

## PEDIGREE SELECTION IN BREAD WHEAT UNDER WATER DEFICIT FOR YIELD IN TOSHKKA CONDITIONS

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The present work aimed to study the effect of two cycles of pedigree selection for highly grain yield in two segregating populations of wheat under water stress, during the two winter seasons of 2015/2016 and 2016/2017 at Toshka Research Station, Desert Research Center, Aswan, Egypt. The water treatments were 100 and 67% of the irrigation requirements of wheat in Toshka as normal and drought condition, respectively. A transgressive segregation in both populations for all studied traits inducted the suitability of those material for pedigree selections. The genetic advanced for grain yield/plant and its components were greater in population 2 than in population 1 in the first cycle in pedigree selection. Highly significant differences among the selected families for all the studies traits were observed in both populations under normal and drought conditions. After one cycles of selection, the broad sense heritability was very high for most traits and reached 77.79 and 92.02% for grain yield/plant under normal irrigation, while were 87.53 and 93.12% under drought stress in population 1 and population 2, respectively. Two cycles of pedigree selection for grain yield/plant was enough to detect the best families and could be performed in the early segregating generations. It could be concluded that single trait selection was efficient to improve the selection criteria in these populations. These genotypes could be sources for drought tolerance.

**Keywords:** *Triticum aestivum*, pedigree selection, genotypic and phenotypic variation, heritability, observed gain from selection

In developing countries, wheat (*Triticum aestivum* L.) is one of the most important crops as it can be considered as the main source of carbohydrate. Besides being a high carbohydrate food, wheat contains

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valuable protein, minerals, and vitamins. In food industry, wheat is necessary to produce breads, rolls, crackers, cookies, etc. In Egypt, there is a big gap between needs and production of wheat. To fill up this gap, the imported amount reached about 49.80% of the total amount of wheat consumption (FAO, 2018). Although wheat is the most cultivated area occupies more than 44.41% of cereals cultivation area (FAO, 2018). In the last two decades, Egypt population increased by about 84% (FAO, 2018), while the cultivated land and water resources remains the same.

By 2025, more than 2.8 billion people in 48 countries will face water stress or water scarcity conditions and Egypt one of these countries (UNECA, 2000). Drought tolerance is the ability of a variety to remain relatively more productive than others under limited water conditions (Blum et al., 1983). Drought is the main environmental abiotic stress, which have devastating effects on wheat productivity. Wheat production is adversely affected by drought in 50% of the developed area and in 70% of the developing countries (Trethowan and Pfeiffer, 2000). Hence, the introduction of varieties with improved tolerance to drought stress has been one of the most important goals of crop improvement programs (Ludlow and Muchow, 1990).

To start a proper wheat breeding program for improving drought tolerance, the source populations should possess a great amount of genetic variability amenable for efficient selection. Selection from established cultivars would rarely isolate a new genotype (Poehlman and Sleper, 1995). Selection from segregating generations of wheat hybrid combinations succeeded to develop new genotypes that possess adaptive traits of drought tolerance, such as early maturity (Menshawy, 2007 and Al-Naggar et al., 2007), glaucousness (Al-Naggar et al., 2004 and Al-Bakry, 2007), high water use efficiency (Farshadfar et al., 2011) and high grain yield/plant under water deficit conditions (Al-Naggar and Shehab El-Deen, 2012). To practice an efficient selection program for drought tolerance in segregating generations of wheat hybrids, the additive genetic variance should play a major role in the inheritance of such adaptive traits.

The present work aimed to study the effect of two cycles of pedigree selection for highly grain yield/plant in two segregating populations of wheat under water stress at Toshka region. The main objective of the present investigation was to develop new wheat genotypes (transgressive segregates) of high grain yield/plant under water stress conditions. The detailed objectives were to (i) estimate variance components, heritability and expected genetic advance from selection in  $F_2$  and  $F_3$  crosses under water stress and normal conditions, (ii) evaluate 50 selections along with their parents for drought. Therefore, the present study was conducted to evaluate the response of  $F_3$  segregating population under water stress condition for yield/plant.

## MATERIALS AND METHODS

The present work was carried out at Toshka Station, Desert Research Center, Aswan, Egypt, during the two winter seasons of 2015/2016 and 2016/2017. Drip irrigation system was applied in these experiments. The irrigation requirements in the reclaimed soils was 1800 m<sup>3</sup> per feddan (1 feddan = 4200 m<sup>2</sup>) during the season used as a control, while the drought stress was 67% (1200 m<sup>3</sup>) of the total irrigation requirement. The monthly mean of temperature, relative humidity and wind speed at Toshka region during these seasons are presented in table (1). While, soil of the experimental site was sandy.

**Table (1).** Monthly average weather data at Toshka during 2015/2016 and 2016/2017 growing seasons.

Month (Mean)	Average T <sup>†</sup> (°C)	Min. T <sup>†</sup> (°C)	Max. T <sup>†</sup> (°C)	R.H. • %	W.S.♦ km/h	Rainfall amount (mm)
<b>2015/2016 season</b>						
<b>November 2015</b>	23.12	16.11	30.17	46.28	14	0
<b>December 2015</b>	18.43	11.76	25.25	44.51	17	0
<b>January 2016</b>	16.50	9.42	23.77	40.70	12	0
<b>February 2016</b>	18.34	10.53	26.16	44.18	19	0
<b>March 2016</b>	22.17	14.12	30.28	48.21	22	0
<b>April 2016</b>	27.13	18.80	35.47	50.67	18	0
<b>May 2016</b>	31.29	23.25	39.13	46.80	16	0
<b>2016/2017 season</b>						
<b>November 2016</b>	25.43	17.72	33.19	50.91	15	0
<b>December 2016</b>	21.01	13.41	28.79	48.46	19	0
<b>January 2017</b>	19.47	11.12	28.05	48.03	14	0
<b>February 2017</b>	20.17	11.58	28.78	48.60	21	0
<b>March 2017</b>	25.27	16.10	34.52	54.96	25	0
<b>April 2017</b>	26.70	16.14	33.26	59.79	21	0
<b>May 2017</b>	30.74	22.70	38.78	51.48	18	0

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

### 1. Genetic Materials

Two cycles of pedigree selection were achieved for grain yield. The genetic materials were the F<sub>2</sub> and F<sub>3</sub> of two populations of bread wheat (*Triticum aestivum* L.). The first population (pop. 1) stemmed from the cross (ICARDA 2×ICARDA 5) and the second population (pop. 2) stemmed from the cross (ICARDA 1× Gemmeza 7). The pedigree and release of the parental varieties are shown in table (2). Growing seasons, planting dates, genetic materials and experimental design were as follows:

Season	Date	Generation	Experimental design
2015/2016	5/11/2015	F <sub>2</sub>	Non-replicated
2016/2017	2/11/2016	F <sub>3</sub>	RCBD with three replications

**Table (2).** The pedigree of the parental varieties.

No.	Entry name	Pedigree	Origin
1	ICARDA 1	CGSS02Y00144S-099M-099Y-099M-47Y-0B	ICARDA
2	ICARDA 2	ICB98-0771-0AP	ICARDA
3	ICARDA 5	ICB97-1207-0AP	ICARDA
4	Gemmeza 7	CMH74A.630/5x//Seri82/3/Agent CGM4611-2GM-3GM-1GM-OGM	Egypt

## 2. Season of 2015/2016; F<sub>2</sub>- generation

The two aforementioned populations in the F<sub>2</sub>- generation were sown in spaced plants; each in 7 rows, 4 m long, 30 cm apart and 10 cm between hills within a row. The parents were sown; each in two rows. The recommended cultural practices for wheat production were adopted throughout the two growing seasons. The following characteristic were recorded on 250 guarded plants from each population, and 10 plants from each parent. The recorded characters were days to heading (DH), plant height (PH), number of spikes/plant (NSPP), spike length (SL), grain yield/spike (GYPS), number of grains/spike (NGPS), biological yield/plant (BYPP), grain yield/plant (GYPP) and 100-grain weight (100-GW).

After harvest, ten grains from each of the 250 plants from Pop. 1 and pop. 2 were bulked to give an unselected bulk sample for each population. Grains of the best 25 plants for grain yield/plant from each population were saved.

## 3. Season of 2016/2017, F<sub>3</sub>- generation

The 25 F<sub>3</sub>-families along with the unselected bulk sample and the two parents were sown in two separated experiment under normal irrigation and drought stress in RCBD with three replications for each population separately (Gomez and Gomez, 1984). The plot size was two rows as in the previous season. The characters were recorded as in the previous season as an average of ten guarded plants from each family.

## 4. Statistical Analysis

Estimates of genotypic and phenotypic variances as well as heritability broad sense were calculated from EMS components of the selected families as presented in table (3).

**Table (3).** The form of analysis of variance and mean squares expectations.

Source of variation	d.f.	M.S.	Expected mean squares variance
Replications	r-1	M <sub>3</sub>	$\sigma^2e + g\sigma^2r$
Entries	g-1	M <sub>2</sub>	$\sigma^2e + r\sigma^2g$
Error	(r-1)(g-1)	M <sub>1</sub>	$\sigma^2e$

Where: r and g are number of replications and genotypes, respectively.  $\sigma^2e$  and  $\sigma^2g$  are the error variance and genetic variance components; respectively. The phenotypic ( $\sigma^2p$ ) and genotypic ( $\sigma^2g$ ) variances were calculated according to the following formulae:

$$\sigma^2p = \sigma^2g + \sigma^2e / r \qquad \sigma^2g = (M_2 - M_1) / r$$

Two separate analysis of variance were done. The first includes the entries (25 selected families along with the bulk samples and the two parents) to measure the variability and the significance of the observed gain. The second include the selected families only to calculate phenotypic (PCV), genotypic (GCV) coefficients of variability and heritability estimates in broad sense.

**Heritability**

The following equation was used to estimate heritability in broad sense.

$$(H) = (\sigma^2g / \sigma^2p) \times 100$$

The phenotypic and genotypic coefficients of variation were estimated using the formula developed by Burton (1952).

- The phenotypic coefficient of variability (PCV) =  $(\sigma p / \bar{X}) \times 100$ .
- The genotypic coefficient of variability (GCV) =  $(\sigma g / \bar{X}) \times 100$ .

Comparisons between means were calculated using Revised L.S.D, was calculated using the formula developed by Al-Rawi and Khalafalla (1980).

**RESULTS AND DISCUSSION**

**1. The Estimation of the Base Population (F<sub>2</sub> Plants)**

Results in tables (4 and 5) show that grain yield/plant (GYPP) ranged from 4.88 to 27.20 g with an average of 12.57 g for pop. 1 and in pop. 2 it ranged from 5.85 to 32.33 with an average of 13.11 g. The range in pop. 1 and pop. 2 in grain yield/plant in the F<sub>2</sub> generation fell outside the range of their respective parents, reflecting high level of heterozygosity and/or transgressive segregation in both populations. This indicates the feasibility of selection for yield. Variation coefficient (CV%) were 26.20 and 31.10% for pop. 1 and pop. 2, respectively. Phenotypic variance ( $\sigma^2p$ ) were 10.85 and 16.62, while genotypic variance ( $\sigma^2g$ ) was 10.56 and 16.42 for pop. 1 and pop. 2, respectively. The low percentage of phenotypic variability

( $\sigma^2_p$ ) of the parents was the estimation of the environmental variance, and that reflects the homozygosity, purity and stability of the parents in each population.

The phenotypic ( $\sigma^2_p$ ) and genotypic ( $\sigma^2_g$ ) variances of grain yield/plant (GYPP) in pop. 2 were close, while the heritability in broad sense ( $H^2_b\%$ ) were 97.27 for pop. 1 and 98.80% for pop. 2. Expected genetic advance ( $\Delta G$ ) were 5.61 and 7.05% for pop. 1 ( $F_2$  plants) and pop. 2 ( $F_2$  plants), respectively. The percentage between  $\Delta G$  and mean were 44.60 and 53.76% in pop. 1 and pop. 2, respectively. These results are in agreement with those reported by El-Morshidy et al. (2010) and Ahmed et al. (2014).

**Table (4).** Means, maximum and minimum values, phenotypic ( $\sigma^2_p$ ) and genotypic ( $\sigma^2_g$ ) variances, variation coefficient (CV%), heritability ( $H^2_b\%$ ) and expected genetic advance ( $\Delta G$ ) of the base pop. 1 ( $F_2$ ) and its parents for all studied traits (season 2015/2016).

Pop. 1	DH	PH	NSPP	SL	GYPS	NGPS	BYPP	GYPP	100-GW
Means $\pm$ SE	70.22 $\pm$ 0.53	68.69 $\pm$ 0.68	6.08 $\pm$ 0.09	10.43 $\pm$ 0.10	2.46 $\pm$ 0.03	57.94 $\pm$ 0.55	30.13 $\pm$ 0.51	12.57 $\pm$ 0.21	4.28 $\pm$ 0.04
Max.	93.00	96.25	11.78	14.38	3.79	85.42	55.40	27.20	5.77
Min.	59.00	43.26	2.41	6.18	1.51	37.39	12.03	4.88	2.78
CV %	12.04	15.70	23.18	15.44	18.04	14.92	26.74	26.20	16.15
$\sigma^2_g$	71.10	114.81	1.87	2.55	0.19	70.91	61.01	10.56	0.47
$\sigma^2_p$	71.52	116.34	1.98	2.59	0.20	74.71	64.93	10.85	0.48
H	99.42	98.68	94.12	98.29	95.39	94.91	93.97	97.27	98.14
$\Delta G$	14.71	18.63	2.32	2.77	0.74	14.36	13.25	5.61	1.19
$\Delta G$ /Mean (%)	20.95	27.12	38.18	26.56	30.12	24.78	43.98	44.60	27.73
<b>ICARDA 2</b>									
Means $\pm$ SE	64.00 $\pm$ 0.26	76.47 $\pm$ 0.20	6.20 $\pm$ 0.11	11.03 $\pm$ 0.03	1.75 $\pm$ 0.01	42.30 $\pm$ 0.47	30.70 $\pm$ 0.49	10.82 $\pm$ 0.16	4.13 $\pm$ 0.03
Max.	65.00	77.00	6.50	11.10	1.79	44.40	32.70	11.45	4.25
Min.	63.00	75.60	5.70	10.90	1.69	41.06	28.90	10.20	4.03
CV %	1.28	0.81	5.74	0.85	2.46	3.53	5.07	4.72	2.20
$\sigma^2_p$	0.67	0.38	0.13	0.01	0.002	2.23	2.43	0.26	0.01
<b>ICARDA 5</b>									
Means $\pm$ SE	67.50 $\pm$ 0.13	72.64 $\pm$ 0.52	5.10 $\pm$ 0.10	11.70 $\pm$ 0.09	2.29 $\pm$ 0.04	48.16 $\pm$ 0.73	30.40 $\pm$ 0.74	11.63 $\pm$ 0.18	4.75 $\pm$ 0.03
Max.	68.00	74.80	5.50	11.90	2.42	50.01	33.50	12.34	4.88
Min.	67.00	70.83	4.70	11.30	2.11	44.89	27.90	10.93	4.65
CV %	0.60	2.26	6.40	2.42	5.58	4.81	7.65	4.95	2.05
$\sigma^2_p$	0.17	2.69	0.11	0.08	0.02	5.37	5.41	0.33	0.009

$\Delta G$  = Expected genetic advance from selection 10% superior plants.

**Table (5).** Means, phenotypic variance ( $\sigma^2_p$ ), genotypic variance ( $\sigma^2_g$ ), phenotypic coefficient (CV), heritability in broad sense (H) and expected genetic advance ( $\Delta G$ ) of the base pop. 2 ( $F_2$ ) and its parents of the studied traits (season 2015/2016).

<b>Pop. 2</b>	<b>DH</b>	<b>PH</b>	<b>NSPP</b>	<b>SL</b>	<b>GYPs</b>	<b>NGPs</b>	<b>BYPP</b>	<b>GYPp</b>	<b>100-GW</b>
Means $\pm$ SE	65.98 $\pm$ 0.33	64.46 $\pm$ 0.61	6.25 $\pm$ 0.11	10.28 $\pm$ 0.10	2.10 $\pm$ 0.02	54.43 $\pm$ 0.87	29.95 $\pm$ 0.58	13.11 $\pm$ 0.26	4.05 $\pm$ 0.06
Max	85.00	85.25	12.67	13.94	3.40	83.13	62.33	32.33	5.79
Min	58.00	37.54	2.48	6.18	1.40	30.80	12.57	5.85	2.11
CV %	7.81	14.93	26.89	14.75	14.50	25.13	30.42	31.10	22.57
$\sigma^2_g$	26.37	90.93	2.77	2.23	0.08	179.14	80.74	16.42	0.82
$\sigma^2_p$	26.59	92.63	2.83	2.30	0.09	187.11	83.02	16.62	0.84
H	99.16	98.16	97.89	97.16	90.26	95.74	97.25	98.80	98.52
$\Delta G$	8.95	16.53	2.88	2.58	0.48	22.92	15.51	7.05	1.58
$\Delta G/\text{Mean} (\%)$	13.56	25.65	46.06	25.08	22.90	42.11	51.77	53.76	38.91
<b>ICARDA 1</b>									
Means $\pm$ SE	66.33 $\pm$ 0.15	70.67 $\pm$ 0.39	4.85 $\pm$ 0.08	11.02 $\pm$ 0.07	2.50 $\pm$ 0.03	53.52 $\pm$ 1.08	33.83 $\pm$ 0.59	12.10 $\pm$ 0.16	4.68 $\pm$ 0.04
Max	67.00	72.00	5.05	11.30	2.61	56.15	35.60	12.80	4.83
Min	66.00	69.00	4.50	10.80	2.35	48.70	31.23	11.75	4.55
CV %	0.71	1.76	5.12	1.90	4.35	6.38	5.55	4.07	2.48
$\sigma^2_p$	0.22	1.56	0.06	0.04	0.012	11.66	3.52	0.24	0.01
<b>Gemmeza 7</b>									
Means $\pm$ SE	64.67 $\pm$ 0.15	69.80 $\pm$ 0.43	5.38 $\pm$ 0.08	10.80 $\pm$ 0.09	2.02 $\pm$ 0.02	49.05 $\pm$ 0.65	28.95 $\pm$ 0.32	10.85 $\pm$ 0.13	4.12 $\pm$ 0.03
Max	65.00	71.00	5.70	11.20	2.13	51.75	30.35	11.32	4.25
Min	64.00	67.90	5.12	10.50	1.94	46.73	27.95	10.35	3.99
CV %	0.73	1.95	4.45	2.73	3.91	4.22	3.52	3.66	2.58
$\sigma^2_p$	0.22	1.85	0.06	0.09	0.01	4.28	1.04	0.16	0.011

$\Delta G$  = Expected genetic advance from selection 10% superior plants.

The range of the grain yield and its components in the  $F_2$  populations fell outside the range of their respective parents, except for spike length in both populations. Number of spikes/plant for the parent ICARDA2 was higher than means in pop. 1, biological yield/plant (BYPP) for the two parents ICARDA2 and ICARDA5 were higher than pop. 1, but in pop. 2 only parent Gemmeza7 was higher than  $F_2$  plants and for grain yield/spike the parent ICARDA1 gave higher yield than pop. 2. In the same trend, for the two populations, plants were less than their parents in plant height and for days to heading, Gemmeza7 was earlier than  $F_2$  plants pop. 2. This indicates transgressive segregation and/or heterozygosity. Means of the  $F_2$  generation for the other traits rather grain yield/plant, respect to their respective parents differed in the two populations. This proves that the gene pool of the two populations were different in gene associations.

Heritability broad sense estimates in pop. 1 and pop. 2 were higher than 90% for all traits in this study, days to heading were 99.42 and 99.16%,

plant height was 98.68 and 98.16%, number of spike/plant was 94.12 and 97.89%, spike length was 98.29 and 97.16%, grain yield/spike was 95.39 and 90.26%, number of grain/spike was 94.91 and 95.74%, biological yield/plant was 93.97 and 97.25%, grain yield/plant was 97.27 and 98.80% and 100-grain weight was 98.14 and 98.52%. High estimates of broad sense heritability coupled with high or moderate  $\sigma^2_p$  gave high estimates of expected genetic advance from selection of 10% superior plants for days to heading, plant height, number of grains per spike and biological yield per plant. The expected genetic advance ranged from 14.71 and 8.95% for DH to 18.63 and 16.53% for PH, 2.32 and 2.88% for NSPP, 2.77 and 2.58% for SL, 14.36 and 22.92% for NGPS, 13.25 and 15.51% for BYPP and 1.19 and 1.53% for 100-GW in pop. 1 and pop. 2, respectively.

The correlation coefficient among all traits in the  $F_2$  plants (pop. 1 and pop. 2) are presented in table (6). Simple correlation coefficients for both populations were small, and highly and/or significant. That is mainly due to the large number of plants in the base populations. Grain yield/plant showed positive and significant correlation ( $p \leq 0.05 \leq 0.01$ ) between all studied traits for the two populations, except days to heading (DH), which was negative and significant in pop. 1 and only negative in pop. 2. Simple correlation coefficients was negative and significant between DH and all studied trait in pop. 1 and only between NGPS in pop. 2, the positive and significant ( $p \leq 0.05 \leq 0.01$ ) between all traits in the two populations, except NGPS between NSPP and SL in pop. 1 and NGPS between BYPP and GYPP and between NSPP and 100-GW in pop. 2. The results of correlations indicated that different genes were controlling for both populations. These results are in agreement with those reported by El Ameen et al. (2013) and Al-Naggar and Shehab El-Deen (2012).

**Table (6).** Simple correlation coefficients among the traits in the  $F_2$  generation in pop. 1 (above diagonal) and in pop. 2 (below diagonal).

Traits	DH	PH	NSPP	SL	GYPS	NGPS	BYPP	GYPP	100-GW
DH	-	-0.294**	-0.163*	-0.337**	-0.388**	-0.196**	-0.053	-0.101**	-0.255**
PH	0.124	-	0.336**	0.765**	0.591**	0.053	0.384**	0.351**	0.574**
NSPP	0.010	0.214**	-	0.340**	0.280**	0.003	0.841**	0.898**	0.301**
SL	0.179**	0.864**	0.220**	-	0.673**	-0.036	0.403**	0.361**	0.752**
GYPS	-0.119	0.264**	-0.036	0.224**	-	0.477**	0.571**	0.521**	0.654**
NGPS	-0.390**	-0.474**	-0.088	-0.610**	0.385**	-	0.221**	0.277**	-0.342**
BYPP	0.052	0.395**	0.853**	0.422**	0.318**	-0.099	-	0.951**	0.411**
GYPP	-0.043	0.287**	0.890**	0.275**	0.409**	0.112	0.921**	-	0.314**
100-GW	0.407**	0.655**	0.049	0.786**	0.147*	-0.836**	0.265**	0.087	-

\*, \*\*, significant at 5% and 1% levels of probability, respectively.



**2. Pedigree Selection for GYPS, NGPS, 100-GW and (GYPP), Variability and Heritability Estimates**

Combined analysis of variance under two water stresses of the RCBD design for the studied 27 entries of wheat (25 selected families + 2 parents + bulk sample) is presented in tables (7 and 8). Mean squares due to irrigation were significant ( $p \leq 0.01$ ) for all traits study in both populations, except for NGPS in the two populations.

**Table (7).** Mean squares, heritability in broad sense (H), genotypic (GCV%) and phenotypic (PCV%) coefficients of variability of the selected families for grain yield per plant (GYPP) in the F<sub>3</sub> generation in both populations, season 2016/2017 under normal and drought irrigations.

	S.O.V.	df	DH	PH	NSPP	SL	GYPS	NGPS	BYPP	GYPP	100-GW	
Normal irrigation	Pop. 1	Reps	2	0.81	12.42	0.760*	0.438	0.405**	190.57**	291.09**	37.03**	0.075*
		Entries	27	33.23**	136.15**	3.626**	4.844**	0.288**	59.00**	227.24**	42.35**	0.458**
		Error	54	1.31	11.23	0.237	0.195	0.058	24.04	34.12	3.74	0.017
		GCV%		5.02	8.91	19.22	11.77	10.00	5.87	22.60	25.90	8.00
		PCV%		5.25	9.98	21.12	12.45	14.10	11.18	27.85	29.37	8.49
		H		91.44	79.62	82.86	89.39	50.30	27.55	65.87	77.79	88.71
	Pop. 2	Reps	2	21.94**	82.88**	0.046	0.396	0.113*	55.90*	76.78*	3.21	0.005
		Entries	27	188.18**	150.03**	7.307**	2.526**	0.283**	108.39**	581.27**	96.51**	0.832**
		Error	54	1.45	7.11	0.215	0.141	0.032	15.03	22.37	2.20	0.021
		GCV%		10.81	9.26	24.27	7.68	5.78	8.65	25.29	27.43	9.86
		PCV%		10.92	9.93	25.40	8.35	8.50	10.95	27.08	28.59	10.32
		H		97.85	86.84	91.36	84.50	46.13	62.42	87.17	92.02	91.27
Drought irrigation	Pop. 1	Reps	2	1.87	3.76	0.035	0.463	0.090*	48.23*	30.38*	4.10*	0.019
		Entries	27	41.22**	141.58**	4.307**	4.934**	0.165**	72.39**	103.10**	28.23**	0.318**
		Error	54	1.29	8.42	0.199	0.187	0.023	15.08	8.29	1.17	0.023
		GCV%		6.45	10.25	23.70	13.88	9.14	8.48	22.30	29.90	7.41
		PCV%		6.62	11.13	25.04	14.62	12.28	11.82	25.15	31.96	8.30
		H		94.92	84.79	89.56	90.15	55.33	51.38	78.60	87.53	79.79
	Pop. 2	Reps	2	7.43*	27.70**	0.117	0.512**	0.083*	44.22	28.13	2.40	0.001
		Entries	27	99.74**	78.20**	6.585**	2.725**	0.089**	98.01**	288.77**	40.21**	0.427**
		Error	54	1.95	5.32	0.223	0.089	0.024	15.83	9.20	0.79	0.036
		GCV%		8.79	7.48	23.01	9.49	5.30	8.94	25.39	25.89	9.87
		PCV%		9.01	8.25	24.17	9.93	8.94	11.39	26.72	26.83	11.19
		H		95.04	82.28	90.67	91.27	35.13	61.71	90.26	93.12	77.87

\*, \*\*, significant at 5% and 1% levels of probability, respectively.  
H= heritability in broad sense.

**Table (8).** Mean squares of the selected families for grain yield per plant (GYPP) in the F<sub>3</sub> generation in both populations over two irrigation levels, season 2016/2017.

	S.O.V	df	DH	PH	NSPP	SL	GYPS	NGPS	BYPP	GYPP	100-GW
Pop. 1	Irrigation	1	1625.04**	2679.81**	15.232**	114.838**	11.864**	804.26	5071.99**	742.90**	19.948**
	I (Rep.)	4	1.34	8.09	0.397	0.451	0.248	119.40	160.74	20.56	0.047
	Genotype	27	69.57**	271.04**	7.772**	9.649**	0.430**	126.25**	311.31**	69.44**	0.698**
	I*G	27	4.88**	6.69	0.162	0.129	0.023	5.13	19.03	1.14	0.078**
	Error	108	1.30	9.83	0.218	0.191	0.041	19.56	21.20	2.46	0.020
Pop. 2	Irrigation	1	3198.15**	4256.89**	4.445**	111.594**	28.776**	383.22	7713.34**	1513.22**	60.648**
	I (Rep.)	4	14.68	55.29	0.082	0.454	0.098	50.06	52.45	2.80	0.003
	Genotype	27	274.83**	186.34**	13.784**	4.876**	0.329**	200.56**	828.84**	129.87**	1.132**
	I*G	27	13.09**	41.89**	0.108	0.376**	0.043	5.85	41.20**	6.85**	0.127**
	Error	108	1.70	6.22	0.219	0.115	0.028	15.43	15.78	1.49	0.028

\*, \*\*, significant at 5% and 1% levels of probability, respectively.

After the first cycle of pedigree selection rapidly depleted the variability in the selection criterion (grain yield/plant (GYPP)). Its PCV were high (more than 10%), which were 29.37% in pop. 1 and 28.59% in pop. 2 under normal irrigation, while were 31.96 and 26.83% in pop. 1 and pop. 2 under drought stress, respectively, in F<sub>3</sub> generation. The GCV also was high (more than 10%), 25.90 in pop. 1 and 27.43 in pop. 2 under normal irrigation and 29.90 and 25.89% for pop. 1 and pop. 2 under drought stress, respectively. Therefore, further cycle of selection for GYPP will be fruitful under the two water irrigation and in both populations and selection for this trait should be practiced in this cycle of F<sub>3</sub> segregating generations. Selection under direct (normal irrigation) and indirect (drought stress) selection to GYPP were the same for these entries. The PCV and GCV for most other traits in pop. 1 under normal irrigation and drought stress were high (more than 10%), except for DH and 100-GW under both water stresses for phenotypic and genotypic coefficient variances and for PH under normal irrigation. GCV% was less than 10% under drought irrigation for GYPS and NGPS for both irrigation regimes. In the same trend, the phenotypic and genotypic coefficients of variability in pop. 2 were high (more than 10%) for NSPP and BYPP under both water irrigations. However, it recorded less than 10% for PH, SL and GYPS under two the water stresses and for DH under drought stress. GCV% was less than 10% for NGPS and 100-GW under normal irrigation and drought stress, and resulted high estimates of heritability for all studied traits, except for NGPS in pop. 1 under normal irrigation (27.55%) and for GYPS in pop. 2 under drought stress (35.13%). The other cause of very high estimates of heritability was the large mean squares of families compared to small error variance. This could be ascribed to evaluate the selected families at Toshka region for one season. These results are in general agreement with those reported by Memon et al. (2018) and Patel et al. (2019).

### 3. Means and Direct Observed Selection Gain

Means of the nine studied traits under the two irrigation water practices (normal irrigation and drought stress) for 25 families and their parents for two populations, which selected in the F<sub>3</sub> generation to GYPP is presented in table (9). In general, The average observed selection gain for GYPP was significant ( $p \leq 0.05 \leq 0.01$ ) and higher than bulk sample under normal irrigation and drought stress, respectively. GYPP of the family number 16 was the best and highly significant ( $p \leq 0.01$ ) than average, better parent and unselected bulk sample under both water treatments. Families number 9 and 14 under water stress recorded higher values than means, bulk and these parents. Family number 10 was only significant ( $p \leq 0.05$ ) under normal irrigation, while families number 1, 4, 5 and 6 were significant under both irrigation treatments in pop. 2. The average of grain yield/plant (GYPP) for observed selection gain in pop. 2 was significant ( $p \leq 0.05 \leq 0.01$ ) and higher than bulk sample under normal irrigation and drought stress, that must be the best selected families with high and significant ( $p \leq 0.05 \leq 0.01$ ) GYPP.

For DH trait, family number 22 in pop. 1 showed the lowest number of days of the lower parent under both water irrigations. The families number 4 and 11 under normal irrigation and water stress give the highest plant height in Pop. 1, and family No 25 recorded the high plant height under water stress in Pop. 2. Regarding to NSPP, the families No. 15 in Pop. 1, families No. 5 and 16 under normal and drought stress in Pop. 2, respectively. While the two families No. 11 and 7 recorded the best values for SL in Pop. 1 and Pop. 2, respectively. On the same trend, the families No. 17 and 7 recorded the highest values in GYPS in Pop. 1 and Pop. 2 under normal irrigation. For NGPS the family No. 16 given the best number of grains/spike under both water irrigations in Pop. 1 and family No. 24 in Pop. 2 for the same trait. The highest value for BYPP were recorded by families No. 15 and 16 under the two-water irrigations in Pop. 1 and Pop. 2, respectively. While for 100-GW the family No. 3 given the best value under both water irrigations in Pop. 1, however, in Pop. 2 the families No. 15 and 1 under normal irrigation and water stress, respectively. This result concluded that selection for these traits in these families might be useful in direct environment (under water stress) and indirect environment (normal irrigation).

**Table (9).** Mean performance all studied characters of the selected families in the F<sub>3</sub> generation in two populations for GYPP under normal and drought stress, season 2016/2017.

Family	Pop. 1	Pop. 2	Pop. 1	Pop. 2	Pop. 1	Pop. 2	Pop. 1	Pop. 2
	Normal irrigation		Drought stress		Normal irrigation		Drought stress	
	<b>DH</b>				<b>PH</b>			
1	64.67	70.00	60.67	61.67	72.78	74.71	69.75	67.92
2	67.67	66.67	61.67	62.00	77.00	68.20	70.00	62.00
3	68.33	69.33	62.33	63.00	78.19	75.44	71.08	69.83
4	70.33	71.00	63.33	62.00	88.83	73.79	81.00	67.08
5	70.00	70.67	62.67	63.00	88.73	73.70	80.67	69.42
6	65.00	72.00	61.67	63.67	68.93	85.25	62.67	77.50
7	65.33	69.00	60.00	61.00	71.87	86.72	65.33	77.50
8	67.00	68.00	62.00	61.00	87.27	72.05	79.33	65.50
9	65.33	67.00	62.00	60.33	72.42	67.83	65.83	62.92
10	68.67	71.33	62.00	63.67	73.79	77.73	67.08	72.00
11	70.33	69.67	63.00	61.67	92.22	72.05	83.83	65.50
12	66.33	68.67	62.00	61.33	73.98	72.88	66.75	66.25
13	62.67	67.67	60.33	61.33	64.08	71.50	58.25	65.00
14	68.33	67.00	62.33	61.00	88.18	62.24	80.17	56.58
15	67.00	68.67	62.00	61.33	81.40	67.47	74.00	61.33
16	67.00	72.33	61.00	63.67	79.02	81.13	71.83	73.75
17	67.00	78.33	61.67	71.67	74.80	80.33	68.00	71.33
18	64.00	80.33	57.33	70.33	73.80	82.33	65.77	66.67
19	64.00	81.33	57.00	74.67	75.83	83.33	62.33	64.00
20	62.33	75.67	54.67	66.33	73.03	86.67	65.70	68.67
21	60.33	86.33	56.00	77.67	71.60	77.00	60.40	61.00
22	58.67	90.67	50.67	76.00	69.67	73.00	57.73	60.67
23	60.00	83.67	51.33	68.33	72.63	84.33	65.47	63.00
24	61.00	91.00	54.00	77.00	74.83	86.33	63.63	72.00
25	62.00	90.00	53.67	73.33	76.13	90.33	67.17	68.33
Average	65.33	74.65	59.41	65.88	76.84	77.05	68.95	67.03
P1	65.33	68.33	56.67	60.33	78.00	71.67	67.27	63.34
P2	68.50	65.67	59.67	58.67	75.03	70.50	68.00	60.53
Bulk	70.33	77.00	61.67	67.00	77.67	77.33	69.00	64.33
RLSD 0.05	1.67	1.72	1.66	2.04	5.06	3.90	4.24	3.49
RLSD 0.01	2.18	2.25	2.17	2.67	6.65	5.10	5.54	4.58
	<b>NSPP</b>				<b>SL</b>			
1	6.82	9.07	6.26	8.23	12.31	11.40	10.71	9.92
2	7.05	6.12	6.48	5.67	10.83	11.98	9.42	10.42
3	6.83	6.49	6.65	6.33	13.27	11.07	11.54	9.63
4	6.06	8.90	5.64	8.57	12.36	11.93	10.75	10.38
5	5.89	9.30	5.80	8.63	10.97	12.31	9.54	10.63
6	6.21	8.20	5.92	7.75	11.64	13.18	10.13	11.46
7	6.02	5.73	5.80	5.55	10.83	13.75	9.42	11.96
8	6.57	5.36	5.99	5.12	13.13	12.70	11.42	11.04

**Table (9). Cont.**

9	7.05	7.47	6.21	7.25	11.79	11.55	10.25	10.04
10	6.47	7.54	5.53	7.21	11.12	12.84	9.67	11.17
11	6.02	7.11	5.64	6.73	13.46	11.16	11.71	9.71
12	5.13	5.37	4.95	5.27	10.59	12.41	9.21	10.79
13	5.92	6.37	5.64	6.40	11.64	10.73	10.13	9.33
14	7.05	8.35	6.53	7.57	13.27	12.12	11.54	10.54
15	8.01	6.27	7.24	6.14	10.88	12.51	9.46	10.88
16	7.06	9.03	6.80	8.78	12.17	12.60	10.58	10.96
17	5.20	5.23	4.80	5.10	12.17	12.67	10.58	10.95
18	4.74	4.67	4.12	4.53	10.32	12.80	8.43	11.17
19	4.71	6.03	3.96	5.90	9.92	12.50	7.50	9.95
20	4.91	4.58	4.00	4.50	9.53	11.00	7.80	9.18
21	4.21	4.48	3.40	4.45	10.44	10.27	7.97	9.00
22	3.81	4.90	3.11	4.70	9.17	9.98	7.87	8.08
23	4.50	4.83	3.51	4.68	9.58	10.90	8.07	8.62
24	4.31	4.92	3.53	4.66	8.87	11.23	7.43	9.13
25	4.14	5.27	3.24	4.95	9.80	11.83	8.47	9.02
Average	5.79	6.46	5.23	6.19	11.20	11.90	9.58	10.16
P1	6.40	5.17	4.83	4.37	11.23	11.25	9.17	11.02
P2	5.10	5.07	4.67	4.03	11.17	11.23	9.21	10.80
Bulk	5.97	5.13	5.05	4.77	11.67	11.00	9.90	9.53
RLSD 0.05	0.73	0.68	0.65	0.69	0.65	0.55	0.63	0.43
RLSD 0.01	0.97	0.89	0.85	0.90	0.84	0.72	0.83	0.57
	<b>GYPS</b>				<b>NGPS</b>			
1	2.29	3.10	1.90	2.28	47.40	58.88	43.71	51.98
2	2.31	2.70	1.79	1.95	48.57	52.17	42.80	48.52
3	2.80	2.77	2.09	2.04	52.26	54.20	42.97	47.88
4	2.64	3.09	2.13	2.15	53.75	60.57	48.80	54.75
5	2.38	3.09	1.78	2.04	47.13	57.24	42.67	52.25
6	2.48	3.32	1.91	2.41	48.86	60.85	44.86	58.04
7	2.39	3.24	1.82	2.28	46.31	57.68	41.82	56.58
8	2.33	3.10	1.88	2.24	51.44	58.19	47.13	56.71
9	2.45	3.23	2.03	2.38	55.16	59.78	49.75	56.00
10	2.75	3.05	2.07	2.16	58.32	58.80	51.87	55.80
11	2.73	3.16	2.18	2.10	54.53	61.10	52.23	58.23
12	2.77	2.99	2.04	2.09	56.36	54.90	53.99	52.43
13	2.68	2.90	2.02	2.10	52.92	55.63	49.58	53.63
14	2.55	2.81	2.02	2.04	54.48	55.47	53.23	53.87
15	2.69	3.22	2.14	2.05	54.39	56.70	52.59	54.96
16	2.82	3.09	2.12	2.17	62.13	62.53	56.14	61.04
17	2.87	2.59	2.12	1.87	57.87	59.36	55.94	58.63
18	2.16	2.91	1.65	2.03	49.96	67.32	45.46	60.22
19	2.11	2.65	1.60	1.81	44.52	53.77	41.12	52.79
20	1.94	2.96	1.53	2.10	47.08	60.50	40.80	57.80
21	2.08	3.16	1.71	2.23	51.26	63.70	46.41	60.45

**Table (9). Cont.**

22	2.15	2.89	1.81	2.11	50.00	69.73	46.71	67.61
23	2.00	2.76	1.55	2.04	50.84	66.14	46.55	63.09
24	2.21	3.17	1.75	2.25	52.81	75.30	46.44	70.62
25	2.35	2.78	1.94	2.03	53.52	71.03	49.89	67.34
Average	2.44	2.99	1.90	2.12	52.07	60.46	47.74	57.25
P1	1.79	2.45	1.48	1.85	43.62	51.60	41.29	49.27
P2	2.35	2.25	1.74	1.78	50.13	53.42	46.00	49.78
Bulk	1.87	2.05	1.26	1.71	45.30	51.47	37.64	53.15
RLSD 0.05	0.40	0.27	0.24	0.26	9.41	6.11	6.50	6.27
RLSD 0.01	0.50	0.35	0.32	0.34	12.89	8.04	8.05	8.25
	<b>BYPP</b>				<b>GYPP</b>			
1	39.67	73.52	29.87	50.59	15.61	28.16	11.88	18.76
2	41.57	44.27	29.23	29.98	16.37	16.51	11.63	11.01
3	46.47	47.47	35.63	37.11	19.15	18.01	13.87	12.93
4	41.50	69.07	28.53	51.41	16.04	27.56	11.97	18.41
5	36.57	72.25	24.37	47.61	13.97	28.69	10.22	17.64
6	40.13	66.83	27.50	51.50	15.53	27.19	11.34	18.53
7	37.59	48.35	25.56	35.10	14.62	18.58	10.63	12.68
8	36.87	41.35	27.59	31.89	15.39	16.60	11.28	11.45
9	43.80	59.10	28.82	47.39	17.18	24.02	12.53	17.19
10	46.67	57.37	26.89	43.01	17.81	22.97	11.44	15.56
11	41.20	57.32	28.60	38.85	16.41	22.35	12.27	14.12
12	34.34	43.10	23.78	30.29	14.14	15.92	10.12	10.96
13	39.84	51.33	27.67	37.29	15.93	18.40	11.39	13.37
14	46.13	60.02	32.29	43.52	17.94	23.46	13.12	15.46
15	53.73	52.65	37.34	35.85	21.52	20.17	15.56	12.57
16	49.33	76.53	34.59	51.51	19.93	27.98	14.47	18.99
17	39.87	37.62	23.97	25.09	14.90	13.53	10.19	9.53
18	28.12	35.98	20.67	25.64	10.17	13.53	6.79	9.19
19	27.35	42.57	19.70	28.62	9.91	15.98	6.32	10.60
20	28.47	36.02	20.53	25.71	9.51	13.58	6.13	9.40
21	25.40	37.00	19.13	26.86	8.73	14.18	5.82	9.90
22	23.50	37.93	16.60	27.64	8.18	14.15	5.63	9.90
23	22.60	34.73	17.23	25.93	9.01	13.34	5.46	9.57
24	23.47	41.78	18.00	30.16	9.54	15.56	6.19	10.48
25	24.83	42.16	16.90	29.50	9.73	14.62	6.26	10.01
Average	36.76	50.65	25.64	36.32	14.29	19.40	10.10	13.13
P1	29.97	34.58	20.77	21.95	11.43	12.65	7.06	8.02
P2	31.07	29.43	22.63	19.69	11.99	11.39	8.09	7.15
Bulk	30.80	27.80	18.77	28.97	11.10	10.48	6.33	8.10
RLSD 0.05	9.20	6.91	4.35	4.43	2.92	2.17	1.58	1.30
RLSD 0.01	12.11	9.04	5.71	5.79	3.84	2.83	2.07	1.70

**Table (9). Cont.**

<b>100-GW</b>				
1	4.83	5.28	4.34	4.39
2	4.76	5.16	4.19	4.01
3	5.38	5.12	4.85	4.28
4	4.94	5.11	4.37	3.94
5	5.04	5.40	4.16	3.90
6	5.07	5.46	4.25	4.15
7	5.15	5.62	4.36	4.03
8	4.54	5.32	3.99	3.95
9	4.45	5.39	4.08	4.25
10	4.72	5.20	3.99	3.87
11	5.01	5.16	4.18	3.62
12	4.90	5.43	3.79	3.96
13	5.07	5.21	4.07	3.91
14	4.68	5.07	3.79	3.79
15	4.94	5.68	4.08	3.73
16	4.54	4.95	3.79	3.56
17	4.96	4.38	3.78	3.21
18	4.31	4.32	3.63	3.38
19	4.73	4.94	3.89	3.42
20	4.11	4.89	3.76	3.63
21	4.05	4.97	3.69	3.69
22	4.30	4.14	3.87	3.12
23	3.94	4.17	3.34	3.24
24	4.19	4.20	3.78	3.20
25	4.39	3.92	3.89	3.01
Average	4.68	4.98	4.00	3.73
P1	4.10	4.75	3.58	3.75
P2	4.69	4.21	3.78	3.58
Bulk	4.11	3.97	3.35	3.21
RLSD 0.05	0.19	0.21	0.23	0.28
RLSD 0.01	0.25	0.28	0.30	0.37

### CONCLUSION

This study concluded that selection in segregating generations of the two wheat populations for higher yielding genotypes under Toshka condition were suitable for these populations to practice the direct selection for grain yield/plant. The family no. 15 had recorded the maximum values for grain and biological yield/plant in pop. 1, and the families no. 5 and 16 in pop. 2 had the same trait. According to the high estimates of heritability, selection in segregating generation for heading date, number of spikes/plant and grain yield/plant traits would be effective in obtaining genotypes earlier in heading and higher in grain yield than its corresponding parents. The 50 superior

segregates selected from F<sub>3</sub> families has been occurred due to selection of transgressive segregates from F<sub>2</sub> evaluated plants and may be promoted to the F<sub>4</sub> generation 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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## الإنتخاب المنسب للمحصول في قمح الخبز لنقص الماء بتوشكي

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أجريت هذه الدراسة بمحطة بحوث توشكي التابعة لمركز بحوث الصحراء، بمحافظة أسوان، مصر خلال موسمين ٢٠١٦/٢٠١٥ و ٢٠١٧/٢٠١٦. والهدف منها هو دراسة تأثير الإنتخاب المنسب لصفة محصول الحبوب لدورتين إنتخابيتين تحت ظروف الإجهاد المائي على عشيرتين من محصول قمح الخبز. وكانت معاملتي الري المستخدم هي ٦٧ و ١٠٠٪ من إحتياجات الري الطبيعية لمحصول القمح بمنطقة توشكي. الإنعزالات الوراثية في كلا العشيرتين لجميع الصفات المدروسة أعطت مؤشرات ملائمة هذه التراكيب الوراثية لطريقة الإنتخاب بسجل النسب. التقدم الوراثي في صفة محصول الحبوب ومكوناته كان أعلى في العشيرة الثانية عن العشيرة الأولى بعد دورة إنتخاب واحدة. الإختلافات كانت عالية المعنوية بين العائلات المنتخبة لجميع الصفات المدروسة في كلا العشيرتين وتحت معاملتي الري المستخدم بعد الدورة الإنتخابية الأولى. أوضحت الدراسة أن درجة التوريث بمعناها الواسع كانت عالية جداً في معظم الصفات وكانت بنسبة ٧٧.٧٩ و ٩٢.٠٢٪ لصفة محصول الحبوب تحت معاملة الري الطبيعي ولكن كانت بنسبة ٨٧.٥٣ و ٩٣.١٢٪ تحت معاملة نقص الماء في العشيرة الأولى والثانية، على التوالي. وقد أشارت الدراسة أنه بعد إجراء دورتين إنتخابيتين بصفة محصول الحبوب كانت كافية لإظهار أفضل العائلات، وهذا يمكن إتباعه في الأجيال الإنعزالية المبكرة. ونستنتج من هذه الدراسة أن الإنتخاب لصفة إنتخابية واحدة كان ذو كفاءة في تحسين معيار الإنتخاب في هذه العشائر، وهذه التراكيب الوراثية يمكن أن تستخدم كمصدر من مصادر تحمل الجفاف.