II.12 SELECTION EFFICIENCY UNDER BOTH NORMAL IRRIGATION AND WATER DEFICIT CONDITIONS IN DURUM WHEAT

SOLIMAN, G.M.M.[1], M.A. El-MORSHIDY[2], K.A. KHEIRALLA[2] and I.A. AMIN[1]

1. *Wheat Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.*
2. *Dept. of Agron. Fac. of Agric., Assiut University, Egypt.*

Abstract

The present research was carried out to study the efficiency of pedigree selection in improving grain yield under normal irrigation and deficit irrigation conditions. Three cycles of selection were completed under each environment on the F_2 to F_5-generations. At the last season the selected families under each environment were evaluated under both environments. The genotypic variance was slightly less than the phenotypic variance under both environments and generally decreased from the base population (F_2) to F_5-generation. Broad sense heritability estimates for grain yield plant^{-1} under normal and deficit irrigation conditions were 93.3 and 90.8% after three cycles of selection, respectively. The realized heritability under normal irrigation was 10.9, 23.2 and 52.8% compared to 9.8, 31.3 and 36.9% under deficit irrigation conditions for cycles 1, 2 and 3, respectively. The average observed yield gain from selection under normal irrigation and evaluated under both environments showed significant difference in grain yield from the bulk sample by 9.3 and 26.3%, and from the better parent by 9.9 and 10.2%, respectively. Selected families for grain yield under deficit irrigation and evaluated under both environments showed significant difference in grain yield from the bulk sample by 4.6 and 7.7%, and from the better parent by 4.1 and 11.3%, under normal and deficit irrigation, respectively. Drought susceptibility index (DSI) ranged from 0.01 to 3.13 for the families selected under normal irrigation, and from 0.09 to 2.36 for the families selected under deficit irrigation. Results indicated that the antagonistic selection increased sensitivity to deficit irrigation, while the synergistic selection decreased it. Selection for grain yield plant^{-1} under normal irrigation (synergistic selection) was better than under deficit irrigation (antagonistic selection).

Keywords: *Triticum turgidum var. durum,* synergistic and antagonistic selection, realized heritability.

INTRODUCTION

Wheat is the most important grain crop in the world. It provides food to 36% of the global population, and contributes 20% of food calories, (Singh and Chaudhary, 2006). Durum wheat (*Triticum turgidum var. durum*), sometimes called macaroni wheat, covers about 9% of the wheat area. Modern durum wheat cultivars are higher in grain yield than bread wheat cultivars, and the kernels of durum wheat are typically larger, heavier, and harder than those of bread wheat. In Egypt, wheat crop is considered as the essential strategic cereal crop for thousands of years. Egypt wheat yield annual consumption is about 14 million t, while the annual local production is about 8.5 million t in 2011 (Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt). Many of the world's wheat areas (especially in the Arab countries) are exposed to deficit irrigation and terminal heat stress. One of the important objectives in many wheat breeding programs is to develop drought-tolerant cultivars. Selection for stress tolerance in breeding programs has been impeded by lack of appropriate strategies and screening techniques (Gozlan and Mayer, 1981), and lack of genotypes that show clear differences in response to specific growth stages to well-defined environmental stress (Hanson and Nelson, 1980). Pedigree selection method has become the most effective method for selection in wheat crop (Mahdy, 1988; Ismail *et. al.,* 1996; Kheiralla *et. al.,* 1993 and Ali, 2011).

The objectives of the present study were to study the relative merits of pedigree selection for grain yield under normal and deficit irrigation conditions, and the sensitivity of the selected lines to deficit irrigation.

MATERIALS AND METHODS

The present study was carried out during the four successive seasons, i.e. 2009/2010 to 2012/2013 at Shandaweel Agricultural Research Station, Agricultural Research Center (ARC), Ministry of Agriculture and land reclamation, Egypt. The genetic materials chosen for this study included F_2 durum wheat population. The pedigree and origin of the parents are presented in Table 1.

Table 1. Pedigree and origin of the parents of the population.

Parent	Pedigree	Origin
Parent $_1$	21564/Fg"S"//Rabi"S"/3/810	CIMMYT
Parent $_2$	SOOTY-9/RASCON-37	CIMMYT

This population was grown under two treatments of irrigation, the normal irrigation treatment (six irrigations in addition to sowing irrigation), while the deficit irrigation treatment had irrigation stopped at the beginning of the booting stage, All other normal agricultural practices have been applied to both treatments.

In the first season, 1500 plants of F_2 population were grown in non-replicated plots under normal irrigation and deficit irrigation conditions. The experimental plot consisted of 30 rows, 5-m. long, 30-cm apart and 10-cm between plants within rows. Also, the parents of the population were grown. After maturity, plants were individually harvested and threshed. Data collected on all the guarded plants. Forty plants from each treatment were taken. In the next season (F_3 families) were evaluated under the same treatment of selection. Each family was planted in a separate row 2.5-m long, 30-cm apart and 10-cm between plants within row in a randomized complete block design with three replications. Parents and unselected bulk were also grown in each replicate. Selection between and within families was practiced. The best 20 plants from best 20 families were selected from each experiment and retained to be raised as F_4 families next season. In the next season (F_4 generation) two field experiments were conducted to evaluate F_4 families selected from each treatment and sown in same treatment. Each family was planted in a separate row 2.5-m long, 30-cm apart and 10-cm between plants within rows in randomized complete block design with three replications. Parents and unselected bulk were also grown in each replicate. Selection between and within families was practiced. The best 10 plants from best 10 families were selected from each experiment and retained to be raised as F_5 families in the next season. In the next season (F_5 generation) four field experiments were conducted to evaluate F_5 families selected from each treatment was sown in both conditions (the plants selected under normal irrigation were evaluated under normal irrigation and deficit irrigation. The plants selected under deficit irrigation were evaluated under normal irrigation and deficit irrigation). Each plant was sown in a separate row 2.5-m long, 30-cm apart and 10-cm between plants within rows in randomized complete block design with three replications. Parents and unselected bulk were also grown in each replicate. The studied traits included number of spikes plant^{-1} (S/plant), plant height (PLH), biological yield plant^{-1} (BY), grain yield plant^{-1} (GY), harvest index (HI), 100-kernel weight (100-KW) and number of kernels spike^{-1} (K/S).

Statistical analysis

Analysis of variance and combined analysis were performed according to Snedecor and Cochran (1980) using MSTAT-C computer program in a randomized complete blocks design (RCBD). Estimates of phenotypic and genotypic variances, as well as heritability estimates were calculated from EMS of the variance and covariance components of the selected families. Genotype means were compared using Revised Least Significant Difference (RLSD) according to El-Rawi and Khalafalla (1980). The phenotypic (σ^2p) and genotypic (σ^2g) variances and heritability in broad sense were calculated according to the following formula:

The genotypic variance $\sigma^2 g = (M_2-M_1)/r$.

The phenotypic variance $\sigma^2 p = \sigma^2 g + \sigma^2 e/r$

Heritability in broad sense "$H^2{}_{.bs}$" was estimated as the ratio of genotypic ($\sigma^2 g$) to the phenotypic ($\sigma^2 g + \sigma^2 e/r$) variance according to Walker (1960). Realized heritability (h^2) was calculated as: $h^2 = R/S$ (Falconer, 1989), where R = response to selection and S = selection differential. The phenotypic (pcv%) and genotypic (gcv%) coefficients of variability were estimated using the formula developed by Burton (1952). Drought susceptibility index (DSI) was calculated according to the method of Fischer and Maurer (1978). The sensitivity and relative merits of selected families were assessed as described by Falconer (1990). The relative merits of the two types of selection in changing the mean is expressed as the ratio:

(Change of mean by antagonistic selection)

(Change of mean by synergistic selection)

Antagonistic selection: selection in a bad environment or in a good one, selection and environment acted in the same direction on the characteristic.

Synergistic selection: selection in a good environment or in a bad one, selection and environment acted in opposite direction on the characteristic.

RESULTS AND DISCUSSION

1- Description of the base population; 2009/2010 season

The base population used in this study was the F_2-generation. The studied traits of the two parents and the F_2 generation under both conditions are shown in Table 2. The first parent had high tillering ability, higher plant height, high biological yield, low grain yield, high 100-kernel weight, low harvest index and small number of grains spike^{-1} than the second parent under normal irrigation (N). On the other hand, under deficit irrigation (D) conditions, the first parent had a high tillering ability, higher plant height, high biological yield, high grain yield, low 100-kernel weight, low harvest index and high number of grains spike^{-1} than the second parent. All the studied traits showed over dominance under normal irrigation, while under deficit irrigation all the studied traits showed over dominance except for harvest index and 100-kernel weight. Deficit irrigation caused a reduction in number of spikes plant^{-1}, biological yield, grain yield, harvest index, 100-kernel weight and number of kernels spike^{-1} by 9.13, 10.93, 24.04, 10.34, 8.22 and 6.61%, respectively. While, plant height was more stable and not affected by drought treatment. Kheiralla *et. al.*(2004) reported that skipping irrigation at any stage of wheat growth reduced number of spikes plant^{-1}.

The coefficient of variability under normal irrigation ranged from 8.1 for plant height to 47.0 for grain yield, while under deficit irrigation it ranged from 7.7 for plant height to 53.8 for grain yield. Similar results have been stated by Ismail (1995), Eissa (1996), Mahdy *et. al.*(1996), Amin (2003), Zakaria *et. al.*(2008), El-morshidy *et. al.*(2010) and Ali (2011). Broad sense heritability under normal irrigation was higher than that under deficit irrigation conditions for all the studied traits except for harvest index, ranging from 47.3 for harvest index to 78.7 for grain yield under normal irrigation, and from 30.8 for plant height to 69.6 for biological yield under deficit irrigation conditions.

The expected genetic advance under selecting the best 9.35% of F_2 plants under normal irrigation and 8.40% of F_2 plants under deficit irrigation was high and ranged from 8.08% for plant height to 65.08 for grain yield under normal irrigation, and from 4.29% for plant height to 56.45 for biological yield under deficit irrigation conditions. Similar result has been found by Zakaria *et. al.* (2008).

2 – Selection for high grain yield plant^{-1}

2.1 – Variability and heritability estimates

The phenoltypic variance σ^2_p was larger under normal irrigation for cycles C_0, C_2 and C_3, while it was smaller for cycle C_1 than that under deficit irrigation (Table 3). On the other hand, genotypic variance σ^2_g was also larger under normal irrigation for cycles C_0, C_2 and C_3, while it was smaller for cycle C_1 than that under deficit irrigation. The phenotypic coefficient of variability was generally larger than the genotypic coefficient of variability. The phenotypic coefficient of variability (PCV) for grain yield plant^{-1} in the F_2 generation was 47.0% under normal irrigation and decreased to 15.6%, 15.3% and 9.4% in F_3, F_4 and F_5 generations, respectively. Likewise, the PCV% under deficit irrigation was more than that under normal irrigation and it was 53.8%, 19.7%, 15.9% and 10.4% for C_0, C_1, C_2 and C_3, respectively, which may be due to the fact that the mean of grain yield plant^{-1} under normal irrigation was higher than that under deficit irrigation.

The genotypic coefficient of variability (GCV) for grain yield plant^{-1} in the F_2 generation was 37.0% under normal irrigation and decreased to 14.9%, 14.1% and 9.1% in C_1, C_2 and C_3, respectively. Likewise, the GCV% under deficit irrigation was 30.1%, 19.2%, 14.7% and 10.0% for C_0, C_1, C_2 and C_3, respectively. The realized heritability increased from C_1 to C_3 and under normal irrigation was 11.0%, 23.2% and 52.8% for cycles C_1, C_2 and C_3, respectively. On the other hand, under deficit irrigation it was 9.8, 31.4 and 37.0 for cycles C_1, C_2 and C_3, respectively. These results are in agreement with those of Ahmed (2006), Ali (2011) and Mahdy *et. al.* (2012).

2.2 – Means and observed gains under normal irrigation selection

The group of families selected for grain yield plant^{-1} under normal irrigation which were evaluated under both conditions, in case of normal irrigation, it ranged from 19.0 g plant^{-1} for family no. 415 to 25.9 g plant^{-1} for family no. 248 with an average of 22.4 g plant^{-1} (Table 4). The average observed gain under normal irrigation was significant and was 9.3% and 10.0% from the bulk sample and the better parent, respectively. And it ranged from -7.0% for family no. 415 to 26.4% for family no. 248 compared to the bulk sample, while it ranged from -6.5% for family no. 415 to 27.2% for family no. 248 compared to the better parent.

The selected families no. 10, 18, 89, 143, 218, 232 and 248 showed significant ($P \leq 0.01$) observed gain from the better parent, four of them showed significant observed gain from the bulk sample. On the other hand, when the selected families were evaluated under deficit irrigation it ranged from 17.4 g plant^{-1} for family no. 143 to 25.8 g plant^{-1} for family no. 248 with an average of 20.9 g plant^{-1} (Table 4). The average observed gain under deficit irrigation was significant and was 26.3% and 10.2% from the bulk sample and the better parent, respectively. And it ranged from 5.4% for family no. 143 to 56.3% for family no. 248 compared to the bulk sample, while it ranged from -8.0% for family no. 143 to 36.4% for family no. 248 compared to the better parent. All the selected families except family no. 143 showed significant ($P \leq 0.01$) observed gain from the bulk sample, five of them showed significant observed gain from the better parent.

2.3 – Means and observed gains under deficit irrigation selection

The group of families selected for grain yield plant^{-1} under deficit irrigation were evaluated under both conditions. Under normal irrigation, it ranged from 19.0 g plant^{-1} for family no. 45 to 27.5 g plant^{-1} for family no. 26 with an average of 22.9 g plant^{-1} (Table 4). The observed gain ranged from -13.0% for family no. 45 to 25.9% for family no. 26 compared to the bulk sample, while it ranged from -13.4% for family no. 45 to 25.3% for family no. 26 compared to the better parent. The selected families no. 26, 45, 73, 198, 227 and 457 showed significant ($P \leq 0.01$) observed gain from the better parent, five of them showed significant observed gain from the bulk sample. On the other hand, when the selected families were evaluated under deficit irrigation it ranged from 17.8 g plant^{-1} for family no. 26 to 21.3 g plant^{-1} for family no. 227 with an average of 19.5 g plant^{-1}.

The average observed gain under deficit irrigation was 7.7% and 11.9% from the bulk sample and the better parent, respectively. And it ranged from -1.4% for family no. 26 to 17.7% for family no. 227 compared to the bulk sample, while it ranged from 2.4% for family no. 26 to 22.3% for family no. 227 compared to the better parent. The selected families no. 171, 227, 318 and 457 showed significant ($P \leq 0.01$) observed gain from the better parent, two of them showed significant observed gain from the bulk sample.

Generally we can state that selection for high grain yield plant^{-1} for three cycles under normal irrigation in this case was better than selection under deficit irrigation. Kheiralla (1989) stated that pedigree selection for grain yield increased grain yield by 20.8% of the bulk sample. Ismail (1995) found that genetic gains in grain yield over the bulk sample and the better parent was (8.47 and 4.86) and (6.96 and6.41) in two populations. Kheiralla *et. al.*(2006) reported that two cycles of selection for grain yield increased grain yield by 20.2% and 7.6 from the bulk sample and the better parent. Similar results have also been found by Ali (2011) and Mahdy *et. al.*(2012).

2.4 – Average observed gain after three cycles of selection for high grain yield plant^{-1}

The observed gain from selection for high grain yield plant^{-1} under normal irrigation was 6.1, 6.4 and 10.0% from the better parent in C_1, C_2 and C_3, respectively. The observed gain from selection for high grain yield plant^{-1} under deficit irrigation was 13.7, 9.3 and 11.9 from the better parent in C_1, C_2 and C_3, respectively. On the other hand, the observed gain from selection for high grain yield plant^{-1} under normal irrigation was 8.9, 6.2 and 9.3% from the bulk sample in C_1, C_2 and C_3, respectively. The observed gain from selection for high grain yield plant^{-1} under deficit irrigation was 26.0, 9.2 and 7.7 from the bulk sample in C_1, C_2 and C_3, respectively.

The results in these material showed that the selection under deficit irrigation was more effective in the early generations, while the selection under normal irrigation was more effective in the late generations. This may be due to the increase of levels of homozygosity in the late generations. The third cycle of selection was evaluated under both conditions, and the observed gain in the normal irrigation group were 10.0 and 4.1% from the better parent compared to 9.3 and 4.6% from the bulk sample. While under deficit irrigation, the observed gains were 10.2 and 11.9% from the better parent compared to 26.3 and 7.7% from the bulk sample.

Drought susceptibility index and sensitivity to environments

The drought susceptibility index (DSI) and sensitivity to environments of the selected families for high grain yield plant^{-1} are presented in Table 6 and figures 1 and 2. The results indicated that among the families which were selected under normal irrigation and were evaluated under both conditions, six families no. 18, 218, 232, 248, 392 and 415 showed DSI of 0.15, 0.01, 0.40, 0.01, 0.90 and 0.01, respectively. These families were less susceptible to drought. Also these six families gave lower values of sensitivity. These families were more stable under various conditions, while the family no. 10 had good performance under normal irrigation and it has DSI more than unity so it can be sown under normal irrigation. Between these families, family no. 248 had good grain yield and DSI less than unity, so it can be a good stable cultivar.

The results of the deficit irrigation group showed that five families no. 45, 73, 171, 318 and 402 showed DSI of 0.19, 0.32, 0.09, 0.70 and 0.49, respectively. These families were less susceptible to water deficit. Also these five families gave values of sensitivity less than one. These families were more stable under various conditions. While the families no. 26, 198, 227 and 457 had high grain yield plant^{-1} under normal irrigation but they were not good under deficit irrigation and it had DSI more than unity and ranged from 1.04 to 2.36, so it can be sown under normal irrigation. The two parents and the unselected bulk had values of DSI were more than one and more sensitive to deficit irrigation. Falconer (1990) stated that, when selection and environment change the character in opposite direction this is antagonistic selection, i.e. selection upwards in a low environment or downwards in a high environment. Synergistic selection, upwards in a high environment or downwards in a low environment when selection and environment change the character in the same direction.

The relative merits of the two types of selection in changing the mean is according to (Falconer, 1990). A ratio over 1.0 means that antagonistic selection is better, and a ratio less than 1.0 means that synergistic selection is better. In the F_5-generation after three cycles of selection for high grain yield under drought stress (drought group) and under normal irrigation (irrigation group), the two groups of families were evaluated under both conditions. The relative merits were 0.319 and 0.524 when selections were evaluated under deficit and normal irrigation, respectively.

These results indicated that synergistic selection was better than antagonistic selection to increase grain yield plant^{-1} in these materials, whether for evaluation made under normal irrigation or under deficit irrigation conditions. Similar results have been found by Falconer (1990) who reported that to increase the mean performance, selection should be made upwards in a bad environment, and conversely, to decrease mean performance downwards selection should be made in a good environment. Mohamed (2001) stated that antagonistic selection reduced sensitivity of the intermated families and synergistic increased it. Kheiralla *et. al.*(2006) found that selection under early planting (synergistic selection) increased sensitivity of the selected families, while selection under late planting (antagonistic selection decreased it.).

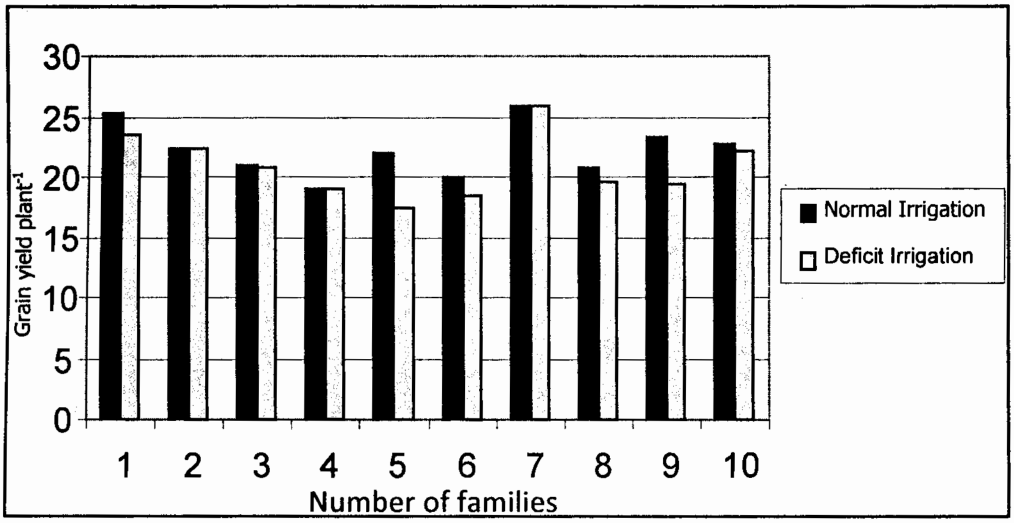

Fig. 1. Configuration of sensitivities of the 10 selected families for grain yield plant^{-1} which were selected under normal Irrigation and evaluated under both conditions.

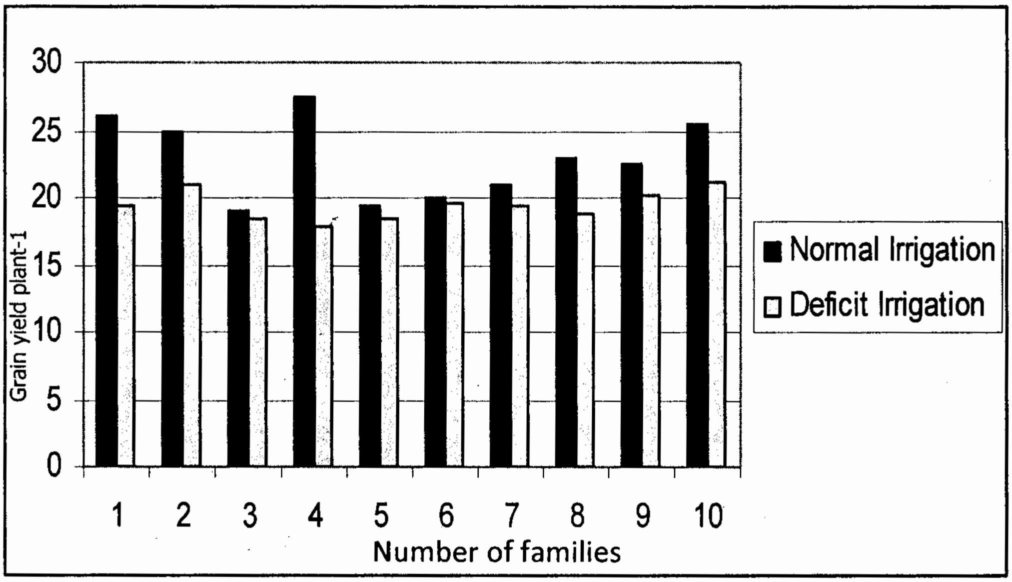

Fig. 2. Configuration of sensitivities of the 10 selected families for grain yield which were selected under water deficit Irrigation and evaluated under both conditions.

Table 2. Means, reduction%, coefficient of variability (CV), broad sense heritability (Hb) and ΔG/mean% of the base population (F2 generation)

Item		Normal irrigation							Deficit irrigation conditions.						
		S/plant	PLH	BY	GY	HI	100-KW	K/S	S/plant	PLH	BY	GY	HI	100-KW	K/S
F_2 Population	Means±SE	12.19± 0.21	104.4± 0.41	60.90± 1.17	19.76± 0.45	0.32± 0.005	4.87± 0.031	32.91± 0.39	11.17± 0.20	105.44± 0.37	54.90± 1.12	15.93± 0.39	0.29± 0.004	4.50± 0.028	30.87± 0.43
	Reduction%								9.13	-0.99	10.93	24.04	10.34	8.22	6.61
	CV %	36.28	8.09	39.90	46.97	22.88	13.03	24.63	39.14	7.66	44.54	53.84	30.48	13.74	30.17
	H (b) %	69.27	56.77	73.55	78.72	47.34	66.14	49.90	56.14	30.79	69.64	55.91	50.70	64.55	45.98
	ΔG/mean%	44.23	8.08	51.64	65.08	19.06	15.17	21.63	39.99	4.29	56.45	54.79	28.12	16.14	25.25
Parent 1	Means±SE	11.5± 0.63	98.0± 1.22	46.56± 4.00	15.79± 1.10	0.25± 0.01	4.82± 0.09	24.65± 2.26	11.0± 1.34	103.4± 2.38	43.84± 5.58	14.25± 2.22	0.32± 0.02	4.69± 0.10	25.05± 2.39
	Reduction%								4.55	-5.22	6.20	10.81	-21.9	2.77	-1.60
	CV %	14.14	2.79	19.19	15.60	8.40	4.28	20.54	25.00	5.14	28.46	34.81	11.61	4.67	21.33
Parent 2	Means±SE	10.20± 0.58	89.60± 2.04	42.72± 1.75	13.34± 0.66	0.29± 0.03	4.72± 0.10	25.82± 1.37	10.20± 0.37	97.6± 2.62	37.92± 1.06	12.55± 1.16	0.33± 0.02	4.60± 0.10	24.66± 2.11
	Reduction%								0.00	-8.20	12.66	6.29	-12.1	2.61	4.70
	CV %	12.78	5.09	9.18	11.15	19.27	4.73	11.85	8.20	6.00	6.26	20.75	14.85	4.77	19.15

ΔG = the expected genetic advance from selecting superior 40/428 plants under normal and 40/476 plants under deficit irrigation conditions.

Table 3. Variability and heritability estimates of grain yield plant-1 after three cycles of selection under normal irrigation (N) and deficit irrigation conditions (D).

Selection cycle	σ^2_p		$\sigma^2 g$		**P.C.V. %**		**G.C.V. %**		**H %**		**R heritability**	
	N	**D**	**N**	**D**	**N**	**D**	**N**	**D**	**N**	**D**	**N**	**D**
F_2 population (C_0)	86.1	73.5	53.4	23.0	46.9	53.8	36.9	30.1	78.7	55.9	--	--
F_3 families (C_1)	16.1	17.6	14.8	16.8	15.5	19.7	14.9	19.2	91.6	95.0	10.9	9.76
F_4 families (C_2)	9.62	8.34	8.15	7.16	15.3	15.9	14.0	14.7	84.6	85.8	23.2	31.3
F_5 families (C_3)	4.42	1.26	4.12	0.98	9.40	10.4	9.08	9.95	93.3	90.7	52.7	36.9

Table 4. Mean grain yield plant-1 and observed gain from the bulk sample (OG% Bulk) and from the better parent (OG% BP) for the high grain yield plant-1 selected families after three cycles of selection under normal and deficit irrigation conditions.

Item	Fam. No.	Evaluation under normal irrigation			Evaluation under deficit irrigation		
		Mean	OG%Bulk	OG% BP	Mean	OG%Bulk	OG% BP
Selection under normal irrigation	10	25.37	24.06**	24.79**	23.57	42.59**	24.45**
	18	21.01	2.74	3.34	20.80	25.83**	9.82**
	89	23.26	13.74**	14.41**	19.32	16.88**	2.01
	143	21.97	7.43*	8.07**	17.42	5.38	-8.03*
	218	22.44	9.73*	10.38**	22.43	35.69**	18.43**
	232	22.77	11.34**	12.00**	22.17	34.12**	17.05**
	248	25.85	26.41**	27.15**	25.83	56.26**	36.38**
	354	20.06	-1.91	-1.33	18.36	11.07**	-3.06
	392	20.84	1.91	2.51	19.6	18.57**	3.48
	415	19.01	-7.04	-6.49	19.00	14.94**	0.32
	M	22.36	9.34*	9.99**	20.88	26.32**	10.24**
	Pa	18.90			18.94		
	Pa	20.33			17.69		
	B	20.45			16.53		
R.L.S.D.		2.02			1.71		
Selection under deficit irrigation	26	27.53	25.88**	25.25**	17.80	-1.44	2.42
	28	23.00	5.17	4.64	18.83	4.26	8.34
	45	19.03	-12.99**	-13.42**	18.50	2.44	6.44
	73	19.37	-11.43*	-11.87**	18.43	2.05	6.04
	171	19.93	-8.87*	-9.33*	19.67	8.91	13.18**
	198	26.00	18.88**	18.29**	19.40	7.42	11.62*
	227	25.47	16.46**	15.88**	21.25	17.66**	22.27**
	318	22.60	3.34	2.82	20.23	12.02*	16.40**
	402	20.93	-4.30	-4.78	19.41	7.48	11.68*
	457	24.87	13.72**	13.15**	20.99	16.22**	20.77**
	M	22.87	4.57	4.05	19.45	7.70	11.91*
	Pa	20.13			13.13		
	Pa	21.98			17.38		
	B	21.87			18.06		
R.L.S.D.		2.52			2.27		

* and** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 5. Means and observed gain from selection for high grain yield plant-1 under normal irrigation and deficit irrigation from the bulk sample and the better parent.

Cycle	Mean	Normal Irrigation		Deficit irrigation	
Cycle (1)	Families mean	25.80		21.34	
	Parent (1)	23.33		16.49	
	Parent (2)	24.31		18.77	
	Bulk sample	23.70		16.92	
	OG % (Bulk)	8.86		26.02**	
	OG%(Better parent)	6.13		13.69*	
R. L.S.D. 0.05		3.18		2.56	
R. L.S.D. 0.01		4.30		3.46	
Cycle (2)	Families mean	20.27		18.15	
	Parent (1)	19.06		16.60	
	Parent (2)	16.42		15.46	
	Bulk sample	19.09		16.62	
	OG % (Bulk)	6.18		9.21	
	OG%(Better parent)	6.35		9.34	
R. L.S.D. 0.05		3.33		2.98	
R. L.S.D. 0.01		4.50		4.03	
Cycle (3) The selected families evaluated under both Conditions		Normal	Deficit	Normal	Deficit
	Families mean	22.36	20.88	22.87	19.45
	Parent (1)	18.90	18.94	20.13	13.13
	Parent (2)	20.33	17.69	21.98	17.38
	Bulk sample	20.45	16.53	21.87	18.06
	OG % (Bulk)	9.34*	26.32**	4.57	7.70
	OG%(Better parent)	9.99**	10.24**	4.05	11.91*
R. L.S.D. 0.05		1.49	1.27	1.86	1.63
R. L.S.D. 0.01		2.02	1.71	2.52	2.27

*, ** Significant at 0.05 and 0.01 level of probability, respectively

OG % = observed gain as percent from the bulk sample or better parent.

Table 6. Means of grain yield plant-1, heat susceptibility index (HSI) and sensitivity (S) of the selected families under normal (N) and heat stress (H) and evaluated under both conditions after two cycles of selection (F4 generation).

Item	Selection under normal					Selection under heat stress				
	Fam. No.	N	H	S	HSI	Fam. No.	N	H	S	HSI
F_5 selected families	10	20.61	17.73	3.02	0.56	26	23.76	20.82	3.08	1.27
	18	27.29	22.61	4.91	0.69	28	32.64	29.40	3.40	1.02
	89	20.03	18.58	1.52	0.29	45	27.56	26.67	0.93	0.33
	143	17.05	16.76	0.31	0.07	73	19.48	18.93	0.58	0.29
	218	24.71	19.45	5.52	0.85	171	24.50	24.43	0.07	0.03
	232	31.32	18.00	13.97	1.71	198	27.91	24.83	3.23	1.13
	248	26.68	17.98	9.13	1.31	227	26.62	25.18	1.51	0.55
	354	29.32	16.30	13.66	1.78	318	35.42	26.06	9.81	2.70
	392	26.36	20.17	6.50	0.94	402	29.91	25.47	4.66	1.52
	415	24.33	18.42	6.20	0.97	457	25.55	24.83	0.76	0.29
	Mean	24.77	18.60	6.47		Mean	27.34	24.70	2.80	
Parent (1)		19.51	16.04	2.69	0.90		19.51	16.04	2.69	0.90
Parent (2)		21.16	17.54	2.58	0.94		21.16	17.54	2.58	0.94
Bulk		21.16	17.30	2.76	1.00		21.16	17.30	2.76	1.00

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٢-١٢ كفاءة الانتخاب تحت ظروف الري العادي والتقسية المائية في قمح الديورم

جمال محمد محمد سليمان[١] ، محمد عبد المنعم المرشدي[٢] ، كمال عبده خيرالله[٢] ، إبراهيم عبدالهادي أمين[١]

١. قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر.
٢. قسم المحاصيل – كلية الزراعة – جامعة أسيوط.

يهدف هذا البحث إلى دراسة كفاءة الانتخاب المنسب في تحسين محصول حبوب قمح الديورم تحت ظروف الري العادي والمنخفض بعد ثلاث دورات من الانتخاب تحت كل بيئة من الجيل الثاني حتى الجيل الخامس. وفى الموسم الأخير تم تقييم العائلات المنتخبة من كل بيئه تحت ظروف البيئتين. وكان مقدار التباين الوراثي أقل قليلا من التباين المظهري تحت ظروف البيئتين وانخفض عموماً تدريجيا من الجيل الثاني إلى الجيل الخامس. وكانت كفاءة التوريث بالمعنى الواسع لصفة محصول النبات تحت ظروف الري العادي والمنخفض هي ٩٣.٣ و٩٠.٨%، على الترتيب بعد ثلاث دورات من الانتخاب. كانت كفاءة التوريث الفعلية تحت الري العادي ١٠.٩، ٢٣.٢ و ٥٢.٨% مقابل ٩.٨ ، ٣١.٤ و ٣٧.٠% تحت تأثير الري المنخفض للدورة الأولي والثانية والثالثة، علي الترتيب. وقد أظهرت التراكيب الوراثية المنتخبة تحت ظروف الري العادي والتي جرى تقييمها تحت الري العادي والمنخفض فروق معنوية عالية في محصول الحبوب للنبات بالنسبة لمخلوط العشيرة بمقدار ٩.٣ و ٢٦.٣% وبمقدار ٩.٩ و ١٠.٢% بالنسبة للأب الأعلى، على التوالي. ولكن العائلات المنتخبة لمحصول الحبوب العالي تحت الري المنخفض والتي قيمت تحت ظروف الري العادي والمنخفض أظهرت زيادة معنوية لمحصول الحبوب بمقدار ٤٠.٦% و ٧.٧% بالنسبة لمخلوط العشيرة وبمقدار ٤.١ و ١١.٩% بالنسبة للأب الأفضل، على التوالي. وتراوحت قيم معامل الحساسية للجفاف من ٠.٠١ إلى ٣.١٣ للعائلات المنتخبة تحت الري العادي، بينما تراوحت بين ٠.٠٩ إلى ٢.٣٦ للعائلات المنتخبة تحت الري المنخفض. وأظهرت النتائج أن الحساسية للإجهاد المائي زادت في حالة الانتخاب المتضاد، بينما انخفضت في حالة الانتخاب المتوافق. وكان الانتخاب للمحصول العالي تحت الري العادي (الانتخاب المتوافق) أفضل من الانتخاب تحت الري المنخفض (الانتخاب المتضاد).