SELECTION RESPONSE FOR DROUGHT TOLERANCE IN TWO BREAD WHEAT CROSSES

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Abstract

This study was carried out at Shandaweel Agric. Res. Station, during 1998/99, 99/2000 and 2000/2001 wheat growing seasons. It aimed to estimate observed and expected responses to selection and other genetic parameters under normal and drought conditions. Two populations of bread wheat were used in the F_2, F_3 and F_4 generations. The results showed that the values of observed responses for selection to high yield were higher than that for selection to low yield and the observed responses was less than the expected responses for yield and yield components. Broad sense heritability under the two environments were high for all studied characters, while the narrow sense one under drought stress ranged from 34.31 to 47.38 % for days to heading, from 23.39 to 42.78 % for flag leaf water loss, from 31.25 to 42.78 % for number of spikes/plant, from 27.63 to 42.41 % for number of kernels/spike, from 31.72 to 40.33 % for 100-kernel weight and from 19.13 to 39.63 % for grain yield/plant. The respective realized heritabilities ranged from 51.82 to 59.64 %, 61.87 to 79.28 %, 32.45 to 48.84 %, 17.43 to 23.19 %, 42.89 to 57.14 % and 31.03 to 39.90 % for the same characters. These results showed that pedigree method of selection was effective to produce new lines tolerant to drought stress.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is considered one of the most strategic food in Egypt since 7000 years ago. It is used as a basic staple food for almost of urban areas and /or in blending with maize in rural ones. In addition, straw yield is important fodder for cattles. Wheat provides more than one-quarter of the total world cereals, and constitutes the main source of calories for more than 1.5 thousand million people. In Egypt, increasing grain yield of cereal crops is considered one of the important national goals to face the growing needs of the population. Therefore, it has become necessary to develop genotypes, which consistently show superior yields. Overcoming the gab between cereal production and consumption depends mainly on horizontal extension of cultivated area of cereals and on raising yield per unit area is encountered by unfavorable conditions such as drought, heat and high salinity of soils. The first step is to identify, the superior tolerant genotypes to be used in the breeding programs.

Selection for stress tolerance in breeding programs has been impeded by lack of appropriate strategies and screening techniques (Gozlan and Mayer 1981). Development of cultivars tolerant to drought stress is an objective in many breeding programs, but success has been limited. Genetic improvement of stress tolerance in crop plants requires identification of relevant physiological stress tolerance mechanisms as selection criteria (Mayer and Gozlan 1982) and testing to verify the value of such criteria for improvement of stress tolerance.

Results of drought stress (Moshref, 1996) showed that broad sense heritability were high for No. of spikes/plant and No. of grains/spike, while it was moderate for grain yield/plant and 100-kernel weight. On the other hand, narrow sense heritability values were high for No. of spikes/plant and No. of kernels/spike, while they were moderate for grain yield/plant and 100-kernel weight. Expected genetic advance values under drought stress were high for No. of spikes/plant, moderate for No. of kernels/spike and low for 100-kernel weight, heading date, plant height and grain yield/plant. To achieve genetic improvement through selection, heritability must be reasonably high. However, heritability of characters such as yield is often low under drought conditions due to non-uniform testing condition, small genotypic variance or large genotypic x environment interaction variance (Smith *et al.* 1990). This study aimed to investigate the response to selection in the early segregating generations for producing lines having high grain yield under drought stress, hopping to assist wheat breeders to identify superior genotypes.

MATERIALS AND METHODS

The present study was carried out from 1998 /1999 to 2000 / 2001 wheat growing seasons, at Shandaweel Agric Res. Sta., Agric. Res. Center, Ministry of Agric and found seclamation., Egypt. To estimate the response of pedigree selection under drought stress, in early generations of two bread wheat (*Triticum aestivum* L. em. Thell) populations. The genetic parameters of phenotypic, genotypic variances, variability and heritability were estimated in F_2, F_3 and F_4 generations. Four parents were chosen for their diverse physiological and yield characters 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 taken from Shandaweel bread wheat breeding program.

In the 1998 / 1999 season, 1500 plants from the two populations F_2 generation were grown in plots consists of 12 rows, 7m long, 30 cm. apart and 10 cm between plants within rows. Also, the parents and a local check for drought tolerance (Sahel 1), were grown alongside in two rows for each plot. The drought stress was imposed during reproductive development by preventing irrigation after jointing stage. Data were 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 twenty random plants from each population.

In 1999/2000 season two field experiments were conducted with three replications. The first did not receive any irrigation water after jointing stage (drought stress "D"). The second experiment was grown using supplemental water applied regularly as recommended (normal "N"). Each experiment comprised 60 F_3 families (20 high and 20 low yielding were selected and 20 unselected families). An equal number of grain composites from each F_3 plants to give F_4 bulk progenies in addition to the parents and the check. These entries were grown in a single row plots with 2 m. long, 30 cm apart and 10 cm between plants within row in a randomized complete block design (RCBD) with three replications.

In 2000/2001 season, experimental design and the cultural practices for the F_4 families were similar to that used in F_3. Recommended field practices for wheat production were adopted over all the growing seasons. Sowing dates were through the last week of November in the three seasons. Data were recorded on ten randomly guarded plants from each family in F_3 and F_4 generations. The means of the ten plants were subjected to the statistical and genetic analysis.

The measured characteristics were days to 50 % heading, Flag leaf water loss (the technique of excised leaves outlined by Clarke and Mc Caig, 1982), number of spikes /plant, number of kernels/spike, 100-kernel weight "gm" and grain yield /plant "gm".

Analysis of variance for (RCBD).

1. The observed and expected response to selection were calculated using the following formula :
   Observed response= the difference between the mean of the selected families and the mean of bulk population.
   Expected response = i H_n σ p
   where i = selection intensity (at 10% i = 1.76), H = broad sense heritability and σ p = is the phenotypic standard deviation.

The degrees of freedom and expected mean squares are present in Table (1).

Table 1. The ANOVA and expected means of squares for (RCBD).

Source of variance	D.F	M . S	E . M . S
Replication	r – 1	M_3	$\sigma^2 e + g\, \sigma^2 r$
Genotypes	g – 1	M_2	$\sigma^2 e + r\, \sigma^2 g$
Error	(r –1) (g –1)	M_1	$\sigma^2 e$

2. The genotypic variance σ^2 g = $M_2 - M_1$ / r
3. The phenotypic variance σ^2 p = σ^2 g + σ^2 e
4. The genotypic (G.C.V%) and phenotypic (P.C.V%) coefficient of variability were calculated as 6g / $\bar{x}$ and 6p / $\bar{x}$ respectively .
5. Heritability in broad sense (H) was estimated as the ratio of genotypic (σ^2 g) to the phenotypic (σ^2 g + σ^2 e) variances.
6. Heritability in the narrow sense was estimated using the correlation and off spring regression according to Smith and Kinman (1965).
7. Realized heritability was calculated according to Alexander *etal* (1984).
8. The genetic parameters were estimated as outlined by Mather and Jinks 1977, and Falconer (1989).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences in the F3 and F4 families under the two environments for all the studied traits (Table 2). Observed responses to selection are presented in Table (3 and 4), indicated that selection for high and low grain yield under drought stress and normal conditions were effective. Days to heading decreased by 2.82 and 2.85 as well as (4.31 and 4.73 days for the bulk F_4 families in population I under drought and normal treatments, respectively. Similar results were found by Kheiralla *et al.,* 1993. Similar trend for the water loss% was observing, its reduction by 6.60 and 4.88 as well as 5.29 and 4.41 % for the two populations respectively. Meanwhile, the actual responses for the high and low selection under drought conditions in the F4 families were (-1.00 and –1.42), (1.47 and 0.87), (0.06 and –0.14 gm) and (0.95 and –0.54 gm) for No. of spikes/plant, No. of kernels/spike, 100-kernel weight and grain yield/plant in population I, respectively, while, it was (0.63 and 0.29), (3.50 and 3.04), (0.25 and 0.27 gm) and (3.52cand 2.58) for the previous characters in population II, respectively.

The expected responses to selection of F_4 families in population I under drought and normal condition for days to heading were 8.35 and 8.24 days, for flag leaf water loss were 6.60 and 3.37 %, for No. of spikes/plant were 1.39 and 0.72, for No. of kernels/spike were 2.93 and 5.50, for 100-kernel weight were 0.20 and 0.32 gm. and for grain yield/plant were 1.94 and 4.17 gm. Meanwhile in the population II they were 6.55 and 8.04 days, 6.78 and 5.76 %, 0.60 and 0.67, 3.35 and 2.39, 0.12 and 1.26 gm. and 1.03 and 2.48 gm. for the previous characters, respectively. The genetic advance percentages from selection under drought and normal conditions in the F_4 generation of population I were 5.19 and 4.43 for days to heading, 7.37 and 4.16 for flag leaf water loss, 10.23 and 10.59 for No. of spikes/plant, 7.00 and 7.13 for number of kernels/spikes, 3.96 and 6.42 for 100-kernel weight and 11.73 and 14.95 for grain yield/plant.

Meanwhile, in population II, they were (4.26 and 5.00%), (7.40 and 6.52%), (4.04 and 9.47%), (9.05 and 6.65%), (3.39 and 5.19%) and (7.56 and 10.28%), for the previous characters in sequence.

These results express that selection for high yield under drought stress was more effective in improving grain yield/plant in the dry land through earliness, flag leaf water loss and some major yield components. These results agreed with those obtained by Kheiralla *et al.*(1993) and Tammam (1995).

Table 2. The analysis of variance for some studied characters under normal (N) and drought stress (D) for F_3 and F_4 generations in two wheat crosses.

Generation	Treatments	S.o.v	D.F	Population I						Population II					
				Days to heading	Flag leaf water loss	No. of spikes / plant	No. of kernels / spike	100 K.W	Grain yield / plant	Days to heading	Flag leaf water loss	No. of spikes / plant	No. of kernels / spike	100 K.W	Grain yield /plant
F_3	N	Reps	2	1.55	33.444	2.65	16.63	0.04	1.66	4.43	10.37	0.72	6.86	0.02	6.80
		Geno types	19	90.08**	94.79**	4.08**	31.67**	0.23 **	2.69**	71.75**	23.59 **	2.29* *	19.12**	0.19**	10.09* *
		Error	38	3.85	10.47	0.40	6.69	0.01	1.00	3.15	2.53	0.75	1.47	0.04	1.22
	D	Reps	2	12.12	0.25	0.20	0.56	0.04	0.28	1.22	3.59	0.47	12.04	0.03	5.34
		Geno types	19	80.26**	23.22**	0.45**	36.67**	0.25 **	3.13**	53.35**	30.13 **	1.89* *	28.29**	0.07**	9.32**
		Error	38	2.47	3.74	0.12	8.46	0.05	0.94	3.22	4.45	0.57	9.11	0.01	1.59
F_4	N	Reps	2	12.95	7.06	1.80	11.08	0.02	1.80	16.46	0.16	0.10	6.29	0.06	7.57
		Geno types	19	73.17**	17.41**	2.49**	48.40**	0.18 **	24.33*	72.69**	45.05 **	1.69* *	19.65**	0.09**	10.74* *
		Error	38	2.09	1.89	0.99	6.22	0.03	2.26	2.73	3.80	0.58	6.29	0.02	1.62
	D	Reps	2	3.23	6.86	1.14	1.09	0.04	3.57	0.12	1.56	1.68	10.62	0.02	2.02
		Geno types	19	80.35**	48.01**	2.77**	26.43**	0.07 **	8.55**	51.23**	53.31 **	0.73* *	26.62**	0.04**	3.48**
		Error	38	3.53	2.66	0.28	7.89	0.02	1.87	2.75	2.44	0.15	5.84	0.01	1.07

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

Table 3. The observed and expected responses to selection and genetic advance % for days to heading, flag leaf water loss and number of spikes/plant in two populations of two wheat crosses under normal and drought conditions

Character	Treatment	Generation	Population I				Population II			
			Observed response		Expected response	Genetic advance %	Observed response		Expected response	Genetic advance %
			Highest	Lowest			Highest	Lowest		
1–Days to heading	Normal	F_3	-0.03	-0.28	8.86	--	-2.54	-3.05	7.89	--
		F_4	-0.27	-0.05	8.24	4.43	-4.31	-4.73	8.04	5.00
	Drought	F_3	0.30	-1.35	8.56	4.28	-1.46	-2.56	6.59	3.08
		F_4	-1.47	-0.42	8.35	5.19	-2.82	-2.85	6.55	4.26
2 – flag water loss	Normal	F_3	-9.40	-8.67	7.96	--	-4.47	-3.73	6.43	--
		F_4	-9.71	-7.85	3.37	6.40	-2.73	0.73	5.76	6.52
	Drought	F_3	-1.91	0.87	3.54	--	3.60	4.71	4.18	--
		F_4	-6.60	-4.88	6.60	7.37	-5.29	-4.41	6.78	7.40
3- No. of spikes/ plant	Normal	F_3	1.06	0.82	1.70	--	1.38	0.85	0.80	--
		F_4	0.18	0.03	0.72	10.59	0.01	0.04	0.67	9.47
	Drought	F_3	0.88	0.02	0.40	5.61	0.71	-0.10	1.51	10.56
		F_4	-1.00	-1.42	1.39	10.23	0.63	0.29	0.60	4.04

Table 4. The observed and expected responses to selection and genetic advance % for no. of kernels/spike, 100-kernel weight and grain yield/plant in two populations of two wheat crosses under normal and drought conditions.

Character	Treatment	Generation	Population I				Population II			
			Observed response		Expected response	Genetic advance %	Observed response		Expected response	Genetic advance %
			Highest	Lowest			Highest	Lowest		
4- No. of kernels/ spike	Normal	F_3	3.20	2.76	3.78	--	1.54	0.05	3.81	--
		F_4	1.23	0.01	5.50	7.13	2.87	2.16	2.39	6.65
	Drought	F_3	3.98	0.93	3.91	12.32	3.55	10.70	2.86	10.25
		F_4	1.47	0.87	2.93	7.00	3.50	3.04	3.35	9.05
5- 100-kernel weight	Normal	F_3	0.08	0.01	0.44	--	0.15	0.07	0.29	--
		F_4	-0.03	-0.12	0.32	6.42	0.29	0.29	0.26	5.19
	Drought	F_3	0.14	-0.14	0.30	10.10	0.14	0.05	0.20	4.68
		F_4	0.06	-0.10	0.20	3.96	0.25	0.21	0.12	3.39
6- Grain yield/ plant	Normal	F_3	2.71	1.99	0.79	--	5.16	4.21	2.54	--
		F_4	2.48	1.65	4.17	14.95	0.67	0.28	2.48	10.28
	Drought	F_3	4.93	1.17	1.00	12.44	4.72	1.89	2.21	17.79
		F_4	0.95	-0.54	1.94	11.73	3.52	2.58	1.03	7.56

Estimates of the phenotypic and genotypic coefficient of variation presented in Tables 5 and 6 indicated the presence of sufficient variability for No. of spikes/plant, 100-kernel weight and grain yield/plant, while it was moderate for heading date, flag leaf water loss and No. of kernels/spike. The variability suggested that selection among F_2 plants may produce changes in the coming generations. Moreover, the present study showed that the broad sense heritability under drought and normal conditions ranged from (77.82 to 91.30%) and (87.89 to 92.24 %) for days to heading, from (65.80 to 88.76) and (72.77 and 85.98%) for flag leaf water loss, from (43.56 to 85.46) and (38.95 and 75.46%) for number of spikes/plant, from (41.23 to 86.41%) and (41.40 to 80.00%) for number of kernels/spike, from (50.00 to 88.69 %) and (55.56 to 87.50 %) for 100-kernel weight and from (42.78 to 97.23 %) and (35.90 to 76.40 %) for grain yield for the two populations respectively.

The narrow sense heritability under drought stress for the two populations ranged from (34.31 to 47.38 %) for days to heading, from (23.39 to 24.60 %) for flag leaf water loss, from (31.25 to 42.78 %) for number of spikes/plant, from (27.63 to 42.41 %) for number of kernels/spike, from (31.72 to 40.33 %) for 100-kernel weight and from (31.03 to 39.90 %) for grain yield. The realized heritability under drought stress for the two populations ranged from (51.82 to 59.64) for days to heading, from (61.87 to 79.28 %) for flag leaf water loss, from (32.45 to 48.84 %) for number of spikes/plant, from (17.43 to 23.19 %) for number of kernels/spike, from (40.58 to 57.14 %) for 100-kernel weight and from (19.13 to 39.63 %) for grain yield. These results are in general agreement with those obtained by Johnson *et al.* (1983), Saadalla (1994), Tammam (1995), Utz *et al.* (2001) and Wiersma *et al.* (2001).

It is evident from the present study that great response to selection can be achieved from selection in population having great phenotypic an genotypic variations. Although response to selection will be greater in population with larger genetic variance, except for a higher initial mean yield may impose limitations.

Table 5. The genetic parameters of days to 50 % heading, flag water loss and number of spikes/plant for the F2 – F4 generations in the two populations of two wheat crosses under normal and drought conditions.

Items	Population I					Population II				
	Normal		Drought			Normal		Drought		
	F_3	F_4	F_2	F_3	F_4	F_3	F_4	F_2	F_3	F_4
1 – Days to heading										
Pheno. Var.	32.59	25.78	19.84	28.40	29.14	26.02	26.05	19.82	19.93	18.91
Geno. Var	28.74	23.78	15.44	25.93	25.61	22.87	23.32	17.44	16.71	16.91
P.C.V. %	5.15	4.74	4.07	4.92	5.30	4.82	4.98	4.33	4.38	4.35
G.C.V. %	4.85	4.55	3.58	4.70	4.97	4.52	4.71	4.07	1.75	4.11
Heritabillity										
Broad – sense	88.17	92.24	77.82	91.30	87.89	87.89	89.52	87.99	83.84	89.52
Narrow – sense	--	31.34	--	34.35	34.36	--	36.20	--	47.38	34.31
Realized	--	71.87	--	53.23	57.58	--	62.77	--	59.64	51.82
2 – Flag water loss										
Pheno. Var.	38.58	6.94	--	10.17	17.80	18.04	17.45	--	13.01	19.40
Geno. Var	28.11	5.05	--	6.43	15.80	15.51	13.75	--	8.56	16.96
P.C.V.%	9.09	5.30	--	5.62	9.13	7.16	8.06	--	6.47	8.93
G.C.V. %	7.76	4.52	--	4.47	8.60	6.64	7.13	--	5.25	8.35
Heritabillity										
Broad – sense	72.86	72.77	--	63.23	88.76	85.98	78.35	--	65.80	87.42
Narrow – sense	--	52.50	--	--	23.39	--	23.49	--	--	24.60
Realized	--	64.43	--	--	61.87	--	66.32	--	--	79.28
3 – No. of spikes/plant										
pheno. Var.	1.63	1.49	6.09	0.23	1.11	1.26	0.95	9.08	1.01	0.34
Geno. Var	1.23	0.80	4.28	0.11	0.83	0.51	0.37	7.76	0.44	0.20
P.C.V. %	12.53	11.62	22.96	5.72	10.96	10.18	9.68	29.69	10.33	6.17
G.C.V. %	10.82	8.51	19.24	3.95	9.48	6.47	6.04	27.45	6.82	4.73
Heritabillity										
Broad – sense	75.46	53.69	70.20	47.83	74.77	40.48	38.95	85.46	43.56	58.82
Narrow – sense	--	29.78	--	34.48	31.25	--	30.29	--	37.56	42.78
Realized	--	43.68	--	32.45	48.84	--	51.28	--	36.00	41.98

Table 6. the genetic parameters of kernels/spike, 100 - kernel weight and grain yield/plant for the $F_2 - F_4$ generations in the two populations of two wheat crosses under normal and drought conditions.

Items	Population I					Population II				
	Normal		Drought			Normal		Drought		
	F_3	F_4	F_2	F_3	F_4	F_3	F_4	F_2	F_3	F_4
4 – No. of kernel/spike										
pheno. Var.	15.01	20.28	78.89	17.86	13.81	7.35	10.75	112.68	15.50	13.22
Geno. Var	8.33	14.08	66.09	9.40	6.91	5.88	4.45	97.37	6.39	6.93
P.C.V. %	9.50	8.95	13.45	11.33	7.97	6.32	6.96	17.86	10.56	8.41
G.C.V. %	7.08	7.46	12.31	8.22	5.34	5.65	4.48	16.60	6.78	6.09
Heritabillity										
Broad – sense	55.50	69.43	83.77	52.63	44.82	80.00	41.40	86.41	41.23	52.42
Narrow – sense	--	22.73	--	42.41	27.63	--	32.78	--	33.81	41.19
Realized	--	61.90	--	23.19	19.67	--	37.68	--	17.43	19.63
5 – 100-kernel weight										
pheno. Var.	0.08	0.08	0.45	0.12	0.03	0.09	0.04	0.52	0.03	0.02
Geno. Var	0.07	0.05	0.40	0.06	0.02	0.05	0.03	0.41	0.02	0.01
P.C.V. %	6.92	6.36	21.80	9.52	4.21	7.14	4.44	24.39	4.51	3.45
G.C.V. %	6.47	5.02	20.58	6.73	3.44	5.32	3.85	21.58	3.68	2.44
Heritabillity										
Broad – sense	87.50	65.00	88.69	50.00	66.67	55.56	75.00	78.31	66.67	50.00
Narrow – sense	--	36.51	--	40.33	31.72	--	48. 91	--	38.61	34.58
Realized	--	57.69	--	40.58	57.14	--	60.00	--	42.89	44.44
6 – Grain yield/plant										
pheno. Var.	1.56	9.62	62.51	1.67	4.10	4.18	4.66	51.68	4.17	1.87
Geno. Var	0.56	7.35	60.78	0.73	2.23	2.96	3.04	46.78	2.58	0.80
P.C.V. %	8.93	14.14	36.05	11.98	11.12	14.00	11.35	36.18	16.88	8.13
G.C.V. %	5.35	12.36	35.55	7.92	8.19	11.78	9.16	34.42	13.27	5.31
Heritabillity										
Broad – sense	35.90	76.40	97.23	43.71	54.39	70.80	65.28	90.53	61.40	42.78
Narrow – sense	--	40.09	--	38.63	39.90	--	29.43	--	39.86	31.03
Realized	--	71.83	--	20.98	39.63	--	59.33	--	19.13	24.55

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الاستجابة للإنتخاب لتحمل الجفاف فى هجينين من قمح الخبز

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بشندويل خلال المواسم الزراعية ١٩٩٨/٩٩ ، ١٩٩٩/٢٠٠٠ ، ٢٠٠٠/٢٠٠١م لتقدير الاستجابة للانتخاب للمحصول العالى والمنخفض للحبوب بطريقة سجل النسب فى عشيرتين من القمح للهجينين ("جيزة ١٦٥/ناكوزارى-٧٦ و دبيرة/شام ٦) تحت ظروف الجفاف وتحت الظروف العادية.

أشارت نتائج الدراسة إلى أن الاستجابة المشاهدة للانتخاب كانت أقل من الاستجابة المتوقعة تحت ظروف الجفاف كما كانت الاستجابة المشاهدة للانتخاب لمحصول الحبوب العالى أعلى من الاستجابة تحت ظروف الانتخاب للمحصول المنخفض .

كما كان التباين الوراثى والمظهرى متوسطا لصفات عدد أيام التزهير ومعدل فقد الماء من ورقة العلم وعدد الحبوب بالسنبلة ، كما كان منخفضا لصفات محصول الحبوب ووزن ١٠٠ حبة وعدد السنابل للنبات.

كما أظهرت درجة التوريث بالمعنى الواسع قيماً مرتفعة لمعظم الصفات تحت الدراسة ، ووجد كذلك أن درجة التوريث بالمعنى الضيق تحت ظروف الجفاف تتراوح من ٣٤,٣١ إلى ٤٧,٣٨ % لصفة عدد الأيام حتى طرد السنابل ، ٢٣,٣٩ إلى ٢٤,٦٠ % لصفة معدل فقد الماء من ورقة العلم ، من ٣١,٢٥ إلى ٤٢,٧٨ % لعدد السنابل للنبات ، من ٢٧,٦٣ إلى ٤٢,٤١ % لعدد الحبوب بالسنبلة ، من ٣١,٧٢ إلى ٤٠,٣٣ % لصفة وزن ١٠٠ حبة و من ١٩,١٣ إلى ٣٩,٦٣% لصفة محصول الحبوب . كما وجد أن درجة التوريث المحققة تتراوح من ٥١,٨٢ إلى ٥٩,٦٤ % ، من ٦١,٨٧ إلى ٧٩,٢٨ % ، من ٣٢,٤٥ إلى ٤٨,٨٤ % و ٣١,٠٣ إلى ٣٩,٩٠ % للصفات سالفة الذكر على الترتيب.

من النتائج السابقة يتضح أنه يمكن الحصول على سلالات تتحمل الجفاف باستخدام طريقة سجل النسب مع الانتخاب للمحصول العالى تحت ظروف الجفاف بالعشيرة القاعدية.