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LATE AND EARLY PEDIGREE SELECTION FOR GRAIN YIELD WITH DIFFERENT SELECTION CRITERIA UNDER TWO WATER TREATMENTS IN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

The present study was performed on a clay-loam soil at Assiut University, Exp., Farm, during the four successive seasons starting from 2002/2003. One bread wheat (Triticum aestivum L.) cross (Nilein x Giza 160) in F_2, F_3, F_4 and F_5 generations was used in this investigation to do two cycles of early pedigree selection and one cycle of late one under two treatments of irrigations.

The analysis of variance indicated highly significant differences among F_3 families for all studied traits under both treatments of irrigation, reflecting the genetic differences among obtained families.

After two cycles of selection, the G.C.V. and P.C.V. for yield/plant were decreased with different selection criteria as well as after on cycle of late selection.

The grain yield decreased with I_2 (escaping the last two irrigations) compared to I_1 (normal irrigation) under all selection criteria.

Mean of grain yield/plant for the best 5 families after two cycles of early selection recorded 24.92 and 22.74; 34.94 and 29.47; 37.5 and 28.11; 29.28 and 23.18 and 32.34 and 25.99 g for I_1 and I_2 with selection criteria of days to heading, number of spikes/plant, grain yield/plant, harvest index and grain yield with days to heading in combined, respectively. Moreover, it is clear from the results that the one cycle of late selection gave the highest values of grain yield/plant which gave the highest values of grain yield under the two treatments of irrigation (38.56 and 31.87 g, respectively). Also, the two cycles of early selection for grain yield/plant was the best among the different selection criteria which yielded 37.57 and 28.11 g with I_1 and I_2, respectively, but it ranked after the late selection in grain yield.

The one cycle of late selection for grain yield/plant resulted in a remarkable direct response for selections in yield increase which was accounted to 24.19 and 12.32% with I_1 and 27.73 and 9.90 % with I_2 over the better parent and check cultivar Giza 168, respectively.

The families nos. 100, 60 and 19 (in rank) were common to the two treatments of irrigations in the late selection. These families yielded 40.11, 37.54 and 37.49 g under I_1 and decreased by 23.09, 11.69 and 16.59% under I_2, respectively after one cycle of late selection.

Key words: ***Late selection, early selection, wheat.***

INTRODUCTION

Wheat is the world's most important and most widely grown cereal crop. Its importance is derived from many properties and uses of its grains, which makes it a staple food for more than one third of world's population (Poehlman 1987). The main objective of most wheat breeding programs is to develop high yielding varieties with good qualities. Also, breeding for high yield potential under water stress is a major objective of most breeding programs. Pedigree selection for yielding potential in wheat and other cereal crops assumes selection in the F_2 generation of individual plants spaced apart to enable their evaluation. Then selection from F_3 to F_6 generation is practiced among and within families following evaluation in row plots and/or in yield trials (Poehlman and Sleper 1995). Selection for yield from early generation based on single plant evaluation is mostly interesting and should be initiated in the F_2 generation (Shebeski 1967 and Sneep, 1977). Wheat breeders improve grain yield through selection by using grain yield itself as a selection criterion (Loffler and Busch 1982). Mahdy (1988) reported that selection based on grain yield *per se* was effective in improving grain yield as well as increased spike length, number of spikes/plant and grain number/spike. The goal of early generation selection is to increase breeding efficiency through the early identification of superior heterogeneous populations.

Kheiralla (1993) reported that direct selection for spike length, 1000-kernel weight, number of kernels/spike and number of spikes /plant resulted in an increase in grain yield after two cycles of selection.

The early elimination of inferior populations and subsequent concentration of selection efforts within superior populations is assumed to result in increased efficiency. The concept of early generation testing in self-pollinating species as a means to identify superior bulk hybrid populations was first described by Immer (1941) and has been used in various crops with varying success. Numerous variants of early generation selection have been developed and employed. Harlan *et al* (1940) used F_2 bulks to identify superior barley (*Hordeum vulgare* L.) populations. The evaluation in all generations gave similar yield gains and therefore the selected F_2 families would be the most advantageous (Cregan and Busch 1977, Singh *et al* 1990, Singh *et al* 1998 and Martin and Geraldi 2002). Otherwise, Fowler and Heyne (1955) reported poor predictive results from bulk hybrid tests of hard red winter wheat (*Triticum aestivum* L.). Selection for quantitative traits with low heritability must be delayed until later generations (Frederikson and Kronstod, 1985). Furthermore, late pedigree selection started in the F_5 for one cycle increased grain yield/plant in wheat by 13.06% compared to 7.6% from the bulk sample after three cycles of selection started early in the F_3 (Ismail *et al* 1996).

The objective of the current study was to estimate the efficiency of pedigree line selection in late and early generations for grain yield using different selection criteria. Furthermore, to detect the important selection criteria for grain yield to enhance the efficiency of selection under water stress treatments.

MATERIALS AND METHODS

The present investigation was performed on a clay-loam soil at Assiut University, Exp., Farm, during the four successive seasons starting from 2002/2003.

Genetic materials:

Bread wheat (*Triticum aestivum* L.) cross (Nilein x Giza 160) in F_2, F_3, F_4, F_5 generations was used in this investigation.

This cross was chosen on the basis of the presence of favorable genetic behavior especially in heat and drought tolerance in the two parents. The cross included the Egyptian variety (Giza 160) and Nilein Sudanese variety.

Field procedures

In 2002/2003 season; the F_2 seeds were grown under drought conditions by escaping the last two irrigations (four irrigations over all growing season) in non-replicated trail in rows 3 m long, 30 cm apart and 10 cm between seeds to get F_3 seeds. The seeds from 100 F_2 plants were selected for grain yield/plant for the base population in the next season.

In 2003/2004 season; the seeds of F_3-selections (base population), parents and check variety Giza 168 were grown under two treatments of irrigation i.e.: I_1: Normal irrigation (6 irrigations over growing season) and I_2: escaping the last two irrigations (four irrigations over growing season), in a randomized complete block design with three replications.

Seeds of each family were sown by hand in the system of hills in rows 3 m long with 30 cm apart and 10 cm between plants within a row. The experimental unit was a single row. Days to heading were recorded for each row when 50% of the heads emerged from the flag leaf sheath. At harvest time, five guarded plants from each family in each replication were taken to measure the studied traits, via. plant height (cm), spike length (cm), number of spikes/plant, biological yield/plant (g), grain yield/plant (g) and harvest index.

The F_3 family means provided the base of early pedigree line selection, the 20 superior families (selection intensity 20%) were selected for different selection criteria. These early selection criteria were;

1. Days to heading
2. Number of spikes/plant
3. Grain yield/plant
4. Harvest index
5. Grain yield/plant and days to heading in one index.

The superior plant of each selected family was saved to initiate the first cycle of early pedigree line selection. The choice of previous traits as selection criteria were done based on their high genotypic and phenotypic variability (G.C.V and P.C.V).

Moreover, the high genetic correlations between grain yield/plant and each of number of spikes/plant and harvest index help to use these traits as selection criteria (indirect selection for grain yield/plant).

In 2004/2005 season: selection procedure was repeated on F_4-plants using all procedures of those in 2003/2004 season. Means of selections were ranked to initiate the second cycle of pedigree line selection for each selection criterion.

In 2005/2006 season; 5 superior families for each selection criterion (second cycle) were generated in the same way of the first cycle of selection.

Moreover, all families (100 families) with their parents and check variety Giza 168 were grown in each season under the same treatments of irrigation to initiate one cycle of late selection for grain yield/plant in F_5.

The comparison of early and late selections were done over the obtained data.

Statistical analysis

The analyses of variance through base population, the two cycles of early selection for each selection criterion as well as the late selection were performed according to Gomez and Gomez (1984). The phenotypic and genotypic coefficients of variability were calculated according to Burton (1952). Genotypic correlation between grain yield/plant and each of other studied traits in base, all selection criteria of both cycles of selection and late selection was done using the method of Walker (1960). Moreover, the response to selection over better parent and check variety in the generation mean with all selection criteria were calculated for first (C1) and second cycles (C2) of early pedigree line selection as well as for late selection.

RESULTS AND DISCUSSION

Base population

The analysis of variance (Table 1) indicated the highly significant differences among F_3 families for all studied traits under both treatments of irrigation, reflecting the genetic differences among obtained families. Large G.C.V. and P.C.V. were recorded for all studied traits except days to heading under both treatments of irrigation and present a sufficient genetic variation for selection (Table 2). Treatment 2 (I_2) of irrigation revealed higher G.C.V. and P.C.V. than treatment 1 (I_1) of irrigation for plant height, spike length, grain yield/plant and biological yield/plant. The highest values of G.C.V. and P.C.V. were found for grain yield/plant and recorded 21.20 and 22.81% for I_1 and 25.15 and 25.93% for I_2, respectively. The genotypic correlations were high between grain yield/plant and each of number of spikes/plant (0.66 and 0.77) and biological yield/plant (0.79 and 0.86), medium with harvest index (0.42 and 0.41) and low with days to heading (0.28 and 0.24) and plant height (0.25 and 0.04) under I_1 and I_2, respectively.

Table 1. Analysis of variance for studied traits in F_3-families (base population) of wheat under the two treatments of irrigation.

S.O.V.	d.f.	Days to heading	Plant height (cm)	Spike length (cm)	Number of spikes/ plant	Grain yield/ plant (g)	Biological yield/ plant (g)	Harvest index
		I_1						
Rep.	2	82.88	1509.38	48.18	42.73	403.93	2207.81	0.009
Families	99	55.27**	198.82**	4.46**	8.95**	92.04**	647.46**	0.007**
Error	198	2.63	27.69	1.03	1.02	12.58	64.33	0.001
		I_2						
Rep.	2	42.25	2338.75	70.57	29.28	76.30	668.00	0.008
Families	99	48.43**	219.97**	4.52**	6.69**	87.59**	608.15**	0.008**
Error	198	1.67	36.37	0.96	1.32	5.21	47.79	0.001

Afiah and Darwish (2003) found that the most important relationships are that between grain yield/plant and no. of spikes/plant (0.818**) under drought condition. Otherwise, negative values of correlation were recorded between grain yield/plant and spike length (Table 4). Afiah and Darwish (2003) reported that no. of spikes plant have the highest direct effect on grain yield under drought and salinity environments.

Highly significant differences among F_3 families and sufficient genetic variability (as measured via G.C.V. %) were obtained for spike length, number of spikes/plant, biological yield/plant, grain yield/plant and harvest index (Kheiralla 1993 and Ahmed 2006). Moreover, highly significant differences among some genotypes of wheat under non-stress and water-stress conditions for yield and it's attributes were obtained by Taghian and Abo-Elwafa (2003).

Selection response

Mean of grain yield/plant (g) for the best 5 families after two cycles of selection (Tables 2 & 5) recorded 24.92 and 22.74; 34.94 and 29.47; 37.57 and 28.11; 29.28 and 23.18; and 32.34 and 25.99 g for I_1 and I_2 with different selection criteria of days to heading, number of spikes/plant, grain yield/plant, harvest index and grain yield with days to heading, respectively. Moreover, the values of grain yield/plant were 38.56 and 31.87 g after one cycle of selection (late selection) for I_1 and I_2, respectively. It is clear from these results that the one cycle of late selection gave the highest values of grain yield under the two treatments of irrigation (38.56 and 31.87 g). Consequently, it will be a recommended way for selection in wheat. These results are in line with those obtained by Ismail *et al* (1996) and Ahmed (2006). Their results revealed that the late pedigree single trait selection was more effective than early selection in wheat.

Table 2. Mean, phenotypic (P.C.V.) and genotypic (G.C.V.) coefficients of variation for studied traits in the base population and different cycles of selection with different selection criteria under the two treatments of irrigation.

Criteria		Irrig. Treat.		Days to heading	Plant height (cm)	Spike length (cm)	Number of spikes/ plant	Grain yield/ plant (g)	Bio-logical yield/ plant (g)	Harvest index
Base	Mean	I_1		92.53	109.48	10.45	11.71	26.28	70.48	0.35
		I_2		92.58	97.50	9.05	11.68	20.84	58.29	0.36
	G.C.V. %	I_1		4.53	6.90	10.21	13.98	21.20	19.73	12.78
		I_2		4.27	8.02	12.02	11.45	25.15	23.05	12.42
	P.C.V. %	I_1		4.64	7.45	11.65	14.75	22.81	20.79	15.65
		I_2		4.34	8.78	13.56	12.79	25.98	24.08	15.24
Days to heading	Mean	I_1	C_1	93.38	123.00	10.05	12.38	25.80	71.12	0.34
			C_2	86.33	123.67	9.00	11.80	24.92	68.87	0.37
		I_2	C_1	93.58	109.42	9.15	12.32	22.20	63.75	0.36
			C_2	86.47	114.33	8.53	12.13	22.74	73.75	0.36
	G.C.V. %	I_1	C_1	3.67	4.28	7.65	14.23	23.53	24.21	13.41
			C_2	5.75	11.57	8.73	11.47	15.25	23.29	11.75
		I_2	C_1	4.13	9.63	6.21	14.58	24.11	26.10	13.89
			C_2	5.97	9.03	8.56	14.59	14.91	32.65	27.78
	P.C.V. %	I_1	C_1	3.70	4.70	9.21	14.88	26.20	24.48	14.20
			C_2	5.77	11.65	9.44	12.08	15.87	23.50	12.89
		I_2	C_1	4.15	10.00	8.41	15.29	24.76	26.53	15.21
			C_2	5.98	9.14	9.41	14.75	15.35	32.50	27.78
Number of spikes/ Plant	Mean	I_1	C_1	98.65	123.58	10.23	14.36	32.80	85.13	0.39
			C_2	95.33	133.00	9.27	16.93	34.94	101.20	0.34
		I_2	C_1	99.13	108.33	9.50	14.07	27.46	70.18	0.39
			C_2	93.07	116.00	9.20	15.93	28.47	78.20	0.38
	G.C.V. %	I_1	C_1	4.95	6.39	7.25	13.85	15.28	18.16	11.47
			C_2	4.54	6.58	4.82	4.75	22.57	7.83	19.77
		I_2	C_1	4.75	7.40	4.53	15.58	22.87	18.58	12.76
			C_2	1.84	2.43	1.09	8.18	9.50	8.50	2.65
	P.C.V. %	I_1	C_1	4.97	6.64	8.27	14.43	15.91	18.65	14.04
			C_2	4.55	6.71	5.33	5.09	22.88	8.31	20.80
		I_2	C_1	4.77	7.78	7.50	15.93	23.14	19.71	13.26
			C_2	1.87	2.80	3.24	8.55	10.32	9.31	8.37
Grain yield/ plant (g)	Mean	I_1	C_1	99.33	125.02	10.35	14.28	33.07	85.62	0.39
			C_2	96.00	127.67	9.93	15.93	37.58	98.67	0.38
		I_2	C_1	98.90	110.83	9.62	14.33	28.34	70.85	0.41
			C_2	92.33	117.00	9.20	14.00	28.11	71.80	0.39
	G.C.V. %	I_1	C_1	4.75	6.63	6.43	13.49	17.40	18.30	8.80
			C_2	3.78	8.35	11.92	11.17	4.47	10.66	9.04
		I_2	C_1	5.25	7.57	4.61	12.76	17.11	15.53	7.75
			C_2	2.60	6.04	5.25	22.28	11.89	12.64	5.40
	P.C.V. %	I_1	C_1	4.77	7.86	7.86	13.83	18.01	18.76	9.35
			C_2	3.79	8.49	12.20	11.59	5.98	13.06	9.40
		I_2	C_1	5.27	7.95	7.13	13.22	17.67	16.45	10.96
			C_2	2.64	6.32	5.56	22.40	12.31	13.88	6.59

Table 2. Cont.

Criteria		Irrig.		Days to heading	Plant height (cm)	Spike length (cm)	Number of spikes/ plant	Grain yield/ plant (g)	Biological yield/ plant (g)	Harvest index
Harvest index	Mean	I_1	C_1	98.27	124.35	10.40	12.97	29.87	71.58	0.42
			C_2	91.80	119.67	9.47	12.47	29.28	65.87	0.45
		I_2	C_1	98.52	104.58	9.48	13.75	26.90	59.85	0.45
			C_2	91.80	111.33	8.33	12.07	23.18	54.33	0.43
	G.C.V. %	I_1	C_1	5.18	4.86	7.85	17.98	22.16	23.52	12.98
			C_2	1.48	7.51	10.20	21.37	22.94	28.00	6.26
		I_2	C_1	4.52	8.41	8.47	14.46	24.02	25.96	6.97
			C_2	1.04	10.94	12.11	18.21	29.15	23.79	17.88
	P.C.V. %	I_1	C_1	5.20	5.36	8.48	18.34	22.61	23.74	13.35
			C_2	1.51	7.59	10.73	21.43	23.54	28.50	6.64
		I_2	C_1	4.55	8.71	10.11	15.02	24.40	26.36	9.85
			C_2	1.17	11.13	12.34	18.46	29.60	24.31	19.32
Grain yield + days to heading	Mean	I_1	C_1	98.30	124.03	10.20	13.93	31.77	81.58	0.39
			C_2	91.27	127.33	9.47	14.20	32.34	81.07	0.40
		I_2	C_1	98.72	110.58	9.55	13.90	27.26	67.17	0.41
			C_2	91.20	114.67	8.53	12.47	25.99	68.33	0.38
	G.C.V. %	I_1	C_1	4.36	5.22	7.16	11.99	15.24	15.70	11.97
			C_2	9.60	6.43	10.20	14.40	13.17	19.70	9.90
		I_2	C_1	4.33	6.72	5.59	14.14	18.25	17.83	12.91
			C_2	1.10	2.64	8.29	21.72	16.07	16.27	2.62
	P.C.V. %	I_1	C_1	4.38	5.69	8.45	12.58	15.67	16.08	12.21
			C_2	10.14	6.58	10.73	14.62	13.38	19.80	10.21
		I_2	C_1	4.35	7.48	8.18	14.56	18.90	18.60	13.36
			C_2	1.18	2.98	8.56	21.85	16.71	16.84	8.30
Late selection (grain yield)	Mean	I_1		93.40	126.33	9.47	16.93	38.56	99.73	0.39
		I_2		92.67	114.33	8.60	15.53	31.87	78.40	0.41
	G.C.V. %	I_1		1.96	2.23	13.15	4.11	2.03	4.13	3.89
		I_2		2.09	2.11	8.88	8.48	2.43	8.80	5.77
	P.C.V. %	I_1		1.98	3.41	13.31	5.09	2.87	4.47	4.66
		I_2		2.13	2.44	9.25	8.93	3.20	9.53	6.27

Also, the two cycles of direct selection for grain yield/plant was the best among the different selection criteria and yielded 37.57 and 28.11 g with I_1 and I_2, respectively, but it ranked after the late selection in grain yield of wheat.

Moreover, the data in Tables 2 and 5 revealed that the grain yield decreased with I_2 compared to I_1 under all selection criteria and also in late selection. For examples, grain yield/plant decreased from 37.57 to 28.11 g and from 38.56 to 31.87 g after two cycles of direct selection and one cycle of late selection for grain yield/plant, respectively. This result may be due to the lack of water resulted in less filling of grains in I_2 compared to I_1. Wheat genotypes were decreased from no-stress to water stress conditions for yield and it's attributes in wheat (Taghian and Abo-Elwafa 2003 and Solomon and Labuschange, 2003). Their results revealed that the reduction in grain yield from non-stress to stress conditions reached -46.77% over all wheat genotypes.

Table 3. Direct and indirect responses to selection relative to the better parent (bp) and to check cultivar (Ch).

Criteria	Irrig.	Selection cycle		Days to heading	Plant height (cm)	Spike length (cm)	Number of spikes/plant	Grain yield/plant (g)	Biological yield/plant (g)	Harvest index
Days to heading	I_1	C_1	b.p	-10.47	11.82	3.61	3.17	-13.21	-10.32	-10.53
			Ch.	0.95	36.67	-22.67	-11.57	-16.58	-3.60	-12.82
		C_2	b.p	-10.35	3.06	-7.22	-7.09	-19.59	-20.04	-2.63
			Ch.	-3.00	43.80	-28.57	-15.71	-25.99	-20.88	-2.63
	I_2	C_1	b.p	-9.76	2.55	5.17	-2.99	8.29	19.53	-5.26
			Ch.	1.72	20.24	-23.75	-6.23	-17.78	-1.92	-10.00
		C_2	b.p	-10.58	3.94	-12.06	-6.69	-9.40	16.42	-15.00
			Ch.	-1.74	34.51	-29.50	-10.81	-16.79	10.05	-15.00
Number of spikes	I_1	C_1	b.p	-5.42	12.35	5.46	19.58	9.99	-1.01	2.63
			Ch.	6.65	37.31	-21.31	2.50	5.30	6.41	0.00
		C_2	b.p	-1.01	10.83	-4.54	33.31	12.75	16.32	-10.53
			Ch.	7.11	54.65	-26.51	20.93	3.77	16.32	-10.54
	I_2	C_1	b.p	-4.41	1.53	9.20	10.79	33.95	31.60	2.63
			Ch.	7.75	19.04	-20.83	8.23	1.70	7.97	-2.50
		C_2	b.p	-3.75	5.46	-5.15	22.54	17.41	23.58	-5.00
			Ch.	5.76	36.47	-23.97	17.13	7.83	16.72	-5.00
Grain yield	I_1	C_1	b.p	-4.77	13.65	6.70	19.00	10.50	-0.44	2.63
			Ch.	7.38	38.91	-20.38	2.00	6.16	7.83	0.00
		C_2	b.p	-0.31	6.39	2.37	25.43	21.26	13.14	0.00
			Ch.	7.87	48.45	-21.19	13.79	11.61	13.41	0.00
	I_2	C_1	b.p	-4.63	3.87	10.57	12.83	38.24	31.31	7.89
			Ch.	7.50	21.79	-19.83	10.23	4.96	7.74	2.50
		C_2	b.p	-4.52	6.36	-5.15	7.69	11.99	13.37	-2.50
			Ch.	4.92	37.65	-23.97	2.94	2.85	7.16	-2.50
Harvest index	I_1	C_1	b.p	-5.78	13.85	8.04	8.08	0.16	-16.77	10.53
			Ch.	6.24	38.17	-19.38	-7.36	-4.11	-10.53	7.69
		C_2	b.p	-4.67	-0.28	-2.37	-1.81	-5.49	-24.29	18.42
			Ch.	31.46	39.15	-24.84	-10.92	-13.81	-24.28	18.40
	I_2	C_1	b.p	-5.00	-1.99	8.97	8.27	31.22	12.33	18.42
			Ch.	7.09	14.92	-21.00	5.77	-0.37	-7.92	12.50
		C_2	b.p	-5.07	1.21	-14.12	-7.15	-7.65	-14.21	7.50
			Ch.	4.32	30.98	-31.16	-11.25	-15.18	-18.91	7.50
Grain yield + Days to heading	I_1	C_1	b.p	-5.75	12.75	5.15	16.08	6.54	-5.14	2.63
			Ch.	6.27	37.81	-21.54	-0.50	1.99	1.98	0.00
		C_2	b.p	-5.22	6.11	-2.37	11.81	4.36	-6.82	5.26
			Ch.	2.55	48.06	-24.84	1.43	-3.95	-6.82	5.26
	I_2	C_1	b.p	-4.80	3.64	9.77	9.45	32.98	25.55	7.89
			Ch.	7.30	21.52	-2.04	6.92	0.96	3.34	2.50
		C_2	b.p	-5.69	4.25	-12.06	-4.08	3.55	7.50	-5.00
			Ch.	3.64	34.91	-29.50	-8.31	-4.90	1.99	-5.00
Late selection (grain yield)	I_1		b.p	-3.01	5.28	-2.37	33.31	24.43	14.63	2.63
			Ch.	4.94	46.30	-24.84	20.93	15.52	14.63	2.63
	I_2		b.p	-4.17	3.94	-11.34	19.46	26.97	23.00	5.13
			Ch.	5.31	34.51	-28.93	14.19	16.61	17.01	2.50

Table 4. Genotypic correlation between grain yield/plant and each other studied traits in base population, both cycles of selection with different selection criteria and late selection under the two treatments of irrigation.

Criteria	Irrig.	cycle	Days to heading	Plant height (cm)	Spike length (cm)	Number of spikes/ plant	Bio-logical yield/ plant (g)	Harvest index
Base	I_1		0.28	0.25	-0.10	0.66	0.79	0.42
	I_2		0.24	0.04	-0.07	0.77	0.86	0.41
Days to heading	I_1	C_1	0.35	-0.11	0.19	0.68	0.79	0.36
		C_2	-0.20	-0.57	-0.91	0.59	0.98	-0.81
	I_2	C_1	0.27	-0.16	-0.07	0.65	0.76	0.32
		C_2	0.06	-0.50	-0.98	0.30	0.57	-0.41
Number of spikes/ plant	I_1	C_1	0.78	0.46	0.18	0.70	0.74	0.14
		C_2	0.55	-0.26	-0.98	0.94	0.68	0.95
	I_2	C_1	0.50	0.11	0.28	0.65	0.81	0.67
		C_2	0.81	-0.23	0.53	0.88	0.91	0.89
Grain yield	I_1	C_1	0.28	-0.04	-0.11	0.75	0.87	0.26
		C_2	0.13	0.12	-0.95	0.84	0.52	-0.13
	I_2	C_1	0.46	-0.32	-0.09	0.63	0.82	0.65
		C_2	0.62	-0.51	0.85	0.99	0.90	-0.14
Harvest index	I_1	C_1	0.41	-0.39	0.04	0.87	0.89	0.10
		C_2	0.02	0.84	0.70	0.91	0.88	-0.95
	I_2	C_1	0.40	0.32	0.20	0.75	0.98	-0.22
		C_2	-0.81	0.86	0.52	0.38	0.78	0.49
Grain yield + days to heading	I_1	C_1	0.18	0.27	0.10	0.75	0.73	0.44
		C_2	-0.48	0.25	0.81	0.71	0.92	-0.59
	I_2	C_1	0.13	-0.41	0.01	0.70	0.79	0.45
		C_2	0.20	-0.10	-0.82	0.62	0.97	-0.14
Late selection (grain yield)	I_1		0.48	-0.78	0.11	0.49	0.77	0.43
	I_2		-0.14	0.65	-0.57	0.68	0.82	-0.75

The values of G.C.V. and P.C.V. were decreased after two cycles of selection with different selection criteria and after one cycle of late selection for grain yield/plant. The lowest values of G.C.V. and P.C.V. were 2.03 and 2.87

With I_1 and 2.43 and 3.20 with I_2 after one cycle of late selection for grain yield/plant compared to 21.20 and 22.81% (I_1) and 25.15 and 25.93% (I_2) in the base population, respectively. Same view could be found with other selection criteria except harvest index. For example, the G.C.V. and P.C.V. decreased to 4.47 and 5.88% with I_1 and to 11.09 and 12.31% with I_2 after two cycles of direct selection for grain yield/plant compared to the base population (>21%). This result could be expressing the genetic make-up of homogeneity in those obtained families of wheat. It could be mentioned that the values of G.C.V. and P.C.V. decreased from cycle one to cycle two of direct pedigree selection under different selection criteria except the

Table 5.The mean of grain yield/plant for the 5-superior families, parents and check cultivar after two cycles of early selection with different selection criteria as well as one cycle of late selection under the two treatments of irrigation.

Selected families	Days to heading		Number of spikes/plant		Grain yield/plant	
	I_1	I_2	I_1	I_2	I_1	I_2
1	(70) 29.45	(76) 25.99	(100) 40.11	(60) 33.18	(100) 40.11	(100) 30.85
2	(76) 27.56	(70) 24.89	(40) 39.12	(100) 30.85	(40) 39.12	(40) 30.67
3	(74) 25.50	(4) 24.61	(60) 37.54	(40) 30.67	(61) 37.16	(61) 30.22
4	(5) 22.55	(3) 20.47	(30) 37.14	(49) 26.51	(30) 37.14	(42) 25.43
5	(96) 19.53	(96) 17.74	(3) 20.81	(24) 26.13	(31) 34.33	(23) 23.39
Mean	24.92	22.74	34.94	29.47	37.57	28.11
P_1 (Nilein)	29.47	25.01	29.47	25.01	29.47	25.01
P_2 (Giza 160)	30.99	20.40	30.99	20.40	30.99	20.40
Check (Giza 168)	33.67	27.33	33.67	27.33	33.67	27.33
L.S.D. 5%	3.49	2.23	4.23	3.44	4.46	3.77
	Harvest index		**Grain yield + days to heading**		**Late selection**	
	I_1	I_2	I_1	I_2	I_1	I_2
1	(61) 37,16	(81) 31.32	(19) 37.49	(91) 32.73	(100) 40.11	(60) 33.18
2	(81) 35.06	(43) 28.66	(81) 35.06	(49) 26.51	(40) 39.12	(91) 32.73
3	(43) 27.96	(83) 23.05	(91) 31.61	(24) 26.13	(50) 38.55	(81) 31.32
4	(83) 26.04	(68) 17.01	(97) 31.50	(23) 23.39	(60) 37.54	(19) 31.27
5	(68) 20.20	(2) 15.84	(83) 26.04	(34) 21.19	(19) 37.49	(100) 30.85
Mean	29.28	23.18	32.34	25.99	38.56	31.87
P_1 (Nilein)	29.47	25.01	29.47	25.01	28.90	24.95
P_2 (Giza 160)	30.99	20.40	30.99	20.40	31.05	20.86
Check (Giza 168)	33.67	27.33	33.67	27.33	34.33	29.00
L.S.D. 5%	4.08	2.85	3.16	2.88	3.13	3.14

harvest index (Table 2). Similar results were obtained by Mahdy *et al* (1996), Kheiralla (1993) and Ahmed (2006).

Direct and indirect response

The one cycle of late selection for grain yield/plant resulted in a remarkable direct response for selection in yield which accounted to 24.19 and 12.32% with I_1 and 27.73 and 9.90% with I_2 over the better parent and check cultivar Giza 168 (Table 3), respectively. This result my be correlated with high positive indirect response in number of spikes/plant and biological yield/plant under both types of irrigation (I_1 and I_2) (Table 3).

Ismail *et al* (1996) and Ahmed (2006) found that the late pedigree line selection was more effective than early selection in wheat. Moreover, Kheiralla (1993) concluded that the selection based on yield *per se* was the most effective in increasing grain yield itself in wheat. Also, the direct response in grain yield reached to 20.81% (Kheiralla 1993) and 17.76 (Ahmed 2006) in early selection and increased up to 25.51% in late selection (Ahmed 2006).

The direct selection after two cycles of grain yield/plant resulted in a direct response of 21.26 and 11.61% in I_1 and 11.99 and 2.85% in I_2 over the better parent and check cultivar, respectively. Moreover, the indirect selection after two cycles of selection for number of spikes/plant exhibited 12.75 and 3.77% in I_1 and 17.41 and 7.83% in I_2 over the better parent and check cultivar, respectively. It is clear from this result that the two cycles of direct selection of grain yield/plant ranked after the one cycle of late selection in I_1, while the indirect selection for number of spikes/plant ranked after the late one in I_2 (Table 3). Consequently, when the selection was undertaken with water stress, the number of spike/plant could take attention. Also, as mentioned before, the indirect response of biological yield/plant and number of spikes/plant were helpful. This result is in harmony with Afia and Darwish (2003).

The responses in yield with other selection criteria were less or negative and correlated with the indirect responses in other traits. For example, the negative indirect response in grain yield/plant with harvest index, as a selection criterion, after two cycles of pedigree line selection was -5.49 and -13.01% in I_1 and -7.65 and -15.18% in I_2 over the better parent and check cultivar, respectively. These results were correlated with the negative indirect responses of number of spikes/plant and biological yield/plant under both types of irrigation (Table 3). This finding support the importance of those two traits in yield of wheat.

Genotypic correlation

The genotypic correlation between grain yield and other traits in the base population and under different selection criteria is presented in Table (4).

The high positive coefficients of genotypic correlation between grain yield/plant and each of number of spikes/plant (0.66 and 0.77) and biological yield (0.79 and 0.86) of both types of irrigation in the base population is still in the same direction after two cycles of pedigree line selection under different selection criteria as well as after late selection (Table 4).

For example, the genotypic correlation coefficients between grain yield/plant and both of number of spikes/plant and biological yield/plant were more than 0.90 in the treatment 2 of irrigation (I_2) after two cycles of pedigree line selection of grain yield/plant as a selection criterion.

These results are in accordance with results of Ahmed (2006). This mean that these traits could be helpful next to the direct selection to improve the grain yield/plant as found and relative to direct and indirect responses of selection with different selection criteria in wheat (Table 4). These results are confirmed with those obtained by Mahdy (1996) and Ahmed (2006). Also, the high positive genetic correlations between grain yield/plant and each of biological yield/plant and number of spikes/plant were found by Ahmed (2006).

Means of superior selections

Means of grain yield/plant for the 5-superior families after two cycles of pedigree line selection with different selection criteria as well as after one cycle of late selection under both treatments of irrigation are presented in Table(5). As mentioned before the mean of grain yield/plant over all selections after one cycle of direct late selection, took the top rank and were 38.56 and 31.87 g and followed by early direct selection (after two cycles of selection) which recorded 37.57 and 28.11 g for I_1 and I_2, respectively. Moreover, the indirect selection for number of spikes/plant is ranking in third order to improve the yield in wheat which exhibited 34.94 and 29.47 g for I_1 and I_2, respectively.

The families nos. 100, 60 and 19 (in rank) shared in the two treatments of irrigations (I_1 and I_2) in late selection. These families yielded 40.11, 37.54 and 37.49 g under I_1 and decreased by 23.09%, 11.69% and 16.59% under I_2, respectively, after one cycle of late selection. It is clear that the highest family (no. 100) in yield (40.11 g) in I_1 has the highest decrease in yield (23.09%) in I_2. This result is in line with those obtained by Taghian and Abo-Elwafa (2003). Moreover, only the highest two families nos. 100 and 40 matched in direct late and early selection for grain yield/plant, as well as indirect early selection for number of spikes/plant under both types of irrigation. The third family in yield rank, no. 50 yielded 38.55 g under I_1 in late selection and it did not share any other criteria. Also, only family no. 60 combined in direct late selection and indirect selection for number of spikes/plant and yielded 37.54 and 33.18 g under I_1 and I_2, respectively. In addition, the family no. 30 matched in early direct selection for grain yield and indirect one for number of spikes/plant only in treatment one (I_1) of irrigation and yielded 37.14 g. No families obtained in days to heading as a selection criterion shared in other selection criteria.

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الانتخاب المتأخر والمبكر لمحصول الحبوب باستخدام صفات انتخابية مختلفة تحت معاملتين للري في قمح الخبز
(*Triticum aestivum* L.)

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أجريت هذه الدراسة تحت ظروف الأرض الطينية بالمزرعة البحثية لجامعة أسيوط وذلك خلال أربع مواسم زراعية بدأت في موسم 2002 /2003 . حيث أستخدم هجين القمح (نيلين x جيزة 160) في الأجيال الانعزالية F2, F3 ,F4, F5 في هذه الدراسة لأجراء دورتين من الانتخاب المبكر (F4, F5) باستخدام صفات انتخابية مختلفة وكذلك دورة واحدة من الانتخاب المتأخر (F5) تحت معاملتين من الري. وأوضحت النتائج المتحصل عليها الآتي:

- وجود اختلافات عالية المعنوية بين عائلات الجيل الثالث لجميع الصفات المدروسة مما يعكس التباين الوراثى بين تلك العائلات في العشيرة الأساسية.
- كان معامل الاختلاف الوراثى والمظهري عاليا لجميع الصفات المدروسة في العشيرة الأساسية فيما عدا عدد الأيام حتى طرد السنابل تحت كلا من معاملتي الري مما يدل على وجود اختلافات وراثية بقدر كافي للانتخاب في العشيرة.
- بعد دورتين مبكرتين للانتخاب انخفض معامل الاختلاف الوراثى والمظهري تحت مختلف الصفات الانتخابية وكذلك بعد دورة واحدة من الانتخاب المتأخر.
- انخفض محصول الحبوب تحت المعاملة I_2 (أربع ريات فقط خلال موسم النمو) بالمقارنة بالمعاملة I_1 (ست ريات خلال موسم النمو) تحت مختلف الصفات الانتخابية.
- كان متوسط محصول النبات لأفضل خمس عائلات بعد دورتين من الانتخاب المبكر 24.92 و 22.74 ؛ 34.94 و 29.47 ؛ 37.50 و 28.11 ؛ 29.28 و 23.18 ؛ 32.34 و 25.99 جم / نبات لكل من معاملة الري I_1 ومعاملة الري I_2 مع الصفات الانتخابية : عدد الأيام حتى طرد السنابل ، عدد السنابل / نبات ، محصول حبوب النبات ، دليل الحصاد و محصول الحبوب للنبات + عدد الأيام حتى طرد السنابل معا ، على التوالي. بالإضافة إلى أن الانتخاب المتأخر لصفة محصول حبوب النبات لدورة واحدة أعطى أعلى قيم لمحصول حبوب النبات تحت كلا من معاملتي الري (38.56 و 31.87 ، على التوالي).
- أعطت دورتين من الانتخاب المبكر لصفة حبوب النبات أفضل محصول حبوب من بين مختلف الصفات الانتخابية حيث أنها أعطت 37.57 و 28.11 مع كل من I_1 و I_2 على التوالي ولكنها جاءت في الترتيب بعد الانتخاب المتأخر لدورة واحدة لصفة المحصول.

- كانت الاستجابة للانتخاب في المحصول في حالة الانتخاب المتأخر 24.19 و 12.32 % تحت الري العادي I_1 و 27.73 و 9.90 % تحت المعاملة I_2 وذلك بالنسبة للأب الأفضل و الصنف جيزة 168 على التوالي .
- شاركت عائلات رقم 100و 60و 19 (بالترتيب) كأفضل عائلات تحت كلا من الري العادي I_1 و الجفاف I_2 في الانتخاب المتأخر لصفة حبوب النبات حيث أن هذه العائلات أعطت 40.11 و 37.54 و 37.49 جم/ نبات تحت الري العادي I_1 و انخفضت بمقدار 23.59 و 11.69 و 16.59 % تحت ظروف الجفاف I_2 على التوالي بعد دورة واحدة من الانتخاب المتأخر..