changed from environment to environment indicated by genotype by environment interactions. The reduction in number of days to heading under heat stress condition was greater than reduction under water stress condition. These results may be due to the speed of accumulating required heat units for heading in fewer days under hot weather. Similar results reported by Abd El-Shafi *et al* (2001) and Tawfelis (2006).

Respecting number of days to physiological maturity, the average ranged from 140.50 days for genotype Lr7 to 149.83 days for genotypes Lr3 under favorable conditions, meanwhile, it varied from 131.83 days for genotype V18 (Sakha 93) to 139.33 days for genotype Lr1 under water stress conditions, but it was reduced to 117.17 days for genotype V22 (HD 2501) and 128.00 days for genotype V20 (Gemmeiza 9) under late planting conditions. The mean of all genotypes reached 143.05 days in the early sowing , meanwhile reached 135.27 days under water stress conditions but it reached 121.63 days under the late sowing, indicating a reduction of 5.44 and 14.97%, respectively, in days to maturity. The reduction in number of days to maturity under heat stress conditions was more severe than that observed under water stress conditions. These results agree with those reported by Abd El-Shafi *et al* (2001) and Tawfelis (2006). They found that duration from planting to heading and maturity was reduced with the delay in sowing,

From the point of view of a plant breeder, duration of grain filling is important as it is a component of maturity and it affects final grain weight which is a component of grain yield. Drought and heat stresses dramatically reduced duration of grain filling period. The average over all genotypes was 55.26 days in the favorable environment, meanwhile average over all genotypes was 53.76 days under drought condition but it was reduced to 46.15 days in stress condition. The reductions were 2.68 and 16.48% under drought and heat stress conditions, respectively, compared with optimal treatment.

The average of duration of grain filling period for the genotypes under favorable, drought stress and late planting (heat stress) are presented in Table (2). Respecting genotypes, the grain filling period ranged from 50.67 days for genotype V20 (Gemmeiza 9) to 60.0 days for genotype Lr3 under favorable conditions, meanwhile the values ranged from 50.0 days for genotype V20

(Gemmeiza 9) to 56.83 days for genotype Lr1 under drought stress, but reduced grain filling period under heat stress conditions ranged from 42.17 days for genotype Lr13 to 51.50 days for genotype V21 (Sids 1). At Kom-Ombo district where the experiments were carried out, the optimal sowing date of spring wheat is mid-November, heading occurs from the first to mid-February, and grain filling duration (from anthesis to physiological maturity) is completed from the first to mid-April. Average maximum daily air temperature during this period was (C° 25-27), whereas, in late sowing date, heading usually occurs from mid March, and grain filling period is completed until the first of May with an average maximum daily air temperature around C° 30-35.

This increase in temperature during the duration of grain filling reduced 1000-kernel and grain yield by 22.05 and 27.74 % respectively, when compared with the normal temperature prevailing during grain filling period in the optimal planting date. These results are similar to those reported by Bruckner and Forhberg (1987) and Abd El-Shafi *et al* (2001) and Tawfelis (2006). In contrast, Shpiler and Blum (1986) indicated that wheat genotypes were able to maintain a long duration of spike development under terminal heat stress.

Data presented in (Table 3) showed that average plant height ranged from 99.00 cm for cultivar Sakha 93 (V18) to 128.13 cm for genotype Lr6 with an average over all genotypes 113.08 cm under normal planting date, meanwhile plant height ranged from 96.18 cm for cultivar Sakha 93 (V18) to 122.10 cm for genotype Lr2 with an average of 107.23 cm under drought conditions. In addition plant height ranged from 92.30 cm for genotype Lr12 to 112.23 cm for genotype Lr1 under heat stress. Slight reductions of 5.17% and 10.48% in plant height due to water stress conditions and delaying planting, respectively, were also observed (Table3). Most tall genotypes were landraces; in contrast the cultivated cultivars had short stature.

Grain filling rate expresses the growth rate of a wheat kernel from fertilization until its maturity. The average grain filling rate (GFR) is presented in Table (3). The results revealed that the GFR was 99.82, 86.02 and 86.18 Kg/hec/day for normal, water stress and heat stress conditions, respectively. Both type of stresses depressed filling rate with statistically equal percentage as there was non-significant difference between them. The GFR ranged from 69.52 (Lr4) to 128.57 Kg/ha/day V21 (Sids 1), from 61.90 (Lr2) to 119.38 mg/day V21 (Sids 1) and from 64.33 (Lr15) to 119.38 mg/day V18 (Sakha 93) in normal, drought stress and heat stress environments, respectively.

Apparently, the two abiotic stresses showed approximately the same effect on GFR, while the heat stress displayed significantly more severe effects on GFD than water stress; therefore the effect of heat stress on grain yield would be magnified by depressing grain filling period.

These results clearly showed that grain filling rate under late planting is faster than favorable planting because the higher temperature in late planting accelerated grain growth development but finally decreased grain yield. So it should be possible to select genotypes with a high kernel growth rate and short-filling period without sacrificing yield potential. This approach may have promise in double cropping environments, where development of early maturing, high yielding genotypes is the key breeding objective. Also, the best plan for such a hot environment is sowing late- maturing cultivars early in season, and to sow early- maturing cultivars late. Similar results were reported by Bruckner and Forhberg (1987).

Yield and yield components

Data presented in (Table 3) showed that average number of spikes /m^2 ranged from 419.17 for genotype Lr8 to 564.50 spike/m^2 for genotype V21 (Sids 1) with an average 497.72 spikes/m^2 in the favorable environment. Meanwhile the number of spikes/m^2 ranged from 371.50 for genotype Lr15 to 532.50 spike/m^2 for genotype V18 (Sakha 93) with an average of 445.18 spike/m^2 under the water stress conditions; but it ranged from 321.33 spike/m^2 for genotype Lr5 to 490.17 spike/m^2 for genotype V21 (Sids 1) with an average 398.40 spikes/m^2 under heat stress.

The most tillering genotypes were (Lr12, V17, V20, V19, V18, V23 and V21), (Lr14, V24, V22, V21, V23, V20, V19 and V18) and genotypes (V20, Lr11, V17, V24, V22, V19, V18 and V21) that produced greater number of spike/m^2 under the three treatments, respectively. In general, number of spikes per square meter was affected by drought and heat stresses that displayed by 10.55% and 19.95% reductions in the average, respectively, determining that the studied genotypes were able to maintain their tillering capacity under terminal heat stress in Upper Egypt. The mean of maximum air temperature in Upper Egypt during the early stages of wheat growth ranged between 20-22 C°, while average temperature ranged from about 15-18 C°. Fischer (1985) reported that mean temperature of 16-20 C° is favorable for crown root initiation and tillering development in hot environments. Therefore, the reduction of spikes

Table 3. Average performance of plant height "cm" , grain filing rate (kg/ha./day) and number of spikes/m^2 for different wheat genotypes under different conditions during 2004/2005 and 2005/2006 growing seasons.

Ent. No.	Plant height "cm"			Grain filing rate (kg/ha./day)			Number of Spikes/m^2		
	NO*	DS**	HS***	NO*	DS**	HS***	NO*	DS**	HS***
1	120.13	114.73	112.23	89.58	70.10	69.12	472.67	461.67	377.17
2	123.97	122.10	107.83	91.67	61.90	77.98	458.17	388.17	361.67
3	118.75	112.57	111.67	89.50	65.95	74.35	481.00	421.00	360.17
4	121.38	115.75	106.77	69.52	68.58	75.07	486.17	395.17	348.67
5	99.02	97.58	93.88	99.98	80.18	75.70	473.17	398.83	321.33
6	128.13	121.08	109.80	84.37	69.10	72.32	521.00	379.33	362.67
7	108.33	99.82	100.72	105.75	79.37	94.88	511.00	435.50	422.50
8	128.03	109.05	96.30	80.60	70.03	76.68	419.17	398.00	360.50
9	124.02	115.35	101.43	87.63	74.83	74.98	421.33	392.00	360.00
10	109.27	101.78	98.77	90.20	75.00	79.78	445.83	406.67	341.50
11	110.53	101.37	99.38	110.00	88.50	92.65	506.17	457.17	436.33
12	104.32	99.10	92.30	82.22	80.82	72.00	533.00	425.33	337.33
13	121.45	110.90	103.07	90.63	77.70	84.97	474.33	414.50	395.50
14	112.95	107.57	98.52	102.65	86.10	86.95	507.17	474.00	414.67
15	102.13	98.28	99.38	96.13	70.73	64.33	439.93	371.50	350.83
16	115.22	110.85	104.22	97.93	86.58	79.85	473.00	410.00	388.00
17	104.32	99.97	98.50	110.27	107.83	93.22	536.17	472.83	439.67
18	99.00	96.18	93.88	116.45	114.00	119.38	549.83	532.50	483.17
19	104.88	101.57	95.95	121.97	111.08	110.33	543.67	529.83	459.67
20	107.48	105.37	102.87	116.37	112.50	83.77	539.17	523.33	429.00
21	112.85	110.05	103.40	128.57	119.38	118.33	564.50	504.67	490.17
22	115.65	111.28	100.15	110.70	95.13	96.93	513.50	498.83	455.00
23	110.25	103.80	99.25	106.07	97.35	90.97	554.33	504.67	422.00
24	111.77	107.42	99.22	117.00	101.75	103.82	521.00	488.83	444.17
Mean	113.08	107.23	101.23	99.82	86.02	86.18	497.72	445.18	398.40
C.V.%	5.98%			13.90%			9.52%		
L.S.D. at 0.05									
Env. (E)	0.87			1.64			14.36		
Gen. (G)	4.19			8.23			27.80		
E x G	7.25			14.26			48.16		
r$^+$	0.995**			0.999**			0.998**		

NO*=Normal planting date and normal irrigation at the depletion of 50% of the available soil moisture.

DS** =Normal planting date and stress irrigation at the depletion of 75% of the available soil moisture.

HS***= Late planting to impose heat stress and normal irrigation at the depletion of 50% of the available soil moisture.

r$^+$ =Simple correlation coefficient between average effects of genotype and PC1 (first principal component).

per square meter affected due to water stresses can be rationalize since the water stress treatment in the current investigation imposed periodical stress on wheat plants in whole life span, but the heat stresses were imposed on late period of life span. These results suggest that the reduction of spike number may be due to fail of fertilization process or for high mortality rate of young spike because of heat stress.

Data presented in (Table 4) showed that average number of kernels/spike ranged from 45.0 kernels for genotype Lr1 to 55.42 kernels for the cultivar Sids 1 (V21) with an average 48.66 kernels/spike under favorable environment. Meanwhile trait estimates ranged from 37.55 kernels for genotype Lr15 to 51.32 kernels for genotype V21(Sids 1) with an average over all genotypes of 44.20 kernels under drought conditions, but it ranged from 33.80 kernels for genotype Lr15 to 43.65 kernels for genotype V19 (Giza 168) with an average over all genotypes .of 37.71 kernels/spike under heat stress condition. The results showed that drought and heat stress environments reduced number of kernels /spike by 9.17% and 22.50%, respectively, compared with favorable environments. However, Fischer (1985) stated that accelerating development during active spike growth through increases in air temperature reduced the final number of grains, despite the fact that prevailing temperature increases the rate of spike growth.

Also, high air temperature (26 C°) for about 6 to 8 days prior to apex double ridge through terminal spikelets formation in late planting reduced the number of spikelets /spike was reported by Frank *et al.* (1987). Genotypes number V18 (Sakha 93), V19 (Giza 168), V20 (Gemmeiza 9), V21 (Sids1) and V23 (El-Nelian) had the highest number of kernels/spike in the three treatments, respectively. This different response of genotypes to dates and irrigations could be attributed to the genetic make up of these genotypes.

Results in (Table, 4) revealed that normal sowing date gave heavy kernels and this could be due to that grains reached maturity without being affected by high temperature which results in shrinked kernels. The average 1000- kernel weight ranged from 39.38 g for genotype Lr12 to 44.83 g for the cultivar Sids 1 (V21) with an average of 42.16 g over all genotypes in the favorable environment. Meanwhile the average 1000-kernel weight ranged from 33.50 g for genotype Lr6 to 44.02 g for the cultivar Giza 168 (V19) with an average of 38.34 g under water stress conditions. The average 1000-kernel

Table 4. Average performance of number of kernels / spike, 1000-kernel weight "g" and grain yield (ta./hec.) for different wheat genotypes under different conditions during 2004/2005 and 2005/2006 growing seasons.

Ent. No.	Number of kernels / spike			1000-kernel weight "g"			Grain yield (ta. /hec.)		
	NO*	DS**	HS***	NO*	DS**	HS***	NO*	DS**	HS***
1	45.00	45.58	35.67	41.18	39.58	33.65	5.112	4.173	3.383
2	45.80	38.62	36.88	41.73	33.57	30.73	5.131	3.655	3.770
3	47.13	40.27	34.12	41.38	37.05	29.85	5.530	3.854	3.368
4	48.15	43.60	35.50	40.53	37.63	31.57	4.326	4.016	3.650
5	47.53	42.55	35.30	41.37	36.70	31.35	5.580	4.265	3.367
6	45.23	41.07	34.42	42.02	33.50	30.25	4.864	3.870	3.453
7	49.08	41.80	40.23	42.69	33.95	34.78	5.718	4.356	4.454
8	45.93	41.23	36.05	40.72	35.80	30.08	4.726	3.775	3.578
9	46.52	39.62	35.35	41.36	35.90	31.70	5.200	4.109	3.503
10	46.72	41.50	36.00	41.87	36.10	30.80	5.035	3.913	3.712
11	49.05	43.62	40.13	42.19	37.42	34.80	5.742	4.569	4.317
12	48.42	45.07	35.92	39.38	38.33	31.05	4.575	4.307	3.351
13	46.97	43.75	36.88	40.74	38.70	33.12	4.919	4.371	3.573
14	49.13	44.87	37.03	42.35	38.52	35.00	5.690	4.559	4.129
15	45.35	37.55	33.80	40.56	33.68	29.47	5.438	4.060	3.248
16	46.83	41.68	35.35	40.04	37.67	30.30	5.272	4.553	3.580
17	49.95	48.90	38.75	42.53	41.97	33.15	5.706	5.607	4.015
18	53.22	49.72	43.52	43.66	42.45	36.87	6.153	5.504	4.786
19	53.88	50.30	43.65	44.65	44.02	36.48	6.364	5.644	4.918
20	52.13	48.15	39.38	44.15	41.50	34.00	5.736	5.439	4.033
21	55.42	51.32	43.02	44.83	43.83	38.28	6.548	5.870	5.712
22	50.02	46.25	40.20	44.51	39.97	34.15	5.949	4.146	4.372
23	50.42	47.77	39.10	43.66	40.33	33.95	6.158	5.306	4.224
24	49.88	46.05	38.90	43.82	39.90	33.30	5.991	5.208	4.492
Mean	48.66	44.20	37.71	42.16	38.34	32.86	5.478	4.589	3.958
C.V.%	5.87%			6.00%			11.84%		
L.S.D. at 0.05									
Env. (E)	0.59			0.63			0.059		
Gen. (G)	1.67			1.48			0.361		
E x G	2.89			2.57			0.625		
r^{+}	0.999**			0.993**			0.999**		

NO*=Normal planting date and normal irrigation at the depletion of 50% of the available soil moisture.

DS** =Normal planting date and stress irrigation at the depletion of 75% of the available soil moisture.

HS***= Late planting to impose heat stress and normal irrigation at the depletion of 50% of the available soil moisture.

r^{+} =Simple correlation coefficient between average effects of genotype and PC1 (first principal component).

weight ranged from 29.47 g for genotype Lr15 to 38.28 g for the cultivar Sids 1 (V21) with an average of 32.86 g over all genotypes in the stress environment.

These results indicated that drought and late planting (heat stress) significantly decreased 1000-kernel weight by about 9.06% and 22.06% respectively compared with favourable environments. This result could be due to that growing grain may be affected by high temperatures and resulted in shrinked kernels beside the effect of shorter GFP. These results are in harmony with Randall and Moss (1990) and Tawfelis (2002).

Mean grain yield of different genotypes in non-stress and stress environments are shown in Table 4. All genotypes exhibited highest grain yield (yield potential) in the non-stress environment as compared to stress environments. Results indicated .that grain yield of the various genotypes ranged from 4.326 t/ha for genotype Lr4 to 6.548 t/hec for genotype V21 (Sids 1) with an average over all genotypes of 5.478 t/ha in the favorable environment, meanwhile the grain yield ranged from 3.655 t/ha for genotype Lr2 to 5.870 t/ha. for cultivar Sids 1 (V21) with an average of 4.589 t/ha in the drought conditions but it was reduced to 3.248 t/ha for genotype Lr15 to 5.712 t/ha for genotype Sids 1 (V21) with an average of 3.958 t/ha under late planting. The average grain yield over all genotypes decreased from 5.478 t/ha in the favorable environment to 4.589 and 3.958 t/ha in the drought and heat stress environments, respectively, making a reduction of 16.23% and 27.75% in the water and heat stress environments, respectively. These data confirmed earlier work (Randall and Moss 1990) where grain yield was negatively correlated with increasing mean maximum temperature.

The highest mean values were genotypes V21, V19, V18, V23, V24 and V22 in the favourable environment. Meanwhile genotypes V21, V19, V17, V18, V20, V23 and V24 highest yields were obtained by irrigated wheat at 75% depletion of available water. On the other hand, high yield potential genotypes V21, V19, V18, V24, Lr7, V22 and Lr11 exhibited significant higher grain yield under late planting (heat stress).The best genotypes were V21 (Sids 1), V19 (Giza 168), V18 (Sakha 93) and V24 (Deberia) which gave high grain yield under the three environments.

The obtained data illustrated that wheat genotypes showed wide variations either in yield or in its components in response to both heat (sowing dates) and drought (water stress). Thus, the assessment of wheat genotypes must take place under various environments to identify the best genotype for a particular environmental condition. Abd- ElGhani (1999) came to the same conclusion from his study on wheat genotypes.

Stress susceptibility index (SI):

The drought and heat susceptibility indices "SI" based on grain yield for genotypes are presented in Table (5). These indices were used to estimate the relative stress injury (drought and heat) because it is accounted as variation in yield potential and stress intensity. Higher values indicated higher degree of susceptibility and vice versa (Fischer and Maurer 1978).

It is worthy to mention here that drought susceptibility index provides a measure of tolerance based on minimization of yield loss under stress rather than non-stress yield *per se*. Therefore, the stress tolerant genotypes as defined by SI values do not need to have a high yield potential. These genotypes should contain resistance mechanisms, which may need to be incorporated into germplasm with higher yield potential for development of high yielding stress tolerant cultivars.

Table 5 Drought and heat susceptibility indices (SI) calculated for wheat grain yield in twenty four wheat genotypes.

Ent. No.	DSI ^{1}	HSI ^{2}	Ent. No	DSI ^{1}	HIS^2
1	1.13	1.22	13	0.69	0.99
2	1.77	0.96	14	1.22	0.99
3	1.87	1.41	15	1.56	1.45
4	0.44	0.56	16	0.84	1.16
5	1.45	1.43	17	0.11	1.07
6	1.26	1.05	18	0.65	0.80
7	1.47	0.80	19	0.70	0.82
8	1.24	0.88	20	0.32	1.07
9	1.29	1.18	21	0.64	0.46
10	1.37	0.95	22	0.83	0.96
11	1.26	0.89	23	0.85	1.13
12	0.36	0.96	24	0.81	0.90

DSI ^{1} = Drought susceptibility index.
HSI ^{2} = Heat susceptibility index.

Application of susceptibility index based on yield indicated that for genotypes no. 4,12, 13, 16, 17, 18, 19, 20, 21, 22, 23 and 24 had DSI <1 and gave the highest grain yield under the two environmental conditions (normal and drought conditions). Meanwhile genotypes no. 2, 4, 7, 8, 10, 11, 12, 13, 14, 18, 19, 21, 22 and 24 had HSI <1 and gave the highest grain yield under the two environmental conditions (normal and heat stress). Therefore, these genotypes could be considered promising genotypes in wheat breading programs.

It could be concluded that genotype no. 21 (Sids 1) could be considered a superior genotype for drought and heat stress. Genotypes no. 18 (Sakha 93), 19 (Giza 168), 21 (Sids 1), 22 (HD2501) and 24 (Deberia) could be used as a source of drought and heat tolerance/ or factors contributing to general adaptation.

GGE Biplot

Yan and Hunt (1999) and Yan *et al.* (2000) proposed the GGE biplot that allows visual examination of the genotype by environment interaction pattern in which the first (G) is the genotype effect and the second part (GE) is the effect of genotype by environment interaction. A two way table containing the effect of genotypes (rows) plus the effects genotype by environments (columns) interactions can be subjected to singular value decomposition (SVD) to generate the first two principal components (PC1 and PC2 scores). The resulted scores are used to construct a diagram named biplot which illustrate the GE interaction pattern.

The main scientific basis for interpreting of the resulted biplot is, any original value of the analyzed data is sliced to three fractions PC1 and PC2 scores and an error or noise. According to the modified version of the equation [1], each fraction is the result of multiplying genotype i effect ε_{in}^{*} by environment j effect η_{jl}^{*}. The latter effects are used to allocate both genotypes and environments markers in constructing biplot.

Grain yield GGE biplot

Genotype evaluation

Despite the homogeneity of error variance that permits to perform combined analysis over seasons, the biplot figures of each season (three environments) and over seasons (six environments) showed different interaction patterns so that the three biplots would be discussed.

The first two principal component scores for grain yield explained 92.91 and 92.66% of the total variations for 2004/2005 and 2005/2006 season's data, respectively. They are highly significant, see Table (1). The PC1 scores shared by 82.25 and 80.52 in these seasons, respectively, in addition the PC1 scores were highly associated to the average grain yield over environments (treatments) in these seasons with correlation coefficients ($r=0.9994$, $P<0.001$) and ($r=0.9992$, $P<0.001$), respectively. This ensures that the genotype average effects were loaded in the PC1 scores, in other words; PC1 scores express genotype average main effects. Thus, the **GE** effects were loaded in PC2 scores.

The biplots displayed in figures (1-A, 1-B and 1-C) illustrates the **GE** interaction pattern of grain yield in both the first season, second season and over all seasons. The PC1 of the GGE biplot of either seasons or the combined data over seasons tended to separate the 8 improved cultivars at the right side from the 16 landraces allocated at the left side of biplots. Three landraces s Lr7, Lr11 and Lr14 were more productive than the other landraces so that three markers crossed the Y-axis and displayed grain yield more than the general average. Among the cultivar varieties V21 (Sids 1), V19 (Giza 168), and V18 (Sakha 93) were the best cultivars, they have the highest PC1 score. The deduced results about genotype productivity were in complete agreement with that presented in Table (4). However, **Yan *et al* (2000)** stated that the ideal cultivars should have large PC1 score (high yields ability) and a small (absolute) PC2 score (high stability). Ideal tested environments should have large PC1score (more discriminative) of the genotypes in terms of the genotypic main effect and small (absolute) PC2 score (more representative of the over all environments).

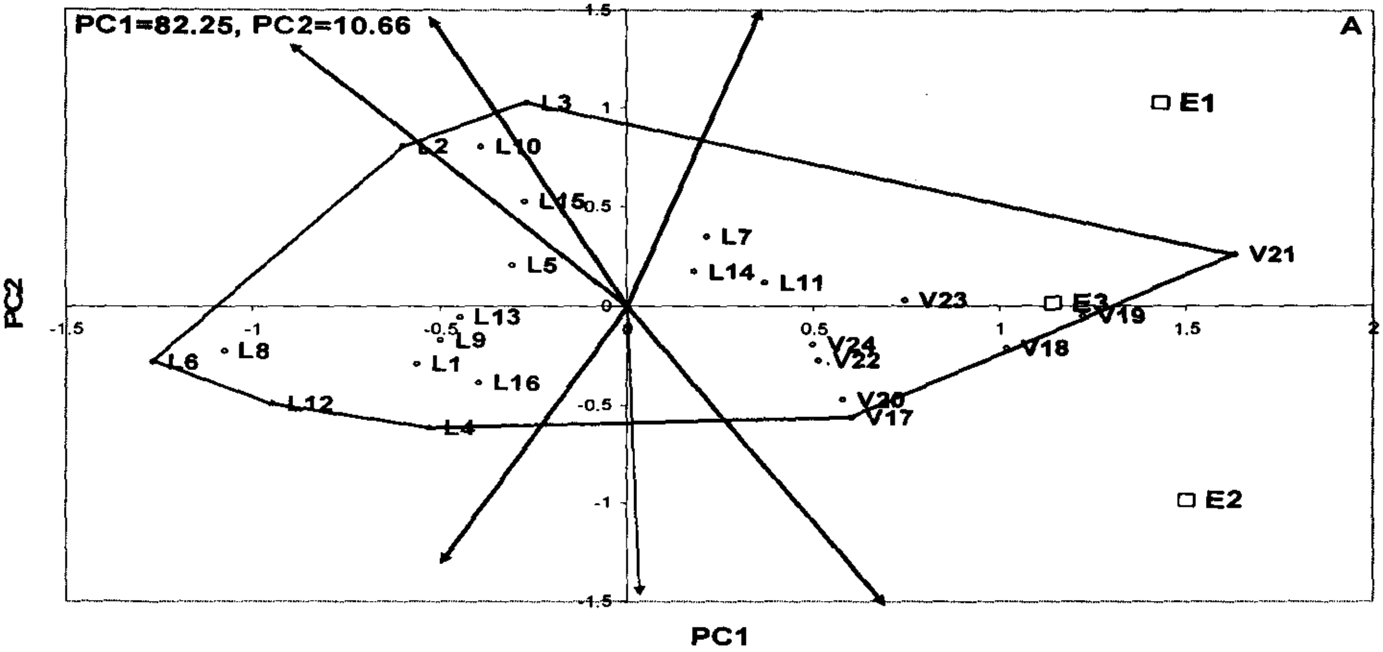

Figure (1-A): Biplot graphs according to GGE model of grain yield on the first season. Markers designated from L1 to L16 represent landraces while markers from V17 to V24 represent cultivars and designated E1, and E4, E2 and E5, and E3 and E6 represent control, drought stress and heat stress.

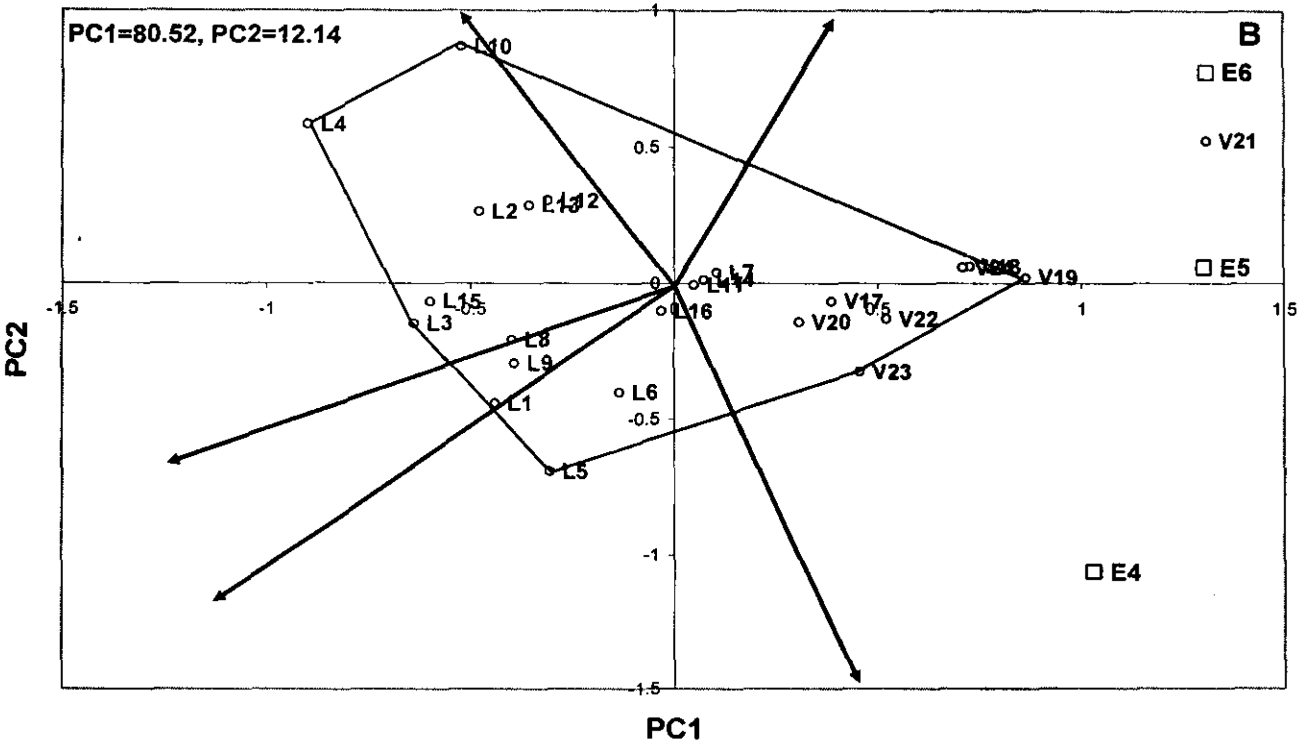

Figure (1-B): Biplot graphs according to GGE model of grain yield on the second season. Markers designated from L1 to L16 represent landraces while markers from V17 to V24 represent cultivars and designated E1, and E4, E2 and E5, and E3 and E6 represent control, drought stress and heat stress.

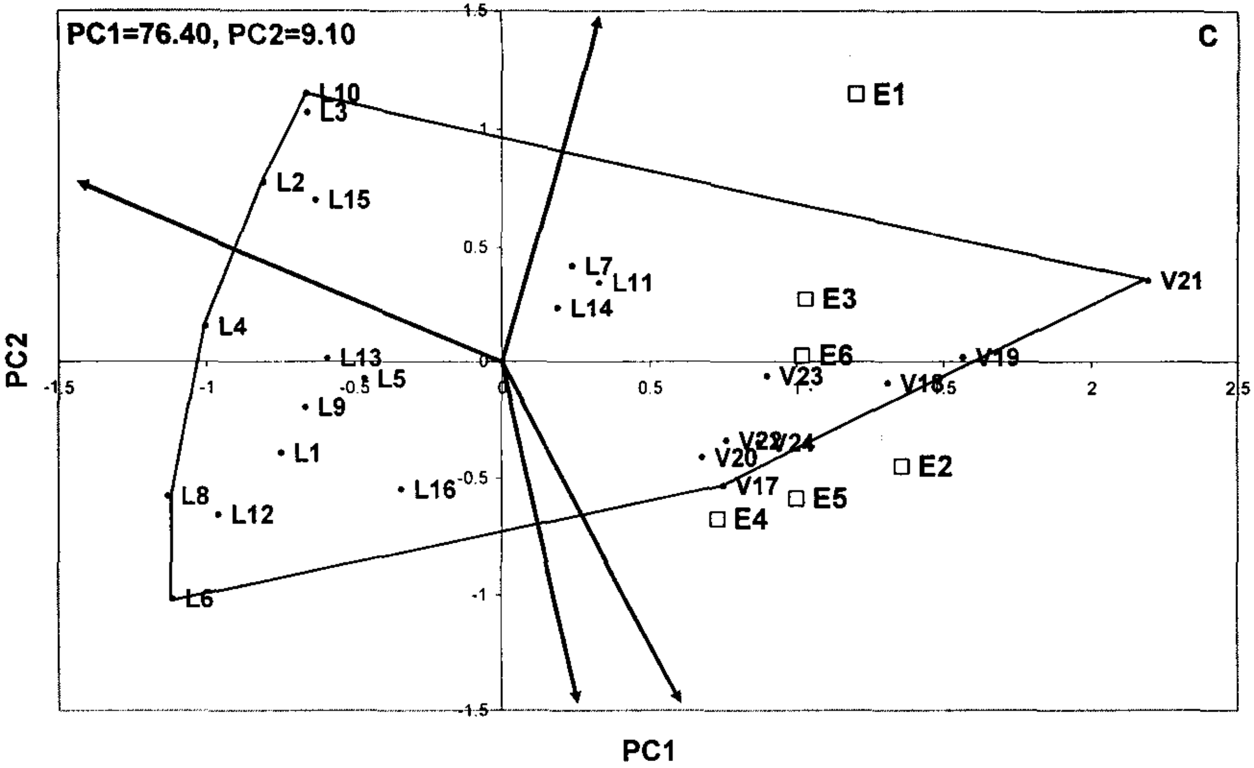

Figure (1-C): Biplot graphs according to GGE model of grain yield on the combined seasons. Markers designated from L1 to L16 represent landraces while markers from V17 to V24 represent cultivars and designated E1, and E4, E2 and E5, and E3 and E6 represent control, drought stress and heat stress.

Interpretations of genotype by environment interaction

The most stable cultivars over treatments in the first season were cultivars V19 (Giza 168) and V23 (El-Nelian), while the most stable landraces were Lr13 and Lr11. In the second season, the stable cultivars were V19 (Giza168), V18 (Sakha 93), V24 (Deberia) and V17 (Sahal 1) and the most stable landraces were Lr5, Lr16, Lr14, Lr7 and Lr11. The seen was also change in the third Figure; the most stable cultivars over treatments and over seasons were V19 (Giza 168), V18 (Sakha 93) and V23 (El-Nelian) while the most stable landraces were Lr13 and LR5. It is apparent that the stability measurements over treatment (normal control, water stress and heat stress) were changed from season to another season what may be due the weather condition that strength or reliefed the imposed stress.

In the first season, the water stress treatment marker was allocated below the X-axis as it has considerable negative PC2 score. All genotypes had markers allocated also below behalf and had negative PC2 score differ from zero would had positive **GE** interaction effect and positively response to water stress, since the negative PC2 score of E2 multiplied by the negative PC score of those genotypes. On other words, those genotypes displayed quite tolerance to water stress. The cultivars displayed water stress tolerant in the first season were V17 (Sahal 1), V20 (Gemmeiza 9), V22 (HD2501), V24 (Deberia) and V18 (Sakha 93) while the tolerant landraces were Lr4, Lr12, Lr16, Lr6, Lr1 and Lr9.

In the second season, the marker of E6 (late sowing where heat stress imposed) was allocated in the upper half where it is counterpart the markers of V21 (Sids 1), Lr10, Lr4, Lr2, Lr12 and Lr13. These genotypes positively interacted under heat stress condition and would be tolerant to this condition. However, the biplot depend on 6 environments classified entries to groups. The first one contains genotypes whose markers were positioned in the upper part with E2 and E5 (water stress) markers; they interacted positively to reveal their tolerance to water stress conditions. In the second group where their genotypes allocated their markers under the X-axis and interacted positively with E3 and E6 (heat stress) revealing their tolerance to heat stress. The genotypes had markers in upper side were V19, V20, V22 and V24 and landraces Lr6, Lr12, Lr16, Lr1 and Lr9. The genotypes had markers located in below half were V21 and landraces Lr7, Lr11, Lr14, Lr10, Lr3, Lr2, Lr15. The markers of the third group were located very close or on the X-axis belonging to cultivars V19, V18 and V23 and landraces Lr15, Lr5 and Lr4 indicating that these genotypes had approximately zero PC2 scores and were stable over tested environments. However, these results slightly concert with results obtained from DSI and HSI measurements shown in table (5), but the results deduced from visual biplot analysis depending on all collected data and the interaction patterns, while susceptibility indices provides a measure of susceptibility based on minimization of yield loss under stress compared with non-stress yield as well as the stress tolerant genotypes as defined by susceptibility indices values do not need to have a high yield potential. Therefore, it is believed that the information deduced from biplot analysis are more persuading.

What- wins- where?

Through developing interpretation of biplot techniques and visual analysis, this term "what-win-where" is raised to express the identification of best performing cultivars in sup-sets of mega-environments sites. Yan *et al.* (2000) represented a method to draw a polygon connection the most responsive cultivar markers either positively or negatively (vertex of the polygon), so that all other markers be inside the polygon. Each side of the polygon has a perpendicular line drawn from the origin of the polygon (0, 0) and extended for to subdivide the biplot into sectors so that each environment and cultivar marker is contained in only one sector. The vertex cultivar of any sector is the best one in all the environments allocated inside its sector, while other cultivar shared its sector perform well in these environments.

All the cultivars and three landraces (Lr7, Lr11 and Lr14) were inside one sector had cultivar V21 (Sids 1) as its vertex and all tested environment markers in the two seasons and over seasons indicating that they the best productive genotypes in all tested environments.

Genotype by traits biplots and traits relations

Kroonenberg (1995) stated that, fundamental association patterns among the traits should be captured by biplots. Each trait has a marker in the biplot, from which to the biplot origin (0, 0) a vector is drawn to visualize the relationships between and among studied traits. The correlation coefficient between any two traits is approximated by the cosine of the angle between their vectors. Thus, r= cos(180°) = -1, cos(0°) = 1 and cos(90°) = 0 (Yan and Rajacan

2002). The adequacy of estimated correlations depends on the amount of variation illustrated in the biplot proportionally to the total variation.

Average performances of the 24 entries over all the six studied environments for number of days to heading (HD), number of days to maturity (MD), grain filling period (GFP), Plant height (PLH), grain filling ratio (GFR) number of spikes/m^2 (S/m^2), number of kernels/spike (K/S) 1000 kernel weight (1000-KW), and grain yield /hec. (GY) were used. These data were arranged in two way table in which, the characters are in the columns and the entries (cultivars and landraces) are in the rows. According to Equation [2], the data were columns (character) centered and standardized. The transformed data were subjected to singular value decomposition (SVD). The singular values were equally and geometrically partitioned on characters and entries eigenvalues to construct symmetrical biplot shown in Figure (2-A). Two additional traits (DSI and HSI) were accompanied with the above characters to construct the biplot shown in Figure (2-B).

The biplot of the 9 characters shown in Figure (2-A) explained 76.26% of the total variation of the standardized data. The grain yield and its components as well as grain filling rate illustrated the largest variation in the biplot, while grain filling period shared by the smallest variation as indicated by the relative length of their vectors.

The apparent relationships revealed by this biplot are: (1) closely positive associations between and among grain yield and its components and between grain yield and grain filling period as a group and another group slowing closely positive correlations were HD, MD and GFR as indicated by very acute angles between vectors, (2) slightly positive association between PLH and each of HD, MD and GFP as indicated from acute angles between them and (3) closely negative associations between traits grouped in the left side of the biplot (PLH, HD, MD and GFP) with those traits grouped in the right side of the biplot (KW, SM^2, K/S, GY and GFR). The angles visualizing these relations were very large abuse. Several investigators recorded similar results deduced by the traditional methods to estimate the correlation coefficients. The significant relationships (correlations) among yield components can illustrate the influence of its genetic make up (Yunus and Paroda 1982).These results are in agreement with those reported by Paroda and Joshi (1970) and Yunus and Paroda (1982).

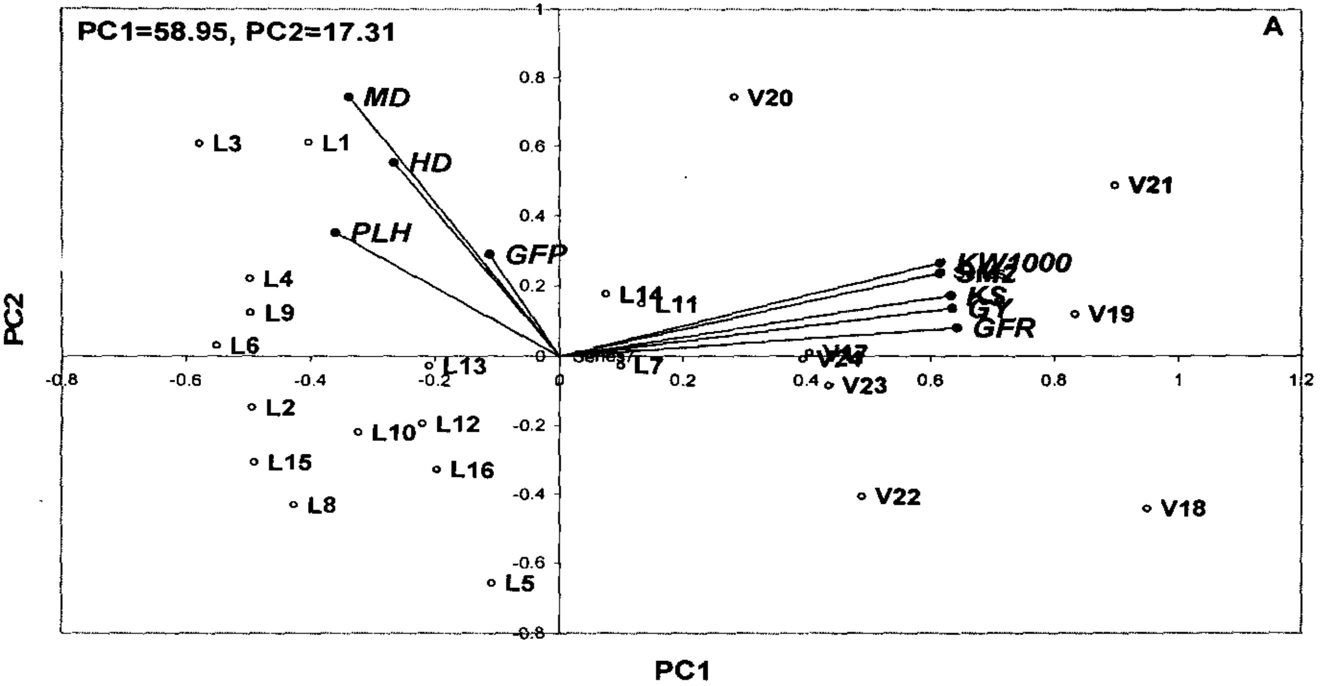

Figure (2-A): Biplot graphs according to GT model for 9 characters. Markers designated from L1 to L16 represent landraces and from V17 to V24 represent cultivars, while markers of the studied characters were HD, MD, GFP, PLH, GFR, S/m^2, K/S, 1000-KW and GY.

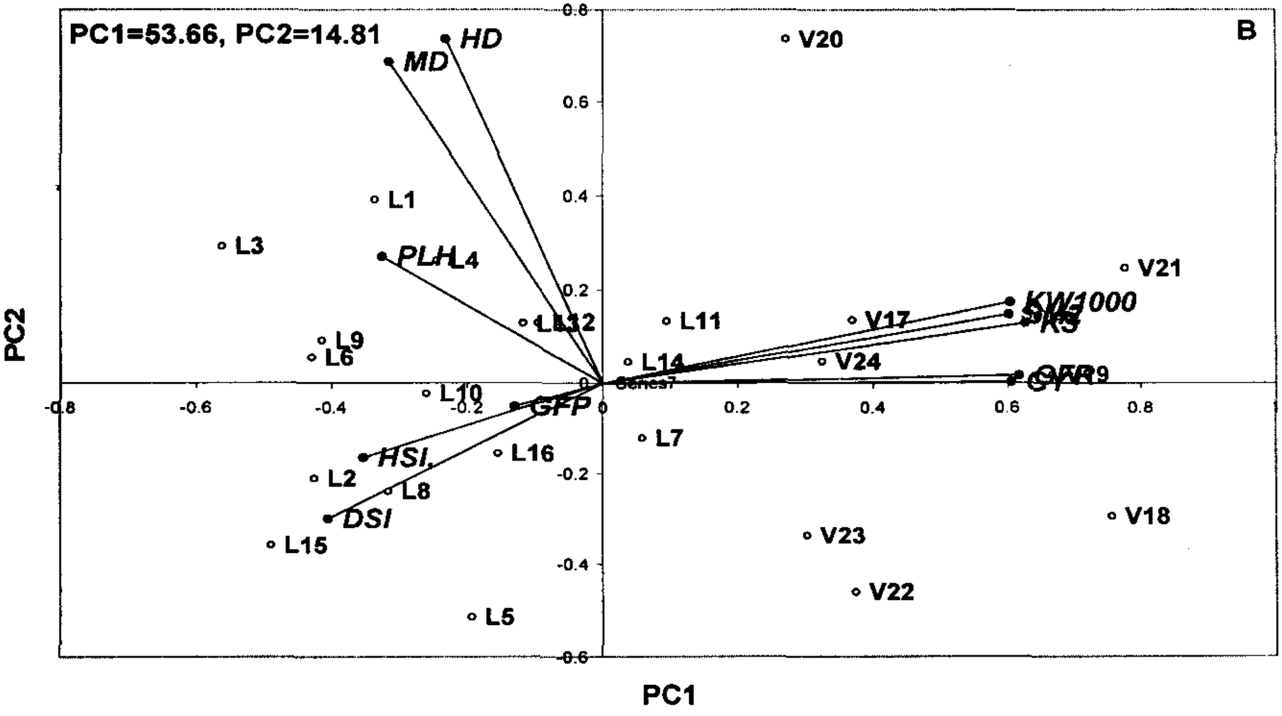

Figure (2-B): Biplot graphs according to GT model for 11 characters. Markers designated from L1 to L16 represent landraces and from V17 to V24 represent cultivars, while markers of the studied characters were HD, MD, GFP, PLH, GFR, S/m^2, K/S, 1000-KW, GY, DSI and HSI.

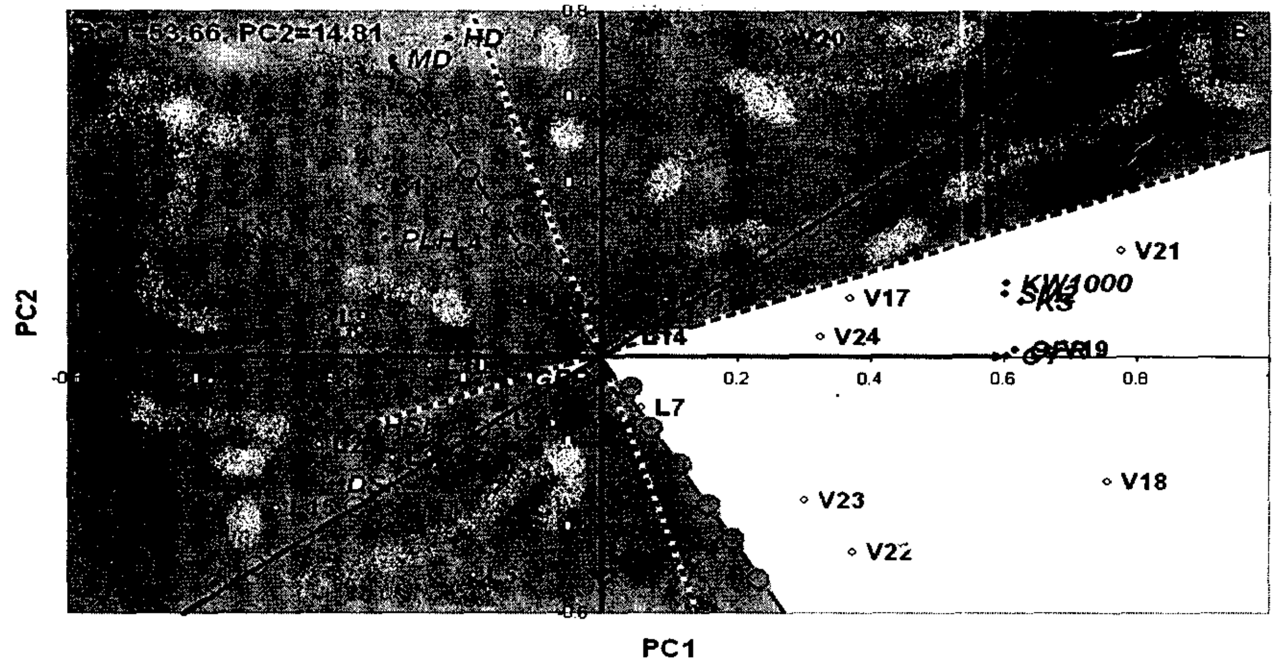

Figure (3): Biplot graphs according to GT model for 11 characters. Markers designated from L1 to L16 represent landraces and from V17 to V24 represent cultivars, while markers of the studied characters were HD, MD, GFP, PLH, GFR, S/m^2, K/S, 1000-KW , GY, DSI and HSI. All genotypes in shaded area were culled as they had lower than average GY, GFR, 1000-KW, S/M^2 and K/S, later flowering date and high susceptibility index for both drought and heat stresses.

Determinations of yield components in wheat and their association to development phases is quite important in determining the yield potential under stress conditions (Fischer1985).

Figure (2-B), in which two additional traits (DSI and HSI), explained only 68.47% of the total variation of the standardized data. Comparing with the former biplot (Figure 2-A), it is apparently indicated that adding more traits complicated the interrelationships among the characters and decreased the collected variation in biplot. However, the relations between and among the 9 characters were still longer with the same trend but with slight changes in correlation coefficients.

Nevertheless, the correlation coefficient between DSI and HSI was positive as the angle between their vectors was acute. This correlation may be due to the effects of warm weather that impose heat stress simultaneously increasing evapotranspiration which in return desiccate suffering plants and display drought syndrome. In addition, both drought and tolerant plants developed systems regulating water loss from cells.

Respecting HSI, it was closely and positively associated with GFP as the angle between their vectors is nearly zero. This relationship can be explained since the long grain filling period increases the possibility of incurrence the small-developed kernels to warm weather, which causes heat stress.

Both HSI and DSI revealed non-association with HD as the angles between their vectors and HD vectors were approximately 90° indicting that the correlation coefficients were also approximately zero. The absence of any relationship between HSI and HD can be explained since the heat stresses imposed on wheat plants occur after anthesis stage and during grain filling period so that there are no logical causes for this relationship. On the other hand, the absent relationship between DSI and HD can be due to the nature of water treatments in the course of this investigation which impose water stress periodically along whole plant life.

The biplot shown in Figure (2-b) visualized the negative associations between DSI and HSI with grain yield and its components. Mainly these relations were expressed by negative correlation coefficients since the angles visualizing these relations were very large abuse. These results were expected because the average performance of traits were calculated over all the six environments, where the most productive entries especially in stressed environments were those having the least DSI and/or HSI.

The correlation coefficients deduced from biplots describes the interrelationships among all traits on the basis of overall pattern of the data whereas correlation coefficients calculated by the traditional methods only describe the relation between two traits (Yan and Rajcan 2002).

The genotypes Lr16 and V24 showed attached markers on the biplot depending on 9 characters and even they had identical position in the distribution pattern suggesting high similarity and equivalent performance (Figure 2-A). Therefore, biplot techniques can be used to find out similarity and relative genotype between several landraces collected from one region and distinguishes the unrelated landraces. However, the markers of these two cultivars were detached on the GT biplot depending on 11 characters (Figure, 2-B), that can be account to the different responses of Lr16 and V24 to water and heat stress. Figures (1: A-C) reveal apparent different responses of these two cultivars under water stress conditions. Finally, when the object of an investigation is finding out the similarity between genotypes, it must increase the studied traits as possible to get accurate relationships.

Selecting genotypes according multiple traits

In general, breeding for heat stress tolerance could involve combining good yield potential in the absence of stress with an appropriate phonology. In Upper Egypt, wheat sowing by mid-November ensure optimum crop yield by avoiding dry winds during the grain filling period. However, the progress is often slow since the target environment is not uniform and stage specific of heat stress cannot be ensured. Therefore, evaluation of materials in multi-environments can help in minimizing year-to-year and location-to-location variations. Tolerant wheat genotypes to heat must possess one or more characteristics for which selection may be practiced (Acevedo *et al* 1991). Sensitivity to heat stress is expressed as reduction of spike bearing tillers, number of grains / spike and grain-filling duration (Shpiler and Blum 1986). Thus, the selection for multiple traits including HSI and DSI on data collected over mutable-environments including abiotic stresses could be suitable selection criteria to detect heat tolerant genotypes.

Yan and Rajcan (2002) stated that the GT biplot can be used to aid genotype selection on the basis of multiple traits. The selection for one trait can be done by drawing a line that passes through the origin (0, 0) and the marker of this trait, followed by drawing a line that passes through the biplot origin and is perpendicular to the trait line (vector). Having the biplot sufficiently approximates the data, the genotypes fell on the same side of the perpendicular line where the trait should have performed above desired average (genotypes to be selected) and whereas genotypes on the other side of the perpendicular line should have performed below desired average (culling genotypes).

Applying the above basis to select for yield productivity, drought tolerance, heat tolerance at seed filling period and earlier flowering, a modified version of Figure (2-b) with supplemental lines was drawn and the undesired genotypes were identified by shading their areas. This biplot were presented in Figure (3). The selected entries (genotypes) for these four traits allocated in the un-shading area, were eight evaluated cultivars (V17, V18, V19, V20, V21, V22, V23 and V24) and one landrace L7, They can be used in future breeding programs. Awaad (2001) stated that, in regions of the terminal drought, breeders seek for genotypes of shorter grain filling duration to escape or at least minimize the detrimental effect of drought on grain yield. His proposal can actually performed as done in the above selection.

REFERENCES

Abd -ElGhani, A.M. (1999). Evaluation of some wheat landraces under moisture stress at sandy soil of newly reclaimed areas. J. Agric. Sci. Mansoura Univ. 24 (11): 7139-7147.

Abdel-Shafi, A.M., M.G. Mosaad, A.M. Abd –El-Ghani and M.B. Tawfelis (2001). Effect of different sowing dates on the yield and other characters of some wheat genotypes in Upper Egypt. Eleventh Regional Coordination NVRSP Meeting, September 23 – 27, 2001, Cairo – Egypt.

Acevedo, E., M. Nachit, and G.O. Ferrara (1991). Effects of heat stress on wheat and possible selection tools for use in breeding for tolerance.401-420 In D.A. Saunders (ed).Wheat for the non-traditional warm areas. CIMMYT, Mexico DF.

Awaad, H.A. (2001). The relative importance and inheritance of grain filling rate and period and some related characters to grain yield of bread wheat (*Triticum aestivum* L.). The 2nd Pl. Breed. Conf., October 2, (Assiut University)

Bruckner, P.L. and R.C. Frohberg (1987). Rate and duration of grain filling spring wheat. Crop Sci. 27(3): 451-455.

Bruckner,L.P., and R.C.Frohberg (1987). Stress tolerances and adaptation in spring wheat. Crop Sci. 27: 31-36.

Curtis,B.C.(1991). Breeding wheat to cope with thermal stresses. In pages 251-266. Improvement of winter cereals under temperature drought and salinity stresses. Proceedings of the international symposium. October 26-29, 1987. Cordoba, Spain.

Damania,A.B. (1989). Genetic resources of wild relatives in cereal crops. I. Germplasm sampling strategy. Rachis 8: 8- 10

Ehdaie,B., J.G.Waines and A.E.Hall (1988). Differential responses of landraces and improved spring wheat genotypes to stress environments. Crop Sci. 28:838-842

Fischer,R.A. (1985). Physiological limitation to producing wheat in semitropical and topical environments and possible selection criteria. P.209-230 Wheats for more tropical environments. A. Proc. int. Symp. CIMMYT. Mexico,DF.

Fischer, R.A. and R.O.Maurer (1976). Crop temperature modification and yield potential in dwarf wheat. Crop Sci 16: 855-859

Fischer,R.A. and R.O.Maurer (1978). Drought resistance in wheat cultivars: I-Grain yield response. Aust. J. Agric. Res. 29:897-912.

Frank, A.B., A. Bauer and A.L. Black (1987). Effect of air temperature and water stress on apex development in spring wheat. Crop Sci. 27: 113-116.

Gomez, K.A. and A.A.Gomez (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons. Inc. New York USA.

Kroonenberg, P.M.(1995). Introduction to biplots for GxE tables. Department of Mathematics, Research Report 51. Univ. of Queensland, Australia.

Paroda, R. S. and A. B. Joshi (1970). Correlations,path-coefficients and the implication of discriminate function for selection in wheat (*Triticum aestivum* L.), Heridity, 25 (3) :383-391.

Randall,P.J. and H.J. Moss (1990). Some effects of temperature regime during grain filling on wheat quality. Aust. J Agric. Res. 41: 603-617.

Saba, M.F.A. (2006). Biplot and traditional line by tester analysis of some sorghum hybrids and their parents. Egypt J. Plant Breed. 10(1): 149-173.

Shpiler,L. and A.Blum (1986). Differential reaction of wheat cultivars to hot environments: Euphytica 35:484-492

Tawfelis, M.B. (2002). The performance of some wheat landrace genotypes and improved cultivars under stress environments. J. Agric. Sci. Mansoura Univ., 27(1): 61-80.

Tawfelis, M.B. (2006) .Stability parameters of some bread wheat genotypes (*Triticum aestivum*) in new and old lands under Upper Egypt conditions. Egypt J. Plant Breed. 10(1): 223-246.

Yan, W. and I. Rajcan (2002). Biplot evaluation of test sites and trait relations of soybean in Ontario. Crop Sci. 42(1): 11-20.

Yan, W. and L. A. Hunt (1999). An equation modeling the temperature response of plant growth and development using only the cardinal temperatures. Annals of Botany, 84(5): 607-614.

Yan, W., L.A. Hunt, Q. Sheng and Z. Szlavnics (2000). Cultivar evaluation and mega-environment investigation based on the GGE biplot. Crop Sci. 40(3): 597-605.

Yunus, M and R. S. Paroda (1982). Impact of bi-parental mating on correlation coefficients in bread wheat. Theor. Appl. Genet. 62: 337 - 343.

استخدام طريقة المحاور الثنائية في تربية القمح تحت ظروف اجهادات بيئية مختلفة

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استخدم تحليل المحاور الثنائية لمعرفة السلوك الوراثي ولتميز السلالات الوراثية المحلية من قمح الخبز بالإضافة إلي بعض الأصناف المحسنة والتي لها المقدرة على تحمل ظروف الجفاف والحرارة العالية بمنطقة مصر العليا. ولهذا أجريت ثلاثة تجارب حقلية في المزرعة التجريبية بمحطة البحوث الزراعية بكوم أمبو- مركز البحوث الزراعية خلال موسمي ٢٠٠٥/٢٠٠٤ ، ٢٠٠٦/٢٠٠٥ ولقد كان هدف هذا البحث هو دراسة سلوك وتقييم وانتخاب بعض السلالات الوراثية المحلية من قمح الخبز بالإضافة إلي بعض الأصناف المحسنة والتي لها المقدرة على تحمل ظروف الجفاف والحرارة العالية . واستخدم في هذا البحث ثلاثة معاملات وهم المعاملة المثلي (موعد الزراعة الموصي به والري للسعة الحقلية عند فقد نسبة ٥٠% من الماء الميسر)، معاملة الجفاف (الري للسعة الحقلية عند فقد نسبة ٧٥% من الماء الميسر) وكذلك معاملة الزراعة المتأخرة (بعد شهر من المعد الموصي به) لتعريض النباتات للحرارة خلال فترة تكوين الحبوب وذلك لدراسة تأثير درجات الحرارة المرتفعة على المحصول ومكوناته والصفات المورفولوجية والفسيولوجية .

أوضحت النتائج أن تعريض النباتات لمعاملتي الجفاف والحرارة العالية في الميعاد المتأخر أدى إلى نقص في عدد الأيام من الزراعة إلى التزهير ، ميعاد النضج الفسيولوجي، فترة امتلاء الحبة، طول النبات، معدل امتلاء الحبة، عدد السنابل في المتر المربع، عدد حبوب السنبلة، وزن الألف حبة ومحصول الحبوب طن/هكتار بمقدار (٧,١٤، ١٣,٩٨%)، (٥,٤٤ و١٤,٩٧%)، (٢,٦٨، ١٦,٤٨%)، (٥,١٧، ١٠,٤٨ %)، (١٣,٨٢، ١٣,٦٦%)، (١٠,٥٥، ١٩,٩٥ %)، (٩,١٧، ٢٥,٥٠ %)، (٩,٠٦، ٢٢,٠٦ %) و (١٦,٢٣، ٢٧,٧٥ %) على الترتيب بالمقارنة بالزراعة في الميعاد والري الأمثل بالمنطقة.

كانت نسبة التباين الراجعة لكل من المتجه الأول والثاني في تحليل ثنائي المحاور (٨٢,٢٥ ، ١٠,٦٦ %) و (٨٠,٥٢، ١٢,١٤ %) و(٧٦,٤٠، ٩,١٠%) من التباين الكلي للسلالات تحت الدراسة لصفة محصول الحبوب للموسم الأول و الموسم الثاني وكذلك للبيئات الستة (ثلاثة معاملات وموسمين زراعيين)، علي التوالي.

أظهرت نتائج المحاور الثنائية أن قطاعا واحدا يحتوى على علامات الثمانية أصناف تحت الدراسة بالإضافة إلى علامات ثلاثة سلالات وراثية محلية أرقام ٧و ١١و ١٤ كما احتوى هذا القطاع على علامات المعاملات الثلاثة في كلا الموسمين وكذلك للبيئات الستة وكان أفضل الأصناف والسلالات في الأداء هو الصنف سدس١ . ونموذج التفاعل بين التراكيب الوراثية والبيئات في رسوم المحاور الثنائية ميز بوضوح التراكيب الوراثية لكل الجفاف والحرارة العالية.

رسمي المحاور الثنائية للتراكيب الوراثية والصفات يحتويان على ٩، ١١ من الصفات تحت الدراسة توضح ٧٦,٢٦ ، ٦٨,٤٧% من التباين الكلى للبيانات القياسية بالتتابع. وهذه الرسوم البيانية للمحاور الثنائية كانت كافية لتوضيح التلازمات بين المحصول، مكونات المحصول، معامل الحساسية لكل من الجفاف والحرارة العالية وبعض الصفات المحصولية الأخرى.

وقد أوضحت النتائج المتحصل عليها من البحث أن درجة التلازم بين كل من المقاومة للجفاف والحرارة العالية كانت عالية بينهم. واستخدم الرسم البياني للمحاور الثنائية للتراكيب الوراثية للصفات كوسيلة للانتخاب لعديد من الصفات والتي برهنت على كفاءتها في هذا الغرض. وهذا يعطى أهمية كبيرة بالنسبة لمربى النبات في استخدامها لتحسين واستنباط الأصناف الجديدة تحت ظروف الجفاف والحرارة العالية بمنطقة مصر العليا .

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