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Selection for Earliness in Bread Wheat (*Triticum aestivum* L.) under Infertile Soil Conditions

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THE CURRENT research was performed during the four growing seasons 2010/2011-2013/2014 at the Experimental Farm of the Agronomy Department, Faculty of Agriculture, South Valley University, Qena. This research aimed to study the response to direct selection for early heading date and the correlated response of other studied characters. Two cycles of pedigree selection for early heading date were practiced on a segregating population of bread wheat cross (SHORAWAKI BW-20313 × IG 41897 ICBW 201657) in F_3 and F_4 generations.

Results revealed highly significant difference among F_3 families for heading date and the other correlated characters. Also little differences were observed between PCV and GCV values, reflecting presence of sufficient amount of genetic variability for selection. Moreover, high estimate of broad sense heritability was observed in heading date (81.52%) in base population. After two cycles of pedigree selection for early heading date, the realized gains recorded -22.22 and -30.36 % decrease in days to heading relative to the bulk sample and better parent, respectively. Negative genotypic correlations between heading date and the other studied characters except for spike length ranged from small to moderate were observed in the base population. However, after two cycles of selection, the correlation direction was inverted, and high positive correlations between heading date and each of 100-kw and grain yield/plant (0.80 and 0.53) were observed. Pedigree selection for early heading date resulted nine earliest families and three from them no. 2, 33 and 44 taking top rank by 58.67 day. The earliest family no. 44 could be considered the best selected family because it showed 8.62 and 53.66 % increase in grain weight over the better parent and the bulk sample, respectively.

Keywords: Bread wheat, Pedigree selection, Early heading date, Grain yield, Realized gains.

Wheat growth season often extends in Egypt to end of April, this increases the probability of exposure of plants to high temperature in ripening stag. Exposure to high temperature, especially in milky and mealy ripe stages and before hardness of kernels, will lead to decreased grain weight and quality of grains. Kherialla *et al.* (2001) found that undesirable effect of exposure to high temperature during grain filling is a major environmental factor which drastically reduces wheat production in Upper Egypt. Furthermore, exposure to high

temperature during floral initiation and spikelet development causes reduction in potential number of grains (Ali, 2011). Cultivars with early heading date are desirable, because of their ability in escaping from drought, heat stress, disease, pests and other stress at the end of the growing season (Menshawy, 2007). In Egypt, whereas there is a big gap between wheat production and demand for consumption, early heading date can be considered as one of the important tools, that contribute in solving this problem by increasing grain yield. On the other hand, early harvesting of wheat, will lead to early sowing of summer crops, especially corn. Since, most of wheat planting area in Upper Egypt is followed by corn crop. An early wheat harvesting increases the chances of obtaining a good yield of corn and twice cultivations in the same season, which duplicates the total production. Aglan & Farhat (2014) denoted that early maturing cultivars aid to fit in crop intensive rotation in Egypt. So development of wheat cultivars with early maturing and without decrease in grain yield is a main objective of many wheat breeding programs. Allard & Harding (1963), Avey *et al.* (1982) and Frederickson & Kronstad (1985) reported that heading date in wheat is an easily identifiable character that can be modified through selection. Decrease in plant height, 1000-grain weight and grain yield/plant were noticed with two cycles of direct selection for earliness under early and late planting (Tammam *et al*., 2004; Zakaria, 2004 and El-Morshidy *et al.*, 2010). May & Van Sanford (1992) mentioned that direct response to selection for early heading date were 5 and 10 days in two populations, respectively. High estimates of heritability for days to heading, 1000-grain weight and grain yield/plant were found under normal and stress conditions by El-Shazly *et al.* (2000) and Attia (2003). Iqbal *et al*. (2006), Erkul *et al.* (2010) and El-Fadly *et al.* (2013) reported that the expected genetic advance from selection was found to be low to moderate for days to heading and maturity. The purpose of this research was to study the response to direct selection for early heading date and investigate the correlated response of the other studied characters under infertile soil conditions in Upper Egypt.

Materials and Methods

Experimental site description

This research was carried out during four growing seasons, 2010/2011-2013/2014 at the Experimental Farm of South Valley University, Qena, Egypt (26°11'N and 32°44'E). Soil of the Experimental Farm is newly reclaimed lands irrigated by saline underground water (7.71 ds m^{-1}). So, it could be considered as infertile soil. Some soil properties of the experimental site are shown in Table 1.

TABLE 1. Pedigree and origin of the parental wheat genotypes.

Parents	Pedigree	Origin
P1	SHORAWAKI BW-20313	Mexico
P2	IG 41897 ICBW 201657	ICARDA (origin country: Morocco)

Selection practices

The population used in the current study was the F_2 generation of the cross: SHORAWAKI BW-20313 × IG 41897 ICBW 201657. The pedigree and origin of the two parents are presented in Table 2. In the first season, 500 plants from F_2 generation were sown individually on19th, November 2010 in non-replicated trial of two plots. Each plot consisted of 10 rows, 3m long, 20 cm apart and 15 cm between hills within row (average 20 plants/row). Also, the parents were sown alongside each row. Heading date for an individual plant was defined as the day of complete spike emergence from the flag leaf sheath. One hundred plants, which headed earliest were selected and harvested. From them, 25 highest grain yielding plants were selected to give F_3-families (5 % selection intensity).

TABLE 2. Some physical and chemical properties of the experimental site (average all growing seasons).

Sand (%)	Silt (%)	Clay (%)	Soil texture	pH (1:1)	Organic matter (%)	EC (ds m^{-1})	$CaCO_3$ (%)	Soluble ions (m mol L^{-1})						
								Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	SO_4^{--}
84.02	7.98	8	Sand	8.8	0.4	7.5	7.4	55.4	0.28	2.0	1.5	10.0	33.0	6.9

An equal number of grains were composited from each F_2 plants to give F_3 bulk sample.

In the second season, the 25 F_3-families parents and F_3 bulk random sample were sown on Nov. 21st with three replications in a randomized complete blocks design (RCBD). Plants were sown on the following basis, each family, bulk sample and parents were sown in a single row, 3 m long 20 cm apart and 15 cm. between hills in each replicate. The earliest 10 plants in heading date in each row were selected and harvested. Heading date was recorded as a number of days to heading of 50 % of plants in each row. In addition, data of plant height (PH), spike length (SL), no. of spikelets/spike, 100-kernel weight (SI) and grain yield/plant (GY) were measured on the ten selected plants. Means of these ten plants were subjected to the statistical and genetic analysis. The best plant in grain yield from each of the earliest fifteen families in heading date was selected to give F_4-families (60 % selection intensity). Next season, the 15 families, parents and F_4- bulk random sample were planted on 21st, November. The experimental design, number of replications, recorded data and selection were practiced as in the previous season. For the second cycle of selection, the best

plant in grain yield from each of the earliest nine families in heading date was selected to give F_5- families (60 % selection intensity).The F_5 selected families, parents and bulk sample were planted on 25th, November, 2013. The experimental design, number of replications, recorded data were practiced as in the previous season. The cultural practices for wheat production were applied during all the growing seasons according to the recommendations of the Ministry of Agriculture.

Statistical analysis

Analysis of variance of RCBD was performed according to Snedecor & Cochran (1980). Significance of differences between means in F_5 generation was tested by using the revised LSD according to El-Rawi & Khalafalla (1980) on the basis of analysis of variance for all genotypes (F_5-selected families, parents and sample bulk). The phenotypic and genotypic coefficients of variation (PCV and GCV) were calculated according to Singh & Chaudhary (1985). Estimates of broad sense heritability (BSH) were estimated as the ratio of genotypic to phenotypic variance according to Falconer (1989). Realized response to selection was calculated as the deviation percentage of the overall mean from the better parent and bulk sample according to Falconer (1989). Genotypic correlation between heading date and each of the other studied characters in base population and the two cycles of selection were measured according to Miller *et al.* (1958).

Results and Discussion

Base population

Analysis of variance presented in Table 3 revealed highly significant differences between F_3 families for heading date and the correlated characters. These results indicate to the presence of sufficient variability to practice of selection. Phenotypic coefficients of variation (PCV) showed 5.67 % for heading date and ranged from 10.75 to 25 % in the correlated characters (Table 3). In addition, genotypic coefficients of variation (GCV) for heading date were 5.12 % and ranged in the correlated characters from 8.92 to 22.5 % (Table 3). The high values of GCV indicate the presence of sufficient genetic variability for further improvement. Little differences were observed between PCV and GCV values, indicating the importance of the genetic effects in inheritance of the characters. High estimate of broad sense heritability was observed in heading date (81.52 %), and ranged from 65.25 to 81.33 % in the correlated characters (Table 3). These results indicated that heading date was mostly controlled by genetic factors and less affected by the environment conditions. Burton (1952) and Sanghi *et al.* (1964) revealed that genetic coefficient of variation together with heritability estimate would seem to give the best picture of the a mount of genetic advance from selection. Generally all the previous results reflect suitable of this base population to practice the direct selection for earliness. The obtained results were in agreement with those reported by Benmoussa & Achouch (2005), Shamroukh (2006) , El-Morshidy *et al.* (2010), Ali (2011) and El-Ameen (2013).

TABLE 3. Mean squares, phenotypic & genotypic coefficients of variability and heritability for all the studied characters of F_3 selected families (base population).

Source of variation	Degrees of freedom	Characters					
		Direct selection	Indirect selection				
		Heading date (days)	PH (cm)	SL (cm)	No. of spikelets/ spike	SI (gm)	GY (gm)
Reps.	2	2.65	16	3.17	1.56	0.10	0.01
Selected families	24	42.55**	241.52**	8.69**	9.50**	0.61**	0.42**
Error	48	2.99	17.17	1.31	1.27	0.02	0.03
Better parent		81	75	11.4	22	3.86	2.70
Bulk sample		76	55	8.2	17	3.54	2.56
PCV (%)		5.67	14.36	20.55	10.75	12.34	25
GCV (%)		5.12	12.95	16.63	8.92	11.81	22.5
BSH (%)		81.52	81.33	65.25	68.33	90.91	81.25

** Significant at 0.01 probability level

Selection response

Mean heading date was earlier by 6 and 11 days after one and two cycles of pedigree selection, respectively compared to the C_0 (Table 4). Results presented in Table 4 indicate realized gains from selection for earliness corresponding to (-16.5 and -18.59 %) and (-22.22 and -30.36 %) decrease in days to heading relative, respectively to the bulk sample and better parent after one and two cycles of selection. Thus it could be said that, selection for earliness succeeded in decreasing days to heading. These results are in the line with those obtained in other studies (Avey *et al.*, 1982, Frederickson & Kronstad, 1985 and Ali, 2011). Moreover, El-Ameen (2013) found that the realized gains for early heading date were 9.41, 10.50 and 15.21 % in the 1^{st}, 2^{nd} and 3^{rd} cycle of selection, respectively.

It is also noticed that progress in early heading date after the first cycle of selection was approximately equal to that achieved after the second cycle (6 and 5 days, respectively). This may be due to equal selection intensity in the two cycles (60 %). In contrast, Avey *et al.* (1982), Frederickson & Kronstad (1985) and May &Van Sanford (1992) found that progress for early heading date in the first cycle of selection was greater than that in the second one. With respect to the correlated response to reduce days to heading, all studied

characters were increased relative to the bulk sample (Table 4). In addition, responses of all studied characters except for no. of spikelets/spike were also increased relative to the better parent after one cycle of selection. These results may be due to the selection procedure, the best plants in grain yield from the earliest plants in heading date being selected in each cycle. However after two cycle of selection, responses of all studied characters except for plant height were reduced. Similar results were obtained by El-Ameen (2013) who reported that the observed correlated responses to selection for heading date in 1000-grain weight, no. of grains, spike length and grain yield over the bulk sample were significant and positive.

In contrast, Ali (2011) revealed that negative correlated responses in plant height, spike length 1000- grain weight and grain yield/plant by selecting for earliness of heading date.

TABLE 4. Means and realized gains (Rg) & correlated responses to selection for early heading measured in percentage from bulk sample and the better parent.

Characters / Cycle		Direct selection		Correlated response									
		Heading date (days)		PH (cm)		SL (cm)		No. of spikelets/ spike		SI (gm)		GY (gm)	
		Mean	Rg	Mean	Rg	Mean	Rg	Mean	Rg	Mean	Rg	Mean	Rg
C_0 (base population)		70.95	-	66.80	-	9.44	-	18.60	-	3.81	-	1.60	-
C_1	Bulk	65.13	- 16.5	85.47	13.96	10.91	36.38	19.69	9.39	3.83	58.92	2.44	73.05
	Better parent		- 18.99		15.5		9.10		- 6.24		13.99		34.76
C_2	Bulk	59.89	- 22.22	83.11	10.81	10.59	21.67	19.07	5.94	3.71	44.36	2.21	34.76
	Better parent		- 30.36		2.60		-11.75		- 4.65		- 0.03		- 4.74

Genotypic correlation

Data of genotypic correlation between heading date and the other studied characters in the base populations and the two cycles of pedigree selection are presented in Table 5. Negative coefficients of genotypic correlation ranged from small to moderate are observed in the base population. With exception of plant height and spike length, the same direction of correlation is still found after one cycle of pedigree selection. However, after two cycles of selection the direction was inverted for all studied characters. For example, high positive correlations between heading date and each of 100-KW and grain yield/plant (0.80 and 0.53) were observed. These obtained results mean that these studied characters could be improved as an indirect response to direct selection for early heading date. This finding support and interpret the positive correlated responses of most of the studied characters to decreased days to heading from bulk sample after two cycles of pedigree selection in our study. In this concern, El-Ameen (2013) found positive correlation between heading date and each of grain yield, 1000-grain weight and spike length in 1^{st} and 2^{nd} cycles of selection except for spike length in 2^{nd} cycle which has negative correlation. In contrast, Mahmoud (2007) indicated that genotypic correlation between grain yield/plant and heading date shifted from positive correlation (0.35) after one cycle to negative correlation (-0.20) after two cycles of pedigree selection.

TABLE 5. Coefficients of genotypic correlation between heading date and each of the other studied characters in base population and the two cycles of selection.

Characters / Cycle	PH (cm)	SL (cm)	No. of spikelets/ spike	SI (gm)	GY (gm)
$\mathbf{C_0}$ (base population)	- 0.31	0.20	- 0.18	- 0.53	- 0.26
$\mathbf{C_1}$	0.34	0.06	- 0.09	- 0.34	- 0.12
$\mathbf{C_2}$	0.31	- 0.55	0.13	0.80	0.53

Performance of superior selections

Performance of the nine superior selected families after two cycles of pedigree selection for early heading date with the bulk sample and parents are presented in Table 6. It is clear from these results superiority of these nine selected families in early heading date compared to the bulk sample and the two parents. It is also noticed that overall family mean were ranged from 58.67-62.67 day. Among them the families' no. 2, 33 and 44, took top rank in early heading date by 58.67 day. Decreases in days to heading relative to the better

parent and the bulk sample are -31.78 and -23.81 %, respectively. In addition the earliest family no. 44 recorded 8.62 and 53.66 % increase in grain weight over the better parent and bulk sample, respectively. So, it could be considered the best selected family. Mostly, the nine selected families had a good performance in the other correlated characters. Thus, it could be concluded that two cycles of pedigree selection for early heading date resulted in nine earlier families with good performance in yielding ability. These results are in harmony with those obtained by Kheiralla *et al.* (2001), Zakaria (2004), Ali (2011) and El-Ameen (2013).

TABLE 6. Mean performance of the nine selected families after the two cycles of pedigree selection for early heading date, parents and bulk sample.

Characters / Selected families	Direct selection	Correlated response				
	Heading date (days)	PH (cm)	SL (cm)	No. of spikelets/ spike	SI (gm)	GY (gm)
1	60.00	88.00	9.33	17.67	3.44	2.17
2	58.67	74.67	11.67	21.00	3.74	2.02
24	59.00	85.00	12.67	21.67	3.33	1.11
31	62.67	81.00	9.00	19.00	4.25	2.11
33	58.67	79.00	8.67	16.00	3.35	1.70
38	60.67	85.67	10.67	18.00	3.81	2.55
44	58.67	87.00	13.00	18.00	2.83	2.52
47	61.67	87.00	9.67	20.67	4.53	3.62
53	59.00	80.67	10.67	19.67	4.07	2.07
Parent 1	88.00	81.00	12.00	17.00	2.37	1.05
Parent 2	86.00	77.00	8.00	20.00	3.72	2.32
Bulk	77.00	75.00	9.00	18.00	2.57	1.64
Revised L.S.D. at 5%	1.17	2.57	1.17	1.34	0.26	0.30

	at 1%	1.56	3.42	1.56	1.80	0.34	0.39

Conclusion

From the results of this study, it can be concluded that pedigree selection for early heading date was effective in decreasing number of days to heading. Furthermore, the two cycles of selection resulted in nine earlier genotypes with good performance in yielding ability, these genotypes can be used in improvement wheat production.

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الانتخاب للتبكير فى قمح الخبز تحت ظروف الآراضى الفقيرة

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نفذت هذه الدراسة خلال أربع مواسم زراعية ٢٠١٠/٢٠١١ - ٢٠١٣/٢٠١٤ فى المزرعة التجريبية لقسم المحاصيل - كلية الزراعة - جامعة جنوب الوادى - قنا. أستهدف البحث دراسة الاستجابة للانتخاب المباشر للتبكير فى طرد السنابل وكذلك الاستجابة المرتبطة للصفات الأخرى المدروسة تحت ظروف الآراضى الفقيرة. تم تنفيذ دورتين من الانتخاب مع تسجيل النسب على عشيرة انعزالية من الهجين (SHORAWAKI BW-20313 × IG 41897 ICBW 201657) فى الجيلين الثالث والرابع .

أشارت نتائج تحليل التباين لعشيرة الأساس وجود اختلافات عالية المعنوية بين العائلات فى صفات تاريخ طرد السنابل وكذلك فى الصفات الأخرى المرتبطة. كما أشارت النتائج إلى وجود فروق بسيطة بين تقديرات معاملات الاختلاف المظهرى والوراثى (PCV , GCV) مما يعكس وجود كمية كافية من التباين الوراثى للانتخاب. كما لوحظ ارتفاع قيمة درجة التوريث لصفة تاريخ طرد السنابل فى عشيرة الأساس (٨١،٥٢ %) . بلغ العائد المحقق بعد دورتى الانتخاب ٢٢,٢٢ % و ٣٠،٣٦ % نقصا فى عدد الأيام حتى طرد السنابل كنسبة من البلك والأب الأفضل على التوالى. أوضحت دراسة الارتباط الوراثى فى عشيرة الأساس وجود ارتباط سالب بين صفة تاريخ طرد السنابل وبقية الصفات المدروسة ما عدا صفة طول السنبلة وبقيم تراوحت بين الصغيرة والمتوسطة. كما لوحظ انعكاس اتجاه الارتباط بالكامل بعد دورتى الانتخاب فلوحظ مثلا وجود ارتباط عالى موجب بين صفة تاريخ طرد السنابل وصفتى وزن الـ ١٠٠ حبة ووزن حبوب النبات (٠،٥٣ و ٠،٨٠). تم عزل تسع عائلات مبكرة فى طرد السنابل بعد دورتى الانتخاب جاءت فى مقدمتهم العائلات أرقام ٢ و ٣٣ و ٤٤ بعدد أيام حتى طرد السنابل بلغ ٥٨،٦٧ يوم . وأعتبرت العائلة رقم ٤٤ الأفضل من بين العائلات المعزولة حيث حققت بجانب التبكير فى طرد السنابل عائدا محققا فى محصول حبوب النبات بلغ ٨،٦٢ و ٥٣،٦٦ % زيادة عن الأب الأفضل والبلك عى التوالى .