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Breeding for drought tolerance and the association of grain yield and other traits of bread wheat

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Abstract

Two populatic is of bread wheat (*Triticum aestivum* L.) were used in selection fo drought tolerance in the F_2, F_3 and F_4 generations during ih three growing seasons 1998/99, 99/2000 and 2000/2001, respectively. Results of the drought susceptibility index showed that thirteen and eight families from 120 families representing the two populations, respectively were selected for high grain yield showed high tolerance for drought stress, as well as had low values of susceptibility index (DSI) from (0.53 - 0.96) of population I and from (0.1 – 0.96) of population II. Stress tolerance index (STI) varied from (61.55 – 99.07) of the F_4 families in population I and from (72.60 – 98.07) of the population II. Results of STI were in conformity with results of susceptibility index (DSI). Phenotypic correlation under drought stress in the population I revealed that grain yield had positive and significant relationships with each of the number of spikes/plant, number of kernels/spike, 100-kernel weight, biological yield/plant, harvest index and number of days to heading in the F_3 and F_4 families except for number of days to heading in the F_3 plants it was negatively and significantly correlated. The same trend was observed in the population II except for number of days to heading in F_4 it was insignificant and negatively correlated. The number of kernels/spike had insignificant and positive correlation in two generations. The magnitude of genotypic correlation was positive and significant for grain yield with each of the number of days to heading, flag leaf area, flag leaf water loss (in the F_4 families only), plant height, number of spikes/plant number of kernels/spike, 100-kernel weight, biological yield/plant and harvest index in the two populations for F_3 and F_4 generations, as well as it had negative genotypic correlation with number of days to heading in F_4 families and flag leaf water loss in two generations. From the results of this study and these materials it can be concluded that these genotypes could be used as sources of drought tolerance or factors contributing to general adaptation or in releasing lines have high grain yielding ability and high tolerance to drought stress.

INTRODUCTION

Wheat is the world most important and most widely grown cereal crop. Its importance is derived from the many properties and uses of its kernels, which make it a staple food for more than one third of the world population (Poehlman, 1979). In many parts of the world food is not sufficient enough due to the shortage in wheat production. Phenotypic and genotypic correlation coefficients are very important in plant breeding programs because they reflect the degree of genetic and non-genetic association between characters. Knowledge of association between important traits (favorable or unfavorable) is needed to any efficient plant breeding program. Longer *et al.* (1979) showed that the genetic correlation coefficient in drought environments and the genetic correlation are positive and close to one. EL-Hawary (2000) indicated positive and significant correlation between grain yield and each of number of spikes/m^2, number of grains/spike at the highest soil moisture stress. The results revealed that improving grain yield of wheat cultivars could be achieved via yield components, number of spikes/plant, number of grains/spike and kernels weight. Stress susceptibility was positively correlated with non stressed yield. This indicates that some characteristics that contribute to yield potential may act to increase susceptibility to stresses and that selection for both drought susceptibility and yield potential may counteract each other.

A drought susceptibility index, which provides a measure of stress tolerance based on a comparison of yield loss under stress with yield under optimum conditions, rather than on *per- se* yield level, has been used to characterize relative drought tolerance of wheat genotypes (Bruckner and Frohberg,1987). Gavuzzi *et al.* (1993) stated that the years characterized by large yield differences between stressed and non stressed environments are those with reduced variation in the drought susceptibility index in 20 bread and durum wheat cultivars under evaluation of drought stress. It is hoped that these results would assist wheat breeders to identifying new strains of bread wheat characterized by high yield under drought stress. The main objective of this study is to evaluate the selected families under drought stress and the relationships of grain yield with other characteristics of bread wheat.

MATERIALS AND METHODS

The present study was carried out during the 1998 /1999, 1999/2000 and 2000/2001 growing seasons, at Shandaweel Agric Res. Stat., ARC, Ministry of Agric, Egypt. The objective was to estimate the response of individual plant to selection (i. e. pedigree selection) under drought stress, in early generations of the two bread wheat (*Triticum aestivum* L. em. Thel) populations. Correlations between grain yield / plant and other traits, were calculated. On the other hand, the drought susceptibility of the selected families were calculated for all characters under study. Four parents were chosen for their diverse physiological and yield response to drought stress. The first population was formed from crossing between Giza 165 x Nacozari – 76 and the second population was derived from the cross Debeira x Cham 6. The two populations were maintained by Shandaweel bread wheat breeding program.

In the 1998 / 1999 season, 1500 plants from the two populations were grown in plots without replicates. Each plot consisted of 12 rows, 7m long, 30 cm. apart and 10 cm between plants within rows. Also, the parents and local check (Sahel 1) for drought tolerance, were grown alongside in two rows for each one. The drought stress was imposed during reproductive development by preventing any irrigation after jointing stage. Data was collected on 600 harvested plants of each population. Grain yield was recorded on each individual plant. The twenty highest and twenty lowest yielding plants were selected, alongside with twenty random plants. In 1999/2000 season two field experiments were conducted with three replications. The first one did not receive any irrigation after jointing stage (drought stress "D"). The second experiment was also grown under supplemental water applied regularly as recommended (Normal "N"). Each experiment comprised 60 F_3 families were formed (20 high and 20 low yielding were selected and 20 random by selected families). These entries were grown in a single row plots. Twenty plants were spaced in 10 cm a part within 2 rows 30 cm apart in a Randomized Complete Block Design. In 2000/2001 season, in the F_4 families entries, experimental design and the cultural practices were similar to that used in F_3, and the recommended field practices for wheat production were adopted over all the growing seasons. Sowing date were 28th, of November in the 1st season, 24th Nov. in the 2nd season and 22nd Nov. in the third production season. Data were recorded on individual plants on a random sample of ten guarded plants from each family in F_3 and F_4 generations. The mean of the ten plants were subjected to the statistical and genetic analysis. The following measurements were taken; days to 50 % heading, flag leaf area "cm^2", and flag leaf water loss, the technique of excised leaves outlined by Clark and Mc Caig (1982a), plant height (cm), number of spikes per plant, number of kernels/spike, 100 kernel weight (gm), biological yield/plant in grams, grain yield per plant (gm) and harvest index %.

Analysis of variance were also performed separately for each moisture treatment for random families in ten plants for each entry.

Phenotypic and genotypic correlation coefficients were calculated by Johanson *et al.* (1955), as follows:

Phenotypic correlation rp xy = cov pxy / (σpx . σpy)

Genotypic correlation rg xy = cov gxy / (σgx . σgy)

– Drought susceptibility Index (DSI): was calculated according to the method of (Fischer and Maurer 1978) using the following formula:

Drought density (D) = $1 - \bar{x}d / \bar{x}w$

Drought susceptibility index (DSIs) = $\bar{Y}w - \bar{Y}d / \bar{Y}W . D$

$\bar{x}d$ = Average yield of family under drought

$\bar{x}w$ = Average yield of family without drought

Yw = yield potential without stress for single line

Yd = yield under drought for single line.

Stress Tolerance Index (STI), for grain yield were computed as formula used by Farshadfar, *et al.* (2001) as follow:

STI = $y_p \times y_s / (y_p)^2 \times 100$ where

Y_p grain yield under normal condition.

Y_s grain yield under stress condition.

RESULTS AND DISCUSSION

I- Drought susceptibility index:

A drought susceptibility index was used to estimate relative stress injury because it is counted for variation in yield potential and stress intensity, low stress susceptibility (DSI < 1) is synonymous with higher stress tolerance (Fischer and

Maurer, 1978). Results of drought susceptibility index for high and low grain yield selection and random plants for two wheat populations, in the F_3 and F_4 generations are presented in Tables (1,2,3& 4) and could be summarized as follows:

A: High grain yield selection: Results indicated that seven and eight genotypes in the population I and II gave low drought susceptibility index (DSI < 1) in the F_3 and F_4 generations, while the genotypes no. (2, 9, 12, 13 and 14) in the population I and no. (12 and 18) in the population II gave relatively high grain yield under drought stress beside high tolerance for drought condition, while the magnitude of stress tolerance index (STI) for grain yield ranged from (61.55 – 99.07 %) from (72.60 – 98.07 %) in the F4 generation for two populations, respectively. The results of STI were correlated with results of DSI and the correlation values were ranged from r= -0.88 to - 0.99 for population I (Tables 1&2) and from r = -0.77 to -0.99 for population II (Tables 3&4) .

B: Low grain yield selection: Data cleared that five and nine families in the population I and II respectively had low drought susceptibility index in the F_3 and F_4 generations, but the families which were superior for drought tolerance and exhibited high grain yield were no. (6, 7 and 17) in the population I and no. (7, 11, 12 and 18) in the population II. Therefore, STI for grain yield for populations I and II varied from 74.23 to 96.18 % and 72.25 to 97.09 % in the F_4 generations, respectively.

C: Random plants (unselected): Results showed that six families in both population revealed low drought susceptibility index. On the other hand the families no. (3, 5, 9, 15 and 20) and no. (15 and 19) in the population I and II, respectively, had relatively high grain yield under drought stress and exhibited high tolerance for drought, but STI values ranged from 70.67 – 94.90 % and 69.16 – 94.37 % for populations I and II, respectively. These results of STI for grain yield were in conformity with the results obtained from drought susceptibility index (DSI).

Results of drought susceptibility index (DSI) and stress tolerance index (STI) indicated that, 13 families in population I and 8 families in population II which had relatively high grain yield under drought stress and low drought susceptibility index (tolerance for drought), could be used as source of drought tolerance or factor contributing to general adaptation and can be used in breeding programs to produce lines or cultivars having high grain yield ability and high tolerance for drought stress. Similar results were obtained by Kheiralla *et al.* (1993) and Farshadfar *et al.* (2001).

A grain yield-based, stress susceptibility index was used to estimate relative susceptibility to stress because it adjusts for variation in yield due to differences in genotypic yield potential and environments stress intensity. Low stress susceptibility for drought (DSI < 1) is synonymous with higher stress resistance (Ehdai and Waines, 1989).

Table 1. Grain yield (G.Y), drought susceptibility index (DSI), stress drought index (STI) and correlation (r) between DSI and STI of high, low yield selection and random plants in the F_3 families for wheat population I.

Family No.	Population I											
	Highest				Lowest				Random			
	G.Y		DSI	STI	G.Y		DSI	STI	G.Y		DSI	STI
	N	D			N	D			N	D		
1	15.53	12.40	1.01	79.85	13.71	9.97	1.52	72.72	14.60	9.85	1.41	67.46
2	13.85	11.14	0.96	80.43	15.16	12.80	0.66	84.43	12.58	10.02	0.88	79.65
3	15.91	11.38	1.18	71.53	16.17	10.51	1.71	64.99	14.24	12.02	0.68	84.41
4	12.11	9.86	0.94	81.42	15.04	12.08	1.09	80.32	15.90	12.64	0.89	79.50
5	14.16	10.45	1.31	73.80	13.02	11.10	0.50	85.25	15.48	12.69	0.78	81.98
6	16.25	11.19	1.56	68.86	15.24	13.30	0.71	87.27	14.48	10.65	1.15	73.55
7	15.55	13.90	0.53	89.39	13.38	12.95	0.81	96.79	13.55	8.60	1.59	63.47
8	14.41	11.41	1.04	79.18	14.05	11.69	0.93	83.20	13.50	10.57	0.94	78.30
9	14.95	12.91	0.98	86.35	15.00	11.87	1.16	79.13	14.59	11.81	0.83	80.95
10	13.84	10.61	1.17	76.66	14.91	9.76	1.92	65.46	13.87	11.08	0.81	79.88
11	14.40	8.53	1.69	59.24	17.17	12.62	2.09	73.50	12.53	10.97	0.54	87.55
12	14.70	12.45	0.77	84.69	13.39	10.35	1.26	77.30	15.13	10.87	1.22	71.84
13	14.48	12.36	0.82	85.36	14.17	11.49	1.05	81.09	13.06	10.40	0.88	79.63
14	15.28	12.37	0.96	80.95	14.53	12.29	0.86	84.58	13.06	10.01	1.02	76.65
15	15.19	11.94	1.07	78.60	13.08	13.05	0.36	99.77	14.09	10.88	0.99	77.22
16	15.88	12.57	1.06	76.16	13.22	10.47	1.16	79.20	13.55	10.27	1.05	75.79
17	14.60	12.93	0.57	88.56	13.79	11.93	0.75	86.51	12.91	9.59	1.12	74.28
18	13.98	10.94	1.09	78.25	13.80	10.75	1.22	77.90	14.51	10.05	1.33	69.26
19	14.08	11.23	1.01	79.75	15.00	12.47	0.93	83.13	13.60	11.37	0.71	83.60
20	15.89	12.09	1.20	76.09	12.85	11.85	0.43	92.22	14.28	11.43	0.87	80.04
Mean	14.75	11.63			14.03	11.73			13.98	10.78		
$LSD_{0.05}$	1.76	1.71			1.83	1.80			1.65	1.59		
Correlation (r)			- 0.95**				- 0.88**				- 0.99**	

Table 2. Grain yield (G.Y), drought susceptibility index (DSI) and stress drought index (STI) and correlation (r) between DSI and STI of high, low yield selection and random plants in the F_4 families for wheat population I.

Family No.	Population I											
	Highest				Lowest				Random			
	G.Y N	G.Y D	DSI	STI	G.Y N	G.Y D	DSI	STI	G.Y N	G.Y D	DSI	STI
1	24.26	19.45	1.42	80.17	20.16	17.03	1.04	84.47	23.04	17.59	1.51	76.35
2	24.24	22.24	0.59	91.75	19.89	17.54	0.79	88.19	17.96	15.98	1.46	88.98
3	23.08	20.30	0.85	87.95	23.00	17.59	1.57	76.48	23.33	20.83	0.63	89.28
4	21.09	18.71	0.81	88.72	17.54	15.47	0.78	88.20	20.33	17.10	0.93	84.11
5	19.47	16.48	1.10	84.64	19.38	16.87	0.86	87.05	21.14	19.09	0.57	90.30
6	22.30	17.49	1.12	78.43	22.92	19.57	0.97	85.38	28.67	20.60	1.66	71.85
7	18.89	17.41	0.53	92.16	20.61	20.13	0.16	97.67	19.02	18.78	0.07	98.74
8	24.84	15.28	2.75	61.55	24.48	16.09	2.28	65.73	21.82	15.42	1.73	70.67
9	19.38	19.20	0.07	99.07	18.65	17.85	0.36	95.71	20.40	19.36	0.30	94.90
10	26.59	19.49	1.51	73.30	19.61	14.98	1.57	76.39	22.83	18.79	1.04	82.30
11	23.04	18.49	1.10	80.25	19.70	18.94	0.25	96.14	25.57	18.87	1.54	73.80
12	21.81	20.41	0.45	93.59	22.96	20.19	0.80	87.94	22.35	17.05	1.39	76.29
13	20.88	18.36	0.86	87.93	19.50	18.53	0.33	95.03	24.91	18.85	1.43	75.67
14	20.74	19.14	0.52	92.29	19.01	14.82	1.47	77.96	16.38	14.58	0.65	89.01
15	19.89	19.14	0.27	96.23	24.29	19.03	1.44	78.34	23.22	20.82	0.61	89.66
16	18.54	17.09	0.69	92.18	21.58	16.19	1.67	75.02	23.35	17.61	1.44	75.42
17	22.30	17.23	1.67	77.26	18.98	18.84	0.29	99.26	19.21	17.65	0.48	91.88
18	18.54	17.23	0.50	92.93	22.14	19.12	0.91	86.36	22.61	20.41	0.55	90.27
19	19.74	16.01	1.34	81.10	21.39	16.94	1.39	79.20	22.43	17.98	1.17	80.16
20	25.22	18.58	1.79	73.67	22.65	17.69	1.67	78.10	19.23	18.03	0.37	93.76
Mean	21.74	18.39			20.92	17.67			21.89	18.26		
$LSD_{0.05}$	2.40	2.33			2.66	2.45			2.47	2.25		
Correlation (r)			- 0.97**				- 0.99**				- 0.94**	

Table 3. Grain yield (G.Y), drought susceptibility index (DSI) and stress drought index (STI) and correlation (r) between DSI and STI of high, low yield selection and random plants in the F_3 families for wheat population II.

Family No.	Population II											
	Highest				Lowest				Random			
	G.Y		DSI	STI	G.Y		DSI	STI	G.Y		DSI	STI
	N	D			N	D			N	D		
1	17.54	12.70	1.97	72.41	15.82	9.42	2.74	59.54	13.75	11.45	0.98	83.27
2	17.84	12.20	2.28	68.39	17.10	11.40	1.62	66.67	16.21	13.76	0.89	84.89
3	12.37	10.56	1.04	85.37	16.68	11.38	1.73	68.23	13.54	13.04	0.22	96.31
4	18.33	9.87	3.15	53.85	17.53	13.62	1.37	77.70	13.40	10.99	1.02	82.01
5	11.53	10.36	0.72	89.85	17.36	16.36	0.82	94.24	11.40	8.52	1.48	74.74
6	13.17	11.74	0.78	89.14	13.85	13.57	0.21	97.98	13.73	10.62	1.25	77.35
7	13.01	12.39	0.34	95.23	14.52	13.11	0.69	90.29	16.85	15.06	0.63	89.38
8	15.88	13.87	0.63	87.34	15.32	13.74	0.74	89.69	16.03	9.96	2.23	62.13
9	15.85	12.70	1.42	80.13	16.05	13.57	1.10	84.55	15.60	14.04	0.59	90.00
10	17.52	14.39	1.04	82.13	12.83	11.96	0.48	93.22	14.98	13.09	0.74	87.38
11	13.96	12.40	0.80	88.83	14.57	12.62	0.96	86.62	16.90	14.94	0.68	88.40
12	15.33	13.28	0.96	86.63	15.75	13.58	0.98	86.22	12.63	11.34	0.60	89.79
13	11.14	10.16	0.63	91.20	18.05	14.68	1.33	81.33	12.72	12.05	0.31	95.73
14	13.96	13.59	0.16	97.35	15.35	13.70	0.77	89.25	13.68	11.23	10.5	82.09
15	15.20	13.82	0.65	90.92	14.48	12.89	0.63	89.02	13.79	11.57	0.95	83.90
16	18.96	14.95	1.51	78.85	14.52	9.52	2.46	65.56	17.88	12.57	1.75	70.30
17	17.54	13.30	1.40	75.83	13.95	13.56	0.66	97.20	15.75	13.30	0.91	84.44
18	14.80	12.84	0.84	86.76	12.09	11.10	0.58	91.81	16.87	10.37	2.27	61.47
19	16.76	15.52	0.53	92.60	12.45	10.92	0.88	87.71	11.26	9.74	0.79	86.50
20	13.81	13.68	0.10	99.06	15.34	13.08	1.06	85.27	15.12	13.77	0.52	91.07
Mean	15.23	12.72			15.18	12.69			14.60	12.20		
$LSD_{0.05}$	1.81	1.80			1.70	1.87			1.81	2.07		
Correlation (r)			- 0.94**				- 0.95**				- 0.99**	

Table 4. Grain yield (G.Y), drought susceptibility index (DSI) and stress drought index (STI) and correlation (r) between DSI and STI of high, low yield selection and random plants in the F_4 families for wheat population II.

Family No.	Population II											
	Highest				Lowest				Random			
	G.Y N	G.Y D	DSI	STI	G.Y N	G.Y D	DSI	STI	G.Y N	G.Y D	DSI	STI
1	17.35	16.34	0.53	94.18	18.96	17.95	0.43	95.68	22.13	18.82	1.07	85.04
2	17.20	14.51	1.42	84.36	19.37	18.09	0.66	93.39	20.16	16.91	1.15	83.88
3	18.21	15.81	1.20	86.82	18.69	17.58	0.59	94.06	20.45	16.78	1.28	82.05
4	18.62	18.06	0.27	96.99	20.95	17.96	1.43	85.73	17.30	16.19	0.46	93.58
5	18.65	15.96	1.31	85.58	20.89	17.94	1.41	85.88	17.25	14.36	1.19	83.25
6	18.34	17.32	0.51	94.44	18.01	16.77	0.69	93.11	17.05	16.74	0.13	98.18
7	19.41	15.14	0.22	78.00	19.88	18.02	0.94	90.64	17.73	16.57	0.43	93.45
8	20.84	15.13	2.44	72.60	17.82	17.46	0.19	97.98	19.63	15.83	1.41	80.64
9	21.41	18.42	1.23	86.03	20.67	18.28	1.11	88.44	19.29	17.17	0.79	89.01
10	21.29	19.66	0.70	92.34	18.39	17.24	0.63	93.75	19.47	17.93	0.86	92.09
11	16.60	15.22	0.78	91.69	21.20	20.54	0.31	96.89	17.16	14.20	1.23	82.75
12	20.09	19.62	0.21	97.66	19.89	18.43	0.27	92.66	17.04	15.51	0.64	91.02
13	18.69	17.79	0.52	95.18	19.18	15.33	2.01	79.93	17.28	13.82	1.43	79.98
14	18.33	17.66	0.33	96.34	17.69	16.84	0.48	95.20	23.28	19.47	1.16	83.63
15	23.03	19.47	1.41	84.54	21.00	15.53	2.63	73.95	19.00	18.18	0.31	95.68
16	18.76	16.32	1.17	86.99	18.68	18.08	0.32	96.79	17.54	12.13	2.20	69.16
17	20.49	19.15	0.59	93.46	16.77	13.63	1.69	81.28	22.17	18.28	1.25	82.45
18	19.34	18.29	0.49	94.57	19.32	18.06	0.65	93.48	21.38	18.61	0.92	87.04
19	21.42	18.15	1.39	84.73	15.46	11.17	2.43	72.25	19.36	18.27	0.40	94.37
20	19.49	17.65	0.85	90.56	18.15	16.95	0.66	93.39	17.84	13.48	1.75	75.56
Mean	19.38	17.28			18.99	17.09			19.13	16.46		
$LSD_{0.05}$	2.83	2.90			3.07	2.57			2.08	1.70		
Correlation (r)			- 0.77**				- 0.98**				- 0.99**	

II- Phenotypic and genotypic correlation coefficient:

A correlation that exists between economic characters may facilitate the interpretation of results already obtained and provide the basis of planning more efficient programs for the future. Results in table (5 and 6) indicated that the phenotypic correlation for grain yield in the population I under drought stress was positive and significant or highly significant with each of days to heading (0.62), plant height (0.58), number of spikes/plant (0.79), number of kernels/spike (0.46), biological yield (0.63) and harvest index (0.34), but it was positive and insignificant with each of flag leaf area (0.29), flag leaf water loss (0.25)and 100-kernel weight (0.19) of the F_4 generation.

Meanwhile the phenotypic correlation of the population II in the F_4 families was positive and significant or highly significant among grain yield and each of number of spikes/plant (0.97), 100-kernel weight (0.34), biological yield (0.78) and harvest index (0.32), while it was negative and insignificant with days to heading (-0.10), flag leaf water loss(-0.15). On the other hand, it was positive and insignificant with each of flag leaf area (0.16), plant height (0.29), and number of kernels/spike (0.17). The magnitude of the genotypic correlation in the F_4 generation for grain yield under drought stress was positive and significant with all studied traits, except harvest index for population I. While it was positive and significant with flag leaf area, plant height, number of spikes/plant, 100-kernel weight, biological yield and harvest index, it was negative and insignificant with days to heading and flag leaf water loss in the population II .

These results suggest that substantial genetic variability exist among genotypes of the studied characters and selection is likely to be useful in improving characters as heading date, number of spike / plant, 100 kernel weight and biological yield for improving grain yield under drought stress. These results are in line with Hamada, (1988), Ehdaie and Wines (1989), Busch and Rauch, (1993) and Tammam *et al.* (2000), while Kherialla *et al,* (1993) reported the phenotypic and genotypic correlation coefficient in the F3 families between grain yield and each of heading date (0.20) and (0.29), plant height (0.08 and 0.10), number of spikes / plant (0.45 and 0.67) and 100 kernel weight (0.07 and 0.13). Furthermore, Tammam (1995), concluded that positive and significant phenotypic and genotypic correlation coefficient in the F_4 families between grain yield and each of number of spikes / plant (0.38 and 0.33), number of kernels / spike (0.48 and 0.33), 100-kernel weight (0.52 and 0.58) and harvest index

(0.39 and 0.38), while it was negative and significant with days to heading (-0.22 and -0.40).

It is evident from the present study that knowledge of the phenotypic and genotypic correlation help the breeders to improve the efficiency of selection by using the favorable combinations of traits under drought stress and to minimize the retarding effect of negative correlation. High yield under stress conditions is associated with morphological and physiological characters, which are different from those associated with high yield under optimum conditions.

Table 5. Phenotypic (rp) and Genotypic (rg) correlation coefficients from F_3 and F_4 generations population I of wheat for grain yield / plant and all other traits studied under normal and drought stress.

Character	Grain yield / plant							
	Normal				Drought			
	F_3		F_4		F_3		F_4	
	rp	rg	rp	Rg	rp	rg	rp	Rg
Days to heading	- 0.67**	- 0.90**	0.19	0.27	- 0.33*	- 0.32*	0.62**	0.75**
Flag leaf area	- 0.24	- 0.42**	- 0.03	- 0.04	0.16	0.24	0.29	0.47**
Flag leaf water loss	0.04	0.06	0.04	0.09	- 0.04	- 0.06	0.25	0.36*
Plant height	- 0.16	- 0.23	0.30	0.17	0.26	0.35*	0.58**	0.93**
Number of spikes / plant	0.35*	0.27	0.57**	0.64**	0.37*	0.56**	0.79**	0.46**
Number of kernels / spike	0.41**	0.62**	0.36*	0.51**	0.44**	0.59**	0.46**	0.76**
100 kernel weight	0.32*	0.51**	0.07	0.10	0.32*	0.60**	0.19	0.36*
Biological yield	0.48**	0.56**	0.60**	0.62**	0.51**	0.82**	0.63**	0.92**
Harvest index	0.37*	0.37*	0.10	0.12	0.56**	0.64**	0.34*	0.31

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

Table 6. Phenotypic (rp) and Genotypic (rg) correlation coefficients from F3 and F4 generations population II of wheat for grain yield / plant and all other traits studied under normal and drought stress.

Character	Grain yield / plant							
	Normal				Drought			
	F_3		F_4		F_3		F_4	
	rp	rg	rp	Rg	rp	rg	rp	rg
Days to heading	0.25	0.29	- 0.10	- 0.11	0.47**	0.69**	- 0.10	- 0.16
Flag leaf area	0.36**	0.36**	- 0.07	- 0.13	0.04	0.14	0.16	0.32*
flag leaf water loss	- 0.07	- 0.03	0.09	0.07	- 0.06	- 0.11	- 0.15	- 0.14
Plant height	0.05	0.10	0.29	0.32*	0.04	0.15	0.29	0.44**
Number of spikes / plant	0.44**	0.73**	0.59**	0.86**	0.41	0.44**	0.97**	0.83**
Number of kernels / spike	0.41**	0.51**	0.49**	0.38*	0.15	0.11	0.17	0.13
100 kernel weight	- 0.08	- 0.23	0.37*	0.39*	0.29	0.41**	0.34*	0.88**
Biological yield	0.42**	0.57**	0.78**	0.87**	0.23	0.38*	0.78**	0.41**
Harvest index	0.56**	0.48**	0.36*	0.40*	0.71**	0.75**	0.32*	0.33*

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

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التربية لتحمل الجفاف والارتباط بين محصول الحبوب وبعض الصفات الأخرى.16 من قمح الخبز

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أستخدمت عشيرتين من قمح الخبز ، بغرض الانتخاب لتحمل الجفاف من الجيل الثانى الى الجيل الرابع فى ثلاثة مواسم زراعية ١٩٩٨ /٩٩ ، ١٩٩٩ / ٢٠٠٠ و٢٠٠٠ / ٢٠٠١ بمزرعة تجارب محطة البحوث الزراعية بشندويل.

يهدف البحث الى تقدير معامل الحساسية للجفاف تحت مستويات الانتخاب المختلفة وكذلك حساب درجة الارتباط المظهرى والوراثى بين صفة المحصول وباقى الصفات المورفوفسيولوجية والمحصول ومكوناته موضع الدراسة .

أظهرت النتائج أنه يوجد هناك ثمانية تراكيب وراثية من العشيرة الأولى وكذلك أثنى عشر تركيب وراثى من العشيرة الثانية أعطت محصولا عاليا نسبياً تحت ظروف الجفاف وكذلك معامل حساسية للجفاف منخفض (أقل من واحد). أعطى الارتباط المظهرى للعشيرة الأولى والثانية إرتباط موجب ومعنوى بين المحصول وكل من عدد السنابل للنبات ، عدد الحبوب للسنبلة ، ووزن ١٠٠ حبة والمحصول البيولوجى ومعامل الحصاد وعدد الأيام حتى طرد السنابل فى الجيل الثالث والرابع ماعدا عدد الأيام حتى طرد السنابل فى الجيل الثالث للعشيرة الأولى أعطى إرتباط سالب ومعنوى مع المحصول وإرتباط سالب وغير معنوى فى الجيل الرابع للعشيرة الثانية . بينما كان هناك إرتباط وراثى معنوى وموجب بين محصول الحبوب وكل من عدد الأيام حتى طرد السنابل ومساحة ورقة العلم ومعدل فقد الماء بالنبات (فى الجيل الرابع) ومع طول النبات وعدد السنابل بالنبات وعدد الحبوب بالسنبلة ووزن ١٠٠ حبة والمحصول البيولوجى للنبات ومعامل الحصاد للعشيرتين فى الجيل الثالث والرابع ، ووجد أن هناك إرتباط سالب بين المحصول وعدد الأيام حتى طرد السنابل فى الجيل الرابع ، مع معدل فقد الماء فى الجيلين .

ويتضح من النتائج السابقة أنه يمكن استخدام التراكيب الوراثية ذات المحصول العالى نسبياً وذات معامل الحساسية المنخفض كمصدر للتراكيب الوراثية التى تتحمل الجفاف أو يمكن استخدامها فى برامج التربية لإنتاج سلالات أو أصناف عالية المحصول وعالية فى تحمل الجفاف.