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GENOTYPE X ENVIRONMENT INTERACTION OF SOME BREAD WHEAT GENOTYPES (*Triticum aestivum* L.).

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Abstract.: Eight promising lines and two commercial varieties were grown at two sowing dates under two irrigation regimes in two successive seasons of 2002/2003 and 2003/2004 (8 environments). Highly significant differences among genotypes, planting dates, irrigation regimes, and significant G x E interactions were obtained for all the studied traits.

Delaying sowing date and water stress reduced all studied traits. The highest grain yield / feddan were obtained from genotypes F_{10} (129), Giza 164 and Giza 168 which recorded 15.0, 15.8 and 16.1 ardab/ feddan, respectively), these previous genotypes had late heading date.

The regression coefficient was highly significant and positively correlated with the mean performance for most studied traits, indicating that low yielding genotypes were generally stable while high yielding ones were rather responsive.

However, genotypes H109, Giza 164 and Giza 168 exhibited stability and high yielding. On the other hand, the bi values for genotypes H109, Giza 164 and Giza 168 were > 1, this indicating that these genotypes are more adaptive for highly favorable environments.

The results of path-coefficient analysis under recommended and late sowing date, showed strong positive direct effects of the No. of spikes / plant and spike length and moderate one of 1000-kernel weight on yield for those studied genotypes of wheat.

Moreover, the direct effect of days to heading, No. of spikes/ plant, spike length and 1000-kernel weight on yield decreased from recommended to late sowing date.

Key words: G x E interaction, Stability analysis, Wheat, Planting dates, Water stress, Path analysis.

Introduction.

Genotype by environment interaction (GxE) is a major problem in the study of quantitative traits because it complicates the interpretation of genetical experim-ents and makes predictions difficult. It is particularly a problem in plant breeding where genotypes have to be selected in one environment and used in another (Michael and Pooni, 1996).

In a breeding program, GxE interactions cause some difficulties when testing new lines developed by plant breeders. The environmental factors that affect the performance of genotypes change depending on both micro- and macro environmental levels.

Spring wheat is successfully grown in a very large range of environments. Cultivars adapted to the major agroclimatic zones have characteristic patterns of response to photoperiod and temperature which allow them to be sown and developed at times of the year when the environment is the most favorable. It is generally accepted that this adaptation is made possible by the existence in the species of considerable variation in response to these factors (Halse and Weir, 1970 and Wall and Cartwright,1974). Thus, cultivars bred and tested in a particular region will generally out yielded in other different agro-climatic zone when a comparable effort has gone into the breeding for them.

Dominant temperature and drought through growth of plants are the main limiting factors in crop production. The tolerance of wheat plant to temperature and drought depends on its genetic potential to adapt, the duration and intensity of exposure and stage of growth.

Ragasits 2000; Shivani *et al* 2001, Khalifa *et al* 1998 and Ismail, 1995 stated that the wheat yield and its attributes tended to decrease by delaying sowing date.

The production of wheat and stability under water stress were investigated by Purchase *et al* (2000) and Kheiralla *et al* (2004).

The stability parameters studied in three cereal by Yue *et al* (1990) indicated that wheat crop in general was more stable in yield than maize and sorghum.

The environmental factors such as temperature, fertility status and irrigation treatments, especially in the arid region, play an important role in the varietal performance. The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is grown. A genotype is considered more adaptive or stable, if it has high mean yield with low degree of fluctuation in yielding ability when grown over diverse environments. However, Eberhart and Russell's Model (1966) is one of the techniques used to rank the genotypes for stability. They defined a stable variety which possessed a regression coefficient of unity(b=1) and non-significant deviation from regression ($S^2d=0$). Therefore, a variety with a high mean yield over the environments, unit regression coefficient (b=1) and deviation from regression as small as possible ($S^2d=0$) will be a right choice as a stable and better variety.

Generally, correlation coefficients revealed relationships among independent characteristics and the degree of linear relation among these characteristics. However, path analysis is needed to clarify relationships among characteristics deeply compare to correlation coefficient which describe these relationships in a simple manner (Korkut *et al* 1993).

So, the objectives of the present study were to evaluate the performance of ten spring wheat genotypes at two different sowing dates under two irrigation regimes for yielding ability and its attributes. Moreover, partitioning of genotype x environment interaction into stability parameters was done for these genotypes. Also, path coefficient analysis was done to determine the direct and indirect effects of some examined traits on grain yield .

Material and Methods.

This study was carried out in 2002/2003 and 2003/2004 seasons at the farm of Faculty of Agriculture Assiut university, Assiut, Egypt.

The genetic materials in this investigation were eight promising wheat lines and two commercial varieties (Giza 164 and Giza 168) (Table 1). Genotypes were planted in two sowing dates , 25 Nov., (SD_1) as a recommended date and 25 Dec.,(SD_2) as a late date in both seasons. The irrigation regimes were I_1 (Normal irrigation) and I_2 (Stopped irrigation at anthesis stage)

Table(1): The pedigree of studied wheat genotypes.

No:	Code:	Parents:	Pedigree:
1	H165	S.69 x 1210	(Inia RL 4220 x (134 x S.69/20113/392/1)
2	H349	Giza 164 x 1203	(kvz/buha's'/kaL/Bb x 5500-10-21/29)
3	H58	Giza 164 x 1203	(kvz/buha's'/kaL/Bb x 5500-10-21/29)
4	H109	Giza 164 x 1203	(kvz/buha's'/kaL/Bb x 5500-10-21/29)
5	H280	S.69 x 1210	(Inia RL 4220 x (134 x S.69/20113/392/1)
6	H100	Giza 164 x 1484	(Giza 164 x Gamset)
7	F_{10}(129)	Giza 164 x 1203	(kvz/buha's'/kaL/Bb x 5500-10-21/29)
8	H198	Giza 164 x 1203	(kvz/buha's'/kaL/Bb x 5500-10-21/29)
9	Giza 164	-------	(kvz/buha's'/kaL/Bb)
10	Giza 168	------	MRL/BUC//SERI

* The lines 1-8 developed by Prof. Dr: Mohamed El- Morshdy, Agronomy Dep., Assiut Uni, Egypt.

The experimental design was a split-split plot in a Complete Randomized Blocks design with three replications. The sowing dates were located in the main plot, irrigation regimes in the sub-plot and the genotypes were assigned randomly at the sub-sub-plot. Plot size was 5 m^2 . Grains were sown in 5 cm apart with distance of 10 cm between grains within rows. All other cultural practices were applied as recommended. At maturity data were recorded on random ten plants of each plot.

Data were recorded on:

1- Days to heading (Number of days from planting to 50% of the heads protruded from the flag leaf sheath)

2- Plant height, in cm of ten main culms.

3- No. of spikes/ plant

4- Mean spike length, in cm of ten main culms/ plot

5- 1000-kernel weight (g).

6- Grain yield/ feddan (ardab) calculated from yield of plot.

7- Protein percentage(It was determined by the semi-micro Kjeldahel method as outlined by the A.O.A.C.(1970).

Statistical analysis.

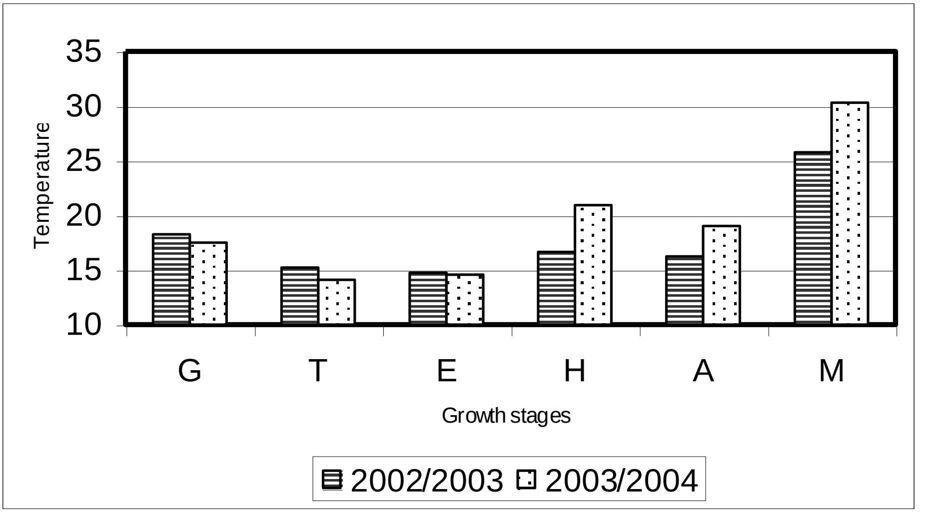
The combined analysis of variance was performed according to Gomez and Gomez (1984). The stability analysis was computed as outlined by Eberhart and Russell (1966). Path analysis was performed according to the procedure of Dewey and Lu (1959).

Results and Discussion

The weather:

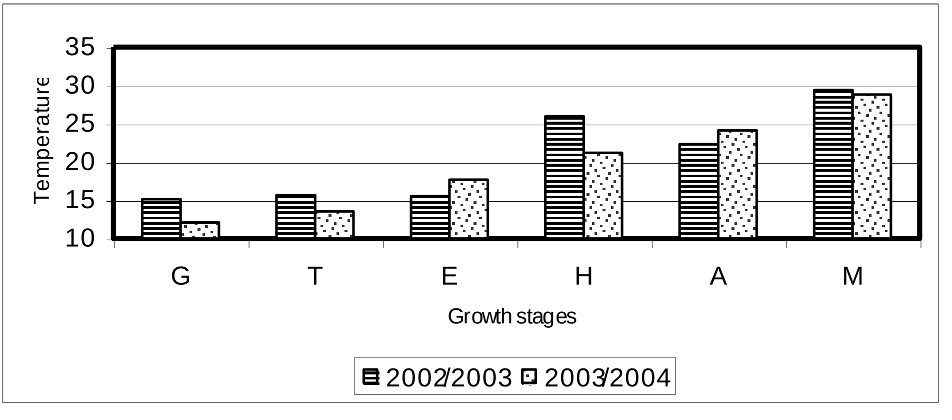
There is no rainfall happened during the growing seasons 2002/2003 and 2003/2004. Thus, there is no effect on irrigation regimes due to rainfall.

Temperature through growing seasons are shown in Fig 1, 2 and 3. The data illustrated that a wide fluctuations of the temperature over growing seasons were found. The temperature at different growing stages of the same sowing date were not equal in the two seasons study (Fig 1and 2). Therefore, the values of studied traits fluctuated from season to season for the same sowing date. Likewise, the temperature of growing months was fluctuated from season to season (Fig 3). Based on the climatic data, the investigated genotypes were grown under different conditions i.e: climatic condition, sowing date and irrigation regimes.



Where:G=Germination, T=tilliring, E=elongation, H=heading, A=anthesis and M=maturity.

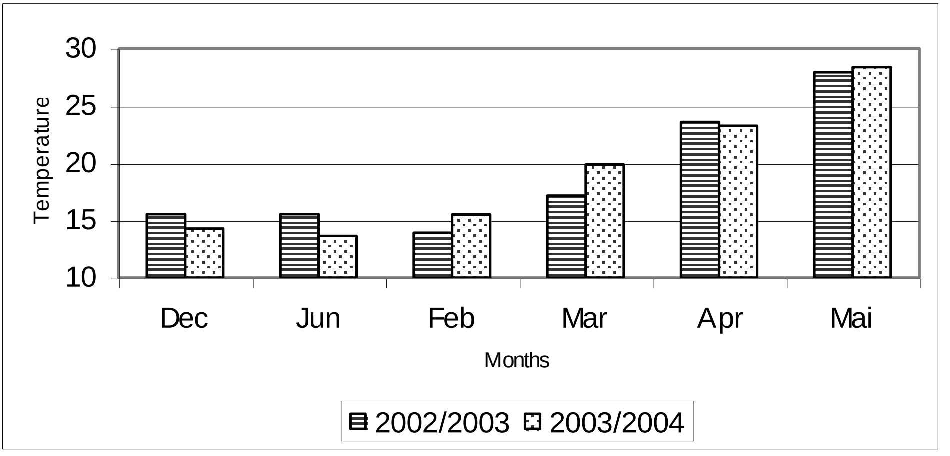
Fig(1): The fluctuation of temperature through different wheat growth stages at 2002/2003 and 2003/2004 seasons when sowing date was 25 Nov.,(SD $_1$)



Where:G=Germination, T=tilliring, E=elongation, H=heading, A=anthesis and M=maturity

Fig(2): The fluctuation of temperature through different wheat growth stages at 2002/2003 and 2003/2004 seasons when sowing date was 25 Dec.,(SD$_2$)

Fig(3): The differences in temperature for months of growth period at 2002/2003 and 2003/2004.



The statistical results of combined analysis:

The combined analysis of variance (Table 2)indicated that highly significant differences between years for all studied traits. This result reflects that the wide differences in climatic conditions between the two years. The fluctuation of seasonal temperatures confirmed last result as shown in Fig 1, 2 and 3. The main effect of sowing dates was highly significant for all studied traits, except protein was only significant as it would be expected for optimum and late sowing dates(Ismail, 1995 and Ragasits, 2000). Because of irrigation regimes had been started after heading, the influence of irrigation regimes was highly significant for spike length, 1000-kernel weight, Grain yield/ feddan and protein %. The studied genotypes as well significantly differed for all traits reflecting the genetic diversity among them. The interactions between years and sowing dates, and also between irrigation and genotypes were highly significant for most traits, this indicated that the effect of sowing dates and irrigation varied from year to another on the performance of wheat genotypes. The interactions between years and genotypes as well as sowing dates and genotypes were highly significant for all studied traits reflecting the sensitivity of these wheat genotypes for sowing dates and years. The interactions between sowing dates, irrigation and genotypes were significant for most of studied traits. Accordingly, there were a different response of genotypes for their performance under sowing dates and irrigation. These results reflect the sensitivity of these genotypes to the environmental changes, suggesting the assessment of genotypes performance under different environments for identifying the best genotypes for particular environment as well as finding the stable ones over such array of conditions.

A-The performance of genotypes:

a-1-Days to 50% heading.

The average of days to 50% heading at the second sowing date (SD_2) was nearly early by one week compared to first sowing date (SD_1) (Table 3). Theses results could be due to the fact that heat units and the accumulated metabolites required for wheat flowering were done in reduced time in the late sowing date (SD_2).

The data in Tables 3 and 4 illustrated that the earliest genotype was genotype H198 (79.3 days),on the other hand the latest heading date (90.7 days) was recorded for variety Giza 164. This result reflects the genetic variability in days to heading and in line with those reported by Ismail 1995 and Khalifa *et al* 1998. No differences were obtained between the two irrigation regimes under both sowing dates.

a-2-Plant height (cm).

The results revealed that the height of wheat genotypes responded differently when they were grown at different sowing dates and climatic conditions. Moreover, plants which obtained from early sowing date (SD_1) (96.9 cm) were taller than those obtained from late sowing (SD_2) (93.3 cm) (Tables 3 and 4).The same results were obtained by Shivani *et al* 2001. Large range of plant height obtained and ranged from 86.4 cm (genotype H349) to 108.2 cm (genotype H280) with an overall average of 95.1 cm.

a-3-No. of spikes/ plant.

The early sowing date (SD_1) has more spikes (9.8) than the late sowing (SD_2) (8.2) (Tables 3 and 4). The two commercial varieties Giza 164 and Giza 168 gave the highest overall means of No. of spikes / plant and recorded 12.2 and 12.3, respectively. But, the lowest No. of spikes / plant (5.7) obtained from genotype H58.

a-4- Spike length (cm).

The spike length was affected by irrigation treatments, sowing dates as well as by genotypes. Sowing date as a recommended date (SD_1) with the normal irrigation (I_1) (13.5 cm) increased significantly the spikes length compared to late sowing (SD_2) with stopped irrigation (I_2) at heading stage (12.6 cm).

Table(2): Combined analysis for all studied traits under different treatments.

S.O.V	d.f	Days to 50% heading	Plant height (cm)	Spikes/ plant	Spike/ Length (cm)	1000-kernel weight (g)	Grain yield/ Feddan (ardab)	Protein %
Year	1	1255.8**	162.84**	62.22**	24.64**	113.99*	32.49**	1.49**
Year/rep.,	4	0.96	15.94	1.44	0.048	1.28	0.41	0.05
SD	1	1943.7**	782.97**	148.52**	22.27**	425.60**	268.42**	0.09*
Y x SD	1	2.60	6586.8**	0.03	142.76**	252.97**	38.12**	0.93**
Error (a)	4	0.54	5.53	0.28	1.08	16.29	0.45	0.009
I	1	0.04	73.38	0.02	4.85**	634.40**	28.27**	4.79**
Y x I	1	0.20	23.76	0.07	3.98**	0.204	21.82**	0.115
SD x I	1	0.10	2.04	0.14	0.570	10.09	0.002	25.19**
Y x SD x I	1	0.34	6.90	0.0001	17.01**	22.33	3.56*	0.002
Error (b)	8	0.78	25.85	0.048	0.451	14.17	0.65	0.03
G	9	317.5**	1505.1**	148.44**	115.54**	292.63**	138.58**	12.91**
Y x G	9	32.5**	74.84**	15.86**	4.52**	15.15**	12.72**	0.53**
SD x G	9	11.36**	223.51**	3.29**	4.59**	47.28**	6.59**	3.36**
Y x SDx G	9	7.39**	188.76**	1.57**	3.83**	27.30**	3.94**	0.38**
I x G	9	0.57	29.48**	0.139	1.12**	22.21**	2.94**	19.14**
Y x I x G	9	0.38	38.63**	0.279	0.93**	6.05	4.85**	0.20**
SD x I x G	9	0.38	22.11*	0.251	0.89**	9.98**	4.81**	9.52**
YxSDxIxG	9	0.37	25.55**	0.103	0.73*	12.57**	2.38**	0.456**
Error (c)	144	0.30	9.92	0.182	0.34	3.56	0.85	0.026

Where: Y= years SD= sowing dates I= irrigations G= genotypes

This result may be due to the heat units, moisture and metabolites stored in normal irrigation (I_1) results highest plants, vigorous growth and tallest spikes. The presented data in Tables 3 and 4 illustrated that the spike length for genotypes ranged from 9.7 to 15.5. It is clear to noted that the genotype (H58) which gave the lowest No. of spikes/ plant (5.7) recorded the tallest spike length (15.1 cm). This result may be due to the reversal genetic make-up of both traits. These results are in agreement with Abdel-Karim 1991 and Kheiralla 2004.

a-5- 1000- kernel weight(g).

Recommended sowing date (SD_1) and normal irrigation (I_1) gave the highest 1000-kernel weight (50.6 g). Normal sowing date and irrigation plants in all growth stages offer the optimum requirements of temperature and moisture for plants.

So, the obtained seeds under these conditions will be filled and 1000-kernel weight will be high. This results are in harmony with Kheiralla 2004 and Desalegn *et al* 2001. 1000-kernel weight ranged from 40.9 g (Giza 168) to 52.7 g (genotype H165) with an overall average of 48.00 g (Tables 3 and 4). Ismail 1995, studied the performance of 20 wheat genotypes and found that seed index ranged from 25.3 g for genotype Ergina to 42.4 for variety Giza 164.

a-6- Grain yield /feddan(ardab).

Late sowing and water stress caused decreasing in grain yield/ feddan. The late sowing decreased the grain yield/ feddan by about 15 % compared to normal date. Also, the decreasing in yield was 5% under water stress (I_2) compared to normal irrigation (I_1). This result was different from genotype to another. The grain yield of differed significantly among the genotypes and ranged from 9.9 ardab (H58) to 16.1 (Giza 168) with an overall average of 13.1 ardab/ feddan (Tables 3 and 4) . The presented data in Tables 3 and 4

Table(3): Means of studied traits for years, sowing dates, Irrigation and wheat genotypes.

Factors		Days to 50% heading	Plant height (cm)	No. of spikes/ plant	Spike/ Length (cm)	1000-kernel weight (g)	Grain yield/feddan (ardab)	Protein %
Years	1	83.5	95.9	9.5	13.4	47.3	13.4	12.2
	2	88.1	94.2	8.5	12.8	48.7	12.7	12.4
F		**	*	**	**	*	**	**
SD	1	88.6	96.9	9.8	13.4	49.3	14.1	12.3
	2	82.9	93.3	8.2	12.8	46.7	12.0	12.3
F		**	**	**	**	**	**	*
I	1	85.8	95.6	8.9	13.2	49.6	13.4	12.5
	2	85.8	94.5	8.9	12.9	46.4	12.7	12.2
F		n.s	n.s	n.s	**	**	**	**
H165		82.9	92.3	11.3	9.7	52.7	14.4	12.3
H349		87.9	86.4	6.1	14.9	47.1	11.2	12.3
H58		87.3	87.5	5.8	15.1	47.0	9.9	12.3
H109		86.7	90.3	7.9	15.0	47.6	14.6	13.0
H280		81.8	108.2	10.3	10.6	52.2	12.8	12.3
H100		83.9	100.2	9.4	10.4	46.4	10.3	11.7
F_{10}(129)		88.8	105.1	7.9	15.5	50.8	15.0	12.6
H198		79.3	94.1	6.6	13.9	49.5	10.5	11.8
$Giza_{164}$		90.7	100.2	12.2	12.4	45.4	15.8	13.8
$Giza_{168}$		88.7	86.5	12.3	13.2	40.9	16.1	11.1
$L.S.D_{0.05}$		0.31	1.78	0.25	0.33	0.98	0.52	0.09

revealed that there are no significant differences between the two commercial varieties for grain yield/ feddan, which yielded 15.8 and 16.1 ardab/ feddan for Giza 164 and Giza 168, respectively, and were significantly the highest two genotypes for yielding compared to other genotypes. These results could be attributed to the large number of spikes / plant for both varieties . Otherwise, reducing number of spikes caused a great reduction in grain yield / feddan for other genotypes. These results in harmony with El-Far and Teama 1999, Ragasits 2000 and Shivani *et al* 2001.

a-7- Crude protein %.

The normal irrigation and optimum sowing date produced protein percentage higher than water stress treatment and late sowing date (Tables 3 and 4). These results are in line with those obtained by Yiwei and Bingru 2002. They found that protein content decreased in drought-stressed plants.

The presented data in Tables 3 and 4 , showed that the average of crude protein percentage for genotypes ranged from 11.1 % for Giza 168 to 13.8 for Giza 164 with an overall average 12.3 %.

B-Stability analysis.

The joint regression analysis of variance (Table 5) indicated that highly significant differences were obtained among genotypes for all studied traits. Furthermore, partitions of the genotypes x environments interaction as indicated by Env.+ (GxEnv.), Env. (Linear), and GxE (Linear) were highly significant for all the studied traits. Because of, the genotype x environment (Linear) was significant, it could be proceed in the stability analysis (Eberhart and Russell, 1966). Results in Table 5 Indicating that the phenotypic expression of the genotypes varied with environment. Highly significant genotype x environment interactions for several wheat traits were reported by Kheiralla *et al* 2004, Mahak *et al* 2002, Mondal and Khajuria 2002, Kara 1999 and Kheiralla and Ismail 1995.

Table(5): Summary of the joint regression analysis of variance for studied traits.

S.O.V	d.f	Days to 50% heading	Plant height (cm)	Spikes/ plant	Spike/ Length (cm)	1000-kernel weight (g)	Grain yield/ feddan	Protein %
Genotypes	9	107.19**	501.7**	49.24**	38.45**	98.45**	46.19**	4.30**
Env. +(GxEnv.)	70	10.36**	62.2**	1.90**	1.74**	13.06**	3.51**	1.60**
Env.(linear)	1	563.39**	2546.2**	69.50**	72.06**	463.63**	131.15**	10.89**
GxEnv(Linear)	9	12.60**	68.0**	2.48**	2.90**	11.85*	3.92**	3.26**
Pooled deviation	60	0.81**	19.9**	0.69**	0.40	5.73**	1.32**	1.19**
Pooled error	144	0.29	9.9	0.18	0.34	2.95	0.85	0.03

* and ** are significance at 0.05 and 0.01 level of probability.

b-1- Days to 50% heading.

The stability parameters (b_i and S^2d) and the mean performance($\bar{x}$) of the individual genotypes were presented in Table 6 and illustrated graphically in Fig 4 . The genotypes H165 and Giza 168 only were stable for number of days to 50% heading. The b_i for genotype Giza 168 was < 1 and the S^2d tend to be zero, therefore this genotype was stable and adapted to abnormal environments. In the same time genotype H165 has the same trend and could be stable and desired genotype for early flowering (82.9 day).

b-2- Plant height (cm).

All investigated genotypes were stable for plant height ,except genotypes F_{10} (129), H198 and Giza 164 (Table 6 and Fig 4). The b_i value of genotypes H.58, H109 and Giza 168 were < 1 indicating that , these genotypes adapted to abnormal environments.

b-3-No. of spikes/ plant.

The stability results in Table 6 and Fig 4 ,indicated that genotypes H165, H349, H109 and H280 were stable for No. of spikes/ plant. Genotypes H349 and H109 were stable and exhibited below average response to different environments (b_i < 1), they are considered relatively better in less favorable environments. So, the No. of spikes / plant for these genotypes were the lowest among all genotypes under study. This result are in line with the previous studies that showed the stable genotypes had low yield Tabia *et al* 1994 and Geletu *et al* 1995

On the other hand, genotypes H165 and H280 could be considered the best, since they had No.of spikes/ plant more than the average of all genotypes beside their stability.

b-4- Spike length (cm).

Data in Table 6 and Fig 4 showed that all genotypes were unstable for spike length except genotypes i.e. H165, H58, H100 and F_{10}(129). The genotypes H58 and F10 (129)could be considered the best, because they were stable and had spike length more than the average of all genotypes (Table 6).

b-5- 1000-kernel weight (g).

All genotypes were stable for 1000- kernel weight ,except genotypes H100 and F_{10}(129). All stable genotypes have 1000-kernel weight less than the mean average , except genotypes H165 and H280 which weighted 1000-kernal weight more than the mean average (Table 6 and Fig 4).

b-6- Grain yield / feddan (ardab).

As for grain yield / feddan. The illustrated data in Table 6 and Fig 4 showed that, six genotypes were stable (H109, H280, H100, H198, Giza 164 and Giza 168). The bi

values for genotypes H100 and H 198 were <1 and this result indicated that ,low response for fluctuation in environments , On the other hand, genotypes H109, H280, Giza 164 and Giza 168 were more adaptive for highly favorable environments. Beside stability for H109, Giza 164 and Giza 168, they had grain yield/ feddan exceeded significantly the average of all genotypes. The last three genotypes could be recommended for late sowing dates. Moreover, H109 genotype has stable performance for grain yield / plant and No. of spikes/ plant (Table 6).

b-7- Protein (%).

In Table 6 and Fig 4 we observed that all genotypes under investigation were unstable for protein % trait. The S^2d values for all genotypes were highly significant. Yiwei and Bing (2002) found that protein content decreased in drought conditions.

The correlation between b_i and $\bar{x}$.

The correlation between b_i and $\bar{x}$ (Table 6) for Days to 50% of heading, Plant height, No. of spikes/ plant, Spike length and grain yield/ feddan were positive and highly significant, indicating that the studied genotypes combined relatively high performance and high sensitivity to environments for these studied traits.

C- Path- coefficient analysis.

The direct and indirect effects of five examined traits on grain yield were estimated by path-coefficient analysis (Table 7).

Path-coefficient analysis revealed that the strong positive direct effects of the No. of spikes/plant and spike length and moderate effect of 1000-kernel weight on grain yield under recommended and late sowing date . The obtained data exhibited that, days to heading had medium and positive correlation with grain yield, but its direct effect was very low at both of sowing dates.

On the other side, spike length and 1000-kernel weight had negative and low correlations with grain yield, in spite of , their direct effects were high. According to these results, linear relations among examined characters are insufficient in plant breeding programs to indicate selection criteria in the wheat breeding programs. It is essential that, the levels of direct and indirect effects of the causal components are to be determined. The same results were obtained by Indoo *et al*, 2004 and Dhaliwal and Sukhchain, 2003. Moreover, the direct effect of days to heading, No. of spikes/ plant, spike length and 1000-kernel weight on yield was decreased from recommended to late sowing date (Table 7).

Table(7): Direct and indirect effects of examined traits on grain yield of some wheat genotypes.

Type of effect	Recommended Sowing date	Late sowing date
Days to heading vs. grain yield		
Correlation	***r = 0.4353***	***r = 0.5840***
Direct effect. P_{16}	0.1387	0.0384
Indirect effect via plant height, r_{12} P_{26}	0.0901	-0.0064
Indirect effect via No. of spikes , r_{13} P_{36}	0.1829	0.2721
Indirect effect via spike length , r_{14} P_{46}	0.4589	0.4266
Indirect effect via1000-kernel weight, r_{15} P_{56}	-0.4307	-0.1508
Plant height vs. grain yield		
Correlation	***r = 0.1295***	***r = 0.1551***
Direct effect. P_{26}	-0.3220	0.0915
Indirect effect via days to heading , r_{21} P_{16}	-0.0388	-0.0027
Indirect effect via No. of spikes , r_{23} P_{36}	0.4656	0.3092
Indirect effect via spike length , r_{24} P_{46}	-0.4055	-0.3086
Indirect effect via 1000-kernel weight , r_{25} P_{56}	0.4307	0.0706
No.of spikes vs. grain yield		
Correlation	***r = 0.7618***	***r = 0.6307***
Direct effect. P_{36}	1.6629	1.2369
Indirect effect via days to heading , r_{31} P_{16}	0.0153	0.0085
Indirect effect via plant height , r_{32} P_{26}	-0.0900	0.0229
Indirect effect via spike length , r_{34} P_{46}	-0.7684	-0.5355
Indirect effect via 1000-kernel weight, r_{35} P_{56}	-0.0596	-0.1027
Spike length vs. grain yield		
Correlation	***r = -0.1819***	***r = 0.1238***
Direct effect. P_{46}	1.0672	0.9077
Indirect effect via days to heading , r_{41} P_{16}	0.0596	0.0180
Indirect effect via plant height , r_{42} P_{26}	0.1223	-0.0311
Indirect effect via No.of spikes , r_{43} P_{36}	-1.1973	-0.7297
Indirect effect via 1000-kernel weight , r_{45} P_{56}	-0.2319	-0.0449
1000-kernel weight vs. grain yield		
Correlation	***r = -0.1588***	***r =-0.1962***
Direct effect. P_{56}	0.6626	0.3208
Indirect effect via days to heading , r_{51} P_{16}	-0.0902	-0.0180
Indirect effect via plant height , r_{52} P_{26}	-0.2092	0.0201
Indirect effect via No.of spikes , r_{53} P_{36}	-0.1466	-0.3958
Indirect effect via spike length , r_{54} P_{46}	-0.3735	-0.1271

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التفاعل بين التركيب الوراثى والبيئة في بعض الطرز الو راثية لقمح الخبز

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- ثمانية سلالات مبشرة و صنفين تجاريين من القمح تمت زراعتهم تحت ميعادي الزراعة فى 25 نوفمبر و 25 ديسمبر تحت نظامين للرى (الرى العادى ومنع الرى بعد التزهير) وذلك خلال موسمى نمو 2003/2002 و 2004/2003 لدراسة الأداء المحصولى والثبات وكذلك معامل المرور فى هذه التراكيب الوراثية. والنتائج أوضحت الاتى:
- التاخير فى الزراعة وتعرض النباتات للجفاف أدى ألى أنخفاض قيم كل الصفات المدروسة، و أعلى محصول من الحبوب للفدان وهو 15 ، 15.8 ،16.1 أردب للفدان تم الحصول عليه من التراكيب الوراثية F10(129) ، Giza 164 ، Giza 168 على التوالى وكانت تلك التراكيب متاخره فى التزهير.
- معامل الانحدار كان مرتبط معنويا وموجبا مع متوسط الاداء لمعظم الصفات المدروسة مما يدل على أنه بصورة عامة التراكيب الثابته يكون أنتاجها منخفض ولكن على الرغم من ذلك أظهرت التراكيب الوراثية Giza 164 ، Giza 168 ، H109 ثباتا وأنتاجية عالية . وعلى الجانب الاخر وجد أن قيم bi للتراكيب الوراثية السابقة كانت أكبر من الوحدة وهذا يدل على ملائمة هذه التراكيب للزراعة تحت الظروف الملائمة.
- معامل المرور تحت كل من ميعاد الزراعة الموصى به والمتاخر أوضح أن هناك تأثير مباشر قوى وموجب لكل من عدد السنابل للنبات ، طول السنبلة و وزن ال 1000 حبة على محصول الحبوب.
- التأثير المباشر لصفات التزهير و عدد سنابل النبات و طول السنبلة ووزن الألف حبة على المحصول إنخفض من ميعاد الزراعة الموصى به إلى الميعاد المتأخر للزراعة.