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Late and early pedigree selection for grain yield with three selection criteria in two populations in bread wheat

Hamam, K.A.
Agronomy Department, Faculty of Agriculture, 827524 Sohag University, Sohag, Egypt
E-mail: ***khalafhamam@agr.sohag.edu.eg***

ABSTRACT

The present study was carried out during the four successive seasons of 2009/2010, 2010/2011, 2011/2012 and 2012/2013 at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt. Bread wheat populations (*Triticum aestivum* L.) in F_3, F_4, F_5 and F_6 generations of the (Sids 12 x HAAMA-14) and (Giza 168 x TRI 2592) crosses were used in this investigation. One hundred 3 families of each population, which underwent pedigree selection in the 3 basic material for the derived F_6 families used in this study. The aim was to compare the effectiveness of late pedigree selection vs. early pedigree selection in developing high yielding genotypes of bread wheat. Forty families were selected in F_4 using grain yield, 100-kernel weight and days to heading as selection criteria. Twenty families were selected in F_5 using the same criteria. However, ten families were selected as promising in F_6 using late and early selection for grain yield. Analysis of variance showed highly significant differences between F_3 families and satisfactory genotypic coefficients of variation, indicating the presence of sufficient variability for direct and indirect selection. After three cycles of selection in the F_3 families, the genotypic coefficients of variability rapidly decreased for all studied traits. Estimates of broad sense heritability were relatively high and ranged from 76.73% for no. of spikes/plant to 99.94% for no. of kernels/spike in population 1 and from 72.34% for no. of spikes/plant to 98.61% for no. of kernels/spike in population 2. The expected genetic advance as percent of F_3 ranged from 19.70% for days to heading to 94.94% for number of spikes/plant in population 1 and ranged from 23.21% for plant height to 79.24% for spike length in population 2. The late pedigree selection increased grain yield after one cycle of selection in the population compared to the best parent and the bulk population by 12.39 and 25.44% in population1 and by 9.26 and 23.74% in population 2. Grain yield increased after three cycles of early selection of both populations compared to the best parent and the bulk population by (20.66 and 34.67%); (17.08and 32.59%), respectively. 100-kernel weight increased by (11.32 and 24.25%); (7.98 and 22.28%), respectively, in both populations compared to the best parent and the bulk population. The best two families No. 42 and 56 were isolated from population1 increased more than the best parent by 28.58 and 31.52% using selections criteria for grain yield, respectively. In population 2 the best two families No. 52 and 56 increased more than the best parent by 24.74 and 27.60% using selections criteria for grain yield, respectively. After three cycles of selection of wheat realized gains indicated that heading date was reduced by -9.84 and -10.86% compared to the best parent of both populations. The high grain yield families using different criterion obtained from this study could be used in developing new wheat lines and effective for breeding methodology in developing high yielding.

Keywords: Early selection - Late selection- bread wheat.

INTRODUCTION

Improvement of bread wheat yield is usually directly approached by breeding for yield. Increasing both wheat area and the continuous rise in grain yield/ha as a result as of cultivating high yielding varieties and improved cultural practices (Afiah and Darwish 2003). Individual plant selection in early segregating generations for quantitatively inherited traits such as grain yield has meet with success. This imposition may due to several factors such as polygenic nature, high heritability of a trait (grain yield, number of spikes per plant, 100-kernel weight, number of kernels/spike, etc.), linkage, additive gene effects and environmental effects. This is important for selection in self-pollinated crops, as the action of additive genes would be retained through subsequent inbreeding. The effectiveness of early generations selection therefore depends on the presence of true genetic differences between genotypes in these generations and on their persistence following selection (Islam *et al.* 1985). The response to selection measured as the difference between F_4 progeny means derived from high and low F_2 selections was reported by Mitchell *et al.* (1982). Early pedigree selection for yielding potential in wheat and other cereal crops assumes selection in the F_3 families 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 (Poelhman 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 (Sneep 1977) although several reports have shown that this seems to be ineffective (Knott 1972 and De Pauw and Shebeski. 1973).

Fasoulas (1993) recognized the pedigree selection in wheat is practiced from F_2 to F_6 generation among and within families based on yield determination of individual plants equidistantly and widely spaced arrangement which ensures that all genotypes are evaluated under nil interplant competition among genotypes using the same objective criteria. Direct selection for grain yield was effective for increasing grain yield (Loeffler and Busch 1982). Knott and Talukdar (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. Mahady *et al.* (1996) found that direct selection for plant height, spike length, 1000-kernel weight and grain yield/plant were accompanied by an increase in grain yield which accounted 36.34, 1.98, 13.45 and 12.6% respectively, after three cycles of selection calculated as a deviation from the best parent. Ismail *et al.* (1996) reported that after three cycles of selection in the population of wheat, the realized gains indicted that heading date was reduced by 7.55% compared to the bulk. The two main steps of the analytical approaches have been described by Zobel (1983) and Clarke (1992): 1. Screening and selection of potential parents carrying the desired traits (for incorporation of these morphophysiological traits into new cultivars). 2. Selection in the segregating populations for the morphophysiological traits rather than selection for yield. Zobel, (1983) found 'indirect selection' or 'associative breeding' traits of interest are selected due to their association with yield. Thus the choice among favorable, optimum or stress growing conditions as the most effective selection environment to develop broadly adapted varieties is crucial. From the voluminous literature on this subject (Gauch and Zobel, 1997) the recommended environment selection seems to be the one that closely resembles to the target growing conditions the variety is to be cropped. Many workers indicated that pedigree selection was effective in improving grain yield (Hammam, 2008 and Ali, 2011). However, selection for yield or production traits is a problem which continues to perplex plant breeders.

` Results of Pawar *et al.* (1986) showed that pedigree selection method proved to be superior in mean values of the selected crosses. Srivastave *et al.* (1989) reported that pedigree method was as effective as bulk method for tillers/plant, kernels/spike and grain yield/plant. El-Ameen *et al.* (2013) showed that pedigree method of selection was more effective in improving plant height and yield and its components. The pedigree selection method was effective in improving the grain yield and its components (Abd El-Shafi (2014), also selection was effective to produce new lines with highest yield.

The high heritability associated with high genetic advance for main quantitative traits in wheat offer better scope of selection of genotypes in early segregating generations (Memon *et al.* 2005). In this regard heritability estimates plays an important role for planning the breeding strategy. The heritability of the character determines the extent to which it is transmitted from one generation to the next and it is most valuable tool when used in conjunction with other parameters in predicting genetic gain that follows in the selection for that character (Baloch *et al.* 2003, Ansari *et al.* 2005, El-Ameen *et al.* 2013). The heritability values become a measure of the genetic relationship between parents and progeny; hence considerable research work has been carried out to incorporate the desirable genes in present wheat varieties to increase the productivity of the crop (Rebetzke and Richards 2000 and Sial *et al.* 2002). Tammam and Abd EL-Rady (2010) found that Broad sense heritability values varied from intermediate to high for plant height and yield and its components.

The objectives of this study were, 1) to develop wheat families through three cycles of pedigree selection in F_3, F_4, F_5 and F_6 generations, procedure developing earliest, heavy grain weight and high yielding lines in bread wheat. 2) to compare the effectiveness of late pedigree selection vs. early pedigree selection in developing high yielding in bread wheat.

MATERIALS AND METHODS

Plant material and location:

The present investigation was carried out during the four successive seasons, i.e. 2009/2010 2010/2011, 2011/2012 and 2012/2013 at the experimental farm of Faculty of Agriculture, Sohag University, Sohag, Egypt. The bread wheat crosses, i.e. (Sids 12 x HAAMA-14) and (Giza 168 x TRI

2592) in F_3, F_4, F_5 and F_6 were used in this study. The original parents are spring wheat cultivars (*Triticum aestivum* L.) of diverse origin, i.e. Giza 168 and Sids 12 from Egypt, HAAMA-14 from ICARDA-Syria and TRI 2592 (Indian) from IPK-Gatersleben Genebank-Germany. Three cycles of early selection and one cycle of late selection were achieved under optimum conditions. The selection was based on three selection criteria, i.e. earliness, 100-kernels weight, grain yield.

Field experiments:

Early selection: 100 F_2 plants from each population were selected based on each of three selection criteria, i.e. earliness, 100-kernels weight, grain yield. For each selection criterion F_3 families were grown in 2009/2010 season. Forty F_3 families were selected for each selection criterion to be evaluated in F_4 generation. The F_4 families were evaluated in 2010/2011 season. Twenty F_4 families were selected and evaluated in F_5 generation (2011/2012 season). Ten F_5 families were selected for each selection criterion and evaluated in F_6 generation (2012/2013 season).

Late selection: The seed of F_2 plants selected on the basis of grain yield/plant were divided into two parts. The first part was used in early selection as previously mentioned. The other part was used in late selection. The F_3, F_4 and F_5 families were grown in non-replicated plots. In F_5 generation ten families were selected on the basis of grain yield/plant. The ten F_6 families were evaluated in 2012/2013 season.

In all cases, the best plant was selected from the best family to rise the next generation. Randomized complete block design with three replicates was used in all experiments. Each family was represented by one row, 3 m long, 30 apart and 5 cm between seeds within a row. Days to heading was measured on plot mean base as number of days from planting to 50% of the heads protruded from the flag leaf sheath. At harvest time, ten 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, 100-kernel weight (g), number of kernels/ spike and grain yield/plant(g).

Statistical analysis: the analysis of variance thought base population; the three cycles of early selection for each section criterion as well as the late selection were performed according to Gomez and Gomez (1984). The phenotypic (P.C.V) and Genotypic (G.C.V), coefficients of variation were calculated according to Burton (1952). Heritability in broad sense (H) was calculated according to Walker (1960). Genotypic correlations between grain yield and each other studied traits in base; all selection criteria of both cycles of selections and late selection were done using method of Walker (1960). Genotypes means were compared using Revised Least Significant Differences test (RLSD) according to Petersen (1985). The significance of observed direct and correlated response to selection were measured as deviation percentage of families mean from the bulk or the better parent or the check using L. S. D. where, L.S.D = least significant differences between the bulk or the better parent and mean of the selected families, and was calculated as: $LSD = t\alpha.\sqrt{MSE/r + MSE/fr}$, where, f = number of families, r = number of replication. Genetic advance in percentage was calculated as

$GA\% = (GA/\overline{X})x100$ where, GA= k x (δp) x h^2_b and k= standardized selection differential (2.06) in this study at 10% selection pressure, δp = phenotypic standard deviation of F_3 population, h^2_b = broad sense heritability and $\overline{X}$ = mean of the trait. Moreover, the response to selection over better parent and bulk population for all selection criteria were calculated for (C1), (C2) and (C3) of early selection as well as late selection.

RESULTS AND DISCUSSION

F_3 base populations

The analysis of variance revealed highly significant differences between F_3 families for all studied traits, reflecting the genetic variations among obtained families of population. Sufficient variability as measured by the genotypic coefficient of variability (G.C.V.) and phenotypic coefficient of variability (P.C.V.) were found for all studied traits and present a sufficient genetic variation for selection in the base population (Table 1). Highly significant differences 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 (Ahmed 2006 and Mahmoud 2007). In our results within family genetic variance component instead of decreasing from F_3 to F_6, as expected, either increased or remained constant. Population (Pop.1) revealed higher G.C.V. and P.C.V. than population (Pop.2) for the all studied traits, except days to heading and 100-kernel weight. The highest values of G.C.V. and P.C.V. of were found for No. of spikes/plant counted 30.38% and 34.68% for Pop.1 and 23.36% and 27.46% for Pop.2, respectively under F_3 base population. The small differences between P.C.V. and G.C.V. were confirming the importance of genetic components of variability controlling all studied traits rather than the environmental effects. Abd El-Shafi (2014) reported that greater response to selection can be expected from selection in families having greater phenotypic and genotypic variances. These results indicate that most studied traits were less affected by environmental factors. These results are in line with those obtained by Tammam & Abd EL-Rady (2010), Ahmadi-Zadeh *et al.* (2011) and El-Ameen *et al.* (2013).

Heritability in broad sense was generally high under both populations. Estimates of broad sense heritability were relatively high and ranged from 76.73% for no. of spikes/plant to 99.94% for no. of kernels/spike in Pop.1 and from 72.34% for no. of spikes/plant to 98.61% for no. of kernels/spike in Pop.2. Tammam and Abd EL-Rady (2010) found that broad sense heritability values varied from intermediate to high for plant height and yield and its components. These results are in line with those reported by Zakaria *et al.* (2008) and Mahdy *et al*. (2012).

The expected genetic advance as percent of F_3 ranged from 19.70% for days to heading to 94.94% for number of spikes/plant in population1 and ranged from 23.21% for plant height to 79.24% for spike length in population

2 (Table 1). These results indicated the possibility of practicing selection in early generations and obtain high yielding genotypes. Therefore, selection in those particular populations should be effective and satisfactory for successful breeding purposes. The degree of improving studied traits were based on the high heritability and genetic advance shown by the different characters, especially; spike length, number of spikes/plant, number of kernels/spike, 100-kernel weight and grain yield /plant. For this reason, a high response should be achievable after several selection cycles. The information of the gene actions, the knowledge about the nature, magnitude of correlation among various characters, heritability and genetic advance help the breeders in deciding the most appropriate breeding procedure to enhance the genetic potentialities and to make breakthrough in the productivity of crop (Yadav and Singh 2011).

Table 1: Mean, mean squares, phenotypic (P.C.V. %), genotypic (G.C.V. %) coefficients of variability and heritability in broad sense (H), genetic advance (GA) in the two base populations (F_3 generation).

Trait		Days to heading	Plant height (cm)	Spike length (cm)	No. of spikes /plant	No. of grains /spike	100-kernels weight (g)	Biomass /plant (g)	Grain yield/plant (g)
Population 1									
Mean	F3	111.61	101.10	12.51	8.62	50.93	5.29	78.27	27.58
	Sids 12	98.44	101.34	10.12	8.44	48.54	4.91	70.64	25.16
	HAAMA-14	112.88	102.23	11.2	8.62	48.68	4.85	72.11	26.24
	Bulk	115.46	104.26	11.40	8.46	44.24	4.88	71.46	23.51
Mean squares	Families	120.32 **	198.73 **	29.60 **	26.82 **	261.05 **	0.98 **	338.01 **	34.71 **
	Error	3.24	6.08	3.72	6.24	0.16	0.12	34.08	3.64
	G.C.V%	6.56	7.55	23.47	30.38	18.31	10.14	12.86	11.67
	P.C.V.%	6.65	7.67	25.10	34.68	18.31	10.80	13.56	12.33
	H%	97.31	96.94	87.43	76.73	99.94	88.16	89.92	89.51
Genetic advance%		19.70	27.84	78.32	94.94	65.31	33.98	43.51	39.38
Population 2									
Mean	F3	95.25	106.16	15.29	10.18	64.16	5.42	90.88	31.04
Mean squares	Giza 168	95.25	104.80	14.60	9.92	61.22	5.16	86.64	30.44
	TRI 2595	97.24	102.60	12.86	8.96	59.66	4.84	82.58	28.68
	Bulk	99.25	110.24	13.58	9.68	54.12	5.04	80.22	26.88
	Families	169.83 **	148.85 **	38.33 **	23.43 **	340.71 **	1.80 **	348.13 **	34.50 **
	Error	5.40	2.92	1.92	6.48	4.72	0.06	35.34	3.84
	G.C.V%	7.77	6.73	22.79	23.36	16.50	14.03	13.96	10.29
	P.C.V.%	7.90	6.79	23.38	27.46	16.61	14.29	11.85	10.92
	H%	96.82	98.04	94.99	72.34	98.61	96.40	89.85	88.87
Genetic advance%		27.29	23.21	79.24	70.89	58.45	49.17	38.00	34.64

****, Significant at 0.01 levels of probability.**

The effect of selection procedures on the genetic variability

Variance is considered one of the most important factors for efficiency of selection and breeding methods. Data of genotypic coefficient of variation G.C.V. are presented in Table 2. Results showed different values of genotypic coefficient of variation G.C.V. according to families and generations. These results are in agreement with those obtained by Ortiz-Ferrara (1981) and Tammam (2004). The lowest G.C.V. were (1.79%) with Pop.2 for days to heading trait using days to heading criteria and (2.53 %) with Pop.2 after three cycles for 100-kernel weight trait using 100-kernel weight criteria compared to 7.77% (Pop.2) for days to heading trait and 14.03% in (Pop.2) for 100-kernel weight trait in the base population. On other hand, the lowest G.C.V. were (1.73%) for Pop.1 and (1.74%) for Pop.2 both for100-kernel weight trait after one cycle of direct selection for using grain yield/plant (late selection) compared to base population 10.14% for Pop.1 and 14.03% for Pop.2. The early pedigree selection decreased G.C.V. from cycle one to cycle three using different selection criteria (Table 2). The variability of G.C.V has low percentages indicating decrease of variability after three criterion selection. These results suggested that the directional of selection reduce variability for studied traits in the F_4, F_5 and F_6. Difference between genotypic coefficient of variation were low indicated that decreasing the variability among families and were less affected by environmental factors. This is clearing in the high values of broad sense heritability for all studied traits in F_6 generation. These results are in agreement with those reported by Ortiz Ferrara (1981), Tammam 2004 and Tammam and Abd EL-Rady (2010). The values of G.C.V. were decreased after three cycles of selection with different selection criteria and after one cycle of late selection for grain yield/plant. Falconr (1989) and Ismail (1995) stated that selection reduce the variance. Results of Ismail (2001) reported that the importance of selection for high yielding wheat families. These results are in line with those obtained by (Mahdy *et al.* 1996, Kheiralla 1993, Ahmed 2006, Mahmoud 2007 and Hamam 2008).

Direct and indirect response

The realized gain and correlated response from selection measured as the deviation of the overall cycle means from the bulk population and the best parent are presented in Table 3. The three cycles of early selection for grain yield/plant resulted in a remarkable direct response which accounted to (20.66 and 34.67%) with Pop.1 and (17.08 and 32.59%) with Pop.2 over the better parent and bulk population using grain yield criteria, respectively. These results correlated with high positive indirect response in spike length, No. of spikes/plant, 100-kernel weight and biomass under both populations (Table 3). Kheiralla (1993), Ahmed (2006) Mahmoud (2007) and Mahdy *et al.* (2012) found that early pedigree selection was more effective than late selection in wheat. On other hand, Kheiralla (1993) found that the direct response in grain yield reached to 20.81% and in early selection 17.76%, but late selection increased up to 25.51% by Ahmed 2006, in early selection was 21.26%, but late selection increased up to 26.97% by Mahmoud 2007 and early selection increased up to 28.19% El-Morshidy *et al.* (2010), early selection increased 25.00% over the bulk populations Ali (2011) and in early selection increased up to 33.03% Mahdy *et al.* (2012).

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The present study for the direct selection for grain yield/plant is effective for its improvement in both populations. The response to indirect early selection of for grain yield/plant revealed (11.32 and 24.25%) in Pop.1 and (7.98 and 22.28%) in Pop.2 over the best parent and bulk population using 100-kernels weight criteria, respectively. The responses in yield with other selection criteria were moderate and correlated with the indirect response in other traits. The indirect response in grain yield with days to heading as selection criteria, after three cycles of early selection exhibited (11.17 and 24.07%) in Pop.1; (2.76% and 16.37%) in Pop.2 over the best parent and bulk population, respectively, (Table 3). The one cycle of late selection for grain yield/plant resulted in a remarkable direct response for selection for yield which accounted to (12.39 and 25.44%) in Pop.1 and (9.26 and 23.74%) in Pop.2 over the better parent and bulk population respectively (Table 3). Mohamed and Abo-El-Wafa (2006) they reported the direct selection for earliness using late sowing date is expected to be more effective than indirect selection. Furthermore, genetic gains were realized only in the F_2 and F_3 generations whereas negative or no progress was realized in the later generations reported by (Goulas and Stratilakis 1994). Loeffler and Busch (1982), Mahdy (1988) and Kheiralla (1993) reported that selection based on grain yield *per se* was most effective in improving such complicated trait. Holbrook *et al.* (1989), Abo-Elwafa and Ahmed (2005) and Ismail *et al.* (2005) revealed that two cycles of direct selection for yield produced greater yield response than other selection criteria. The pedigree selection method was effective in improving the grain yield and its components (Abd El-Shafi 2014), also selection was effective to produce new lines with highest yield.

Selection improved earliness by -9.84 and -11.86 % in Pop.1 and by -10.86 and -14.45 % in Pop.2 from the best parent and bulk population after three cycles using days for heading criteria, respectively. However, deleterious effects on the realized gain and correlated responses of traits with best parent using days to heading criteria, and accounted, (-9.84 and -10.86%); (1.68 and 1.81%); (23.84 and 10.41%); (-0.81 and 18.25%); (7.09 and 7.46%); (10.72 and 1.16%); (9.35 and 5.97%); (11.17 and 2.76%) for days to heading, plant height, spike length, No. of spikes/plant, No, of kernels/spike, 100-kernel weight, biomass and grain yield respectively, after the third cycle for both populations. The realized gain and correlated responses traits between best parent and each of days to heading, plant height, spike length, No. of spikes/plant, No, of kernels/spike, 100-kernel weight, biomass and grain yield were exhibited, (-0.31 and 1.20%); (0.08 and 2.13%); (13.84 and 6.71%); (17.05 and 20.06%); (5.03 and 5.21%); (19.79 and 15.31%); (13.08 and 9.28%); (11.32 and 7.98%) respectively, after the third cycle for both populations using 100-kernel weight criteria (Table 3). Meanwhile, the realized gain and correlated responses traits between best parent and each of days to heading, plant height, spike length, No. of spikes/plant, No, of kernels/spike, 100-kernel weight, biomass and grain yield exhibited, (-4.10 and -4.34%); (-5.40 and -7.72%); (12.95 and 5.89%); (15.31and 18.25%); (5.79 and 5.96%); (15.05 and 10.66%); (16.86 and 12.94%) and (20.66 and 17.08%), respectively, after the third cycle for both populations using grain yield criteria (Table 3). On other hand, the realized gain and correlated responses traits between best parent and each of days to heading, plant height, spike length, No. of spikes/plant, No. of kernels/spike, 100-kernel weight, biomass and grain yield exhibited, (-6.97 and -7.24%); (-8.93 and -5.97%); (11.52 and 3.15%); (9.51and 11.29%); (0.23 and -0.34%); (8.66 and 4.65%); (10.00 and 5.18%) (12.39 and 9.26%) respectively, after the third cycle for both populations using late selection criteria (Table 3). The present results are in agreement with result of (Mahmoud 2007). This result mean that these traits could be helpful next to the direct selection to improve the grain yield/plant as found relative to direct and indirect responses of selection with different selection criteria in wheat Table 3. Ismail *et al.* (1996) obtained a reduced by 7.55% in days to heading and increased in grain yield/plant by 7.92% after three cycles of pedigree selection. The present results confirmed with those revealed by Mahdy *et al.,* (1996) Ahmed (2006), Mahmoud (2007) and Hamam 2008.

Selection response:

Means of superior families selections: The results were obtained means of grain yield/plant for the 10-superior families after three cycles of early selection with different selection criteria, as well as after one cycle of late selection for two populations (Table 4). In Pop.1 mean of grain yield/plant over all selections criteria descending, grain yield/plant, grain yield (late selection), 100-kernel weight and heading date (31.66, 29.49, 29.21 and 29.17) respectively. Selection criteria in Pop.2 were ranged for grain yield/plant, late selection in grain yield, 100-kernel weight and heading date were (35.64, 33.26, 32.87 and 31.28), respectively (Table 4). The present results indicated that the selection criteria for grain yield/plant gave the highest mean values of grain yield (Table 4). That, selection criteria of grain yield/plant will be a recommended way for selection in bread wheat. Also, the results revealed that the early pedigree selection were more effective than late selection in wheat. However, the three cycles of direct selection for grain yield/plant were the best among the different selection criteria exhibited under study 34.51 and 38.84 for Pop.1 and Pop.2, respectively, while the three cycles of indirect selection for 100-kernel weight were the second best among the different selection criteria produced 34.11 and 38.34 g for Pop.1 and Pop.2, respectively (Table 4). The presence of the differences between high and low suggested that selection would be effective in these families. These findings were in harmony with those obtained by El-Morshidy *et al.* (2010), Ali (2011), Mahdy *et al.* (2012), El-Ameen *et al.* (2013) and Abd El-Shafi (2014). The two families No. 40 and 93 were shared in the selection criterion 100-kernel weight, grain yield/plant and late selection (grain yield), in Pop.1 yielded (34.11, 32.41 and 32.09); (31.14, 31.51 and 31.38 g) for both families, respectively. Pop.2 were shared with two families No. 52 and 112 under the selection criterion 100-kernel weight, grain yield/plant and late selection (grain yield) (38.34, 37.97 and 33.06); (35.04, 36.48 and 36.20 g) for two families, respectively.

Only one family in Pop.1 was combined in the selection criterion heading date, 100-kernel weight, grain yield/plant and late selection (grain yield), in Pop.1 yielded (31.28, 34.11, 32.41 and 32.09 g) for family No. 40, respectively. Also in Pop.2 one family No. 62 was shared with the selection criterion heading date, grain yield/plant and late selection (grain yield) produced (36.48, 38.84 and 35.59 g), respectively, these presented in Table 4. The pedigree selection method was effective in improving the grain yield and its components (Abd El-Shafi 2014), also selection was effective to produce new lines with highest yield. The present results are agreement with those obtained by (Ismail 1995 and Mahmoud 2007).

In conclusion, the present data indicated that early selection is the most effective breeding method to develop high yielding. The two families No. 40 and 93 in Pop.1 produced (34.11 and 31.14); (32.41 and 31.51); (32.09 and 31.38 g.) for selections criteria 100-kernel weight, grain yield/plant and late selection (grain yield). While we found the best two families No. 52 and 112 in Pop.2 produced (38.34 and 35.04); (37.97 and 38.48); (33.06 and 36.20 g.) for selections criteria 100-kernel weight, grain yield/plant and late selection (grain yield). The best two families No. 42 and 56 in Pop.1 produced (33.74 and 34.51 g.) and families No. 52 and 62 in Pop.2 produced (37.97 and 38.84 g.) for selection criteria grain yield/plant. Kheiralla (1993) reported that selection based on grain yield *per se* was most effective in improving such complicated trait. Ismail *et al.* (1996), Ali (2011) and Mahady *et al.* (2012) revealed that three cycles of direct selection for yield produced greater yield. The results revealed to that selection for early heading resulted in earlier by -9.84 and -10.86% for the first and second populations comparing to the base population from the best parent, respectively. Our results were found both direct selection and indirect selection improve the grain yield/plant as found relative to direct and indirect responses of selection with different selection criteria in wheat. The early pedigree selection and late pedigree selection methods were effective in improving the grain yield and its components. Also selection was effective to produce new lines with highest yield.

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الانتخاب المنسب المتأخر والمبكر لمحصول الحبوب فى عشيرتين انعزالتين فى قمح الخبز باستخدام ثلاث صفات انتخابية

خلف على همام
قسم المحاصيل – كلية الزراعة – جامعة سوهاج – مصر

تم استخدام عشائر قمح الخبز في الجيل الثالث، الرابع، الخامس والسادس الناتجة من الهجينين (Giza 168 x TRI 2592)&(Sids 12 x HAAMA-14) في الدراسة. استخدمت فى هذه الدراسة مائة عائلة في الجيل الثالث من العشيرتين، تم تطبيق الانتخاب المنسب المبكر على عشائر الجيل الثالث حتى الوصول إلى عائلات الجيل السادس. الهدف من هذه الدراسة مقارنة فاعلية تأثير دورة واحدة من الانتخاب المنسب المتأخر مقارنة بإجراء ثلاث دورات من الانتخاب المنسب المبكر، في تطوير محصول عالي من قمح الخبز. تم انتخاب أربعون عائلة في الجيل الرابع باستخدام (محصول الحبوب، وزن مائة حبة و عدد الأيام حتى طرد السنابل) كصفات انتخابيه. تم انتخاب عشرون عائلة في الجيل الخامس باستخدام (محصول الحبوب، وزن مائة حبة و عدد الأيام حتى طرد السنابل) كصفات انتخابيه. بالإضافة إلى ذلك، تم انتخاب عشرة عائلات مبشرة في الجيل السادس باستخدام الانتخاب المنسب المتأخر والمبكر كصفات انتخابيه. أجريت هذه الدراسة خلال أربعة مواسم ناجحة 2010/2009 ، 2011/2010 , 2012/2011 و 2013/2012 م فى المزرعة البحثية لكلية الزراعة – جامعة سوهاج - مصر. وجدت اختلافات عالية المعنوية بين عائلات الجيل الثالث ، ووجدت اختلافات وراثية بقدر كافى للانتخاب المباشر وغير المباشر في العشيرتين لكل الصفات موضع الدراسة. بعد إجراء ثلاث دورات انتخابية من عائلات الجيل الثالث قلت درجة الاختلافات الوراثية لكل الصفات تحت الدراسة. وجدت درجة التوريث العامة عالية وتتراوح من 76.73% لصفة عدد السنابل لكل نبات إلى 99.94% لصفة عدد الحبوب لكل سنبله في العشيرة الأولى و 72.34% لصفة عدد السنابل لكل نبات إلى 98.61% لصفة عدد الحبوب لكل سنبله في العشيرة الثانية. وأظهرت النتائج أن قيم النسب المئوية للتحسين الوراثي المتوقع في الانتخاب تراوحت بين 19.70% لصفة عدد الايام حتى طرد السنابل إلى 94.94% لصفة عدد السنابل لكل نبات في العشيرة الأولى، وتراوحت بين 23.21% لصفة طول النبات إلى 79.24% لصفة طول السنبلة في العشيرة الثانية. الانتخاب المتأخر أدى إلى زيادة محصول الحبوب بعد دورة واحدة من الإنتخاب فى كل من العشيرتين بالمقارنة بأحسن الآباء والعينة العشوائية بمقدار 12.39و 25.44% فى العشيرة الأولى وبمقدار 9.26 و 23.74% فى العشيرة الثانية على التوالي. وجد أن محصول الحبوب زاد بعد اجراء ثلاث دورات من الانتخاب المبكر فى كل من العشيرتين بالمقارنة بأحسن الآباء والعينة العشوائية بمقدار 20.66و 34.66% فى العشيرة الأولى وبمقدار 17.08و 32.59% في العشيرة الثانية على التوالى. باستخدام وزن المائة حبة كصفة انتخابية زادت وزن المائة حبة بعد إجراء ثلاث دورات من الانتخاب المبكر فى كل من العشيرتين بالمقارنة بأحسن الآباء والعينة العشوائية بمقدار 11.32و 24.25% فى العشيرة الأولى وبمقدار 7.98و 22.28% فى العشيرة الثانية على التوالى. فى العشيرة الأولى وجد أن أحسن عائلتين نتجت من الانتخاب المنسب هما العائلتين رقم (42 و 56) وأدت إلى زيادة بمقدار 28.58 و 31.52% بالمقارنة بأحسن الآباء باستخدام محصول الحبوب كصفة إنتخابية.

بينما فى العشيرة الثانية وجد ان احسن عائلتين نتجت من الانتخاب المنسب هما العائلتين رقم (52 و 62) وأدت إلى زيادة بمقدار 24.74 و 27.60% بالمقارنة بأحسن الآباء تحت الصفة الإنتخابية لمحصول الحبوب. بعد ثلاث دورات من الانتخاب المنسب أدت إلى تبكير بمقدار 9.84- و-10.86% بالمقارنة بأحسن الآباء في العشير ة الأولى والثانية على التوالي. العائلات ذات المحصول العالي باستخدام الصفات الانتخابية المختلفة تبين أنه يمكن تطوير سلالات قمح جديدة وذات تأثير فعال لطرق التربية لتطوير محصول الحبوب.

Table 2. Means, genotypic (G.C.V. %) coefficients of variability for the studied traits in the three selection and late selection yield

Criteria	Cycles	Populations	Families	Days to heading	Plant height (cm)	Spike length (cm)	No. of spikes/ plant	No. of grains/spike	100-kernels weight (g)	Biomass /plant(g)	Grain yield/plant (g)
Days to heading	C1	Pop.1	F4 families	107.66	100.58	13.02	8.41	51.48	5.31	78.61	27.10
			G.C.V.%	4.60	6.79	19.23	28.26	15.45	9.35	14.45	11.97
		Pop.2	F4 families	92.52	105.53	15.15	10.69	65.13	5.44	93.34	31.91
			G.C.V.%	6.33	6.08	18.00	18.74	16.15	12.86	13.50	10.37
	C2	Pop.1	F5 families	104.82	101.56	13.55	8.39	52.54	5.28	77.45	27.37
			G.C.V.%	4.31	6.68	14.93	27.75	13.56	7.27	13.72	10.44
		Pop.2	F5 families	87.43	105.28	14.72	11.23	64.41	5.38	93.34	32.19
			G.C.V.%	3.46	5.55	11.18	17.11	13.78	9.36	12.56	9.31
	C3	Pop.1	F6 families	101.77	103.95	13.87	8.55	52.13	5.37	78.85	29.17
			G.C.V.%	4.21	6.57	10.18	23.68	13.87	4.71	13.16	10.02
		Pop.2	F6 families	84.91	106.7	16.12	11.73	65.79	5.22	91.81	31.28
			G.C.V.%	1.79	3.97	10.63	11.32	12.86	7.06	12.17	8.92
100 kernel weight (g)	C1	Pop.1	F4 families	111.11	100.55	12.64	9.23	50.71	5.59	80.12	28.75
			G.C.V.%	5.23	5.69	21.90	18.85	17.86	2.96	12.94	9.79
		Pop.2	F4 families	94.74	105.68	15.45	10.89	63.87	5.73	93.04	32.04
			G.C.V.%	5.69	5.23	21.90	19.05	17.88	2.95	13.09	9.79
	C2	Pop.1	F5 families	111.58	100.35	12.63	9.42	50.73	5.71	81.58	29.08
			G.C.V.%	5.22	5.66	15.34	14.51	15.60	2.54	12.73	9.76
		Pop.2	F5 families	94.55	106.13	15.43	11.11	63.90	5.85	94.73	32.73
			G.C.V.%	5.62	5.22	17.07	15.78	16.13	2.69	12.73	9.61
	C3	Pop.1	F6 families	112.53	102.31	12.75	10.09	51.13	5.81	81.54	29.21
			G.C.V.%	3.80	5.25	13.29	8.69	15.86	2.70	10.05	8.39
		Pop.2	F6 families	96.39	107.03	15.58	11.91	64.41	5.95	94.68	32.87
			G.C.V.%	5.37	3.80	13.29	14.50	15.62	2.53	10.51	9.15
Grain yield/plant (g)	C1	Pop.1	F4 families	109.06	101.11	12.81	9.50	50.71	5.46	83.67	30.19
			G.C.V.%	3.74	7.30	22.08	25.02	17.97	6.46	15.00	9.96
		Pop.2	F4 families	95.26	103.73	15.65	11.21	63.87	5.59	97.16	33.97
			G.C.V.%	7.00	3.95	17.74	7.82	18.27	4.29	8.97	4.09
	C2	Pop.1	F5 families	108.7	98.6	12.9	9.7	51.1	5.5	84.8	31.0
			G.C.V.%	3.02	7.00	15.89	14.73	16.65	3.63	12.32	9.03
		Pop.2	F5 families	92.9	103.4	15.8	11.5	64.4	5.6	98.4	34.8
			G.C.V.%	6.02	3.74	14.90	4.18	16.67	3.09	5.83	3.77
	C3	Pop.1	F6 families	108.25	96.71	12.65	9.94	51.50	5.58	84.27	31.66
			G.C.V.%	2.67	5.83	12.02	2.97	15.75	2.81	5.82	3.73
		Pop.2	F6 families	91.12	102.97	15.46	11.73	64.87	5.71	97.85	35.64
			G.C.V.%	5.82	2.67	12.73	2.84	11.58	1.53	3.81	3.74
Grain yield (late selection)		Pop.1	Mean	105.01	93.10	12.49	9.44	48.79	5.27	79.32	29.49
			G.C.V.%	3.21	7.52	21.23	7.22	12.72	1.73	4.01	4.38
		Pop.2	mean	88.35	98.54	15.06	11.04	61.01	5.40	91.13	33.26
			G.C.V.%	7.50	3.21	21.55	7.16	12.74	1.74	3.94	4.34

Pop.1 = Population 1 Pop.2 = Population 2

Table 3. Realized gain and correlated responses from pedigree selection and late selection yield measured in percentage from the bulk sample and the best parent.

Criteria	Cycles	Populations		Days to heading	Plant height (cm)	Spike length (cm)	No. spike/ plant	No of grains/ spike	100-kernels weight (g)	Biomass /plant(g)	Grain yield/plant (g)
Days to heading	C1	Pop.1	Bulk	-6.76**	-3.53**	14.21	-0.59	16.37*	8.81**	10.01*	15.27**
			Best parent	-4.62**	-1.61*	16.25	-2.44	5.75**	9.48**	9.01**	3.28*
		Pop.2	Bulk	-6.78**	-4.27*	11.56	10.43	20.34**	7.94**	16.36**	18.71**
			Best parent	-2.87	0.70	3.77	7.76	6.39**	5.43**	7.73	4.83**
	C2	Pop.1	Bulk	-9.22**	-2.59**	18.86**	-0.83	18.76**	8.20**	8.38**	16.42**
			Best parent	-7.14**	-0.66	20.98**	-2.67	7.93**	8.87**	7.41**	4.31*
		Pop.2	Bulk	-11.91**	-4.50**	8.39	16.01	19.01**	6.75**	16.36**	19.75**
			Best parent	-8.21**	0.46	0.82	13.21	5.21**	4.26**	7.73	5.75**
	C3	Pop.1	Bulk	-11.86**	-0.30	21.67**	1.06	17.83**	10.04**	10.34**	24.07**
			Best parent	-9.84**	1.68*	23.84**	-0.81	7.09**	10.72**	9.35**	11.17**
		Pop.2	Bulk	-14.45**	-3.21*	18.70**	21.18*	21.56**	3.57**	14.45**	16.37**
			Best parent	-10.86**	1.81	10.41*	18.25	7.46**	1.16	5.97**	2.76*
100 kernel weight	C1	Pop.1	Bulk	-3.77**	-3.56**	10.88	9.10	14.62**	14.55**	12.12	22.29**
			Best parent	-1.57	-1.64*	12.86	7.08	4.17**	15.26**	11.11	9.57**
		Pop.2	Bulk	-4.55**	-4.14*	13.77	12.50	18.02**	13.69**	15.98**	19.20**
			Best parent	-0.54	0.84	5.82	9.78	4.33**	11.05**	7.39**	5.26*
	C2	Pop.1	Bulk	-3.36**	-3.75**	10.79	11.35	14.67**	17.01**	14.16**	23.69**
			Best parent	-1.15	-1.84*	12.77	9.28	4.21**	17.73**	13.13**	10.82*
		Pop.2	Bulk	-4.74**	-3.73**	13.62*	14.77	18.07**	16.07**	18.09**	21.76**
			Best parent	-0.73	1.27	5.68	12.00	4.38**	13.37**	9.34*	7.52**
	C3	Pop.1	Bulk	-2.54**	-1.87**	11.84*	19.27*	15.57**	19.06**	14.11**	24.25**
			Best parent	-0.31	0.08	13.84*	17.05*	5.03**	19.79**	13.08**	11.32**
		Pop.2	Bulk	-2.88**	-2.91**	14.73*	23.04*	19.01**	18.06**	18.03**	22.28**
			Best parent	1.20	2.13*	6.71	20.06*	5.21**	15.31**	9.28**	7.98**
Grain yield/ plant (g)	C1	Pop.1	Bulk	-5.54**	-3.02**	12.37	12.29	14.62**	11.89**	17.09**	28.41**
			Best parent	-3.38*	-1.10	14.38	10.21	4.17*	12.58**	16.03**	15.05**
		Pop.2	Bulk	-4.02**	-5.91**	15.24**	15.81	18.02**	10.91**	21.12**	26.38**
			Best parent	0.01	-3.52	7.19	13.00	4.33**	8.33**	12.14**	11.60**
	C2	Pop.1	Bulk	-5.85**	-5.43**	13.16	14.66	15.51**	12.70**	18.67**	31.86**
			Best parent	-3.70**	-3.55**	15.18	12.53	4.97**	13.40**	17.60**	18.14**
		Pop.2	Bulk	-6.40**	-6.20**	16.35*	18.80	18.99**	11.11**	22.66**	29.46**
			Best parent	-2.47**	-5.92	8.22	15.93	5.19**	8.53**	13.57**	14.32**
	C3	Pop.1	Bulk	-6.24**	-7.24**	10.96	17.49	16.41**	14.34**	17.93**	34.67**
			Best parent	-4.10**	-5.40**	12.95*	15.31	5.79**	15.05**	16.86**	20.66**
		Pop.2	Bulk	-8.19**	-6.59**	13.84*	21.18*	19.86**	13.29**	21.98**	32.59**
			Best parent	-4.34**	-7.72	5.89	18.25	5.96**	10.66**	12.94**	17.08**
Late selection (grain yield)		Pop.1	Bulk	-9.05**	-10.70**	9.56	11.58*	10.28**	7.99**	11.00**	25.44**
			Best parent	-6.97**	-8.93**	11.52	9.51	0.23	8.66**	10.00**	12.39**
		Pop.2	Bulk	-10.99**	-10.61**	10.90	14.05*	12.73**	7.14**	13.60**	23.74**
			Best parent	-7.24**	-5.97**	3.15	11.29	-0.34	4.65**	5.18**	9.26**
Pop.1 = Population 1						Pop.2 = Population 2					

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

Table 4. Mean of grain yield/plant for ten super families, after third cycle of pedigree selection and late selection yield using different selection criteria in population 1 and population 2.

Selection criteria	Grain yield /plant, g											
	Population 1											
Family No.	21	22	23	26	29	40	42	45	62	83	Mean	$RLSD'_{0.05}$
Days to heading	30.06	(31.51)	30.73	30.49	26.98	31.28	(33.74)	25.78	26.11	25.06	29.17	1.05
Family No.	9	10	13	26	36	40	42	56	70	93		
100-grain weight /g	29.77	29.13	30.21	28.91	24.01	(34.11)	30.49	25.69	28.66	(31.14)	29.21	1.11
Family No.	16	19	21	22	23	34	40	42	56	93		
Grain yield/plant	30.60	31.28	30.06	31.14	30.70	30.70	32.41	(33.74)	(34.51)	31.51	31.66	1.15
Family No.	40	42	49	52	53	56	64	72	86	93		
Late selection (Grain yield)	(32.09)	31.14	28.46	29.31	27.58	28.35	28.55	28.96	29.09	(31.38)	29.49	1.15
Better parent (HAAMA-14)	26.24	26.24	26.24	26.24	26.24	26.24	26.24	26.24	26.24	26.24		
Bulk	23.51	23.51	23.51	23.51	23.51	23.51	23.51	23.51	23.51	23.51		
	Population 2											
Family No.	11	17	19	32	55	75	30	62	72	91	Mean	$LSD'_{0.05}$
Days to heading	34.02	34.05	30.87	33.02	32.81	27.02	27.60	(36.48)	28.20	28.70	31.28	0.89
Family No.	13	16	19	40	52	61	76	79	91	112		
100-grain weight /g	33.51	32.78	28.91	34.31	(38.34)	34.00	32.54	27.52	31.80	(35.04)	32.87	1.24
Family No.	16	19	21	22	23	34	52	56	62	112		
Grain yield/plant	34.55	35.21	33.83	35.47	34.55	34.44	(37.97)	35.04	(38.84)	36.48	35.64	1.29
Family No.	23	34	49	52	53	56	62	72	86	112		
Late selection (Grain yield)	32.66	32.10	33.99	33.06	32.23	31.98	35.39	32.81	32.20	(36.20)	33.26	1.29
Better parent (Giza 168)	30.44	30.44	30.44	30.44	30.44	30.44	30.44	30.44	30.44	30.44		
Bulk	26.88	26.88	26.88	26.88	26.88	26.88	26.88	26.88	26.88	26.88		

( ) brackets are set for best families.