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Selection response for grain yield in a segregation population of bread wheat under heat stress

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Abstract

This study was carried out in the private farm in Tahta city, Sohag, Egypt, during the four successive seasons, i.e., 2016/2017 2017/2018, 2018/2019 and 2019/2020 to estimate observed and expected responses to selection and other genetic parameters for a bread wheat population (Debeira × Sakha 8) in F2, F3, F4 and F5 generations under timely and late planting (heat stress). The results showed that observed direct response to selection for grain yield in F4 and F5 generations resulted in significant positive observed gain compared with bulk, better parent and the check cv (Sids 12) under the two conditions. On the other hand, the expected responses to selection were 6.89 and 11.60 % in F4 generation and were 2.36 and 4.60 % in F5 generation under timely and heat stress, respectively. The narrow sense heritability was 55.02, 44.50 and 27.83 % in F_3, F_4 and F_5 generations under timely conditions, respectively. Meanwhile, they were 55.44, 57.05 and 24.68 % in the same generations under heat stress. These results showed that the pedigree method of selection was effective to produce new tolerant lines to heat stress with high grain yield. Depending on Drought Susceptibility Index, the two lines, i.e., no. 453 and 459 in F4 and F5 generations produced relatively high grain yield under heat stress due to high yield potential, rather than having low susceptibility to stress. These lines could be used as source of heat tolerance/or factors contributing to general adaptation.

Keywords:
Wheat, Pedigree selection, Genetic parameters, Heat stress.

INTRODUCTION

Wheat is one of the most important food crops not only in Egypt but also all over the world. The wheat is grown under a wide range of climatic conditions, and it is subjected to different stress throughout the growing season. In Egypt, the cultivated area is 3.4 million feddan, produced 8.5 million tons with an average of 18 ardab/feddan (F.A.O Statistic 2020). Total consumption of wheat reached 18.6 million tons, therefore increasing wheat production is a major aim to reduce the gap between production and the consumption. Wheat is the most important strategic cereal crop, it has been grown in Egypt since ancient Egyptian times, serving as the principal source of calories in Egyptian diet. Thus, it is imperative that wheat production must be increased to meet as much of the shortfall in wheat production as it possible. This can be achieved by developing high yielding varieties and by the improved the new lines. Heat stress is one of the major constraints of wheat (*Triticum aestivum* L.) production in many areas around the world. While late heat stress is a problem in 40% of temperate environments (Reynolds et al., 2001). Many studies were able to identify traits that could be used as selection criteria under heat stress conditions (Shpiler and Blum., 1991 and Hu and Rajaram; 1994). The uniqueness of the wheat growing environment in Egypt necessitates the search for relevant selection criteria that might be associated with yield under such environment and accelerate developing heat-tolerant wheat cultivars. This is important for selection in self-pollinated crops, as the action of additive genes would be retained through subsequent inbreeding. The effectiveness of selection therefore depends on the presence of true genetic differences between genotypes in these generations and on their persistence following selection. Early pedigree selection for yielding potential in wheat and other cereal crops assumes selection in the F_3 families of individual plants spaced apart to enable their evaluation. Then selection from F_3 to F_6 generation is practiced among and within families following evaluation in row plots and/or in yield trials. Thus, the choice among favorable, optimum or stress growing (heat stress) conditions as the most effective selection environment to develop broadly adapted varieties is crucial. Many workers indicated that pedigree selection was effective in improving grain yield (Hamam, 2008 and Ali, 2011). However, selection for yield or production traits is a problem which continues to perplex plant breeders. The assessment of heritability provides the information about the particular character, which can be transmitted from one generation to the next generation. Heritability values can be used as a measuring scale, to determine genetic relationship between parents and progeny (Memon et al, 2007), and the correlation of different traits helps to make the decision of direct or indirect selection (Neyhart et al. 2019). The present study amid to investigate the response to selection in the segregation generations for producing lines having high grain yield under heat stress, hopping to assist wheat breeders to identify superior genotypes.

MATERIALS AND METHODS

The present study carried out at private farm in Tahta city, Sohag, Egypt, during the four successive seasons, i.e., 2016/2017 2017/2018, 2018/2019 and 2019/2020. Three cycles of selection under timely and late planting (heat stress) were achieved.

The plant materials

Population of bread wheat (*Triticum aestivum* L.) was derived from the cross Debeira × Sakha 8 at F_2 generations (Base population), then the F3, F4 and F_5 generations were developed by pedigree selection using selection criteria based on grain yield under both of timely and late planting conditions. In the 2016/2017 season, 1000 plants from F2 population were grown in timely (17^{th} Nov. 2016) and late (19^{th} Dec. 2016) planting conditions. Randomized complete block design (RCBD) with three replications were used. Each replicate was grown in drills spaced 30 cm apart and spaced 5 cm within the hills. Data were collected on 600 harvest plants. Data were recorded on number of days to heading, spike length (cm), no of spikes/plant and grain yield/plant (g) for each individual plant. The 60 highest yielding plants (10% selected F_2 plants for high yield) were selected from each population.

In the 2017/2018 season, the 60 selected plant from the F2 generation were sown and their parents, to consist of F3 population in timely (29th

Nov. 2017 and late (2nd Jan. 2018) planting date. In a randomized complete block design (RCBD) with three replications. Each replicate was grown 60 plants in drills spaced 20 cm apart and spaced 5 cm apart within the hills. The highest yielded of 6 families (10% selected F3 families for high yield from each environment) were selected based on the previous selection criteria in timely sowing dates as well as in late sowing.

In the 2018/2019 season, the 8 selected families (F3) were sown plus their parents, check cultivar (Sids 12) and bulk population to consist of F4 population in timely (1^{st} Dec. 2018) and late (1^{st} Jan. 2019) planting date using the same experimental design and the same plot size of the previous season. The highest 6 families (50% selected F4 families for high yield from each environment) were selected.

In the 2019/2020 season, (F5 generation), two field experiments were conducted as in the previous season. The selected plants from the F4 generation (6 lines) were evaluated under timely (1^{st} Dec. 2018) and late (1^{st} Jan. 2019) planting date; along with the two parents, bulk sample and the check cultivar Sids 12 using the same experimental design and the same plot size of the previous season. The following measurements were recorded for each family in F3, F4 and F5 generations: Days to 50% heading, spike length (cm), no. of spike/plant, and no. of kernel/spike, 1000-kernel weight (g) and grain yield/plant (g). Recommended field practices for wheat production were adopted over all the growing seasons. The trend of temperature (^{0}C) during the two seasons was recorded (Table 1).

Statistical analysis

The analysis of variance thought base population; the three cycles of early selection for each section criterion as well as the late selection were performed according to Gomez and Gomez (1984). The phenotypic (P.C.V) and Genotypic (G.C.V), coefficients of variation were calculated according to Burton (1952).

Observed response

The difference between the mean of the selected families and the mean of bulk population, best parent and check cultivar. Expected response = i H_n σ p where σ p = is the phenotypic standard division, H = narrow sense heritability and i = selection intensity. Heritability in the narrow sense was estimated using the correlation and offspring regression according to Smith and Kinman (1965). Genotypes means were compared using Revised Least Significant Differences test (RLSD) according to Petersen (1985).

The significance of observed direct and correlated response to selection were measured as deviation percentage of families mean from the bulk or the better parent or the check using L. S. D. where, L.S.D = least significant differences between the bulk or the better parent and mean of the selected families, and was calculated as:

$$LSD = t\alpha.\sqrt{MSE/r + MSE/fr}$$

where, f = number of families, r = number of replication. Heat susceptibility (HSI) was calculated for each genotype according to the formula of Fischer and Maurer, 1978.

Table (1). The trend of temperature (0C) during the two seasons (2016/17 and 2019/20).

Season	Months	2016/17		2017/18		2018/19		2019/20	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
HC Air temperature [°C]	Nov.	13.84	28.17	11.54	25.87	13.58	27.18	14.63	29.26
	Dec.	6.21	19.56	10.20	23.39	7.41	20.81	8.08	22.19
	Jan.	5.69	20.04	5.46	20.34	5.40	19.17	4.71	18.84
	Feb.	5.87	22.03	11.27	26.67	7.34	21.90	7.03	21.88
	Mar.	10.30	26.64	14.08	31.62	9.37	25.56	10.81	27.56
	Apr.	15.50	32.39	16.06	33.32	13.95	30.50	14.15	30.59
	May	20.017	37.29	22.11	38.56	20.84	38.78	19.82	36.50

RESULTS AND DISCUSSION

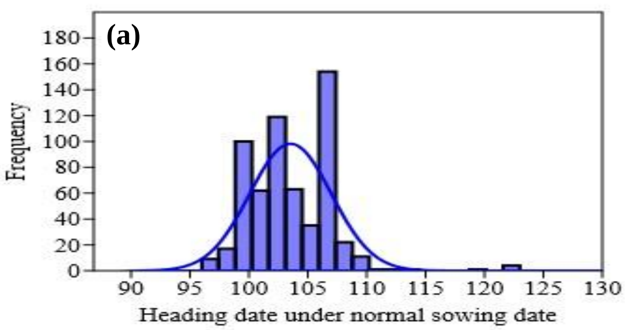
A – Evaluation of the base population

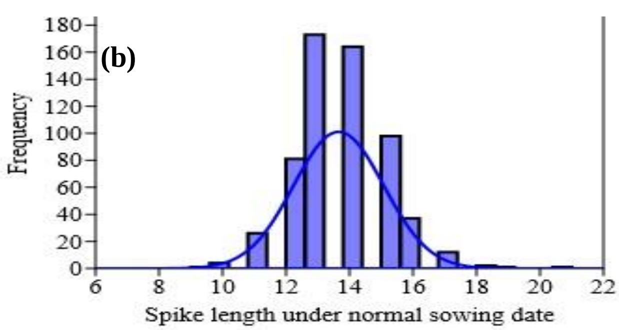
Data in Table (2) showed the average and range for days of heading, spike length, No. of spikes/plant and grain yield/plant in F2 plants under timely sowing date. Number of days to 50 % heading ranged from 96.00 to 123.00 days with an average of 103.53 days in F_2 plants under timely sowing date (Fig. a). spike length ranged from 9.00 to 20.00 cm with an average of 13.66 cm (Fig.b). Number of spikes/plant ranged from 3.00 to 20.00 spikes/plant with an average of 10.96 spikes/plant (Fig.c). Grain yield/plant ranged from 7.56 to 32.95 g with an average of 20.19 g (Fig. d).

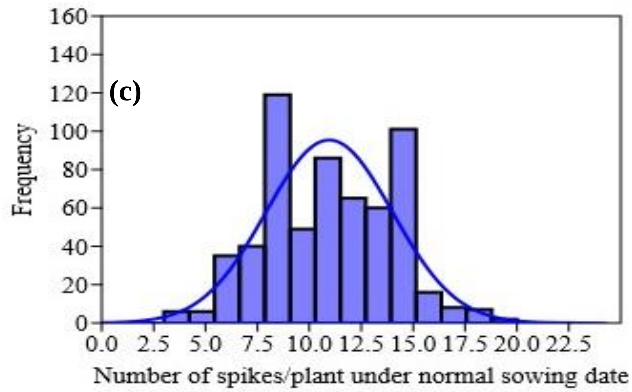
Table (2) the range and mean values for traits in F_2 generation under timely sowing date.

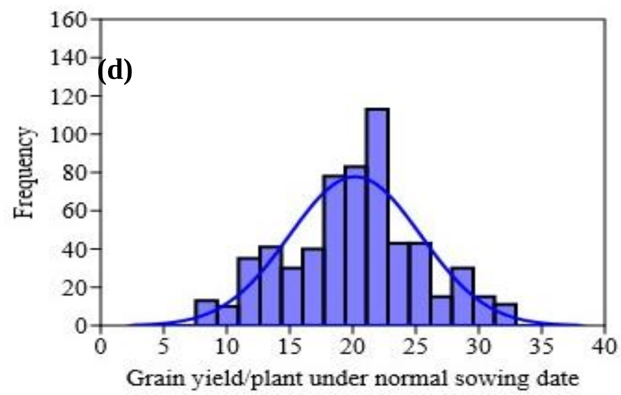
Characters	Timely sowing date	
	Range	Mean±SD
Days to heading	96.00 – 123.00	103.53±3.46
Spike length	9.00 – 20.00	13.66±1.42
No. of spikes/plant	3.00 – 20.00	10.96±3.05
Grain yield / plant	7.56 – 32.95	20.19±5.21

Fig. a, b, c and d shows the normal distribution of days to heading, spike length, No. of spikes/plant and grain yield/plant, respectively as traits on the F2 plants under timely conditions.









B – Response to selection for grain yield under timely and late sowing dates

The efficiency of a breeding program for heat tolerance is largely dependent upon the efficiency of selection criteria and the selection method used to achieve genetic improvement through selection. This study was designed to obtain estimate of the response to selection for grain yield/plant compared with the bulk population, mid parents, best parents and check cultivar (Sids 12) in F_3, F_4 and F_5 generations of population of bread wheat (*Triticum aestivum* L.)**.**

B-1- Phenotypic, genotypic coefficients of variability and heritability

The phenotypic (P.C.V.%) and genotypic (G.C.V.%) coefficients of variation and heritability (h^2) estimates for grain yield in $F_{3,}$ F_4 and F_5 generations under timely and late sowing date conditions are presented in Table (4). The results showed that the phenotypic coefficient of variation was 18.73, 8.90 and 9.71% in $F_{3,}$ F_4 and F_5 generations, respectively under timely conditions, while it was 25.13, 11.57 and 9.06% under late sowing date in the same generations, respectively. Likewise, the genotypic coefficient of variability for grain yield was 14.32, 7.95 and 7.73% in F_3, F_4 and F_5 generations, respectively under timely condition, while was 19.04, 8.09 and 6.60% under late sowing date treatment in the two generations, respectively. Similar results were obtained, El-Morshidy et al. (2010), Singh et. al. (2013), Tasfaye et. al. (2016), Prakash et. al. (2019), Alam et al. (2022) and Dagnaw et. al. (2022). Heritability estimates in F_3, F_4 and F_5 generations were generally high and moderate for grain yield/plant in the two conditions. The broad sense heritability for grain yield/plant was 58.48 and 57.40 % in F_3 generation under timely and heat stress, respectively and 79.79 and 48.89 % in F_4 generation under timely and heat stress conditions, respectively and 63.28 and 53.10 % in F_5 generation under timely and heat stress conditions, respectively. The narrow sense heritability was 55.02, 44.50 and 27.83 % in F_3, F_4 and F_5 generations under timely conditions, respectively. Meanwhile, the narrow sense heritability was 55.44, 57.05 and 24.68 % in F_3, F_4 and F_5 generation under heat stress conditions (Table 4). These results are in agreement with those obtained by El-Morshidy et al. (2010), Modarresi et al (2010), Kumar et al. (2014), Prakash et. al. (2019), Alam et. al. (2022) and Dagnaw et. al. (2022).

B-2-Response to direct selection for grain yield under timely and heat stress conditions.

Variance and means

Mean squares for grain yield/plant (Table 3) showed highly significant differences between the families in F_3, F_4 and F_5 generations under timely and late sowing dates conditions.

Table (3): The analysis of variance for F_3, F_4 and F_5 generation for all traits studied under Timely and late sowing dates.

Generation	Treatments	S.o.v	D.F	Mean Squares					
				Days to	Spike	No. of	No. of	1000	Grain
F_3	Timely	Reps	2	22.42	0.743	0.188	3912.53	139.40	13.12
		Genotypes	63	48.06**	2.23**	2.13**	5700.9**	115.57**	19.07**
		Error	126	3.87	0.401	0.839	1332.98	33.93	3.65
	Late	Reps	2	11.67	0.794	0.626	5064.39	35.24	3.08
		Genotypes	63	33.88**	2.03**	1.49**	5253.9**	169.64**	21.53**
		Error	126	3.43	0.528	0.711	1252.52	35.10	4.27
F_4	Timely	Reps	2	28.14	0.302	0.957	106.20	8.99	0.950
		Genotypes	11	81.86**	2.25**	1.29**	3815.3**	57.94*	8.35**
		Error	22	3.73	0.211	0.448	129.69	30.20	0.649
	Late	Reps	2	4.69	1.88	0.155	38.75	18.14	2.72
		Genotypes	11	87.91**	1.69**	0.640**	1738.8**	21.04**	6.85**
		Error	22	2.72	0.263	0.112	147.46	3.02	0.770
F_5	Timely	Reps	2	1.84	0.150	0.095	5407.23	3.80	8.17
		Genotypes	9	50.97**	5.11**	0.577**	7305.5**	21.76**	9.81**
		Error	18	0.913	0.144	0.086	879.27	5.35	1.05
	Late	Reps	2	1.03	0.400	0.051	197.33	0.911	2.80
		Genotypes	9	1.33**	4.06**	0.460**	6833.5**	22.65**	5.76**
		Error	18	0.367	0.228	0.07	1179.63	6.94	0.65

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

Table (4): The genetic parameters of grain yield/plant in F_3, F_4 and F_5 generations of highest yielding families under timely and late sowing dates.

Items	Timely			Late		
	F_3	F_4	F_5	F_3	F_4	F_5
Pheno. Var.	2.96	1.79	2.08	3.17	1.86	1.67
Geno. Var.	2.27	1.60	1.66	2.40	1.30	1.22
P.C.V. %	18.73	8.90	9.71	25.13	11.57	9.06
G.C.V. %	14.32	7.95	7.73	19.04	8.09	6.60
Heritabillity						
Broad – sense	58.48	79.79	63.28	57.40	48.89	53.10
Narrow – sense	55.02	44.50	27.83	55.44	57.05	24.68

Table (5): The range and the mean values in F3 generation for all studied traits of highest yielding families under timely and late sowing date conditions.

Trait	Timely		Late sowing date	
	Range	Means±S.D	Range	Means±S.D
Grain yield / plant (g)	**Direct response**			
	11.47-19.28	15.59±1.79	8.09-15.88	12.48±1.73
P1	--	17.22	--	13.78
P2	--	19.62	--	14.45
Bulk	--	14.35	--	11.00
Sids 12	--	20.44	--	15.00
Days to heading	**Correlated response in**			
	86.33-102.00	92.79±3.34	84.33-101.00	88.67±3.07
P1	--	94.67	--	89.00
P2	--	93.33	--	90.33
Bulk	--	93.51	--	87.25
Sids 12	--	96.00	--	92.00
Spike length (cm)	9.59-14.37	11.89±1.08	8.92-12.37	10.90±0.82
P1	--	11.22	--	10.22
P2	--	10.67	--	10.11
Bulk	--	12.15	--	11.05
Sids 12	--	12.78	--	11.67
No. of spikes / plant	5.67-8.89	7.38±0.78	5.11-7.22	6.60±0.63
P1	--	8.44	--	8.00
P2	--	7.33	--	7.00
Bulk	--	7.20	--	7.05
Sids 12	--	7.50	--	7.33
1000 kernel weight (g)	23.68-41.12	32.14±4.32	11.68-29.36	21.80±3.88
P1	--	39.16	--	25.17
P2	--	42.49	--	26.56
Bulk	--	34.46	--	22.49
Sids 12	--	39.09	--	26.01
Number of kernels/plant	305.39-501.17	403.61±39.02	272.17-422.67	338.89±35.27
P1	--	424.67	--	362.89
P2	--	393.00	--	317.22
Bulk	--	391.50	--	318.45
Sids 12	--	484.00	--	384.33

Table (6): Mean grain yield and correlated traits of highest yielding families in F4 generation under timely condition.

Selected families	Selection criteria	Correlated traits				
	Grain yield/plant	Days to heading	Spike length	No. of spikes/	1000 kernel weight	No. of kernels/
29	21.16	92.75	13.50	7.90	43.49	395.60
95	20.16	109.50	12.60	7.80	46.42	371.02
305	21.69	94.00	14.15	8.40	44.99	409.70
444	21.21	107.25	12.65	8.75	42.38	370.53
451	20.57	104.00	12.95	8.50	35.98	467.67
453	19.75	106.00	12.65	8.70	37.83	373.47
459	19.36	105.50	13.35	8.35	38.40	402.00
572	18.95	107.00	12.60	8.40	40.39	439.52
Mean	**20.36**	**103.25**	**13.06**	**8.35**	**41.23**	**403.69**
P1	18.33	99.00	11.22	8.22	40.97	370.89
P2	19.19	102.00	11.11	7.89	39.03	403.89
Bulk	17.55	103.85	12.10	8.00	37.74	392.50
Sids 12	20.03	106.00	13.44	8.00	38.82	434.56
RLSD $_{0.05}$	1.28	2.99	0.74	1.31	12.11	17.17
RLSD $_{0.01}$	1.81	4.20	1.05	1.82	18.30	23.65

The results in Tables (5, 6 and 7) showed the performance of highest yielding selected families for grain yield/plant and correlated traits in F_3 and F_4 generations under timely and late sowing dates conditions. The results indicated that the average of grain yield/plant in F_3 and F_4 selected families ranged from 11.47 to 19.28 with an average of 15.59 g/plant and from 18.95 to 21.69 with an average of 20.36 g/plant under timely sowing date condition respectively, while it ranged under heat stress from 8.09 to 15.88 with an average of 12.48 g/plant and from 16.16 to 17.69 with an average of 16.83 g/plant, respectively.

Furthermore, the average of grain yield/plant in F_3 and F_4 generation were (14.35, 19.62 and 20.44 g/plant) and (17.55, 20.89 and 20.03 g/plant) for bulk, better parent and check (Sids 12), respectively under timely condition and were (11.00, 14.45 and 15.00 g/plant) and (15.70, 15.11 and 16.11 g/plant), respectively under late sowing date condition. The selected families no. 29, 305, 444 and 451 in F_4 generation were significantly exceeded the better parent under timely condition, also the selected families no. 95, 305, 453, 459 and 572 were significantly out-yielded the high yielding parent under heat stress.

Meanwhile, the range of F_5 generation (8 and 9) varied from 19.55 to 23.69 with an average of 22.12 g/plant under timely condition and was from 16.76 to 19.17 with an average of 17.87 g/plant under heat stress condition. Furthermore, the average of grain yield/plant in F_5 generation were 19.95, 20.82 and 21.89 g/plant for bulk population, better parent and check, respectively under timely condition and were 16.48, 16.64 and 17.76 g/plant, respectively under heat condition. The selected lines of highest yielding selected lines no. 29, 95 and 305 were significantly exceeded the better parent under timely condition, also the selected lines no. 305, 444 and 453 were significantly out-yielded the high yielding parent under heat stress. Meanwhile, the selected family no. 95 was significantly exceeded the check (Sids 12) for grain yield/plant under timely condition and the selected lines no. 305 and 453 were significantly exceeded the check under heat stress conditions.

Moreover, the values of grain yield in significantly lines varied from 2.45 g for family no. 305 to 2.87 g for family no. 95 and from 1.08 g for family no. 444 to 2.57 g for family no. 453 compared with better parent under timely and heat stress environments, respectively. Meanwhile, the values of grain yield in significantly families no. 29 and 95 varied 1.87 and 1.99 g compared with the check (Sids 12) under timely condition and lines no. 305 and 453 varied 1.33 and 1.67 g compared with the check under heat stress conditions, respectively (Table 8 and 9). These results express that pedigree method of selection was more effective in improving grain yield/plant through earliness and the same major yield components.

Table (7): Mean grain yield and correlated traits of highest yielding families in F4generation under late sowing date.

Selected families	Selection criteria	Correlated traits				
	Grain yield/plant	Days to heading	Spike length	No. of spikes/ plant	1000 kernel weight	No. of kernels/ plant
29	16.26	85.25	12.50	7.20	37.76	350.80
95	16.78	96.25	11.35	7.20	37.34	334.20
305	17.49	86.75	12.40	7.70	38.02	347.10
444	16.39	99.25	11.30	7.50	37.36	347.90
451	16.16	97.25	12.10	7.15	33.21	393.00
453	17.18	97.50	11.60	7.40	33.97	369.45
459	17.32	97.75	12.15	7.05	33.26	368.15
572	17.05	98.25	11.60	7.60	35.22	348.60
Mean	**16.83**	**94.78**	**11.88**	**7.35**	**35.77**	**357.40**
P1	15.00	95.67	10.00	7.56	28.16	370.11
P2	15.11	94.33	10.44	7.33	34.42	318.11
Bulk	15.70	95.00	10.70	7.00	33.66	335.60
Sids 12	16.00	98.22	11.67	7.11	33.76	374.22
$RLSD_{0.05}$	1.42	2.49	0.86	0.57	2.89	19.32
$RLSD_{0.01}$	2.14	3.32	1.22	0.81	4.10	26.86

Table (8): Mean grain yield and correlated traits of highest yielding families in F5 generation under timely condition.

Selected families	Selection criteria	Correlated traits				
	Grain yield/plant	Days to heading	Spike length	No. of spikes/ plant	1000 kernel weight	No. of kernels/ plant
29	23.57	102.00	15.40	8.07	53.95	410.93
95	23.69	105.33	12.87	8.07	49.51	437.07
305	23.27	101.67	13.47	8.53	51.52	454.40
444	21.88	100.67	12.40	8.20	50.18	421.27
453	20.77	110.67	12.27	8.60	46.58	470.32
459	19.55	102.67	12.00	8.27	45.69	469.23
Mean	**22.12**	**103.84**	**13.07**	**8.29**	**49.57**	**443.87**
P1	19.35	105.25	12.15	7.20	40.46	430.56
P2	20.82	102.33	11.33	8.00	48.89	370.87
Bulk	19.95	102.00	10.80	7.87	51.98	412.13
Sids 12	21.70	106.00	13.73	7.53	46.11	424.00
$RLSD_{0.05}$	1.76	1.47	0.58	0.50	4.25	49.46
$RLSD_{0.01}$	2.79	1.93	0.82	0.71	6.17	70.16

Table (9): Mean grain yield and correlated traits of highest yielding families in F5generation under late sowing date.

Selected families	Selection	Correlated traits				
	Grain yield/plant	Days to heading	Spike length	No. of spikes/ plant	1000 kernel weight	No. of kernels/ plant
29	16.76	93.00	14.13	7.60	44.11	360.00
95	17.23	91.67	12.13	7.47	41.96	391.40
305	18.83	93.00	12.27	8.33	41.87	431.27
444	17.68	92.00	12.40	8.13	39.50	403.13
453	19.17	94.00	11.53	8.40	37.55	415.53
459	17.56	92.67	10.73	7.73	38.85	387.40
Mean	**17.87**	**92.72**	**12.20**	**7.94**	**40.64**	**398.12**
P1	16.54	93.33	11.05	7.05	35.49	384.60
P2	16.60	94.67	10.00	7.80	35.79	394.40
Bulk	16.48	93.33	10.60	7.20	43.83	309.20
Sids 12	17.50	93.00	11.87	7.20	39.57	370.00
$RLSD_{0.05}$	1.06	1.14	0.76	0.45	5.07	59.74
$RLSD_{0.01}$	2.01	1.68	1.06	0.67	7.47	83.05

The observed and expected responses of high yield selection under timely and heat stress conditions presented in Tables (10 and 11). The results indicated that the observed responses of the high yield families compared with bulk, better parent and check (Sids 12) were (16.01, 6.10 and 1.65 %) and (7.20, 11.38 and 5.19 %) in F_4 families under timely and heat stress conditions, respectively and were (10.88, 6.24 and 1.94 %) and (8.04, 2.11 and 7.65 %) in F_5 families under timely and heat stress conditions, respectively. Also, the observed direct response to selection for grain yield in F_4 and F_5 resulted in significant positive observed gain compared with bulk, better parent and check under the different conditions. On the other hand, the expected responses to selection were 6.89 and 11.60 % in F_4 generation and were 2.36 and 4.60 % in F_5 generation under timely and heat stress conditions, respectively. These results are in agreement with many studies, El-Morshidy et al. (2010), Mahdy et al (2012), Salous et. al. (2014), Mutawe el. Al. (2018).

Table (10): The observed and expected responses to selection in F4 generation for all studied traits of highest yielding families under timely (N) and heat stress (s) conditions.

Traits	Conditions	Response to selection as deviation from							
		Bulk		Best patent		Check (Sids 12)		Expected response	
		unit	%	unit	%	unit	%	unit	%
Grain yield / plant	N	Direct response						1.39	6.89
		2.81**	16.01**	1.17*	6.10**	0.33	1.65**		
	S	1.13	7.20**	1.77	11.38**	0.83	5.19**	1.87	11.60
Days to heading	N	Correlated response in						2.69	2.57
		-0.60	-0.58	4.25**	4.29**	-2.75*	-2.59*		
	S	-0.22	-0.23	0.45	0.48	-3.44**	-3.50**	3.93	3.97
Spike length	N	0.96**	7.93**	1.84**	16.40**	-0.38	-2.83**	0.71	5.58
	S	1.18**	11.03**	1.44**	13.79**	0.21	1.80**	1.07	9.22
No. of spikes/plant	N	0.35	4.38**	0.13	1.58**	0.35	4.38**	0.69	8.70
	S	0.35	5.00**	-0.21	-2.78**	0.24	3.38**	0.43	6.04
1000 kernel weight	N	3.49	9.25*	0.26	0.63	2.41	6.21	2.70	6.62
	S	2.11	6.77**	1.35	3.92**	2.01	5.95**	2.33	6.42
No. of kernel/plant	N	11.19	2.85	-0.20	-0.05	-30.87**	-7.10	20.76	4.98
	S	21.80**	6.50	-12.71	-3.43	-16.82*	-4.49	23.37	6.49

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

Table (11): The observed and expected responses to selection in F5 generation for all studied traits of highest yielding families under timely (N) and heat stress (s) conditions.

Traits	conditions	Response to selection as deviation from							
		Bulk		Best patent		Check (Sids 12)		Expected response	
		unit	%	unit	%	unit	%	unit	%
Grain yield / plant	N	Direct response						0.52	2.36
		2.17**	10.88**	1.30	6.24**	0.42	1.94*		
	S	1.33	8.04**	0.37	2.11*	1.27	7.65**	0.87	4.60
Days to heading	N	Correlated response in						3.93	3.90
		-1.41*	-1.34*	1.51*	1.48**	-2.16**	-2.04**		
	S	-0.28	-0.30	-0.28	-0.30	-0.61	-0.65	0.87	4.60
Spike length	N	0.92**	7.57**	1.74**	15.36**	-0.66*	-4.81**	0.81	6.03
	S	1.15**	10.41**	0.33	2.78**	1.60**	15.09**	0.14	1.14
No. of spikes/plant	N	1.09**	15.14**	0.29	3.62**	0.76**	10.09**	0.16	2.05
	S	0.89**	12.62**	0.74**	10.28**	0.14	1.79**	0.21	2.72
1000 kernel weight	N	9.11**	22.52**	-2.41	-4.64**	3.46*	7.50**	0.78	1.63
	S	5.19**	14.62**	1.11	2.81	-3.15	-7.19**	0.95	2.32
No. of kernel/plant	N	13.31	3.09	31.74	7.70	19.87	4.69	29.19	6.65
	S	13.52	3.52	28.12	7.60	3.72	0.94	42.75	10.98

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

A-3-Effects of selection for grain yield under timely and heat stress conditions on other traits

Variance and means

Results of the analysis of variance (Table 3) revealed significant differences for heading date, spike length, no. of spikes/plant, 1000 kernel weight and no. of kernels/plant in F_3, F_4, F5 generations.

Data in Tables (6 and 7) indicated that the average of days to heading under timely condition ranged from 92.75 to 109.50 with an average of 103.25 days for F_4 families and ranged from 85.25 to 99.25 with an average of 94.78 days under late sowing date condition. Furthermore, the average of days to heading in F_4 generation for bulk population, early parent and check were (103.85, 102.33 and 106.00 days) and (95.00, 94.33 and 98.22 days) under timely and heat conditions, respectively. The range of days to heading under timely condition (Tables 6 and 7) varied from 100.67 to 110.67 with an average of 103.84 days and was from 91.67 to 94.00 with an average of 92.72 in F_5 generation under heat stress condition. Furthermore, the average of days to heading in F_5 generation for bulk, early parent and check were (102.00, 99.00 and 106.00 days) and (93.33, 93.00 and 93.00 days) under timely and heat conditions, respectively. The results in F_5 generation showed that one line (no. 444) of highest yielding selected lines was significantly earlier than the earlier parent in days to heading under heat stress conditions. Meanwhile, under timely condition families no. 29 and 305 of highest yielding selected families was significantly earlier than the check (Tables 6 and 7). These results showed that direct selection for grain yield under heat stress was not associated with isolating early genotypes.

The average spike length in F4 generation (Tables 6 and 7) was 13.06 cm with a range from 12.60 to 14.15 and from 11.30 to 12.50 with an average of 11.88 cm under timely and heat stress conditions, respectively. Meanwhile, the average of spike length for bulk population, better parent and check were (12.10, 11.22 and 13.44 cm) and (10.70, 10.44 and 11.67 cm) under timely and heat environments, respectively. The average spike length in F_5 generation (Tables 8 and 9) ranged from 12.00 to 15.40 with an average of 13.07 cm and from 10.73 to 14.13 with an average of 12.10 cm under the two environments, respectively. Meanwhile, the average of spike length for bulk population, better parent and check were (10.80, 12.15 and 13.73 cm) and (10.60, 11.05 and 11.87 cm) under timely and heat conditions, respectively. Three lines, i.e., no. 29, 95 and 305 in F_5 generation under timely and heat stress conditions was significantly longer than the better parent. While one line i.e., no. 29 under timely and heat stress conditions was significantly longer the check (Sids 12). These results revealed that direct selection for grain yield under heat stress increased spike length and the results refer to the positive association between grain yield and spike length.

The average no. of spikes/plant (Tables 6 and 7) ranged from 7.80 to 8.75 with an average of 8.35 spikes/plant and from 7.05 to 7.70 with an average of 7.35 spikes/plant in F4 generation under timely and heat stress conditions, respectively. Furthermore, the average of no. of spikes/plant for bulk, better parent and check cultivar were (8.00, 8.22 and 8.00 spikes/plant) and (7.00, 7.56 and 7.11 spikes/plant) under timely and heat conditions, respectively. The range of no. of spikes/plant (Tables 8 and 9) varied from 8.07 to 8.53 with an average of 8.29 spikes/plant and from 7.47 to 8.40 with an average of 7.94 spikes/plant in F_5 generation under the two environments, respectively. Furthermore, the average of no. of spikes/plant for bulk population, better parent and check were (7.87, 8.00 and 7.53 spikes/plant) and (7.20, 7.80 and 7.20 spikes/plant) under timely and heat conditions, respectively. Two lines, i.e., no. 305 and 453 in F_5 generation under timely and late sowing dates for no. of spikes/plant were significantly higher than the better parent. While, four lines, i.e., no. 305, 444, 453 and 459 under timely and heat stress conditions surpassed the check cultivar (Sids 12). These results showed that direct selection for grain yield under heat stress was relatively effective in improving no. of spikes/plant and the results refer to the positive association between grain yield and no. of spikes/plant.

Mean 1000-kernel weight (Tables 6 and 7) was 41.23 g with a range from 35.98 to 46.42 and from 33.21 to 38.02 with an average of 35.77 g in F4 generation for highest yielding selected families under timely and heat stress, respectively. While the average of 1000-kernel weight were 37.74, 40.97 and 38.82 g for bulk population, better parent and check (Sids 12), respectively under timely condition and were 33.66, 34.42 and 33.76 g for bulk, better parent and check, respectively under heat stress condition. The average 1000-kernel weight in F_5 generation (Tables 8 and 9) ranged from 45.69 to 53.95 with an average of 49.57 and from 37.55 to 44.11 with an average of 40.64 g under the two conditions, respectively. While the average of 1000-kernel weight were 51.98, 48.89 and 46.11 g for bulk population, better parent and check, respectively under timely condition and were 43.83, 35.79 and 39.57 g for bulk population, better parent and check, respectively under heat condition. One line, i.e., no. 29 under timely condition were significantly higher than the better parent and two lines, i.e., no. 29 and 305 under heat stress surpassed the check. Meanwhile, three lines, i.e., no. 29, 95 and 305 under heat condition were significantly higher than the better parent and These results indicated that direct selection for grain yield was relatively effective in improving 1000-kernel weight under heat stress. The results refer to the positive association between grain yield and 1000-kernel weight.

The average no. of kernels/plant in F_4 generation (Tables 6 and 7) was 357.40 with a range from 334.20 to 393.00 and from 370.53 to 467.67 with an average of 403.69 under timely and heat stress, respectively. Meanwhile, the average of no. of kernels/plant for bulk population, better parent and check were (335.60, 370.11 and 374.22) and (292.50, 403.89 and 434.56) under timely and heat conditions, respectively. The average no. of kernels/plant in F_5 generation (Tables 8 and 9) ranged from 410.93 to 470.32 with an average of 443.87 and from 360.00 to 431.27 with an average of 398.12 under the two conditions, respectively. Meanwhile, the average of no. of kernels/plant for bulk population, better parent and check were (412.13, 430.56 and 424.00) and (309.20, 394.40 and 370.00) under timely and heat conditions, respectively. One line, i.e., no. 305 of highest yielding selected lines in F_5 generation significantly exceeded the check cultivar (Sids 12) under heat stress condition. These results revealed that direct selection for grain yield was relatively effective in improving no. of kernels/plant under heat stress, also they reflect the positive associations between grain yield and no. of kernels/plant.

B-Heat susceptibility index (HSI)

The results indicated that the values of heat susceptibility for the highest yielding lines (Table 12) ranged from 0.59 to 1.30 and from 0.40 to 1.50 in F4 and F5 generations, respectively. The results also showed that three lines in F4 and F5 generations were superior lines for heat tolerance of the selected lines gave the low value of heat susceptibility index (HSI < 1) and the highest grain yield under heat stress conditions. These results are in harmony with the results of Modarresi et. al. (2010), Salous et. al. (2014), Padam et. al. (2020), Mohiy et al., (2021).

Table (12): The heat susceptibility index (HSI) and grain yield of lines selected for high yield in the F4 and F5 generations.

Number of Lines	F_4 generation			F_5 generation		
	Grain yield/plant			Grain yield/plant		
	Timely	**Heat**		**Timely**	**Heat**	
29	21.16	16.26	1.30	23.57	16.76	1.50
95	20.16	16.78	0.94	23.69	17.23	1.42
305	21.69	17.49	1.09	23.27	18.83	0.99
444	21.21	16.39	1.28	21.88	17.68	1.00
453	19.75	17.18	0.73	20.77	19.17	0.40
459	19.36	17.32	0.59	19.55	17.56	0.53

Finally, it could be concluded that heat susceptibility index indicated that heat tolerance could be due to high yield potential and / or low susceptibility to stress (HSI < 1). The two lines, i.e., no. 453 and 459 in F_4 and F_5 generations produced relatively high grain yield under heat stress environments due to high yield potential, rather than having low susceptibility to stress environments. These lines could be used as source of heat tolerance / or factors contributing to general adaptation. 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 heat (HSI < 1) is synonymous with higher stress resistance, Fischer and Marurer (1978).

REFERENCE

Alam, M.A.; Rahman, M.; Ahmed, S.; Jahan, N.; Khan, M.A.-A.; Islam, M.R.; Alsuhaibani, A.M., Gaber, A.; Hossain, A. (2022) Genetic Variation and Genotype by Environment Interaction for Agronomic Traits in Maize (Zea mays L.) Hybrids. Plants, 11, 1522.

Ali MA, 2011. Pedigree selection for grain yield in spring wheat (Triticum aestivum L.) under drought stress conditions. Asian J. of Crop Sci. 3, 158-168.

Burton GW (1952). Quantitative inheritance of grasses. In: Proceedings 6 th International Grassland Congress 1: 273-283.

Dagnaw, T.; Mulugeta, B.; Haileselassie, T.; Geleta, M.; Tesfaye, K. (2022) Phenotypic Variability, Heritability and Associations of Agronomic and Quality Traits in Cultivated Ethiopian Durum Wheat (*Triticum turgidum* L. ssp. Durum, Desf.). Agronomy, 12, 1714.

El-Morshidy, M.A.; K.A.A. Kheiralla, M.A. Ali A.A. Said (2010). Response to selection for earliness and grain yield in wheat (Triticum aestivum L.) under normal and water stress conditions. Assiut J. of Agric. Sci., 41: 1-23.

FAOSTAT (2020). Food and Agriculture Organization of the United Nations. http://faostat.fao.org.

Fischer, R.A. and R. Maurer, (1978). Drought resistance in spring wheat cultivars. Part 1: Grain Yield Response, Aust. J. Agric. Res., 29: 897–912.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures in Agricultural Research. 2 nd Edn. Willey, New york.

Hammam, K.A. (2008). Pedigree selection in F3 and F4 generations for grain yield of durum wheat. Assiut J. of Agric. Sci., 39:1-11.

Hu, H. & S. Rajaram, 1994. Differential responses of bread wheat characters to high temperature. Euphytica 72: 197–203.

Kumar N, Markar S, Kumar V (2014). Studies on heritability and genetic advance estimates in timely sown bread wheat (Triticum aestivum L.). Bioscience Discovery, 5(1): 64-69.

Mahdy, Rasha, E. 2012. Response to selection for earliness and yield in bread wheat under normal and drought conditions. Ph.D. Thesis, Fac. Agric. Assiut Univ. Agron. Dept. Egypt.

Modarresi, A., Mohammadi, V., Zali, A. and Mardi, M. (2010) 'Response of Wheat Yield and Yield Related Traits to High Temperature' Cereal Research Communications 38(1): pp. 23–31.

Mohiy, M., M.S. Salous and Omnya M.A. Elmoselhy (2021) Influence of sowing dates and temperature variability on bread wheat productivity for some exotic and Egyptian genotypes under upper Egypt conditions. SVU-International Journal of Agricultural Sciences, 3 (4): 172-179.

Mutawe, A. A., M. K. Omara, K. A. Amein and T. Bashandy (2018) Response to Selection for Grain Filling Capacity in Wheat (Triticum aestivum L.) under Heat Stress. J. Agric. Chem.and Biotechn., Mansoura Univ., 9(4): 105 – 110.

Padam, B.P. and Mukti, R.P. (2020) 'Heat Stress Effects and Tolerance in Wheat' A Review. Journal of Biology and Today's World. 9(3): pp. 217.

Petersen, R. G. (1985), Design and Analysis of Experiments, Marcel Dekker, Inc., New York and Basel 1985, 436 pp.

Prakash, R.; Ravikesavan, R.; Vinodhana, N.K.; Senthil, A. (2019) Genetic variability, character association and path analysis for yield and yield component traits in maize (Zea mays L.). Electron. J. Plant Breed., 10, 518–524.

Reynolds, M.P.; Nagarajan, S.; Razzaque, M.A. and O.A.A Ageeb. 2001. Heat stress. In: Reynolds MP, Ortiz-Monasterio JI and McNab A (eds) Application of physiology in wheat breeding. Mexico, D.F CIMMYT.

Salous, M.SH., M.A. El-Morshidy, K.A. Kheiralla and M.Kh. Moshref (2014) Selection for Grain Yield in Bread Wheat (Triticum aestivum L.) Under Normal and Heat Stress Conditions. Assiut J. Agric. Sci., 45 (2): 1-18.

Shpiler, L. & A. Blum, 1991. Heat tolerance for yield and its components in different wheat cultivars. Euphytica 51: 257–263.

Singh B, UpadhyayPK (2013). Genetic Variability, Correlation and Path Analysis in Wheat (Triticum aestivum L.). Indian Res. J. Genet. &. Biotechnol. 5(3): 197-202.

Smith J.D. and M.L. Kinman (1965). The use of parent offspring regression as an estimator of heritability. Crop Sci., 5: 595-596.

Tesfaye Wolde, Firdisa Eticha, Sentayehu Alamerew,Ermias Assefa and Dargicho Dutamo (2016) Genetic variability, heritability and genetic advance for yield and yield related traits in Durum wheat (Triticum durum L.) accessions. Sky Journal of Agricultural Research, 5(3):042 – 047.

الملخص العربي

الاستجابة للانتخاب لمحصول الحبوب في عشيرة قمح خبز تحت ظروف الاجهاد الحراري

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أجريت هذه الدراسة في مزرعة خاصة بمدينة طهطا - محافظة سوهاج – جمهورية مصر العربية خلال المواسم الشتوية الأربعة التالية 2017/2016 2018/2017 و2019/2018 و2020/2019 لتقدير الاستجابة للانتخاب للمحصول العالي للحبوب في عشيرة قمح خبز للهجين (دبيرة x سنورة) في أجيال F2 وF3 و4F و F5 تحت ظروف ميعاد الزراعة المثلي والمتأخر (الاجهاد الحراري). أظهرت نتائج تحليل التباين وجود فروق معنوية بين التراكيب الوراثية في F3 وF4 وF5 تحت ظروف الزراعة المثلى والمتأخرة لصفات عدد الايام حتي طرد السنابل وطول السنبلة وعدد حبوب النبات و ووزن الالف حبة ومحصول حبوب النبات. كما أشارت نتائج الدراسة ايضا الي أن الاستجابة المشاهدة لانتخاب محصول الحبوب في أجيال F4 وF5 ادت إلى تحقيق نتائج إيجابية ومعنوية مقارنة بالعشيرة المجمعة والاب الافضل وصنف المقارنة (سدس 12) تحت ظروف ميعاد الزراعة المثلي والمتأخر (الاجهاد الحراري)، من ناحية أخري، الاستجابة المتوقعة للانتخاب كانت 6.89 و11.60٪ في جيل F4 وكانت 2.36 و4.60٪ في الجيل F5 تحت ظروف ميعاد الزراعة المثلي والمتأخر على التوالي. كما كانت قيم درجة التوريث بالمعني الضيق 55.02 و44.50 و27.83٪ في أجيال F3 وF4 وF5 تحت ظروف الزراعة المثلي على التوالي. وفي الوقت نفسه، كانت 55.44 و57.05 و24.68٪ في نفس الأجيال علي التوالي تحت ظروف الاجهاد الحراري. أظهرت هذه النتائج أن طريقة الانتخاب مع تسجيل النسب كانت فعالة في إنتاج سلالات جديدة تتحمل الإجهاد الحراري مع إنتاجية عالية نسبيا من الحبوب. كما أظهر معامل الحساسية للإجهاد الحراري ان التراكيب الوراثية أرقام 453 و459 في أجيال F4 وF5 محصول حبوب مرتفع نسبيًا تحت الإجهاد الحراري مع معامل حساسية منخفض (أقل من واحد) والتي يمكن استخدامها في برامج التربية لإنتاج سلالات أو أصناف عالية المحصول وعالية في تحمل الاجهاد الحراري.