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SELECTION FOR EARLINESS, YIELD AND ITS COMPONENTS IN BREAD WHEAT

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ABSTRACT

Developing new varieties with ideal genetic makeup to increase the yield potential under abiotic stresses is the first aim for wheat breeders to increase production area and narrow the gap between the local production and consumption. This investigation was carried out during three seasons: 2015/16, 2016/17 and 2017/18 at Toshka Agricultural Experiment Station of Desert Research Center, Aswan governorate, Egypt. Ten divergent parents of bread wheat were obtained (3, 4 and 3 genotypes from the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), International Center of Agricultural Research in the Dry Areas (ICARDA) and International maize and wheat improvement center (CIMMYT), respectively)and their five crosses were used. Two cycles of Pedigree selection method were applied. First selection was practiced for the earliest lines in heading in F_2 generation for sixty families and 300 plants from each cross and they were evaluated with their parents. The second selection cycle was done for greater number of grains per spike and 100-kernel weight in F_3 plants. In F_3 data were recorded on number of days to heading (days), number of days to maturity (days), plant height (cm), number of spikes/plant, number of spikelets/spike, 100-kernel weight (g), number of grains per spike and grain yield for each individual plant (g) for P_1, P_2 and F_3 families by using the randomized block design. Highly significant differences were registered among F_3 families for all traits under study. Mean performance for the five F_3 families and parents showed that selected plants of the two crosses (4 and 5) were the earliest in days to heading (72.29 and 69.40 days) and days to maturity (111.37 and 106.91 days) and had the highest values for all traits under study that ranged from 6.97 g for 100 kernel weight to 124.99 cm for plant height in cross 5. While, the estimates of genetic variance within selected plants were higher than those among families for most studied traits in all studied crosses. Narrow sense heritability values were relatively medium to high for the five crosses ranged from 50.33% for maturity date in the cross 3 to 98.60% for heading date in the cross 2. These values were not much lower than the broad sense heritability in all crosses. The genetic variances among the F_3 families exceeded corresponding environmental variances for most traits. The selected 33 plants from 4500 of F_3 families considered to be superior segregants and could be promoted to the F_4 generation to produce promising and improved pure lines and/or used as useful germplasm for future bread wheat breeding programs under stress conditions in Toshka.

Key words: ***Bread wheat (Triticum aestivum), F_3, Transgressive segregation, Yield and its components, Heritability, Genetic advance, Heat stress.***

INRRODUCTION

Bread wheat is the most important widely adapted consumed food cereal in the world. In Egypt, Bread wheat is the first food crop planted in winter season with 1.37 million hectares in the 2018/19 produced 9.2 million tons, However, the gap between the local production and consumption reached 30.83% and continuously increasing due to increasing population with a limited cultivated area. This gap led to the purchase of about 3.7 million tons in 2019/20 that cost about 86 billion EGP (4.8 billion

USD) (FAO 2020). Therefore, Egyptian wheat breeders are concentrating their efforts to meet challenges of food subsidy schemes via increased area and improving the yield potential of wheat to meet the future goals. Therefore, we need detailed information about the nature of gene action, heterosis, inbreeding depression, heritability and predicated genetic gain for yield and its components. These targets could be realized by breeding new high yielding, early maturing, drought, heat and salt tolerant wheat varieties.

Grain yield is a complex character made up of the interaction among different yield components and environmental factors. Through breeding programs (especially in the early generations) yield components should be used as selection criteria for yield improvement for this reason it is necessary to know the genetic architecture of yield components (Misra *et al* 1994). Bread wheat is very sensitive to high temperature which affects the metabolic pathways at every stage of plant development leading to considerable losses in yield (Akter and Islam 2017). Heat stress resulting from the global rise in temperature which is predicted to continue throughout the 21st century (IPCC 2014) adds a further constraint to global wheat production which is expected to dwindle by 6% for every degree Celsius increase (Asseng *et al* 2015). Reduction of number of grains per spike in response to high temperature has also been reported by Kumar *et al* (2016). The terminal heat stress (> 30 ºC) that develops in Egypt at the end of wheat growing season coincides with postanthesis phases of plant development. The adverse effects of high temperature are particularly severe on grain filling, grain yield, biomass, grain number and harvest index which might be reduce yield by 40% (Balla *et al* 2009, Mohammadi *et al* 2011 and Kumar *et al* 2016).

Therefore, enhancing tolerance to heat stress could be approached by: first increasing the assimilating green area of the plant after anthesis, and second, increasing number of grains per spike. Early heading cultivars out-performed later heading cultivars because of two distinct advantages, the early heading cultivars had longer post-heading period. Therefore, longer grain filling period is generally more favorable than the later heading cultivars (Maydup *et al* 2010 and Mohamed *et al* 2019). The results of Tewolde *et al* (2006) suggested that early heading is an important and effective single trait defining wheat cultivars adapted to production systems prone to high temperature stress during the post-heading period. Heading date in wheat is an easily identifiable character that can be modified through selection (Allard and Harding 1963 and Avey *et al* 1982). Meanwhile, May and Van Sanford (1992), Ali (2012) and El Ameen (2012) reported that direct response to selection for the days to heading, grain yield and 1000-grain weight showed highly significant differences among F_3 families and estimates of genetic gains for heading date was earlier by 4.10 and 6.91%. While for improved grain yield/plant ranged from 1.69 to 12.20 %. Based on the evaluated genetic parameters, selection in advanced generations might be effective for number of grains per spike, 1000 grains weight, fertile tillers number and grain yield, due to dominance and epistatic effects (Erkul *et al* 2010). High heritability estimates resulting in high genetic advance for yield components in wheat offer better scope for selection of genotypes in early segregating generations (Singh *et al* 2001 and Memon *et al* 2007).

The present study was carried out to determine genetic gain for days to heading, grain yield and its components after two cycles of selection. Estimate of generations' variances in five crosses of bread wheat and heritability of traits related to maturity such as grain yield and to develop early heading advanced lines adopted to production under heat stress in Toshka region.

MATERIALS AND METHODS

Field experiment was conducted at Toshka Agricultural Experiment Station of Desert Research Center, Aswan governorate, Egypt, (latitude of 22° 28' 13.7" N, longitude 31° 32' 22.3" E and an elevation of 201 m above sea level), during the three successive seasons of 2015/16, 2016/17 and 2017/18. The initial plant materials composed of five segregating (F_2) populations of bread wheat derived from five crosses established among 10 divergent genotypes which had differences in heading, maturity and yield components; (3, 4 and 3 genotypes from the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), International Center of Agricultural Research in the Dry Areas (ICARDA) and International maize and wheat improvement center (CIMMYT), respectively) the name and pedigree of genotypes (parents) are presented in Table (1).

Table 1. The pedigree, source and origin of the 10 parental lines of 5 bread wheat crosses.

Crosse	Source	Pedigree and/or selection history
		Cross 1
Line-1	**ACSAD**	**ATTILA-3//NESMA*2/261-9/3/JOHAR-10**
Line-2	**CIMMY**	**WBLL1*2/VIVITSI/4/D67.2/P66.270//AE.SQUARROSA(32**
Cross 2		
Line-3	**ACSAD**	**TRCH//PRINIA/PASTOR**
Line-4	**ICARDA**	**C80.1/3*BATAVIA//2*WBLL1/5/REH/HARE//2*BCN/…**
		Cross 3
Line-5	**ICARDA**	**SOKOLL/ROLF07**
Line-6	**CIMMY**	**FRET2*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ/5/…**
		Cross 4
Line-7	**ICARDA**	**GK ARON/AG SECO**
Line-8	**CIMMY**	**YUNMAI48//2*WBLL1*2/KURUKU**
		Cross 5
Line-9	**ACSAD**	**FRET2*2/KUKUNA//FRET2/3/TUKURU/4/FRET2/TUKU**
Line-	**ICARDA**	**WBLL1*2/VIVITSI/4/D67.2/P66.270//AE.SQUARROSA(32**

ACSAD ; Arab Center for the Studies of Arid Zones and Dry Lands, Syria.
CIMMYT; International maize and wheat improvement center, Mexico.
ICARDA ; International Center of Agricultural Research in the Dry Areas, Syria.

Drip irrigation system was applied in these experiment using drippers with total amount of water irrigation (3000 m^3/fed) there is no amount of rainfall registered in the three seasons for Meteorological data (the monthly mean of temperature, relative humidity and wind speed) are presented in Table (2). While, soil of the experimental site was sandy in texture, calcareous of CaCo3 reached 3.87and 4.51 % (Table 3). Sowing date was 20, 22 and 27 November in the three seasons, respectively while plot area was of 5 x 5 m. The recommended dose of phosphatic fertilizer at rate (50 Kg P_2O_5/fed.) was added during seed bed preparation, whereas nitrogen fertilizer at rate of 60 kg N/fed. was applied as ammonium sulfate (20.5% N) where 1/3 of the amount was incorporated in dry soil before sowing, 1/3 was added one week before panicle initiation growth stage 18 and the rest was added at grain filling period growth stage 50 of Zadoks' scale (Zadok *et al* 1974).

Table 2. Monthly average weather data at Toshka during 2015/16, 2016/17 and 2017/18 growing seasons.

Month	Avg.T†	Min. T†	Max. T†	R.H. •	W.S.♦	Amount
2015/16 season						
Nov.2015 (Mean)	23.12	16.11	30.17	46.28	14	0
Dec.2015 (Mean)	18.43	11.76	25.25	44.51	17	0
Jan.2016 (Mean)	16.50	9.42	23.77	40.70	12	0
Feb.2016 (Mean)	18.34	10.53	26.16	44.18	19	0
March.2016(Mean)	22.17	14.12	30.28	48.21	22	0
April.2016(Mean)	27.13	18.80	35.47	50.67	18	0
May.2016(Mean)	31.29	23.25	39.13	46.8	16	0
2016/17 season						
Nov.2016 (Mean)	25.43	17.72	33.19	50.91	15	0
Dec.2016 (Mean)	21.01	13.41	28.79	48.46	19	0
Jan.2017 (Mean)	19.47	11.12	28.05	48.03	14	0
Feb.2017(Mean)	20.17	11.58	28.78	48.60	21	0
March.2017 (Mean)	25.27	16.10	34.52	54.96	25	0
April.2017 (Mean)	26.70	16.14	33.26	59.79	21	0
May.2017 (Mean)	30.74	22.70	38.78	51.48	18	0
2017/18 season						
Nov.2017 (Mean)	26.59	18.53	34.70	53.22	16	0
Dec.2017 (Mean)	20.83	13.29	28.53	48.04	19	0
Jan.2018 (Mean)	19.64	11.21	28.29	48.43	14	0
Feb.2018(Mean)	20.91	12.00	29.82	50.37	22	0
March.2018 (Mean)	24.61	15.67	33.61	53.51	24	0
April.2018 (Mean)	28.67	19.25	38.08	60.30	21	0
May.2018 (Mean)	32.19	23.50	40.87	53.82	18	0

†T = Temperature, ● R.H. % = Relative humidity percentage, ♦ W.S. = Wind speed.

Table 3. Soil physical and chemical properties for the experimental site at Toshka region.

A) Soil physical analysis					
Depth (cm)	Coarse sand %	Fine sand %	Silt %	Clay %	Texture
0-15	37.15	55.37	2.22	5.29	Sandy
15-30	54.17	33.24	3.46	9.13	Sandy

B) Soil chemical analysis											
Depth (cm)	pH	ECe dSm^{-1}	$CaCo_3$	Organic matter (%)	Soluble cations (mg/l)				Soluble anions (mg/l)		
					Na^+	Ca^{++}	Mg^{++}	K^+	HCO_3^-	Cl^-	So_4^{--}
0-15	7.39	2.26	3.87	0.24	92	48	11	48	288	64.50	97.30
15-30	7.72	2.03	4.51	0.15	50	75	19	33	192	65.00	139.45

In 2015/16 growing season, the parental genotypes were crossed to produce the five F_1's, crosses as shown in (Table 1). While, two cycles of Pedigree selection method were applied as follows; In 2016/17 growing season, the first cycle, divergent phenotypic selection for the earliest lines in heading and maturity dates were employed in each of the five F_2 populations (a selection intensity of 10%) were selected from a total of 600 plants of each population which grown in 40 rows of 15 plants each, spaced 30 cm within rows set 30 cm apart. In 2017/2018 growing season, the second cycle with directional phenotypic selection for greater number of grains per spike and 100-kernel weight was applied to the F_3 plants selected for earliest lines in heading and maturity dates of each population which were grown under heat stress environment of Toshka. The earliest plants with the greater number of grains per spike and 100-kernel weight (900 plants for the five crosses) were selected (a selection intensity of 10%) from 60 F_3 plants of each population with (plants pooled across blocks).

In each row, data were taken on five random competitive plants (tagged and numbered) for P_1, P_2 and F_3 families by using the randomized complete block design (RCB). Data were recorded on number of days to heading (days), number of days to maturity (days), plant height (cm), number of spikes/plant, number of spikelets/spike, 100-kernel weight (g), number of grains per spike and grain yield for each individual plant (g). Data were analyzed to test the differences among families and differences among parental genotypes for each cross using "t" test according to (Fisher and Yates 1938 and Snedecor and Cochran 2014). Basic generations' variances for each cross including the three populations (P_1, P_2 and F_3) were statistically analyzed on plot mean and individual plant bases and the heritability in the broad (h^2_b) and narrow (h^2_n) senses for F_3 family was done according to (Hallauer *et al* 2010). These values were used in the estimation of additive and dominance genetic variances. A direct F test was made to determine if the differences among F_3 families are significant. The expected genetic advance from selection (Δg) was computed according to (Lush 1940 and Johanson *et al* 1955).

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance (ANOVA) among families (F.) and within selected plants (S.P.) derived from the five populations for 900 F_3 lines of bread wheat under Toshka conditions are presented in Table 4. Mean squares of variance were significant and/or highly significant among the F_3 families in all crosses, indicating sufficient differences in their genetic constitution as well as the possibility of selection among these families and within plants.

Table 4. Analysis of variance for the differences among F_3 families (F.), within selected plants (S.P.) and significance of differences among parents (T.) of five bread wheat crosses for all studied traits under Toshka conditions.

Crosses	SOV	df	Traits							
			Days to 50% heading	Days to 50% maturity	Plant height (cm.)	No of spikes/ plant	No of spikelets/ spike	100-kernel weight (g.)	No of grains/ spike	Grain yield/ Plant (g.)
Cross 1	R.	2	3.00	6.04	7.21	0.35	1.55	0.01	20.55	2.94
	F.	٥٩	153.17**	176.42**	289.77**	11.34**	49.14**	0.31**	312.49**	115.61**
	Error	118	5.10	62.24	15.19	0.65	2.99	0.02	56.94	8.78
	S.P.	720	90.33	105.86	143.79	7.21	30.45	0.22	149.74	82.12
	T test		ns	**	n.s	**	**	**	**	**
Cross 2	R.	2	1.85	40.50	95.99	0.60	2.43	0.02	40.62	5.50
	F.	٥٩	171.63**	164.52**	336.93**	12.00**	52.52**	0.33**	333.58**	127.75**
	Error	118	2.37	69.94	7.83	0.93	5.36	0.03	63.98	9.87
	S.P.	720	85.99	76.58	179.88	6.24	25.5	0.24	160.94	70.15
	T test		**	**	**	n.s	n.s	**	n.s	**
Cross 3	R.	2	1.86	37.29	10.01	0.64	2.89	0.01	53.01	6.89
	F.	٥٩	159.87**	151.62**	367.40**	13.76**	60.05**	0.39**	367.38**	142.82**
	Error	118	2.18	64.47	16.55	0.82	4.78	0.02	71.87	11.09
	S.P.	720	105.51	86.06	181.1	8.27	30.56	0.21	192.3	73.31
	T test		**	**	n.s	n.s	**	**	**	**
Cross 4	R.	2	1.95	34.45	13.62	0.58	6.21	0.02	27.09	5.12
	F.	٥٩	147.07**	139.72**	411.75**	15.58**	55.84**	0.42**	445.40**	163.03**
	Error	118	2.01	59.37	17.36	0.92	14.25	0.04	80.79	12.46
	S.P.	720	93.08	95.59	202.47	10.3	28.63	0.3	200.82	93.72
	T test		**	**	n.s	**	n.s	**	**	**
Cross 5	R.	2	2.27	31.77	19.02	0.65	63.06	0.02	42.71	4.35
	F.	٥٩	133.11**	128.76**	450.33**	17.54**	17.76**	0.49**	488.11**	184.55**
	Error	118	3.85	54.75	28.27	1.03	4.77	0.03	90.75	14.00
	S.P.	720	84.68	65.15	224.01	10.34	9.71	0.27	235.52	104.18
	T test		**	**	n.s	**	**	**	**	**

***,** Denote significance at $P \leq 0.05$ and 0.01 probability level, respectively.**

Highly significant differences were registered among F_3 families (F.) for all traits as well as T test between the ten parents (at 0.01 or 0.05 probability) for all crosses and traits under study except for, days to heading in cross 1, plant height in crosses 1, 3, 4 and 5, no of spikes/plant in the two crosses 2 and 3, no of spikelets/spike in the two crosses 2 and 4 and no of grains/spike in cross 2 indicating to sufficient differences in their genetic constitution, the variability that existed among families and the presence of wide diversity among selected lines. Generally all the previous results reflect suitable of this base population to practice the direct selection for earliness in the first cycle and both number of grains per spike and 100 kernel weight in the second cycle. The obtained results were in agreement with one or more of those reported by Khaled (2013), Aglan and Farhat (2014a and b), Kumar *et al* (2016), Abbasi *et al* (2017), Sowmya *et al* (2017), Darwish *et al* (2018) and Mohamed *et al* (2019).

Mean performance of bread wheat genotypes

The mean performance for different bread wheat parents and F_3 families obtained from the five crosses are presented in Table (5). Results showed significant difference among parents and F_3 families for all studied traits under Toshka conditions. Results showed that the ranges of the performance of the F_3 families exceeded the limits of the minus and plus directions of their parents for all traits, the F_3 selected families was earlier in heading and maturity date than parents by 2.54 and 9.26 days, respectively and surpassed the parents average 98.09 cm, 6.76 spikes, 25.93 spikeletes, 5.70 g, 81.18 grain and 23.79g for plant height, number of spikes/plant, number of spikelets/spike, 100-kernel weight, number of grains per spike and grain yield/plant, respectively. Which reflect the amount of the variability produced from the used parents.

While, the five different crosses families had plants with trasgressive sergeants of parents, F_3 selected plants of the two crosses 4 and 5 were lower than lowest corresponding parent and considered to be the earliest in days to heading (72.29 and 69.40 days) and days to maturity (111.37 and 106.91 days), as well as the maximum values for all traits under study ranged from 6.97 g for 100-kernel weight to 124.99 cm for plant height in cross 5. These results are in agreement with other data obtained by Memon *et al* (2007), Ali (2012), El Ameen (2012), Aglan and Farhat (2014a and b), Hassan (2014), Darwish *et al* (2018) and Mohamed *et al* (2019).

Table 5. Mean performance of parents, the ranges of F_3 families means and overall means for the studied traits in the five bread wheat crosses at Toshka region.

Genotypes			Traits							
			Days to	Days to	Plant	No of	No of	100 kernel	No of	Grain
Parents	Line 1		82.48	133.94	79.00	4.82	21.67	4.65	58.33	13.10
	Line 2		88.00	140.60	77.33	5.03	22.33	5.01	64.33	16.17
	Line 3		88.23	141.98	83.74	5.11	22.97	4.93	61.83	13.89
	Line 4		93.28	149.04	81.97	5.34	23.67	5.31	68.19	17.14
	Line 5		84.70	136.30	88.76	5.42	24.35	5.23	65.54	14.72
	Line 6		89.55	143.08	86.89	5.66	25.09	5.63	72.28	18.16
	Line 7		81.31	130.85	94.09	5.74	25.80	5.54	69.48	15.60
	Line 8		85.97	137.35	92.11	5.99	26.60	5.97	76.62	19.25
	Line 9		78.06	125.61	99.74	6.09	27.35	5.87	73.64	16.54
	Line 10		82.53	131.86	97.63	6.35	28.20	6.33	81.22	20.41
Parents average			85.41	137.06	88.13	5.56	24.80	5.45	69.15	16.50
L.S.D.			1.34	2.10	1.63	0.27	0.85	0.72	1.08	0.65
F_3 familieS	Cross1	Min.	74.00	114.00	75.00	4.00	19.00	4.59	57.00	12.50
		Max.	92.00	142.00	99.00	8.00	27.00	5.52	87.00	29.70
		Mean	83.00	128.00	87.00	6.00	23.00	5.06	72.00	21.10
	Cross 2	Min.	78.44	120.84	79.50	4.24	20.14	4.87	60.42	13.25
		Max.	97.52	150.52	104.94	8.48	28.62	5.85	92.22	31.48
		Mean	87.98	135.68	92.22	6.36	24.38	5.36	76.32	22.365
	Cross 3	Min.	75.30	116.01	84.27	4.49	21.35	5.16	64.05	14.05
		Max.	93.62	144.50	111.24	8.99	30.34	6.20	97.75	33.37
		Mean	84.46	130.255	97.755	6.74	25.845	5.68	80.9	23.71
	Cross 4	Min.	72.29	111.37	89.33	4.76	22.63	5.47	67.89	14.89
		Max.	89.87	138.72	117.91	9.53	32.16	6.57	103.62	35.37
		Mean	81.08	125.045	103.62	7.145	27.395	6.02	85.755	25.13
	Cross 5	Min.	69.40	106.91	94.69	5.05	23.99	5.79	71.96	15.78
		Max.	86.28	133.17	124.99	10.10	34.09	6.97	109.84	37.50
		Mean	77.84	120.04	109.84	7.58	29.04	6.38	90.9	26.64
F_3 families average			82.87	127.80	98.09	6.76	25.93	5.70	81.18	23.79
L.S.D.			2.69	4.91	2.37	1.54	1.30	1.28	2.61	1.04

Genetic and environmental variances analysis

The obtained values for genetic and environmental variances represented that the magnitude of genetic variance among the F_3 families as well as the genetic variance among plants within families exceeded corresponding environmental variance for all studied traits and crosses (Table 6). The estimates of genetic variance within selected plants were larger than those among families for most studied traits in all crosses suggesting that the selection might be more effective within families rather than among families. Where, environmental variance for within families was higher than among families and almost lower or equal to the corresponding genetic variance, suggesting further selection among individual plants within families will be more effective in obtaining earlier and higher yielding genotypes in most crosses. These results are comparable to those obtained by Abbasi *et al* (2017), Darwish *et al* (2018) and Mohamed *et al* (2019). Also, Singh *et al* 2016 and Sowmya *et al* (2017) added that Information of the genetic variability were useful for effective selection for agronomic traits correlated to grain yield and improvement lines under targeted conditions.

Table 6. Genetic (σ^2_g) and environmental (σ^2_e) variance components among F_3 families (F.) and within selected plants (S.P.) for different studied traits in the five bread wheat crosses.

Crosses	SOV		Traits							
			Days to	Days to	Plant	No of	No of	100-kernel	No of	Grain
Cross1	F.	σ^2_g	12.75	32.51	0.71	1.23	0.04	28.26	8.61	12.75
		σ^2_e	6.20	8.90	0.22	0.46	0.01	10.00	2.67	6.20
	S.P.	σ^2_g	24.23	48.77	1.35	2.09	0.07	53.69	12.92	24.23
		σ^2_e	11.78	13.35	0.41	0.78	0.02	19.00	4.00	11.78
Cross 2	F.	σ^2_g	14.33	36.53	0.80	1.39	0.05	31.76	9.68	14.33
		σ^2_e	6.97	10.00	0.24	0.52	0.01	11.23	3.00	6.97
	S.P.	σ^2_g	27.23	54.80	1.52	2.36	0.09	60.34	14.52	27.23
		σ^2_e	11.15	17.00	0.41	0.83	0.02	19.09	4.50	11.15
Cross 3	F.	σ^2_g	13.20	41.04	0.90	1.56	0.05	35.68	10.87	13.20
		σ^2_e	6.42	11.23	0.27	0.58	0.02	12.62	3.37	6.42
	S.P.	σ^2_g	25.08	61.56	1.71	2.65	0.09	67.79	16.31	25.08
		σ^2_e	12.20	16.85	0.51	0.99	0.03	23.98	5.06	12.20
Cross 4	F.	σ^2_g	12.17	46.12	1.01	1.75	0.06	40.09	12.21	12.17
		σ^2_e	5.92	12.63	0.31	0.65	0.02	14.18	3.78	5.92
	S.P.	σ^2_g	23.12	69.18	1.92	2.98	0.10	76.17	18.32	23.12
		σ^2_e	9.47	21.47	0.53	1.04	0.03	24.11	5.67	9.47
Cross 5	F.	σ^2_g	11.21	51.83	1.14	1.97	0.07	45.05	13.72	11.21
		σ^2_e	5.45	14.19	0.35	0.73	0.02	15.94	4.25	5.45
	S.P.	σ^2_g	21.30	77.75	2.17	3.35	0.12	85.60	20.58	21.30
		σ^2_e	10.36	21.29	0.67	1.24	0.03	30.29	6.38	10.36

Variance, heritability in broad and narrow senses and expected genetic advance are considered as the most important factors for efficiency of breeding methods shown in Table 7.

Table 7. Estimates of additive (σ^2A) and dominance (σ^2D) variances, heritability in broad (h^2_b) and narrow senses (h^2_n) and expected genetic advance (Δg) within F_3 family means for the studied characters in the five studied wheat crosses.

Crosses	Source of variance	Traits							
		Days to	Days to	Plant	No of	No of	100-	No of	Grain
Cross1	σ^2_A	137.98	98.56	271.36	9.58	42.12	0.24	247.13	88.67
	σ^2_D	40.34	62.50	12.89	4.45	16.11	0.18	33.68	72.64
	h^2_b	96.67	64.72	94.76	94.27	93.92	93.55	81.78	92.41
	h^2_n	90.09	55.86	93.65	84.45	85.72	78.76	79.08	76.70
	Δg	16.22	14.04	16.56	2.01	5.13	3.01	12.13	5.19
Cross 2	σ^2_A	169.23	94.03	320.13	10.75	46.88	0.24	259.16	111.51
	σ^2_D	0.13	2.20	35.89	1.29	1.12	0.22	41.74	25.50
	h^2_b	98.62	57.67	97.68	92.25	89.79	90.91	80.82	92.27
	h^2_n	98.60	57.15	95.01	89.55	89.26	74.14	77.69	87.28
	Δg	18.58	14.94	17.48	2.26	5.64	1.01	12.40	6.20
Cross 3	σ^2_A	140.72	76.32	348.47	11.90	54.44	0.36	273.67	128.00
	σ^2_D	67.89	43.34	9.52	4.14	3.31	0.05	87.37	14.92
	h^2_b	98.64	57.48	95.50	94.04	92.04	94.87	80.44	92.23
	h^2_n	88.02	50.33	94.85	86.52	90.66	91.94	74.49	89.62
	Δg	16.07	12.80	18.13	2.30	6.03	1.32	12.38	6.69
Cross 4	σ^2_A	132.10	59.52	392.45	12.86	37.63	0.31	361.09	139.67
	σ^2_D	51.83	83.30	7.76	7.18	15.85	0.27	14.07	43.61
	h^2_b	98.63	57.51	95.78	94.09	74.48	90.48	81.86	92.36
	h^2_n	89.82	42.60	95.31	82.57	67.38	74.42	81.07	85.67
	Δg	15.87	10.53	18.91	2.32	4.72	1.13	14.04	6.71
Cross 5	σ^2_A	116.58	70.10	415.18	15.33	12.26	0.44	382.72	159.51
	σ^2_D	50.73	15.64	27.53	4.73	2.91	0.08	58.57	44.18
	h^2_b	97.11	57.87	93.72	94.13	73.14	93.88	81.41	92.41
	h^2_n	87.58	54.44	92.19	87.39	69.05	89.78	78.41	86.43
	Δg	14.98	13.08	20.95	2.60	5.09	1.45	14.17	7.11

The obtained values revealed that additive variance components exceeded the dominance variance portions for all studied traits which indicate to the efficiency of selection procedures for isolates in the early generations. Similar findings were found by Aglan and Farhat (2014a and b) and Darwish *et al* (2018) and both additive and dominance components played an important role in controlling grain yield and its components in the F_3 families for most studied traits in the five crosses except for days to heading and maturity, no of spikes/plant and no. of spikelets/spike in cross 2, plant height in the two crosses 2 and 3 and 100-kernel weight in cross 3. While, narrow sense heritability values were relatively medium to high for the five crosses ranged from 50.33% for maturity date in the cross 3 to 98.60% for heading date in the cross 2 and these values were not much lower than the broad sense heritability in all crosses which had values ranged from 57.48 % for maturity date in the cross 3 to 98.64 % for heading date in the cross 3 indicating that the additive genetic effect might be represent most of the genetic variations in the F_3 generation for most of crosses. The following traits heading date, plant height, no. of spikes/plant, no. of spikelets/spike and grain yield/plant had the highest estimates of heritability and indicated that additive component played an important role in the inheritance of these traits under heat stress. Meanwhile, the expected genetic advance values ranged from 1.01 for 100-kernel weight in cross 2 to 20.95 for plant height in cross 5. These results showed that the most of traits had medium to high estimates of genetic advance. According to the high estimates of heritability and genetic advance, it could be concluded that selection in segregating generation for heading date, plant height and no. of grains/spike traits would be effective in obtaining genotypes earlier in heading and higher in grain yield than its corresponding parents. These results are in harmony with those of Aglan and Farhat (2014 a and b), Hussain *et al* (2017), Sowmya *et al* (2017), Abbasi *et al* (2017), Darwish *et al* (2018) and Mohamed *et al* (2019).

The best 33 selected lines of F_3 families which were characterized by earlier days to heading, high number of grains per spike, high 100-kernel weight and grain yield from the five crosses were showed in Table 8. A significant improvement has been occurred due to selection of transgressive segregants from 4500 evaluated plants, 6 plants (0.66 %), 6 plants (0.66 %), 9 plants (1 %), 5 plants (0.56 %) and 7 plants (0.78 %) were the promising F_3 families from the crosses 1, 2, 3, 4 and 5, respectively which exhibited the earliest in heading and highest grain yield and exceeded parental phenotypic values.

Table 8. Performance of 33 selected plants based on days to heading, number of grains per spike, 100-kernel weight and grain yield from F_3 families of five crosses at Toshka site.

	Crosses	Plants	Traits							
			Days to	Days to	Plant	No of	No of	100-	No of	Grain
F_3 families	Cross1	Line 1	82.00	132.00	89.00	4.85	26.00	4.73	78.00	31.70
		Line 2	82.00	122.00	89.00	5.00	25.00	4.88	73.00	31.60
		Line 3	87.00	132.00	95.00	4.38	25.00	5.09	81.00	32.80
		Line 4	85.00	135.00	88.00	3.75	25.00	5.43	84.00	31.40
		Line 5	88.00	138.00	92.00	4.38	27.00	5.33	79.00	29.30
		Line 6	85.00	135.00	88.00	3.75	25.00	4.43	84.00	30.40
	Cross 2	Line 1	83.28	136.28	97.52	4.64	28.62	4.65	83.74	31.06
		Line 2	80.10	133.10	93.28	3.98	26.50	4.76	89.04	32.04
		Line 3	82.22	130.92	100.70	4.64	26.50	5.40	85.86	31.53
		Line 4	86.92	131.32	94.34	5.30	26.50	5.17	77.38	30.32
		Line 5	76.92	129.92	94.34	5.19	24.38	5.01	82.68	31.48
		Line 6	82.22	135.22	100.70	5.30	22.26	5.71	69.96	30.10
	Cross 3	Line 1	89.55	140.43	103.37	4.92	30.34	5.99	88.76	32.92
		Line 2	86.50	137.38	98.88	4.21	28.09	4.10	94.38	34.79
		Line 3	82.43	133.31	93.26	4.95	25.84	3.61	86.52	30.22
		Line 4	88.53	139.41	106.74	5.62	25.84	3.97	71.91	30.56
		Line 5	83.44	124.15	100.00	5.71	28.09	3.48	82.02	32.13
		Line 6	86.50	137.38	93.26	5.32	23.60	4.70	75.28	30.45
		Line 7	83.44	134.32	100.00	5.48	25.84	4.31	87.64	33.37
		Line 8	76.32	117.02	93.26	4.92	23.60	3.85	82.02	30.00
		Line 9	88.53	139.41	106.74	5.62	23.60	5.06	74.16	31.91
	Cross 4	Line 1	85.97	134.81	109.57	5.11	32.16	5.35	94.09	34.90
		Line 2	84.99	128.95	113.15	5.24	29.78	5.06	96.47	34.30
		Line 3	80.11	119.18	106.00	5.96	29.78	4.81	86.94	34.06
		Line 4	80.11	128.95	106.00	5.36	27.39	4.63	92.90	35.37
		Line 5	84.99	133.83	113.15	5.28	25.01	4.42	78.61	33.82
	Cross 5	Line 1	82.53	129.42	116.15	5.53	34.09	4.73	99.74	36.99
		Line 2	81.59	123.79	119.94	5.52	31.56	4.43	102.26	36.36
		Line 3	75.96	122.85	104.79	5.55	29.04	5.30	97.21	33.96
		Line 4	81.59	128.48	119.94	5.31	29.04	4.70	80.80	34.34
		Line 5	76.90	114.41	112.36	6.00	31.56	5.16	92.16	36.11
		Line 6	79.71	126.61	104.79	5.81	26.51	4.40	84.59	34.21
		Line 7	81.59	128.48	119.94	5.57	26.51	4.80	83.32	35.85

These superior families are the results of transgressive segregation and may be promoted to F_4 and further generations to produce promising pure lines. Observations on transgressive segregation in segregating hybrid generations were previously explained by several research workers Laala *et* *al* 2017, Abbasi *et al* 2017, Hussain *et al* 2017, Darwish *et al* 2018 and Mohamed *et al* 2019 suggested that early generation selection should be restricted to days to plant height, heading date as well as selection to improve grain yield directly or via related traits and could be delayed to later advanced generation in some crosses.

CONCLUSION

This study concluded that selection in segregating generations of the five wheat crosses for earlier and higher yielding genotypes under heat stress was suitable for this base population to practice the direct selection for earliness in the first cycle and both number of grains per spike and 100-kernel weight in the second cycle. The two crosses 4 and 5 had the most promising F_3 families which considered to be the earliest in days to heading and days to maturity and recorded the maximum values for grain yield and its components. According to the high estimates of heritability and genetic advance, selection in segregating generations for heading date, plant height and no. of grains/spike traits would be effective in obtaining genotypes earlier in heading and higher in grain yield than its corresponding parents. The 33 superior segregants selected of F_3 families has been occurred due to selection of transgressive segregants from 4500 evaluated plants and may be promoted to the F_4 and further generations to produce promising and improved pure lines and/or used as useful germplasm for future bread wheat breeding programs under Toshka conditions.

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الانتخاب للتبكير والمحصول ومكوناته في قمح الخبز

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وحدة تربية النبات – قسم الاصول الوراثية النباتية – مركز بحوث الصحراء – المطرية – القاهرة – مصر

يعد الهدف الأول لمربي القمح هو الحصول على تراكيب وراثية محسنة ذات قدرة انتاجية عالية تحت ظروف الاجهادات غير الحيوية، وذلك لزيادة المساحة الإنتاجية والعمل على تضييق الفجوة بين الإنتاج والاستهلاك المحلي. أجريت هذه الدراسة فى ثلاثة مواسم هي ٢٠١٦/٢٠١٥ و٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ في محطة بحوث توشكى للتجارب الزراعية التابعة لمركز بحوث الصحراء – محافظة أسوان ، جمهورية مصر العربية. وكانت

التراكيب الوراثية المستخدمة عشرة آباء متباعدة وراثيا من قمح الخبز (عدد ٣ و ٤ و ٣ من التراكيب الوراثية من المركز العربي لدراسات المناطق الجافة والأراضي الجافة (اكساد) ، المركز الدولي للبحوث الزراعية في المناطق الجافة (ايكاردا) والمركز الدولي لتحسين الذرة والقمح (السيميت)، على التوالي) وتم تكوين خمسة هجن بينها. تم تطبيق دورتين من الانتخاب بطريقة النسب، أول دورة انتخاب للنباتات التى تحمل صفة التبكير بالطرد في الجيل الثاني F_2 وذلك ضمن عدد ستين عائلة تحتوى على ٣٠٠ نبات لكل هجين وآبائها، وتلاها دورة الانتخاب الثانية والتى تم تطبيقها على نباتات الجيل الثالث F_3، حيث كان الاختبار لصفتي عدد الحبوب بالسنبلة ووزن ١٠٠حبة. تم تسجيل البيانات: عدد الايام للطرد (الأيام) ، عدد الأيام إلى النضج (الأيام)، ارتفاع النبات (سم) ، عدد السنابل/النبات، عدد السنيبلات/سنبلة، وزن ١٠٠ حبة (جم) ، عدد الحبوب بالسنلة ومحصول الحبوب للنبات (جم) وذلك لكلا الأبوين P_1 و P_2 وعائلات الجيل الثالث F_3 باستخدام تصميم القطاعات كاملة العشوائية ويمكن تلخيص النتائج فيما يلى: ١- أشارت نتائج تحليل التباين الى وجود إختلافات معنوية الى معنوية عالية بين السلالات المنتخبة فى الخمسة هجن وعشائر الجيل الثالث لجميع الصفات قيد الدراسة. بينما أظهر متوسط أداء النباتات المنتخبة من عائلات الجيل الثالث لكل هجين تفوق النباتات المنتخبة من الهجينين الرابع والخامس وخاصة لصفتي التبكير في الطرد (٧٢,٢٩ و٦٩,٤٠ يومًا) والنضج (١١١,٣٧ و١٠٦,٩١ يومًا) وسجل الهجينين أعلى القيم في غالبية الصفات تحت الدراسة والتى تراوحت بين ٦,٩٧ غرام لصفة وزن ١٠٠ حبة إلى ١٢٤,٩٩ سم لصفة ارتفاع النبات في الهجين الخامس. ٢- أوضحت النتائج ان تقديرات التباين الوراثي داخل النباتات المنتخبة كانت اعلي منه بين عائلات الجيل الثالث في جميع الهجن ولمعظم الصفات المدروسة، بينما كانت قيم كفاءة التوريث بالمعنى الضيق متوسطة إلى مرتفعة نسبيًا بالخمسة هجن حيث تراوحت بين ٥٠,٣٣٪ لصفة تاريخ النضج بالهجين الثالث إلى ٩٨,٦٠٪ لتاريخ الطرد بالهجين الثاني ولم تكن الفروق كبيرة مع كفاءة التوريث بالمعنى الواسع في جميع الهجن. ٣- تجاوزت التباينات الوراثية بين عائلات الجيل الثالث F_3 المنتخبة التباينات البيئية لمعظم الصفات المدروسة. تم انتخاب عدد ٣٣ نباتا متفوقا من بين ٤٥٠٠ ضمن عائلات الجيل الثالث F_3 والتي يمكن الانتخاب من ضمنها بالجيل الرابع F_4 للحصول على سلالات نقية واعدة ومُحسَّنة و/أو يمكن استخدامها كمصادر وراثية مفيدة لبرامج تربية القمح المستقبلية تحت ظروف الاجهاد في توشكي .

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