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PEDIGREE SELECTION IN F_3 AND F_4 GENERATIONS FOR GRAIN YIELD OF DURUM WHEAT

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Abstract: This study was carried out during the three successive seasons of 2004/2005, 2005/2006 and 2006/2007 at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt. Two durum wheat populations (*Triticum durum* L.) in F_3 generation of the crosses Chahba 88 x Bani-Swief 1 and Carcomun x Sohag 3 were used in this investigation. One hundred F_3 families underwent pedigree selection in the F_3 basic materials. The best plant from each of the best 20 families for each selection criterion, namely days to heading, greater 100-kernel weight and higher grain yield were saved to give the F_4 families. The analysis of variance showed highly significant differences between F_3 families in both populations and satisfactory genotypic coefficients of variation were detected for some traits. Grain yield increased after two cycles of selection in the two populations relative to the better parent by 14.14% in Pop.1 and by 15.97% in Pop.2, respectively. Selection for 100-kernel weight increased grain yield by 9.86% in Pop.1 and by 8.03% in Pop.2 as compared to the better parent. The best two families No. 24 and 46 in Pop.1; and No. 1 and 21 in Pop.2 were higher in grain yield than the better parent by 21.15 and 16.67%; 23.62 and 25.56%, respectively, when grain yield was used as a selection criterion. After two cycles of selection, the realized gains indicated that heading date was reduced by 13.42 and 9.21 days for Pop.1 and Pop.2 respectively, as compared to the base population. The pedigree selection procedure has been proposed in wheat as an effective breeding methodology for developing high yielding genotypes.

Keywords: Pedigree selection - durum wheat -- segregating generations.

Introduction

Improvement of durum wheat yield is an important breeding objective. Increasing grain yield per unit area could be accomplished by cultivating high yielding varieties and improving cultural practices (Afiah and Darwish 2003). Pedigree selection for yielding potential in wheat and other cereal crops requires selection in the F_2 populations 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 (Fasoulas

1988, Fasoulas 1993 and Poelhman and Sleper, 1995). Highly significant differences were reported among F_3 families and sufficient genetic variability were obtained for spike length, number of spikes/plant, biological yield/plant, grain yield/plant and harvest index (Mahmoud 2007). Selection for yield in early generations based on single plant evaluation is mostly interesting and should be initiated in the F_2 generation (Shebeski 1967 and Sneep 1977) although several reports have shown that this seems to be ineffective (McGinnis and Shebeski 1968 and Knott 1972). Direct selection for grain yield was effective for increasing grain yield (Loeffler and Busch 1982). Knott and Talukder (1971) reported that wheat grain yield could be increased by selecting for increased grain weight. McNeal *et al.* (1978) concluded that kernel weight and number of spikes/plant were good traits for indirect selection for yield improvement. Kheiralla (1993) found that direct selection for spike length, kernel weight, kernels/spike and spikes/plant was accompanied by increases in grain yield by 5.63, 5.90, 6.93 and 7.50% over the better parent respectively, after two cycles of selection. Ismail (1995) reported that after two cycles of selection in two populations of wheat, the realized gains indicted that heading date was reduced by 7.58% in population 1 and 3.66%, population 2 as compared to the bulk. Zobel (1983) proposed 'indirect selection' or 'associative breeding' for traits of interest according to their association with yield. The two main steps of the analytical breeding approach have been described by Clarke (1992) as: 1. Screening and selection of potential parents in order to assess the desired traits for the incorporation of these morphophysiological traits into new cultivars. 2. Selection in the segregating populations for the morphophysiological traits rather than selection for yield. The objective of this study was to develop wheat families through two cycles of pedigree selection in F_3 and F_4 generations for earliness, greater kernel weight and high yield.

Materials and methods

Plant materials: The breeding materials used in this study were the F_3 and F_4 generations of two durum wheat crosses. One hundred F_3 families which traced back to 100 random F_2 plants were used from each of cross (1) Chahba 88 x Bani-Swief 1 (Pop.1) and cross (2) Carcomun x Sohag 3 (Pop.2). Chahba 88 is a moderately early variety, tall with high yielding ability from Syria. Bani-Swief 1 is a late variety, moderately short and of high yielding capacity from Egypt. Carcomun is a moderately early variety, moderately short and of high yielding ability from Mexico. Sohag 3 is a late variety, moderately tall and of yielding potential from Egypt. The experimental field trials were carried out during 2004/2005, 2005/2006 and 2006/2007 seasons at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt.

Field experiments: Individual experiments were conducted for each population. 100-F_3 families and the original parents were sown on 16 November 2004 in a randomized complete block design with three replications. The plot size was one row 3 m long, 30 cm apart and 5 cm between seeds within a row. Days to heading was measured on plot mean base as the number of days from planting to the day when 50% of the heads were protruded from the flag leaf sheath. At harvest time, ten guarded plants from each family in each replicate were taken to measure the studied traits, namly plant height (cm), spike length (cm), number of spikes/plant, 100-grain weight (g), biomass/ plant (g) and grain yield/plant (g). The best 20 plants from the best 20 families of both populations for each of the selection criteria: heading date, 100-kernel weight and grain yield/plant were selected to give the F_4-families. The F_4-families of both populations were sown on 15 November 2005 season in a separate experiments as in the previous season. The best 10 plants from the 10 promising families were selected for each three selection criteria. The selected 10 promising families were sown on 20 November 2006. Genotypic (G.C.V) and phenotypic (P.C.V) coefficients of variation were calculated on a plot mean basis as outlined by Miller *et al.* (1958). The realized gain from the better parent for the selection criteria and correlated responses were calculated. The revised LSD (Petersen, 1985) was used to compare the means.

Results and Discussion

F_3 base populations: The analysis of variance indicated highly significant differences between F_3 families of both populations for all studied traits, reflecting the genetic differences among obtained families. Wide range in all the studied traits was obtained confirming sufficient genetic variation for selection, Furthermore, the means were accompanied with small standard errors for studied traits (Table 1). Sufficient variability as measured by the phenotypic (P.C.V.) and genotypic (G.C.V.) coefficients of variability was found for some studied traits in both populations and present a sufficient genetic variation for selection in the base population (Table 2). Population 2 (Pop.2) revealed higher G. C. V. and

Table(1): Mean squares, range, mean and standard error of studied traits in the two base F3-families and their parents of the two populations.

S.O.V		D.f	Mean squares						
			Heading date	Plant height (cm)	Spike length (cm)	No spike/ plant	100- grain weight (g)	Biomass (g)	Grain yield/ plant (g)
Population 1									
Replications		2	71.15*	3.50	3.01	2.56	0.13	6.62	93.71**
F3-families		101	436.0**	104.78**	4.41**	11.76**	2.44**	1110.19**	32.79**
Error		202	18.56	16.34	1.63	2.87	0.13	13.11	4.96
Range			61-139	73 - 105	3.5-13.5	2 - 15	2.7 - 7.9	24.4-131.5	16.6 - 34
Mean $\pm S.E$			105.99 ±0.72	88.24 ±0.38	8.57 ±0.09	7.45 ±0.14	6.36 ±0.05	70.38 ±1.11	25.60 ±0.22
Mean	Bani-Swief 1		97.67	98.87	8.40	7.47	5.64	61.16	25.67
	Chahba 88		97	106.03	8.43	8.73	5.37	69.21	25.53
Population 2									
Replications		2	2.59	4.96	2.94	5.25*	0.70*	2.55	2.87
F3-families		101	213.17**	203.44 **	2.23**	11.23**	1.36**	1178.87**	28.16**
Error		202	9.76	15.13	1.48	1.31	0.23	16.15	5.55
Range			69 -129	49 - 108	5.5-12.7	2 - 13	3.8 - 7.9	11 - 124	13.4-30.8
Mean $\pm S.E$			99.08 ±0.50	84.70 ±0.50	8.69 ±0.08	6.71 ±0.12	6.14 ±0.04	57.24 ±1.14	21.06 ±0.21
Mean	Sohag 3		103.33	102.2	8.40	6.63	5.70	45.21	16.17
	Carcomun		96.33	99	8.07	8.83	4.37	55.16	24.19

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

P.C.V. than population1 (Pop.1) for all studied traits except heading date, spike length and 100- grain weight. The highest values of G.C.V. and P.C.V. were particular for no. spikes/plant (23.11% and 32.42%) for base Pop.1 and for biomass (37.49% and 38.42%) for first cycle of Pop.2, respectively using 100-kernel weight criterion. The results are in agreement with those obtained by Kheiralla (1993), Ahmed (2006) and Mahmoud (2007).

Selection response: After two cycles of direct selection for grain yield/plant, which was the best among the different selection criteria, used selections exhibited 29.30 for Pop.1 and 24.55 g for Pop.2, respectively. Meanwhile, after two cycles of indirect selection for 100-kernel weight criteria produced 28.20 g for Pop.1 and 22.87 g for Pop.2. The values of G.C.V. and P.C.V. decreased after two cycles of selection with different criteria for grain yield/plant. Low G.C.V. and P.C.V. or 1.97 and 3.16% (Pop.1) and 2.45 and 3.91 % (Pop.2) were obtained after two cycles for days to heading and 100-kernel weight traits using days to heading and grain yield criteria as compared to 11.13 and 11.85% (Pop.1) and 10.00 and 12.69% (Pop.2) in the base populations, respectively. The pedigree selection decreased G.C.V. and P.C.V. from cycle one to cycle two under different selection criteria (Table 2). Falconer (1989) and Ismail (1995) stated that selection reduces the variance. These results are in line with those obtained by Kheiralla (1993), Mahdy *et al.* (1996), Ahmed (2006) and Mahmoud (2007).

Table(2): Means, phenotypic (P.C.V. %), genotypic (G.C.V. %) coefficients of variability for the studied traits in population 1 (Pop.1) and population 2 (Pop2).

Criteria		Popu-lation	Cy-cle	Days to head-ing	Plant height (cm)	Spike length (cm)	No. spike/ plant	100-grain weight (g)	Biom-ass (g)	Grain yield /plant (g)
Base	mean	Pop.1		105.99	88.24	8.57	7.45	6.36	70.38	25.60
		Pop.2		99.08	84.70	8.69	6.71	6.14	57.24	21.06
	G.C.V %	Pop.1		11.13	6.15	11.23	23.11	13.80	27.17	11.77
		Pop.2		8.31	9.35	5.75	27.10	10.00	34.39	13.03
	P.C.V %	Pop.1		11.85	7.67	18.66	32.42	14.92	27.65	14.64
		Pop.2		8.89	10.42	15.14	32.02	12.69	35.10	17.18
Days to heading	G.C.V %	Pop.1	C1	3.75	5.57	10.84	17.58	6.31	26.35	9.33
		Pop.1	C2	1.97	6.82	15.36	10.90	7.37	6.28	4.50
		Pop.2	C1	3.69	9.57	5.82	24.58	8.23	34.09	18.51
		Pop.2	C2	4.96	9.04	11.78	18.36	3.21	21.76	15.37
	P.C.V.%	Pop.1	C1	4.73	6.96	19.56	27.10	9.14	27.35	11.82
		Pop.1	C2	3.16	7.64	19.89	14.68	8.42	7.28	6.19
		Pop.2	C1	4.73	10.55	14.29	29.22	10.78	34.55	20.63
		Pop.2	C2	5.38	9.74	14.48	20.45	6.08	22.04	17.60
100 kernel weight	G.C.V %	Pop.1	C1	5.68	6.38	16.52	15.24	7.75	22.46	9.18
		Pop.1	C2	2.31	6.36	11.66	12.16	5.19	15.69	4.09
		Pop.2	C1	3.98	9.81	6.82	30.69	4.16	37.49	12.86
		Pop.2	C2	5.03	7.11	7.45	19.25	6.03	15.08	10.21
	P.C.V.%	Pop.1	C1	6.51	7.48	22.09	25.12	10.29	23.97	11.29
		Pop.1	C2	3.17	7.11	16.30	16.03	5.34	15.84	5.89
		Pop.2	C1	7.39	10.64	15.12	35.35	5.23	38.42	13.91
		Pop.2	C2	5.16	8.27	10.50	21.52	7.14	15.80	11.87
Grain yield /plant (g)	G.C.V %	Pop.1	C1	2.45	5.43	10.40	9.24	5.82	23.15	2.68
		Pop.1	C2	2.94	8.49	18.77	15.90	2.68	6.92	2.36
		Pop.2	C1	3.96	6.75	7.63	9.99	6.19	18.73	9.20
		Pop.2	C2	5.49	5.97	6.60	6.42	2.45	10.41	4.67
	P.C.V.%	Pop.1	C1	4.09	7.15	19.25	12.46	8.66	23.58	5.68
		Pop.1	C2	5.04	9.01	19.96	18.63	3.91	7.86	3.17
		Pop.2	C1	5.31	8.36	15.41	22.07	11.41	19.59	12.50
		Pop.2	C2	6.41	7.53	9.72	11.19	3.91	10.93	7.30

Direct and indirect response: The realized and correlated response to selection for all studied traits using different selection criteria are shown in Table 3. The present results indicated that direct selection for grain yield/plant was effective for improving this character in both populations. The direct selection for two cycles for grain yield/plant reached 15.18 and 22.12% from the better parent for the two populations used. However, two cycles of selection for 100-grain weight produced 9.06% in Pop.1 and 16.38% increase in grain yield/plant in Pop.2 over the better parent. After the second cycle of selection, days to heading were decreased by 24.67 and 13.72% (days to heading) and by 7.48 and 1.49% (grain yield) for Pop.1 and Pop.2 compare from the better parent. Selection for 100-grain weight decreased days to heading by 10.77% in Pop.2 from the better parent (Table 3). Mohamed and Abo-El-Wafa (2006) reported that direct selection for earliness was more effective than indirect selection. Moreover, genetic gains were reported to be realized only in the F_2 and F_3 generations whereas negative or no progress was realized in the later generations (Goulas and Stratilakis 1994). O'Brien *et al.* (1978), Loeffler and Busch (1982), Mahdy (1988) and Kheiralla (1993) reported that selection based on grain yield *per se* was most effective in increasing grain yield. Holbrook *et al.* (1989), Abo-Elwafa and Ahmed (2005) revealed that two cycles of direct selection for yield produced greater yield response than other selection criteria. These results are in line with those found by Ismail (1995), Mahdy *et al.* (1996), Afiah and Darwish (2003), Abo-Elwafa and Ahmed (2005), Ali (2005) and Mahmoud (2007).

Means of superior families selections: Means of grain yield/plant for the10-superior families after two cycles of pedigree selection with different selection criteria in the two populations are shown in Table 4. Means of grain yield/plant over all selection criteria; grain yield/plant, 100-kernel weight and heading date were 29.30, 28.20 and 24.80 g in Pop.1 and 24.55, 22.87 and 20.30 g in Population 2 (Table 4). The two families No. 46 and 83 were commonly selected using the two selection criteria; 100-kernel weight and grain yield/plant in population 1 which yielded 30.69 and 29.95; 28.54 and 29.53 g, respectively. Population 2 shared the two families No. 75 and 83 using the two selection criteria; heading date and 100-kernel weight (23.45 and 24.33; 23.13 and 24.68 g) respectively. The present results are agreement with those obtained by (Ismail 1995 and Mahmoud 2007).

Table(3): Direct and indirect response to selection measured in percentage from the better parent.

Criteria	Population	cycle	Days to heading	Plant height	Spike length	No. spike /plant	100-grain weight	Biomass	Grain yield
Days to heading	Pop.1	C1	-2.04	2.53	1.25	-1.97	-3.51	-3.15	-0.62
		C2	-24.67	-9.53	-21.98	6.95	2.91	-10.27	-2.80
	Pop.2	C1	-22.03*	-13.01	-15.49	-6.53	-20.07*	-28.35	0.63
		C2	-13.72	26.16	22.54	-21.93	-0.56	3.33	-9.82
100 kernel weight	Pop.1	C1	0.30	-0.78	-1.07	2.56	1.57	-3.09	-1.03
		C2	3.88	0.00	-2.57	13.49	7.20	1.65	9.06
	Pop.2	C1	-10.47	7.29	3.87	17.48	-1.47	8.34	-1.13
		C2	-10.77	-14.17	-10.66	5.66	6.46	-17.67	16.38
Grain yield /plant (g)	Pop.1	C1	1.22	0.82	1.19	4.11	-2.53	0.21	-1.38
		C2	-7.48	3.88	10.24	22.21	30.04	1.95	15.18
	Pop.2	C1	-9.62	13.04	-11.08	-5.58	10.34	-11.52	5.62
		C2	-1.49	-8.99	24.83	13.59	22.94	17.26	22.12

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

Table(4): Means of grain yield/plant for ten super families, after second cycle of pedigree selection using different selection criteria in population 1 and population 2.

Selection criteria	Grain yield /plant, g											
	Population 1											
Family No.	1	6	7	(9)	20	22	41	65	(86)	96	Mean	LSD'0.05
Days to heading	24.50	24.86	24.26	26.58	24.10	23.66	24.35	24.28	27.58	23.80	24.80	1.81
Family No.	3	11	13	16	(46)	54	70	72	(83)	98		
100-grain Weight /g	27.70	28.50	28.39	27.96	30.69	27.76	27.90	28.04	28.54	26.52	28.20	2.13
Family No.	6	9	12	13	(24)	32	(46)	50	52	83		
Grain yield/ plant	28.59	28.63	29.11	28.75	31.10	29.03	29.95	29.53	28.73	29.53	29.30	1.07
Better parent (Bani-Swief 1)	25.67	25.67	25.67	25.67	25.67	25.67	25.67	25.67	25.67	25.67		
	Population 2											
Family No.	1	25	36	46	49	(75)	76	(83)	94	98	Mean	LSD'0.05
Days to heading	19.45	22.78	18.45	18.12	16.45	23.45	21.45	23.13	17.65	22.12	20.30	1.79
Family No.	1	9	(11)	(24)	36	45	75	80	83	99		
100-grain weight /g	22.00	22.62	25.58	25.00	19.00	23.00	24.33	23.20	24.68	19.33	22.87	2.19
Family No.	(1)	2	11	(21)	25	33	41	44	93	96		
Grain yield /plant	26.17	24.03	22.67	26.58	24.83	22.17	25.06	24.00	24.67	25.35	24.55	2.45
Better parent (Carcomun)	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17		

( ) brackets are set for best families.

Conclusion: In Pop.1, the best two families No. 9 and 86 (days to heading); 46 and 83 (100-kernel weight); 24 and 46 (grain yield) produced 26.58 and 27.58; 30.69 and 28.54; 31.10 and 29.95 g, respectively. While, the best two families No. 75 and 83 (days to heading); 11 and 24 (100-kernel weight); 1 and 21 (grain yield) in Pop.2 produced 23.45 and 23.13; 25.58 and 25.00; 26.17 and 26.58 g for each selection criteria; heading date, 100-kernel weight and grain yield. The results revealed to that selection for early heading resulted in earlier by 14.50 and 10.25 % for both populations after two cycles of pedigree selection from the base population, respectively. The pedigree selection could be a recommended way for selection in durum wheat. Our results indicated both direct and indirect selection improves grain yield/plant as found relative to direct and indirect responses of selection with different selection criteria in wheat.

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الإنتخاب المنسب فى الجيل الثالث والرابع لمحصول الحبوب فى قمح الديورم

خلـــف على همام

قسم المحاصيل – كلية الزراعة – جامعة سوهاج – مصر

اجريت هذه الدراسة خلال ثلاث مواسم ناجحة 2005/2004 ، 2006/2005 و 2007/2006 م فى المزرعة البحثية لكلية الزراعة – جامعة سوهاج – مصر. تم اختيارعشيرتين من قمح الديورم فى الجيل الثالث الانعزالى أنتجت من الهجينين (Chahba 88 x Bani-Swief 1) & (Carcomun x Sohag 3). أستخدمت فى هذه الدراسة مائة عائلة فى الجيل الثالث رُبيت حتى حصلنا على الجيل الخامس فى هذه الدراسة. أنتخبت 20 عائلة فى الجيل الثالث. عشرة عائلات أنتخبت كعائلات مبشرة فى الجيل الرابع بهدف التبكير فى التزهير، وزن المائة حبة العالى ومحصول الحبوب العالى كصفات إنتخابية.

أظهرت النتائج وجود اختلافات عالية المعنوية بين عائلات الجيل الثالث لجميع الصفات المدروسة لكل من العشيرتين، كما وجدت اختلافات وراثية بقدر كافى لبعض الصفات موضع الدراسة. محصول الحبوب زاد بعد اجراء دورتين من الإنتخاب المنسب فى كل من العشيرتين بالمقارنة بأحسن الأباء بمقدار 14.14% فى العشيرة الأولى وبمقدار 15.97% فى العشيرة الثانية على التوالى. وزن المائة حبة ادى إلى زيادة محصول الحبوب بعد اجراء دورتين من الإنتخاب المنسب فى كل من العشيرتين بالمقارنة بأحسن الأباء بمقدار 9.86 % فى العشيرة الأولى وبمقدار 8.04 % فى العشيرة الثانية على التوالى.

وجد أن احسن عائلتين فى العشيرة الأولى نتجت من الإنتخاب المنسب هما العائلتين رقم (24 و 46) وأدتا الى زيادة بمقدار 21.15 و 16.67% بأحسن الأباء مستخدما محصول الحبوب كصفة إنتخابية. بينما فى العشيرة الثانية وجد أن احسن عائلتين نتجت من الإنتخاب المنسب هما العائلتين رقم (1 و 21) وأدتا الى زيادة بمقدار 23.62 و 25.56% بأحسن الأباء مستخدما محصول الحبوب كصفة إنتخابية. وجد تبكير فى العشيرة الاولى والثانية بعد مرور دورتين من الإنتخاب المنسب بمقدار 13.42 و 9.21 يوم بالمقارنة بعشيرة الجيل الثالث القاعدية على التوالى.

ونتيجة لذلك وجد أن إستخدام الإنتخاب المنسب كطريقة تربية أدى إلى تأثير عالى ونطور فى زيادة محصول الحبوب للتراكيب الوراثية.