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Stability of Wheat Genotypes under Different Environments and Their Evaluation under Sowing Dates and Nitrogen Fertilizer Levels

[1]K.A. Hamam and [2]Abdel-Sabour. G.A. Khaled

[1]Department of Agronomy, Faculty of Agriculture, Sohag University, 82786 Sohag, Egypt.
[2]Department of Genetics, Faculty of Agriculture, Sohag University, 82786 Sohag, Egypt.

Abstract: The current study aimed at assessing the heat tolerance of twelve wheat genotypes under six environmental conditions (two locations and three years). Wheat genotypes were sown in two locations (Sohag and Assiut, Egypt) at two dates: November (favorable) and December (heat stress) during winter seasons of 2005/2006, 2006/2007 and 2007/2008. The combined analysis of variance showed that the flag leaf area, days to heading, plant height, spike length, 1000-kernel weight, biomass and grain yield were significantly influenced by years, locations, sowing dates, nitrogen fertilizer levels and genotypes. The results showed that sowing at the favorable date using 100kg/fed Nitrogen fertilizer increased all studied traits. The stability analysis revealed that four and three genotypes were high and intermediate yielding and stable for yield, respectively. The temperatures were decreased up to 2.50 to 6.39 º C at sowing late date than at the favorable sowing date. However among wheat genotypes a wide variation was found in response to heat tolerance. The results indicated that the 1000-kernel weight and grain yield traits are stable under heat stress. Some wheat genotypes conferred productive and adaptive advantages where they expressed high yield and yield stability when compared to other genotypes. This study indicated that higher 1000-kernel weight and days to heading are the two important traits which could be considered as potential selection criteria for yield under heat stress.

Key words: Wheat genotypes, sowing date, nitrogen fertilizer, years, locations, stability.

INTRODUCTION

Terminal heat is a major abiotic stress affecting yield in wheat. Under heat stress, the photosynthetic process is affected especially during grain filling stage when demand for assimilates is the greatest (Kumari *et al*. 2007). Stay-green character is an important trait that allows plants to retain their leaves in active photosynthetic under stress conditions (Rosenow *et al*. 1983). Terminal heat stress can be a problem in 40% of the irrigated wheat growing areas of the world (Fisher and Byerlee, 1991). In the rice-wheat cropping system, crop damage due to heat stress under late planting conditions has become an important factor limiting wheat yields (Aslam *et al*., 1989). Yield reduction in wheat under heat stress could be caused by accelerated phasic development (Frank and Bauer, 1997), accelerated senescence (Kuroyanagi and Paulsen, 1985), increased respiration (Berry and Bjorkman, 1980), reduced photosynthesis (Conroy *et al*., 1994) and inhibition of starch synthesis in developing kernels (Jenner, 1994). High temperatures during early crop development and particularly after anthesis may limit yield (Hunt *et al*., 1991). Temperature fluctuations during grain filling were found to cause deviations from expected dough properties (Blumenthal *et al*. 1991). The rise in daily average temperature, up to about 30 ºC, increased dough strength, while temperatures above this threshold value (35 - 40 ºC), even for periods of only few days, tended to decrease dough strength (Randall and Moss, 1990; Borghi *et al*., 1995 and Corbellini *et al*., 1997). Heat stress tolerance was evaluated as relative reduction in grain yield from normal environment to heat stress under full irrigation (Shpiler and Blum, 1986). The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions (Ali *et al*., 2003). Genotype-environment (GE) interactions are extremely important in the development and evaluation of plant varieties because they reduce the genotypic stability values under diverse environments (Hebert *et al*., 1995). The concept of stability had been defined in several ways and several biometrical methods including univariate and multivariate ones (Crossa, 1990). The most widely used one is the regression method, based on regressing the mean value of each genotype on the environmental index or marginal means of environments (Tesemma *et al*., 1998). A good method for measuring stability was previously proposed (Finlay and

Corresponding Author: K.A. Hamam, Department of Agronomy, Faculty of Agriculture, Sohag University, 82786 Sohag, Egypt.
E-mail: khalafhamam@yahoo.com

Wilkinson, 1963) and was later improved (Eberhart and Russell, 1966). El-sayed *et al*. (2003) found that the average performance over environments and stability parameters for grain yield in some barley genotypes gave the highest stability. The stable variety was defined by a high mean yield, regression coefficient ($b_i = 1.0$) and the deviations from regression as small as possible ($S^2d_i = 0$). In addition, the stability was defined as adaptation of varieties to unpredictable and transient environmental conditions and the technique has been used to select stable genotypes unaffected by environmental changes (Allard and Bradshaw, 1964).

Heading time is affected by complex interactions of temperature and photoperiod (Masle *et al*. 1989). Musich and Dusek (1980) found a decrease in grain yield by delaying sowing date. Dessouki *et al*. (1974) reported that the optimum date of wheat sowing was mid-November in Lower Egypt and 10 days later in Upper Egypt. Spring wheat grain yield and its components were reported to be more closely associated with temperature variation according to locations than with variation in perspiration (Kheiralla *et al*.1989 and Saadalla 1993). Different responses of wheat genotypes to dates and locations were reported by Ismail (1995).

Empirical data have shown that nitrogen is an important factor affecting crop at early stages (Zhong, 1999). Nitrogen fertilization increases the total quantity of flour proteins, resulting in an increase in both gliadins and glutenins (Johansson *et al*., 2004). Yates and Strzepek (1998) assessed the integrated impacts of climatic change on the agricultural economy of Egypt in 2060. Using outputs from three general circulation models (GFDL, UKMO, and GISS A1) the researchers found a decrease in yields from −5 to −51% for wheat, −5 to −27% for rice, and −2 to −21% for other cereals. The objectives of this study were: 1) to evaluate the grain yield of bread wheat genotypes of diverse origin at two sowing dates and two levels of Nitrogen fertilizer, 2) to estimate stability parameters of twelve wheat genotypes under six environments (two locations and three years) for selecting widely adapted genotypes.

MATERIALS AND METHODS

Planting and Treatments:

Twelve wheat genotypes were evaluated for heat stress tolerance in the field under irrigated conditions. The entry name and the source providing of the twelve genotypes used in this study were; (Sedes1, Sakha 93, Local KAH-91 and Giza 168) from Egypt; (Johara-19, Sahel 1 and Bocro-4/kauz"s") from ICARDA; (TRI 18686) from Spain; (TRI 3399) from Iran; (TRI 4157) from China; (TRI 2586) from Afghanistan. The seed material was obtained from Egypt, ICARDA-Syria and IPK-gatersleben Genebank-Germany. The experimental design was a split-split plot arrangement of treatment with three replicates in a randomized complete block design. The sowing dates, nitrogen levels and genotypes were randomly assigned to the main plot, sub-plot and sub-subplot, respectively. Each genotype was sown in a plot of 10.5 m^2 area. Wheat genotypes were sown in the field at two dates, 14 November (favorable) and 26 December (heat stressed), during winter season of 2005/2006, 2006/2007 and 2007/2008. Moreover, two Nitrogen fertilizer levels (70 kg/fed and 100 kg/fed) were applied for each genotypes grown at two locations which differed in their climatic conditions. The first location was at the Experimental Farm of Faculty of Agriculture, Sohag University, Sohag, Egypt, while the second location was at the Experimental Farm of Faculty of Agriculture, Assiut University, Assiut, Egypt.

Morpho-physiological Traits:

Data of flag leaf area (leaf length x width x 0.75) was measured according to Jatimliansky *et al*. (1984). Days to heading recorded the number of days elapsed from sowing until the upper most spikes appeared beyond the auricles of the flag leaf sheath (50% heading). Plant height was measured in cm for ten main culms. Spike length was recorded in (cm) for mean of ten main spikes/plot.

Yield and Yield Components:

The weight of 1000-kernel was recorded. Grain yield (Ardab/fed) from each replication 10.5 m^2 area was harvested at maturity. Biomass (ton/fed) the total above ground biomass was estimated.

Environment:

The monthly mean temperatures varied from year to year (Table 1). The mean daily maximum and minimum temperatures from the time of sowing to first booting stage (SBS1), first booting stage to heading date (BHS2) and heading date to maturity (HMS3) of favorable and late sown crops are given in Table 1. The difference in the maximum temperatures at Sohag location between the late and favorable sowing dates were -3.15 ºC, 3.79 ºC and 4.21 ºC in SBS1, BHS2 and HMS3, respectively. In Assiut location, they were - 4.37 ºC, 4.17 ºC and 3.43 ºC in SBS1, BHS2 and HMS3, respectively (Table 1).

Table 1: Mean maximum and minimum air temperatures (ºC) during wheat growth stages in favorable and late sowing date at Sohag and Assiut locations.

Locations	Months	Years					
		2005/2006		2006/2007		2007/2008	
		Max.	Min.	Max.	Min.	Max.	Min.
Sohag	November	25.90	10.00	24.03	10.69	28.13	13.83
Assiut		26.60	10.98	28.9	10.9	29.50	17.42
Sohag	December	23.40	9.00	21.34	6.88	22.37	8.55
Assiut		23.40	8.76	20.60	5.20	23.11	8.85
Sohag	January	21.50	6.80	19.33	5.16	18.33	4.89
Assiut		20.97	6.90	20.15	5.90	17.65	5.12
Sohag	February	23.50	8.90	27.48	8.52	21.32	7.04
Assiut		23.92	9.05	23.54	10.95	22.01	8.32
Sohag	Mars	26.60	11.0	27.68	11.29	27.60	11.21
Assiut		27.95	10.28	25.63	10.03	30.19	11.72
Sohag	April	30.10	14.60	34.67	21.63	31.33	15.32
Assiut		31.98	14.40	30.98	15.05	32.85	14.97
Sohag	May	34.90	19.10	38.58	26.02	33.64	18.13
Assiut		36.95	18.50	37.01	19.15	30.19	11.72
	Sowing dates	Sowing to booting stage (SBS1)		First booting stage to heading date (BHS2)		Heading date to maturity (HMS3)	
		Max.	Min.	Max.	Min.	Max.	Min.
Sohag	Optimum	24.20	9.83	21.91	6.89	29.66	14.18
	Late	21.05	6.88	25.70	9.66	33.87	19.13
Assiut	Optimum	25.34	10.35	21.37	7.71	29.93	12.74
	Late	20.97	6.79	25.54	10.06	33.33	15.63

Statistical Analysis:

The combined analysis of variance was performed according to Gomez and Gomez (1984). The stability analysis was computed as outlined by Eberhart and Russell (1966). Data analysis for genotypes, revised least significant difference (LSD') between genotypes and the interaction among genotypes and other factors were calculated. The analyses of variance were computed using MSTATIC microcomputer program (MSTATIC, 1990).

RESULTS AND DISCUSSIONS

Wheat production is often limited by terminal heat stress**.** Temperatures through growing seasons are shown in (Table 1). The data showed wide fluctuations of the temperature over the growing seasons. Temperatures at different growing stages of the same sowing date were not fixed in the three seasons of the study. Moreover, the temperature of growing months fluctuated from season to season and from location to location. The investigated genotypes were grown under different climatic conditions namely; sowing date (heat stress), nitrogen fertilizer levels, years and locations. The results showed that grain yield was decreased about 25.32 % under late sowing date in comparison with the favourable sowing date (Table 3). Rosenzweig and Tubiello (1996) reported that consistent decreases in wheat yield due to daily temperature rise.

Combined Analysis:

The combined analysis of variance (Table 2) revealed highly significant differences between genotypes, sowing dates, nitrogen fertilizer levels, years and locations for all studied traits. These results indicated that studied genotypes responded differently to the different environmental conditions suggesting the importance of the assessment of genotypes under different environments in order to identify the best genetic make up for a particular environment. Similar results were obtained by El-Morshidy *et al*. (2001), Abd-Elmajeed *et al.* (2005), Tawfelis (2006) and Menshawy (2007).

The Performance of Genotypes:

Sowing at the favorable date using 100kg/fed Nitrogen fertilizer increased all studied traits (Table 3). Flag leaf area, days to heading, spike length, and 1000-kernel weight traits were increased under Assiut location, while plant height, biomass and grain yield were increased under Sohag location. The results revealed that wheat genotypes responded differently when they are grown at differently seasons. The flag leaf area average ranged from 25.33 to 34.37 cm for Sahel 1 and Johara-19 genotypes, respectively; with an overall average of 30.27 cm. Flag leaf area decreased (13.29 %) by delaying sowing date (Table 3 and 4). When growth resources are limited by heat stress, the size of plant organs such as leaves, tillers, and spikes are reduced (Fischer, 1984). Days to heading: The average of number of days to heading at late sowing date was reduced by 9 days

Table 2: The combined analyses of variance over years (Y), locations (L), sowing dates (D), nitrogen fertilizers (N) and genotypes (G) for studied traits.

Source of variation	d.f	Flag leaf area, cm	Days to heading	Plant height, cm	Spike length	1000-kernel weight	Biomass	Grain yield Ard/fed.
Year (Y)	2	36.74**	5355.48**	4464.14**	47.74**	87.47**	17.06**	99.98**
Location (L)	1	527.44**	16909.52**	1311.48*8	611.72**	11474.89**	20.76**	2929.76**
YL	2	971.08**	12.26**	159.33**	11.48**	2051.08**	0.12	1.23
Error (a)	12	2.58	13.58	11.96	0.74	2.83	1.34	8.33
Sowing dates (D)	1	3999.86**	6983.91**	19145.21**	150.83**	6428.49**	601.80**	3154.21**
YD	2	1.20	5.07**	13.41**	14.29**	56.23**	0.38	1.76
LD	1	66.38 **	556.52**	460.25**	8.13**	39.49**	5.23**	0.83
YLD	2	9.35	0.37	64.77**	17.73**	95.53**	0.02	0.16
Nitrogen fertilizers (N)	1	3686.69	18636.11**	12939.58**	96.80**	2971.86**	264.74**	2466.56**
YN	2	40.22**	13.36**	142.64**	28.23*8	0.65	0.35	1.86
LN	1	220.16**	295.85**	842.73**	10.31**	16.29**	4.36**	99.34**
YLN	2	18.17**	0.14	251.87**	31.78**	4.45**	0.03	0.004
DN	1	116.13**	30.55**	246.12**	6.97**	204.49**	12.08**	2.78
YDN	2	43.69**	0.01	15.16**	1.31**	12.29**	0.04	0.06
LDN	1	96.61**	193.54**	1034.95**	11.03**	70.77**	0.17	67.41**
YLDN	2	43.33**	0.12	6.68**	1.33**	9.02**	0.02	0.05
Genotypes (G)	11	540.46**	2294.73**	797.89**	64.34**	175.89**	23.72**	197.36**
YG	22	112.14**	1.79	159.41**	1.03**	40.48**	0.02	0.36
LG	11	435.29**	971.99**	724.86**	20.42**	154.03**	18.03**	210.18**
YLG	22	105.47**	0.74	155.19**	0.85**	36.89**	0.02	0.23
DG	11	274.22**	70.02**	235.53**	8.04**	60.21**	10.74**	95.67**
YDG	22	52.92**	0.04	54.24**	0.79**	2.42**	0.03	0.31
LDG	11	413.98**	64.35**	265.87**	4.90**	14.09**	7.01**	48.44**
YLDG	22	58.39**	0.05	51.33**	0.82**	1.63	0.02	0.22
NG	11	146.17**	257.76**	105.60**	3.11**	65.79**	2.96**	20.22**
YNG	22	55.81**	0.17	26.33**	1.33**	2.55**	0.01	0.12
LNG	11	248.06**	31.02**	129.57**	4.23**	15.44**	3.19**	18.57**
YLNG	22	56.44**	0.03	26.17**	1.34**	1.68*	0.01	0.19
DNG	11	71.49**	50.31**	84.48**	3.83**	56.52**	2.46**	26.17**
YDNG	22	41.13**	0.04	20.18**	0.72**	1.82*	0.02	0.22
LDNG	11	140.89**	27.51**	94.31**	4.09**	11.37**	2.09**	26.52**
YLDNG	22	42.23**	0.02	19.79**	0.70**	1.12	0.01	0.11
Error (b)	564	2.84	1.23	0.938	0.20	1.05	0.32	1.20

Significant at 0.05 and 0.01 probability levels, respectively.

Table 3: Means of the twelve genotypes over years, sowing dates, Nitrogen fertilizer and locations.

Item	Flag leaf area, (cm)	Days to heading	Plant height, (cm)	Spike length	1000-kernel weight	Biomass (ton/fed)	Grain yield (Ard/fed)
First year	30.63	86.16	95.59	11.48	41.07	4.73	12.45
Second year	29.92	94.78	103.47	12.32	39.96	5.20	13.69
Third year	30.27	90.47	99.53	11.90	40.52	4.96	13.07
$LSD_{0.05}$	2.64	6.05	5.68	1.41	2.76	1.90	4.74
Favorable sowing date	32.43	93.31	104.24	12.32	43.25	5.79	14.97
Late sowing date	28.12	87.63	94.81	11.48	37.78	4.13	11.18
70 kg/fed N fertilizer	28.21	85.83	95.65	11.57	38.66	4.41	11.37
100kg/fed N fertilizer	32.34	95.11	103.41	12.23	42.37	5.52	14.77
Sohag location	29.49	86.05	100.76	11.05	36.87	5.12	14.90
Assiut location	31.05	94.89	98.30	12.75	44.17	4.81	11.24
Mean overall	30.28	90.47	99.53	11.90	40.52	4.96	13.07

(Table 4). Similar results were found by Abdel Karim (1991) and Ismail (1995). The mean number of days to heading of the different genotypes ranged from 81.88 to 104.52 days for Johara-19 and TRI 18686, respectively; with an overall average 90.47 days. The earliest genotypes were Sedes1, Bocro-4/kauz"s", TRI 3399 and TRI 2586 about (72.67 days) at Sohag location in the second sowing date (Table 4). Sivori (1975) reported a delay of 3 days in flowering of wheat by a delay of 15 days in sowing date. Also, Nachit and Ketata (1987) stated that the number of days to heading tended to decrease by delaying sowing date. Plant height: The average of plant height ranged from 80.04 cm to 117.85 cm for the shortest genotype (Sedes1) under late sowing date at Assiut location and for the tallest genotypes (Sakha 93 and Bocro-4/kauz"s") under normal sowing date at Sohag location, respectively, when 100kg/fed N fertilizer was applied at Sohag location with an overall average 99.53 cm (Table 5). The obtained results are on line with those obtained by Nachit and Ketata (1987) and Ismail (1995). Spike length: The shortest spike length was 9.03 cm for Johara-19 genotype under late sowing date at Sohag location, while the tallest spike length was 16.85 cm for TRI 18686 genotype at Assiut location and favorable sowing date using 100kg/fed N fertilizer with an overall average

Table 4: Genotype means at two locations (L), two sowing dates (D) and two nitrogen fertilizer levels (N) for flag leaf area and days to heading over three years.

Genotypes	Flag leaf area								Mean
	L1				L2				
	D1		D2		D1		D2		
	N1	N2	N1	N2	N1	N2	N1	N2	
Sedes1	23.74	31.55	20.16	34.42	38.99	40.74	25.01	26.85	30.18
Sakha 93	30.88	35.71	19.58	15.48	36.93	38.89	29.03	34.33	30.10
Local kah-91	33.44	32.03	33.81	34.18	34.69	47.36	22.12	24.88	32.81
Giza 168	29.54	47.68	24.17	28.83	28.88	30.49	23.54	27.38	30.06
Johara-19	24.03	33.47	26.98	32.93	37.46	43.75	36.33	40.02	34.37
Sahel 1	15.96	31.01	20.84	23.17	27.30	31.73	25.27	27.38	25.33
Bocro-4/kauz"s"	36.59	28.28	24.87	19.79	22.61	27.38	23.70	25.27	26.06
TRI 18686	29.28	33.12	33.40	24.00	28.48	30.54	24.01	28.43	28.91
TRI 3399	33.15	26.01	35.33	35.43	31.78	41.07	26.96	37.91	33.46
TRI 5649	30.66	30.60	28.63	33.74	22.16	34.75	27.17	30.41	29.77
TRI 4157	30.81	32.37	26.33	27.08	32.95	35.81	21.48	31.59	29.80
TRI 2586	31.18	41.71	27.01	32.70	28.35	30.54	28.43	39.49	32.43
Mean	29.11	33.63	26.76	28.48	30.88	36.09	26.09	31.16	30.27
LSD'$_{0.05}$									
Genotypes (G)	= 0.53				G*N	= 0.69			
G*Y	= 0.85				G*L*Y	= 1.20			
G*L	= 0.69				G*D*N	= 0.98			
G*D	= 0.69				G*L*Y*N*D	= 2.39			
				Days to heading					
Sedes1	81.09	83.20	72.67	81.09	90.57	93.73	86.36	90.57	84.91
Sakha 93	90.57	95.83	74.77	91.62	92.67	95.83	88.46	95.83	90.70
Local kah-91	78.98	88.46	73.72	81.09	91.62	97.94	90.57	93.73	87.01
Giza 168	85.30	90.57	80.04	88.46	90.57	95.83	89.52	93.73	89.25
Johara-19	78.98	81.09	74.77	77.93	85.30	89.52	82.14	85.30	81.88
Sahel 1	80.04	88.46	77.93	86.36	87.41	97.94	84.25	90.57	86.62
Bocro-4/kauz"s"	81.09	101.10	72.67	86.36	94.78	104.26	90.57	100.10	91.36
TRI 18686	107.42	122.16	97.94	111.63	94.78	106.37	94.78	101.10	104.52
TRI 3399	87.41	95.83	72.67	89.52	93.73	107.42	92.67	102.20	92.68
TRI 5649	90.57	100.05	74.77	92.67	95.83	108.47	89.52	101.10	94.12
TRI 4157	80.04	94.78	73.72	89.52	93.73	107.42	87.41	103.20	91.23
TRI 2586	80.04	89.52	72.67	83.20	100.05	110.58	92.67	102.20	91.36
Mean	85.13	94.25	76.53	88.29	92.59	101.28	89.08	96.64	90.47
LSD'$_{0.05}$									
Genotypes (G)	= 0.35				G*N	= 0.45			
G*Y	= 0.56				G*L*Y	= 0.79			
G*L	= 0.45				G*D*N	= 0.64			
G*D	= 0.45				G*L*Y*N*D	= 1.58			

Sohag location = L1 Favorable sowing date = D1 70 kg/fed N fertilizer = N1
Assiut location = L2 Late sowing date = D2 100kg/fed N fertilizer = N2

11.90 cm (Table 5). Sowing at the favorable date, 100kg/fed N fertilizer at Assiut location caused taller spikes, because heat units and metabolites stored in favorable sowing date caused taller plants, vigorous growth and taller spikes. The results are in agreement with those obtained by Kheiralla *et al*. (1989) and Ismail (1995). 1000-Kernel weight: The highest weight of kernel was that of Johara-19 genotype (52.66 g) at Assiut location, at the favorable sowing date and 100kg/fed N fertilizer but the lowest was that of TRI 4157 genotype (26.39 g) at Sohag location and late sowing date with an overall average 40.52 g (Table 6). This may be due to high temperatures affecting the grain maturity which resulted in shrinked kernels. The results, as the same trend with obtained by (Menshawy 2007) who reported that high reduction in kernel weight was found under late planting; it could be fully accounted by the reduction in grain filling period. Tawfelis (2006) reported that delaying sowing reduced 1000-kernel weight and grain yield. Biomass: The best genotype was Bocro-4/kauz"s" which produced 9.55 ton/fed biomass at Sohag location under the favorable sowing date with 100 kg/fed N fertilizer (Table 6). Biomass was affected by leaf area, plant growth, plant height and environments. These results are in agreement with those obtained by Saadalla (1993) and Ismail (1995). Grain yield (Ard/fed): The grain yield of the different genotypes ranged from 10.40 to 15.47 Ard/fed for TRI 2586 and Bocro-4/kauz "s" genotypes, respectively, with an overall average of 13.07 Ard/fed. The Bocro-4/kauz "s" genotype grown in Sohag produced the highest grain yield (22.96 Ard/fed) during the favorable condition of wheat sown with 100 kg/fed

Table 5: Genotypes means at two locations (L), two sowing date (D) and two nitrogen fertilizer levels (N) for plant height and spike length over three years.

Genotypes	Plant Height								Mean
	L1				L2				
	D1		D2		D1		D2		
	N1	N2	N1	N2	N1	N2	N1	N2	
Sedes1	96.79	103.31	92.78	101.80	102.15	106.79	80.04	90.57	96.78
Sakha 93	112.80	117.85	105.31	112.33	88.25	107.42	81.09	99.20	103.04
Local kah-91	95.28	104.81	89.77	92.78	109.52	112.26	83.62	99.63	98.46
Giza 168	95.78	101.80	95.28	94.78	100.05	107.00	88.25	90.99	96.74
Johara-19	95.28	99.29	97.29	103.31	101.10	107.84	90.57	102.15	99.60
Sahel 1	92.78	106.82	92.78	95.78	101.31	108.26	84.88	100.68	97.91
Bocro-4/kauz"s"	111.80	117.85	93.28	100.30	106.58	110.58	91.62	102.15	104.27
TRI 18686	107.80	117.35	100.30	100.30	98.99	108.26	89.30	102.15	103.06
TRI 3399	102.80	105.81	95.78	102.80	95.83	104.05	88.25	104.68	100.00
TRI 5649	108.80	114.84	101.30	100.80	97.94	105.73	85.93	105.52	102.61
TRI 4157	100.30	107.32	82.75	102.80	105.31	105.73	89.30	99.41	99.12
TRI 2586	95.28	101.30	86.26	81.74	98.99	99.63	83.62	94.99	92.73
Mean	101.29	108.20	94.41	99.13	100.50	106.96	86.37	99.34	99.53
$LSD'_{0.05}$									
Genotypes (G)	= 0.30			G*N	= 0.40				
G*Y	= 0.49			G*L*Y	= 0.69				
G*L	= 0.40			G*D*N	= 0.56				
G*D	= 0.40			G*L*Y*N*D	= 1.38				
			spike length						
Sedes1	10.53	10.53	10.03	10.03	11.79	12.85	11.37	12.43	11.20
Sakha 93	10.78	13.04	11.53	11.53	13.27	13.69	11.37	11.79	12.13
Local kah-91	11.43	10.53	10.03	10.53	13.90	14.74	13.06	14.11	12.29
Giza 168	11.03	10.03	10.28	10.03	11.16	12.64	10.32	10.95	10.81
Johara-19	9.53	9.53	9.03	10.53	10.53	11.58	10.53	11.58	10.36
Sahel 1	9.03	10.53	9.53	10.03	11.16	12.01	10.74	11.79	10.60
Bocro-4/kauz"s"	11.03	11.53	9.53	12.04	13.48	14.74	12.01	13.06	12.18
TRI 18686	12.04	11.53	10.03	11.03	16.01	16.85	13.06	13.06	12.95
TRI 3399	14.04	12.04	11.03	12.04	14.53	15.80	13.69	14.53	13.46
TRI 5649	11.03	12.54	11.03	12.04	12.01	12.85	11.58	12.22	11.91
TRI 4157	13.04	12.54	9.53	11.53	12.85	14.01	12.22	13.69	12.43
TRI 2586	12.54	12.54	11.03	13.54	12.85	13.06	11.79	12.64	12.50
Mean	11.34	11.41	10.22	11.24	12.80	13.74	11.81	12.65	11.90
$LSD'_{0.05}$									
Genotypes (G)	= 0.14			G*N	= 0.18				
G*Y	= 0.22			G*L*Y	= 0.32				
G*L	= 0.18			G*D*N	= 0.26				
G*D	= 0.18			G*L*Y*N*D	= 0.64				

Sohag location = L1   Favorable sowing date = D1   70 kg/fed N fertilizer = N1
Assiut location = L2   Late sowing date = D2   100kg/fed N fertilizer = N2

N fertilizer (Table 7). The grain yield was greatly affected by the main yield components like kernel weight. The delay in heading date under late sowing was attributed to grains could be affected by high temperature special during this period. Reducing flag leaf area, spike length and kernel weight caused a great reduction in grain yield. Tawfelis (2006) found significant variation in yield and yield component among wheat genotypes under favorable and late planting. The present results are similar to those obtained by Saadalla (1993) and Abd-Elmajed *et al.* (2005).

Stability analysis: The joint regression analysis of variance (Table 8) revealed highly significant differences among genotypes for all studied traits. The partitioning of the genotype x environment interaction, as indicated by Env.+ (G x Env.), Env.(Linear), were highly significant for all the studied traits. G x E (linear) was highly significant for all the studied traits except 1000-kernel weight. Because, genotype x environment (Linear) was significant, it could be proceeded in the stability analysis (Eberhart and Russell 1966). Highly significant genotype x environment interactions for many wheat traits were previously reported (Mahak *et al.* 2002, Mondal and Khajuria 2002, Kheiralla *et al.* 2004 and Mahmoud 2006). Flag leaf area (cm): The stability of parameters (b_i and $s^2{}_d$) and the mean performance ($\overline{X}$) of the individual genotypes are presented in Table 9 and illustrated graphically in Fig., 1. The Local kah-91 genotype was stable for flag leaf area which b_i was 1.01 and S^2d_i tended to zero, therefore this genotype was stable. Days to heading: The results indicated that

Table 6: Genotypes smeans at two locations (L), two sowing date (D) and two nitrogen fertilizer levels (N) for 1000-Kernel weight and biomass (ton/fed) over three years.

Genotypes	1000-Kernel weight								Mean
	L1				L2				
	D1		D2		D1		D2		
	N1	N2	N1	N2	N1	N2	N1	N2	
Sedes1	40.27	42.93	34.19	36.85	46.34	47.39	41.07	43.18	41.53
Sakha 93	34.85	37.42	30.48	32.73	45.28	47.39	42.12	44.23	39.31
Local kah-91	38.21	41.91	33.24	35.36	45.28	49.50	42.12	43.18	41.10
Giza 168	37.16	41.32	33.29	36.26	41.07	46.34	41.07	44.23	40.09
Johara-19	39.82	42.32	34.04	38.97	49.50	50.55	44.23	52.66	44.01
Sahel 1	38.82	41.29	33.87	35.98	47.39	48.44	44.23	45.28	41.91
Bocro-4/kauz"s"	39.02	41.87	32.11	34.19	48.44	50.55	40.02	41.07	40.91
TRI 18686	39.87	43.09	33.50	36.69	41.07	43.18	35.81	38.97	39.02
TRI 3399	41.32	44.13	33.78	37.36	45.28	46.34	36.86	41.07	40.77
TRI 5649	36.51	40.00	27.90	34.26	46.34	50.55	32.65	45.28	39.19
TRI 4157	34.75	37.71	26.39	33.84	45.28	48.44	31.59	47.39	38.17
TRI 2586	38.92	41.92	31.33	37.56	44.23	46.34	34.75	46.34	40.17
Mean	38.29	41.33	32.01	35.84	45.46	47.92	38.88	44.41	40.52
LSD'$_{0.05}$									
Genotypes (G)	= 0.32			G*N	= 0.42				
G*Y	= 0.84			G*L*Y	= 0.73				
G*L	= 0.42			G*D*N	= 0.59				
G*D	= 0.42			G*L*Y*N*D	= 1.46				
			Biomass (ton/fed)						
Sedes1	5.30	5.61	3.74	5.41	4.13	6.32	3.10	4.26	4.73
Sakha 93	4.88	6.24	3.52	5.25	4.64	4.77	3.74	3.87	4.61
Local kah-91	6.86	7.51	4.09	5.70	6.45	7.22	3.23	4.26	5.67
Giza 168	4.53	6.61	3.03	3.50	4.52	5.42	4.26	4.39	4.53
Johara-19	4.40	5.07	3.99	4.43	5.03	5.68	4.90	5.42	4.87
Sahel 1	3.66	5.65	2.77	4.49	5.42	6.71	4.90	5.16	4.85
Bocro-4/kauz"s"	6.70	9.55	5.21	5.75	5.68	6.06	3.87	4.90	5.97
TRI 18686	6.07	9.41	2.97	3.63	4.13	6.32	2.84	3.61	4.87
TRI 3399	4.56	5.83	4.33	5.05	5.81	7.87	3.23	5.93	5.33
TRI 5649	6.35	8.52	4.58	6.15	4.77	5.81	4.13	4.52	5.60
TRI 4157	5.51	6.49	3.29	3.85	3.87	5.81	3.48	3.87	4.52
TRI 2586	4.32	4.93	2.89	3.34	5.16	5.81	2.71	2.84	4.00
Mean	5.26	6.79	3.70	4.71	4.97	6.15	3.70	4.42	4.96
LSD'$_{0.05}$									
Genotypes (G)	= 0.18				G*N	= 0.23			
G*Y	= 0.28				G*L*Y	= 0.40			
G*L	= 0.23				G*D*N	= 0.33			
G*D	= 0.23				G*L*Y*N*D	= 0.80			

Sohag location = L1   Favorable sowing date = D1   70 kg/fed N fertilizer = N1

Assiut location = L2   Late sowing date = D2   100kg/fed N fertilizer = N2

Table 7: Genotypes means at two locations (L), two sowing date (D) and two nitrogen fertilizers levels (N) for grain yield (Ard/fed) of grain yield over three years.

Genotypes	Grain yield (Ard/fed)								Mean
	L1				L2				
	D1		D2		D1		D2		
	N1	N2	N1	N2	N1	N2	N1	N2	
Sedes1	14.24	20.53	12.79	19.09	11.83	17.17	10.07	11.30	14.63
Sakha 93	13.36	18.65	11.54	15.92	10.57	12.29	7.01	10.85	12.52
Local kah-91	13.45	21.34	10.49	11.97	15.62	18.78	10.32	11.67	14.21
Giza 168	15.02	20.22	10.87	14.55	12.04	16.22	11.30	12.29	14.06
Johara-19	9.41	17.10	9.99	14.74	13.76	14.74	11.55	14.50	13.22
Sahel 1	10.31	15.92	6.80	13.15	14.74	19.66	11.06	13.52	13.15
Bocro-4/kauz"s"	17.24	22.96	15.61	18.56	12.60	13.94	11.30	11.55	15.47
TRI 18686	20.69	22.14	7.55	8.85	8.85	11.06	3.93	5.10	11.02
TRI 3399	18.23	20.08	16.85	19.78	10.88	12.29	9.83	11.49	14.93
TRI 5649	18.25	18.21	10.71	14.48	10.57	11.55	4.18	11.06	12.38
TRI 4157	12.58	18.93	10.88	11.85	10.07	11.30	1.72	9.58	10.86
TRI 2586	11.06	14.08	11.02	13.11	11.55	12.29	1.47	8.60	10.40
Mean	14.49	19.18	11.26	14.67	11.92	14.27	7.81	10.96	13.07

Table 7: Continue

$LSD'_{0.05}$					
Genotypes (G)	= 0.34		G*N	= 0.45	
G*Y	= 0.55		G*L*Y	= 0.78	
G*L	= 0.45		G*D*N	= 0.64	
G*D	= 0.45		G*L*Y*N*D	= 1.56	
Sohag location = L1		Favorable sowing date = D1			70 kg/fed N fertilizer = N1
Assiut location = L2		Late sowing date = D2			100kg/fed N fertilizer = N2

Table 8: Joint regression analyses of variance studied traits of bread wheat over six environments (three years and two locations).

Source of variation	D.f	Means of squares						
		Flag leaf area	Days to heading	Plant height	Spike length	1000-kernel weight	Biomass	Grain yield
Genotypes (G)	11	134.87**	391.85**	226.38**	32.47**	55.82**	9.32**	37.05**
Env.+ (G x Env.)	60	103.15**	148.18**	214.40**	4.35**	83.70**	1.40**	27.30**
Env. (linear)	1	1278.43**	5609.94**	3254.51**	159.92**	4096.15**	13.27**	426.10**
G x Env. (linear)	11	152.21**	141.27**	113.39**	5.47**	5.25	2.11**	95.62**
Pooled deviation	48	67.42**	35.98**	174.21**	0.85	18.08**	0.99	3.33**
Pooled error	132	1.499	16.84	0.82	0.743	3.08	0.76	1.06

*,** Significant at 0.05 and 0.01 probability levels, respectively.

Table 9: Genotypes average performance over 6 environments and stability parameters of the twelve wheat genotypes for all studied traits.

Ent.	Genotypes	Flag leaf area (cm)			Days to heading			Plant height (cm)			Spike length (cm)		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1	Sedes1	31.37	2.31	47.37**	85.83	1.13	-5.18	99.47	1.51	34.14**	11.16	0.9	-0.25
2	Sakha 93	33.91	-1.32	53.69**	91.62	0.68	24.42**	100.54	-0.43	340.37**	12.03	1.23	0.34
3	Local kah-91	34.07	1.01	-0.05	85.3	1.37	-2.46	102.4	1.34	95.57**	12.67	1.44*	-0.11
4	Giza 168	29.21	1.09	4.19**	87.94	0.82	-3.94	97.92	1.31	30.89**	11.1	0.53	0.14
5	Johara-19	30.75	1.75	38.04**	82.14	0.87	-5.08	98.19	0.44	11.83**	10.03	0.75	-0.24
6	Sahel 1	21.63	1.28	22.06**	83.73	0.96	-5.37	97.05	1.16	77.09**	10.1	1.19	0.04
7	Bakro-4/Kauz"S"	29.6	-1.5	48.31**	87.94	1.47	-0.978	109.21	1.3	5.74**	12.26	1.37	0.13
8	TRI 18686	28.88	1.33	9.62**	101.1	-0.29	62.64**	103.41	1.43	48.84**	14.03	2.64**	0.22
9	TRI 3399	32.47	2.03	22.18**	90.57	0.76	3.88	99.32	-0.01	75.58**	14.29	0.58	0.08
10	TRI 5649	26.41	1.29	2.55**	93.2	0.87	-3.37	103.38	1.01	35.54**	11.52	0.63	-0.16
11	TRI 4157	31.88	1.7	1.87**	86.89	1.38	-1.84	102.81	1.48	26.93**	12.95	0.36	0.3
12	TRI 2586	29.77	1.05	13.81**	90.05	1.96*	13.83*	97.14	1.47	18.31**	12.7	0.38	-0.08
	Mean	29.99			88.86			100.9			12.07		
	r($\bar{X}$ bi)	-0.14			-0.55*			0.19			0.27		

Ent.	Genotypes	1000-kernel weight			Biomass			Grain yield Ard/fed.		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1	Sedes1	43.31	0.98	0.24	4.72	1.92	-0.02	13.04	1.06	-0.17
2	Sakha 93	40.07	1.09	7.86**	4.76	0.88	-0.25	11.97	1.05	-0.34
3	Local kah-91	41.75	0.99	-1.02	6.66	1.33	-0.25	14.54	-0.56	0.94**
4	Giza 168	39.12	0.85	4.71**	4.53	0.61	-0.24	13.53	1.13	-0.34
5	Johara-19	44.66	1.13	1.95*	4.72	0.07	-0.05	11.59	-1.28	1.86**
6	Sahel 1	43.11	1.07	0	4.54	-1.49	0.59*	12.53	-1.33	2.12**
7	Bocro -4/kauz "s"	43.73	1.12	1.78*	6.19**	2.28**	-0.16	14.92	1.69**	-0.18
8	TRI 18686	40.47	0.74	22.44**	5.1	2.48**	0.49*	14.77	4.10**	3.75**
9	TRI 3399	43.3	0.9	7.46*	5.19	-0.72	0.35	14.56	2.58**	0.75*
10	TRI 5649	41.43	1.12	4.63**	5.56	2.49**	0.18	14.41	2.69**	0.93**
11	TRI 4157	40.02	1.08	8.66**	4.69	2.44**	0.26	11.33	0.94	-0.35
12	TRI 2586	41.58	0.92	1.26	4.74	-0.31	0.06	11.31	-0.05	0.09
	Mean	41.88			5.11			13.21		
r($\bar{X}$, bi)			0.37			0.41			0.61*	

*,** Significant different unity for (bi) and from zero for (S^2di) at the 0.05 and 0.01 probability levels, respectively.

the Sakha 93, TRI 18686 and TRI 2586 genotypes were unstable and gave significant S^2d_i (Table 9 and Fig. 1). Giza 168 genotype was stable for days to heading (b_i and S^2d_i were not significant from unity and zero, respectively). The b_i for Giza 168 genotype was less than one; therefore this genotype was stable and adapted to stress environments. In the same time, Johara-19 and Sahel 1 genotypes expressed the same trend and could be stable, consequently, they are recommended as a source of early heading date (82.14 and 83.72 days). Sedes1, Giza 168, Johara-19 and Sahel 1 genotypes were the best, because they were stable and had decreased days to heading less than the average of all genotypes. Plant height (cm): The results showed that

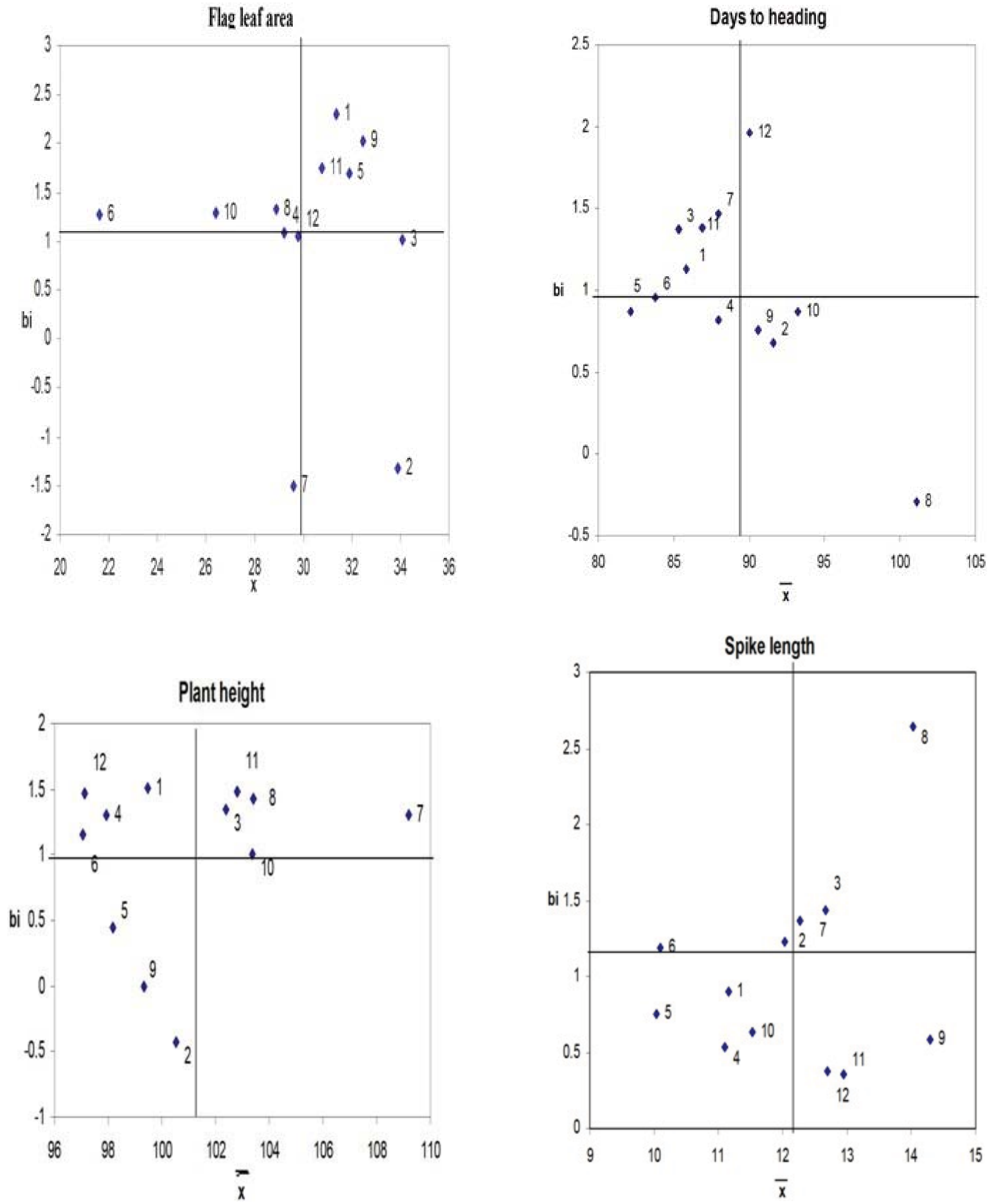

Fig. 1: Graphical illustration of the stability parameter (b_i) and mean performance genotypes ($\overline{X}$) for flag leaf area, days to heading, plant height and spike length.

all the studied genotypes were unstable and gave highly significant S^2d_i (Table 9 and Fig. 1). The b values of Sakha 93, Johara-19 and TRI 3399 genotypes were less than one. Spike length (cm): Results in Table 9 and Fig., 1 showed that Sedes1, Sakha 93 and Sahel 1 genotypes were stable for spike length. S^2d_i tend to zero, therefore these genotypes were stable. 1000-kernel weight (g): The Sedes1, Local kak-91, Johara-19, Sahel 1, BOCRO-4/KAUZ "s", TRI 5649 and TRI 258 genotypes were stable for 1000-kernel weight. Sedes1, Johara-19 and Sahel 1 genotypes were stable for grain yield. It is necessary indicated that stable genotypes (Sedes1, Johara-19, Sahel 1 and Bocro-4/kauz "s") have high kernel weight above the average of all genotypes (Table 9 and Fig., 2). Biomass: The stability results in Table (9) and Fig. (2) indicated that Sakha 93, Local kah-91, Giza 168 and TRI 3399 genotypes were stable for biomass. Sakha 93, Giza 168, Johara-19 and TRI

2586 genotypes were stable and exhibited lower biomass than the average response to different environments (b_i less than one), they are suitable for cultivation in less favorable environments. The b_i for most genotypes was less than one and S^2d_i tend to zero, therefore these genotypes were stable. Grain yield: Data in Table 9 showed that Sedes1, Sakha 93, Giza 168 and TRI 4157 genotypes were stable for grain yield. The results indicated that Local kah-91, Johara-19, Sahel 1, TRI 18686, TRI 3399 and TRI 5649 genotypes gave significant S^2d_i (Table 9 and Fig., 2). The b_i values for Local kah-91, TRI 4157 and TRI 258 genotypes were less than one and this result indicated that, these genotypes were stable for stress environments. The correlation between b_i and $\overline{X}$ The correlation between b_i and $\overline{X}$ (Table 9) for flag leaf area and days to heading was negative (-0.14 and – 0.55*), respectively, (Table 9). Positive correlation was found for plant height, spike length, 1000-kernel weight, biomass and grain yield (0.19, 0.27, 0.37, 0.41 and 0.61*), respectively. The positive and significant correlation for grain yield revealed that the studied genotypes exhibited high performance and high sensitivity to environments.

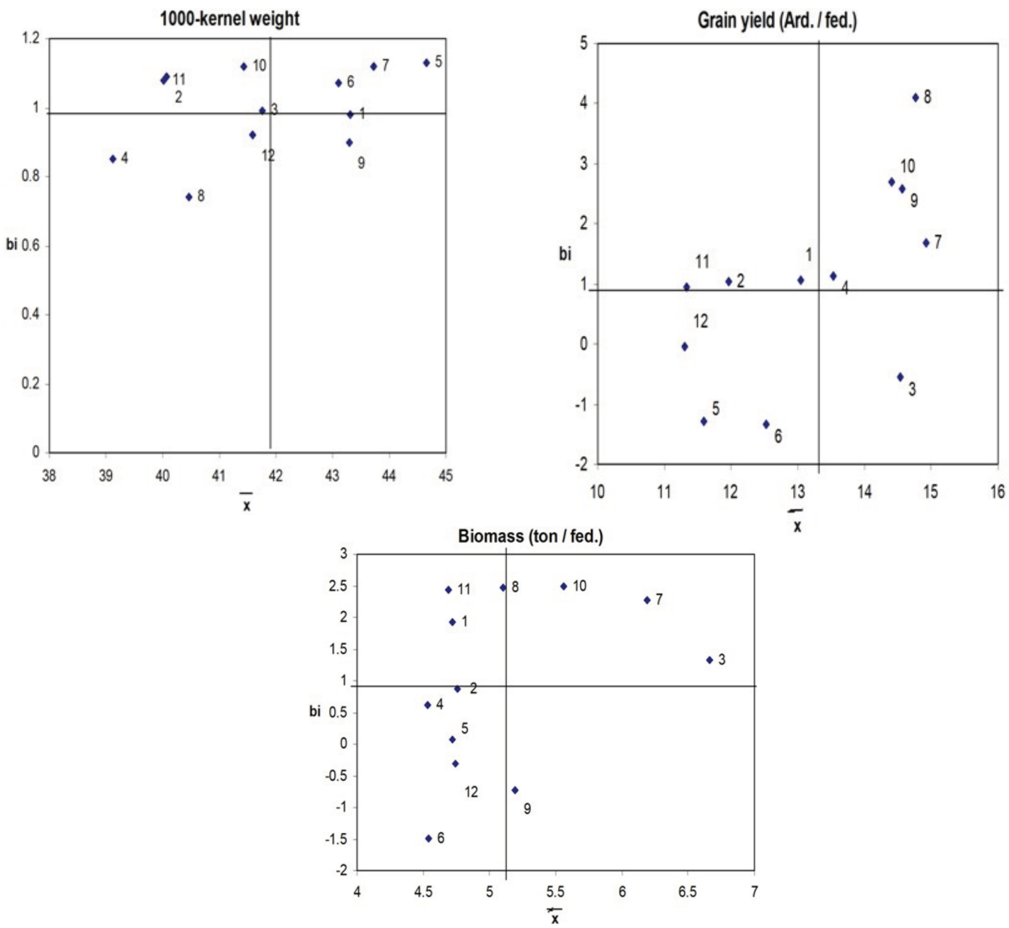

Fig. 2: Graphical illustration of the stability parameter (bi) and mean performance genotypes ($\overline{X}$) for 1000-kernel weight, biomass and grain yield.

The results of the present stability analysis indicate that the moderate and high yielding ability Sedes1, Sakha 93, Giza 168 and TRI 4157 genotypes were stable. This could be due to adaptation of these genotypes to wide differences in climatic conditions which prevailed at the two studied locations. On the other hand, unstable high yielding Local kah-91, TRI 18686, TRI 3399 and TRI 5649 genotypes might be due to their origin where three of them (TRI 18686, TRI 3399 and TRI 5649) are not Egyptian genotypes; consequently, they are not adapted to Egyptian conditions.

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