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Single Trait Selection in Two Segregating Populations of Spring Wheat (*Triticum aestivum* L.)

M.A. Ali
Department of Agronomy, Faculty of Agriculture, South Valley University, Qena, Egypt

ABSTRACT

The objective of the present investigation was to study the effects of two cycles of pedigree selection in improving days to heading, 1000-grain weight and grain yield/plant in two segregating populations of spring wheat (*Triticum aestivum* L.). Two cycles of pedigree selection for the days to heading, 1000-grain weight and grain yield/plant were practiced in two segregating populations of wheat in the F_3-F_5 generations. Highly significant differences among F_3 families in both populations and sufficient genotypic coefficients of variation were observed for all studied traits. Estimates of realized gains showed that heading date were earlier by 4.10 and 6.91% for populations I and II, respectively, than the bulk sample after the two cycles of selection. Grain weight increased 14.72 and 6.43% for populations I and 8.01 and 1.68% for populations II over the better parent and the bulk sample, respectively, after two cycles of selection. Selection also improved grain yield/plant in both populations over the better parent and the bulk sample by 12.20 and 3.37% for populations I and 7.93 and 1.60% for populations II, respectively. In population I, one family (No. 26) yielded 17.21% more and was 4.42% earlier than the bulk sample. In population II, the best selected family (No. 82) was common to the three selection criteria and outyielded the bulk sample by 15.32%, was earlier by 2.73% and produced 9.10% heavier grain weight. Single trait selection proved to be an efficient selection method for improving both studied populations. However, this improvement was often accompanied with significant adverse effects on correlated traits.

Key words: Pedigree selection, days to heading, grain weight, grain yield, segregation, spring wheat (*Triticum aestivum* L.)

INTRODUCTION

Spring wheat (*Triticum aestivum* L.) is the leading cereal crop in Egypt. Increasing wheat production both vertically and horizontally is an important target to meet increased domestic demands. These targets could be realized through expanding the wheat cultivated area particularly in reclaimed as well as rainfed using drought tolerant wheat cultivars (El-Morshidy *et al*., 2010).

To increase the yielding ability of wheat cultivars, direct and indirect effects of various yield components traits should receive prime importance. It also provides the basis for successful breeding programmes and tackling the problem of yield improvement more effectively (Asif *et al*., 2003) in wheat breeding.

Early maturing wheat cultivars are highly needed to fit in the intensive crop rotation systems and enables planting cotton after wheat as well as seeding wheat after harvesting short duration vegetable crops. Early wheat cultivars are also preferred to escape drought, heat stress, disease and pests and other stresses at the end of the growing season (Menshawy, 2007).

Selection of high performing wheat lines is the first step in the breeding and development of new varieties for dry land conditions. Direct selection in terms of grain yield is the simplest way, but various factors affect yield (Sadeghzadeh and Alizadeh, 2005). Maich *et al*. (2000) stated that grain yield increased 15% after two cycles of selection. Singh and Singh (2001) concluded that selection for grain yield in wheat should largely depend on 1000-grain weight, early maturity and spike length components. Tammam *et al*. (2004), Zakaria (2004) and El-Morshidy *et al*. (2010) concluded that direct selection for earliness after two cycles of selection under early and late planting was accompanied with a decrease in plant height, 1000-grain weight and grain yield/plant. They also found that direct selection for the grain yield was effective for improving grain yield. The genotypic coefficient of variation in grain yield was 9.16% (Attia, 2003) and the coefficient of variation was 3.59% (Shamroukh, 2006). Wiersma *et al*. (2001) and Utz *et al*. (2001) found that the broad sense heritability for grain yield ranged between 26.0 and 74.2%. The objective of the present study was to evaluate the effects of two cycles of pedigree selection for improving days to heading, 1000-grain weight and grain yield/plant in two segregating populations of spring wheat.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of South Valley University at Qena during the 2007/2008, 2008/2009 and 2009/2010 successive seasons. The breeding materials used were 100 F_3 families tracing back to a random sample of 100 F_2 single plants from each of the hybrid (Assiut line 103×Gemmiza 7) which are referred to as population I and (Assiut line 106× Sakha 69) referred to as population II.

Separate experiments were conducted for each population. In 2007/2008, the 100 F_3 families from each population and the original parents along of each hybrid, with F_3 bulked random sample were sown on 5th November in a randomized complete block design with three replications. Each plot was a single row 3 m long, 30 cm wide, with hills spaced 5 cm apart within rows. Heading date was recorded on a plot mean basis as days from planting to the day when 50% of the heads protruded from the flag leaf sheath. The earliest head of each plot was labeled. At maturity, individual plant data were taken on ten random plants from the middle portion of each plot. The following traits were measured on each plant, plant height, spike length on the main culm, 1000-grain weight and grain yield/plant. Analysis of variance for randomized complete block design was carried out according to Snedecor and Cochran (1980). The best 20 plants from the best 20 families of each population for each of the selection criteria; heading date, 1000-grain weight and grain yield/plant were saved to give the F_4-families.

In 2008/2009 season, the F_4-families of both populations were sown on 10th November in two separate experiments as in the previous season. The best 10 plants from the best 10 families were selected for each of the three above-mentioned traits as in the 2007/2008 season. In 2009/2010 season, the selected families were sown on the 15th of November. For both experiments of the two populations data were recorded as in the first season.

Statistical analysis: The analysis of variance of measured traits and analysis of covariance between pairs of traits were computed according to Snedecor and Cochran (1980). Genotypic and phenotypic coefficients of variation were computed on a plot mean basis according to Miller *et al*. (1958). The significance of differences among means was tested by the revised LSD method according to El-Rawi and Khalafalla (1980). Heritability in broad sense was calculated as outlined by Walker (1960). The realized gains from selection as a percentage deviation from the bulk sample and the better parent were estimated for the selection criteria and the correlated traits.

RESULTS AND DISCUSSION

The analysis of variance showed significant differences ($p<0.01$) among families for days to heading, plant height, spike length, 1000-grain weight and grain yield/plant of the two populations (Table 1), indicating the presence of genetic variability among selected families in these traits. Similar results were observed by Subhani and Chowdhry (2000), Asif *et al*. (2003), Zakaria (2004), Sadeghzadeh and Alizadeh (2005), Shamroukh (2006) and El-Morshidy *et al*. (2010).

The estimated genotypic coefficient of variability (Table 2) was high for grain yield/plant of the two populations (29.49% for population I and 27.39% for population II).

Sufficient variability for the other traits was observed. This indicates that selection in the base population would be effective for days to heading, 1000-grain weight and grain yield/plant. However, genetic variation may greatly diminish after the second cycle of selection for heading date

Table 1: Mean performance and mean squares of days to heading, plant height, spike length, 1000-grain weight and grain yield/plant in the F_3 families and their parents of the two wheat populations

	Population I						Population II					
	Mean			Mean squares			Mean			Mean squares		
Trait	F_3	Assiut 103	Gemmiza 7	Reps	Families	Error	F_3	Assiut 106	Sakha 69	Reps	Families	Error
Days to heading (days)	87.55	72.00	89.67	458.10**	126.90**	12.10	85.56	78.17	88.67	404.90**	127.60**	17.70
Plant height (cm)	78.13	89.67	82.33	178.10**	245.00**	28.00	83.70	92.67	104.67	0.30	226.50**	16.20
Spike length (cm)	9.35	10.67	9.33	11.90**	13.73**	1.20	10.19	11.67	10.33	1.56	6.24**	1.33
1000-grain weight (g)	38.05	36.30	37.62	8.87	37.02**	4.17	37.58	39.38	33.33	5.80	44.76**	4.76
Grain yield/ plant (g)	11.22	12.85	11.56	8.04	36.12**	4.27	13.33	13.23	12.45	33.13**	45.66**	5.95

** Significant at 0.01 level of probability

Table 2: Phenotypic and genotypic coefficients of variability and heritability in broad sense of the selected traits for the two cycles of selection for both populations

		Population I			Population II		
Selection criterion	Item	p.c.v. (%)	g.c.v. (%)	H	p.c.v. (%)	g.c.v. (%)	H
Days to heading (days)	Base pop (F_3)	7.43	7.06	0.90	7.62	7.07	0.86
	C_1	4.79	4.42	0.85	5.88	5.20	0.78
	C_2	3.55	3.06	0.74	3.05	2.51	0.68
1000-grain weight (g)	Base pop (F_3)	9.12	8.56	0.88	10.38	9.68	0.87
	C_1	6.35	6.05	0.71	6.44	5.88	0.83
	C_2	2.69	2.15	0.64	3.57	3.15	0.78
Grain yield/plant (g)	Base pop (F_3)	31.31	29.49	0.89	28.98	27.39	0.89
	C_1	27.56	23.46	0.72	15.19	13.78	0.82
	C_2	7.63	6.32	0.69	9.11	8.07	0.78

p.c.v., g.c.v: Phenotypic and genotypic coefficients of variability, respectively. H: Heritability in broad sense and 1000-grain weight because selection reduces genetic variance. The estimates of the genotypic coefficient of variation (g.c.v.) indicated the presence of sufficient for increasing grain yield/plant among the selected families after the second cycle of selection in the two populations as they reached 6.32 and 8.07% for the first and second populations, respectively. Similar results on family selection were reported by Ismail (1995), Mahdy *et al.* (1996), Pawar *et al.* (2000), Utz *et al.* (2001), Wiersma *et al.* (2001), Attia (2003), Zakaria (2004), Benmoussa and Achouch (2005), Shamroukh (2006) and El-Morshidy *et al.* (2010).

High estimates of heritability in broad sense were recorded for all studied traits in both populations (Table 2). However, these estimates may be biased upward due to the confounding effects of years and locations in the genetic variance estimated from one location for one season (O'Brien *et al.*, 1978). Theoretically, heritability estimates are expected to increase with the increase in homozygosity due to selfing. Results of this work (Table 2) indicate that pedigree selection reduced broad sense heritability for the three selection criteria in both populations. This could be due to the increased sensitivity of lines to environment as homozygosity increased, resulting in increased phenotypic at the expense of genotypic variance. The heritability estimates were comparable to those reported in other studies. Utz *et al.* (2001), Wiersma *et al.* (2001) and Singh and Chaudhary (2006) reported that broad sense heritability ranged between 26.0 and 74.0% for grain yield/plant. Kheiralla *et al.* (2001) and Shamroukh (2006) obtained high value of heritability in broad sense for days to flowering, plant height 1000-grain weight and grain yield. These results are in line with those obtained by Zakaria (2004), Benmoussa and Achouch (2005) and El-Morshidy *et al.* (2010).

The realized gains and correlated responses to selection measured as the deviation of the means of the selection cycles from the better parent and the bulk sample are presented in Table 3. Data in the Table 3, reveal that selection for earliness in the first population resulted in families those were earlier by 4.10% from the bulk sample. However, this response was accompanied by some negative effects on the other traits correlated with earliness amounting to -8.06, -2.13, -12.51 and -22.00% for plant height, spike length, 1000-grain weight and grain yield/plant, respectively after the second cycle of selection. Likewise, selection for earliness in population II was accompanied with some adverse effects on other correlated traits of the second cycle population.

Selection for heavy grain weight indicated a realized response to selection amounting to 3.04 and 1.98% over the better parent and the bulk sample, in population I, respectively. The respective realized gains in population II amounted to 4.84 and 5.70%. Such increase in grain weight was associated with a delay in heading date and decrease in plant height and spike length in the two populations. As well, grain yield/plant decreased by -8.02 and -9.80% in the first population and was -9.94 and -5.02% in the second population over the better parent and the bulk sample, respectively.

Selection for the grain yield/plant in population I resulted in gains of 9.42 and 7.29% from the better parent and the bulk sample, respectively. The corresponding realized gains in the population II were 4.13 and 9.83%. However, yield increased in both populations were accompanied with a delay in heading date, a decrease in spike length and 1000-grain weight and an increase in plant height from the better parent and the bulk sample. O'Brien *et al.* (1978), Ismail (1995), Mahdy *et al.* (1996), Kheiralla *et al.* (2001) and Zakaria (2004) also found that selection for grain yield per se was most effective in improving this complex trait. Negative sings some values in days to heading, plant height, spike length, 1000-grain weight and grain yield/plant meant that the selected families were earlier, shorter, less, lighter and lower than the better parent or the bulk sample or together, respectively. These results are in line with those reported by Mohamed (2001), Benmoussa and Achouch (2005), Shamroukh (2006) and El-Morshidy *et al.* (2010).

Table 3: Realized gains from and correlated responses to two cycles of pedigree selection for days to heading, 1000-grain weight and grain yield/plant in two spring wheat populations as percent of the bulk sample and the better parent

			Population I				
Selected trait	Item		Days to heading (days)	Plant height (cm)	Spike length (cm)	1000-grain weight	Grain yeild/plant (g)
Populatiou I							
Parents	C_1	Be. P.	77.00	86.67	11.00	39.00	13.52
		Bu. S.	84.67	87.33	11.27	40.80	14.45
	C_2	Better parent	75.33	91.67	11.33	41.67	14.82
		Bulk Sample	83.00	93.00	10.93	42.10	15.11
Days to heading (days)	C_1	Better parent	7.79**	-0.67	-2.12*	-2.52*	-10.01**
		Bulk Sample	-4.29**	-1.43	-4.44**	-6.82**	-15.78**
	C_2	Better parent	5.36*	-6.73**	-5.59**	-11.60**	-20.45**
		Bulk Sample	-4.10*	-8.06**	-2.13**	-12.51**	-22.00**
1000-grain weight (g)	C_1	Better parent	13.56**	-5.96*	-5.31**	7.52**	-8.84**
		Bulk Sample	3.92**	-6.68*	-7.62**	2.78	-14.69**
	C_2	Better parent	14.72**	-4.00	-14.12**	3.04**	-8.02**
		Bulk Sample	6.43**	-5.38	-10.98**	1.98*	-9.80**
Grain yield/plant (g)	C_1	Better parent	11.65**	1.44	-0.94	-0.81	12.51**
		Bulk Sample	1.54**	0.67	-3.35**	-5.19**	5.29*
	C_2	Better parent	12.20**	0.36	-4.41**	-12.48**	9.42**
		Bulk Sample	3.37**	-1.08	-0.91	-13.38**	7.29**
Populatiou II							
Parents	C_1	Better parent	83.33	85.00	10.00	40.00	15.22
		Bulk Sample	87.33	86.33	10.67	39.67	14.42
	C_2	Better parent	80.33	87.00	10.33	40.67	15.56
		Bulk Sample	85.33	89.33	11.00	40.33	14.75
Days to heading (days)	C_1	Better parent	-1.90	-1.27	1.21	-3.96	-9.71**
		Bulk Sample	-6.39*	-2.80	-5.16	-3.15	-4.66
	C_2	Better parent	-1.12	-4.21	-5.48	-6.31*	-15.90**
		Bulk Sample	-6.91**	-6.72*	-11.21	-5.54	-11.30**
1000-grain weight (g)	C_1	Better parent	1.24	-4.80	-3.97	4.38	-0.11
		Bulk Sample	-3.40*	-6.27*	-9.84	5.25	-6.89
	C_2	Better parent	8.01**	-4.21	-9.68	4.84*	-9.94**
		Bulk Sample	1.68	-6.72*	-15.15**	5.70**	-5.02
Grain yield/plant (g)	C_1	Better parent	5.50**	1.86	4.14	-7.62**	3.48
		Bulk Sample	0.67	0.29	-2.50	-6.85	2.91
	C_2	Better parent	7.93**	3.64	-1.61	-9.59**	4.13
		Bulk Sample	1.60	0.93	-7.58	-8.84**	9.83

*, ** Significant and highly significant at 0.05 and 0.01 levels of probability, respectively. Be. P. : Better parent, Bu. S.: Bulk Sample

It is of interest to recall that during pedigree selection in autogamous crops, the breeder may be concerned with the performance of individual selected families which may be masked, in most cases, by the overall mean of selected families. After the second cycle of selection in population I (Table 4), selection for early heading gave three families i.e., no. 21, 26 and 53 which was earlier than the bulk sample by 10.84, 4.42 and 10.04%, respectively. Family No. 26 which was earlier than the bulk sample by 4.42% and it also outyielded this sample by 17.21%. Selection for 1000-grain weight resulted in families that were late in heading date with increased in grain yield in two of them. However, seven of these families showed an average increased realized gains in grain

Table 4: Means of the ten selected families after the second cycle of selection for three selection criteria in population I

Selection criterion	Family No.	Dayes to heading (days)	Plant height (cm)	Spike length (cm)	1000-grain weight (g)	Grain yeild/plant (g)
Days to heading (days)	Better parent	75.33	91.67	11.33	41.67	14.82
	Bulk sample	83.00	93.00	10.93	42.10	15.11
	15	81.00	83.33	10.67	39.00	10.71
	19	80.00	103.33	12.33	38.33	13.42
	21	74.00	88.33	12.33	36.67	11.78
	22	80.00	81.67	10.67	40.33	12.68
	24	81.00	85.00	12.33	41.00	12.55
	26	79.33	88.33	13.00	35.00	17.71
	49	81.00	80.00	10.00	38.67	10.43
	53	74.67	78.33	8.67	27.00	10.51
	55	84.00	78.33	8.67	38.33	8.85
	60	81.00	88.33	8.33	34.00	9.26
Mean		79.60	85.50	10.70	36.83	11.79
$LSD_{0.05}$		3.52	4.54	0.91	2.25	1.86
$LSD_{0.01}$		5.53	5.87	1.18	3.21	2.69
1000-grain weight (g)	1	86.33	85.00	7.67	42.00	11.95
	4	87.00	83.33	7.33	41.67	13.79
	8	86.67	86.67	7.33	42.00	14.55
	9	87.33	91.67	11.33	43.33	17.47
	10	87.67	90.00	10.33	42.33	14.59
	13	86.67	80.00	12.00	42.00	17.36
	42	90.00	90.00	10.67	44.00	14.65
	43	88.33	91.67	12.33	45.33	12.48
	68	90.33	93.33	11.33	43.33	10.63
	69	93.00	88.33	7.00	43.33	8.85
Mean		88.33	88.00	9.73	42.93	13.63
$LSD_{0.05}$		3.09	5.88	0.95	1.77	3.26
$LSD_{0.01}$		4.65	8.82	1.33	2.59	4.82
Grain yield/plant (g)	5	89.00	95.00	10.00	35.33	14.97
	6	84.00	93.33	9.33	33.67	17.49
	9	87.33	91.67	11.33	43.33	17.13
	11	85.33	93.33	10.33	34.67	18.23
	12	87.00	88.33	9.33	35.67	15.77
	13	86.67	85.00	12.00	42.00	17.36
	16	86.67	91.67	12.00	34.67	14.03
	18	83.67	101.67	11.33	36.67	15.77
	26	79.33	88.33	13.00	35.00	17.71
	88	89.00	91.67	9.67	33.67	13.69
Mean		85.80	92.00	10.83	36.47	16.22
$LSD_{0.05}$		0.99	4.62	1.44	1.64	1.75
$LSD_{0.01}$		1.39	6.69	1.98	2.29	2.63

weight reaching 7.67% over the bulk sample for one family (No. 43). Likewise, selection for grain yield/plant resulted in seven high yielding families, of which one family (No. 26) yielded 17.21% more and was 4.42% earlier than the bulk sample.

In population II, after two cycles of selection (Table 5), single trait selection for earliness all the resulted families were earlier and lower in grain yield than the bulk sample except family No. 82 was higher in grain yield than by it 15.32%. All families selected for 1000-grain weight were

Table 5: Means of the ten selected families after the second cycle of selection for three selection criteria in population II

Selection criterion	Family No.	Days to heading (Days)	Plant height (cm)	Spike length (cm)	1000-grain weight (g)	Grain yield/plant (g)
Days to heading (days)	Better parent	80.33	87.00	10.33	40.67	15.56
	Bulk sample	85.33	89.33	11.00	40.33	14.75
	4	79.00	75.00	6.67	35.67	12.18
	6	78.67	68.33	8.00	36.67	13.54
	10	74.00	81.67	10.00	35.33	11.44
	20	78.00	88.33	10.67	40.00	12.73
	22	81.00	93.33	10.67	39.33	13.19
	27	79.33	86.67	11.00	37.67	12.46
	28	80.00	90.00	11.33	36.00	12.34
	43	81.67	83.33	9.33	39.00	13.09
	82	83.00	85.00	10.33	44.00	17.01
	96	79. 67	81.67	9.67	37.33	12.85
Mean		79.43	83.33	9.77	38.10	13.08
LSD $_{0.05}$		3.47	5.31	1.29	2.46	0.98
LSD $_{0.01}$		5.27	7.32	1.83	3.57	1.42
1000-grain weight (g)	71	82.67	91.67	10.33	41.67	13.90
	74	83.00	81.67	9.00	41.33	13.83
	77	85.00	90.00	11.67	43.33	12.96
	82	83.00	85.00	10.33	44.00	17.01
	84	88.33	81.67	9.33	45.00	13.42
	85	85.67	78.33	9.00	41.33	14.15
	88	88.00	85.00	9.00	42.00	14.46
	90	91.67	83.33	8.67	42.67	13.61
	91	87.67	83.33	8.33	43.67	13.32
	100	92.67	73.33	7.67	41.33	13.43
Mean		86.77	83.33	9.33	42.63	14.01
LSD $_{0.05}$		2.19	4.45	1.03	1.71	0.97
LSD $_{0.01}$		3.06	6.31	1.46	2.29	1.37
Grain yield/plant (g)	56	89.00	92.67	11.00	32.67	16.09
	72	90.00	103.33	11.00	31.00	16.40
	73	84.00	87.67	8.67	30.33	19.26
	75	83.33	84.33	10.67	39.00	15.51
	76	84.00	83.00	10.00	41.00	16.83
	78	89.00	94.33	9.33	33.00	13.53
	80	92.00	86.00	8.67	37.00	15.18
	81	86.67	92.67	11.33	38.33	16.56
	82	83.00	85.00	10.33	44.00	17.01
	83	86.00	92.67	10.67	41.33	15.62
Mean		86.70	90.17	10.17	36.77	16.20
LSD $_{0.05}$		2.13	4.35	1.19	1.72	1.64
LSD $_{0.01}$		2.97	6.04	1.72	2.35	2.20

heavier in grain weight than the bulk sample and the better parent. One family (No. 82) showed 9.10 and 8.19% heavier grains and higher in grain yield than the bulk sample and the better parent by it 15.32 and 9.32%, respectively. Moreover, single trait selection for increasing grain yield/plant all the resulted families were higher in grain yield than the bulk sample except family No. 78. In population II, family no. 82 is considered the best selected family showing 15.32% more grain yield, earlier slightly and showed heavier 9.10% grain weight than the bulk sample.

CONCLUSION

From the above results, it may be concluded that single trait selection in spring wheat proved to be an efficient selection method for improving both studied populations. However, this improvement was often accompanied with significant adverse effects on correlated traits.

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