Assiut J. Agric. Sci., 52 (3) 2021 (1-21) *ISSN: 1110-0486*
Website:www.aun.edu.eg/faculty_agriculture/journals_issues_form.php *E-mail: ajas@aun.edu.eg*

Selection for Grain Yield Under Normal and Late Planting Dates Conditions in Durum Wheat (*Triticum turgidum* L. var. *durum*)

Abd El-Rady, A.G.

Wheat Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.

Accepted for publication on: 13/10/2021

Abstract:

The current investigation was conducted at Shandaweel Agric. Res. Station, Sohag governorate, Egypt during 2018/2019 to 2020/2021 seasons. Pedigree selection of grain yield plant^{-1} was practiced independently from the F_2 to F_4 generations under normal and late planting dates. Evaluation was under both planting dates in the F_4 generation. The phenotypic variance was slightly higher than the genotypic variance, and reduced from the F_2 to F_4 generation. Broad-sense heritability was 83.47 and 86.73% under normal planting compared to 88.22 and 89.03% under late planting after the first and second cycle of selection, respectively. The realized heritability was 37.75 and 40.63% under normal planting compared to 57.75 and 83.48% under late planting after cycle 1 and 2, respectively. The average observed gain of grain yield plant^{-1} after two cycles of pedigree selection was 12.59 and 25.33% from bulk sample and 7.45 and 2.69% from the better parent for normal planting selections, while it was 22.05 and 47.18% from bulk sample and 16.48 and 20.59% from the better parent for late planting selections, when the selected families were evaluated under normal and late planting conditions, respectively. The antagonistic selection increased the mean and decreased the sensitivity compared to the synergistic selection either evaluation was under normal or late planting conditions. Based on the path-coefficient analysis, number of spikes plant^{-1} had the greatest positive direct effect on grain yield plant^{-1} followed by number of kernels spikes^{-1} and 100-kernel weight in the base population and cycle two of selection under both planting dates.

Keywords: *Durum wheat, pedigree selection, planting dates, observed gain, heat susceptibility, antagonistic selection and path coefficient.*

Introduction:

Wheat is considered the most essential cereal crops in Egypt as well as in the world. The wheat cultivated area in Egypt reached 1.39 million hectare in 2019/2020 growing season, with an average yield of 6.4 ton hectare^{-1}, and the total production was about 8.9 million ton (USDA GAIN Report., 2020). In Egypt, the total production of wheat is still far below the consumption and the annual demand which resulted in increasing wheat imports. With increasing population, it is expected that increasing demand for wheat will need an increase in wheat production. Elevated air temperature during the grain filling period or post anthesis which known as terminal heat stress is a very serious constraint limiting grain yield and has negative effects on wheat production in many areas around the world and especially with late sowing in Upper Egypt. Terminal heat stress (≥ 32°C) causes reduction in starch content, grain quality, and grain weight which is negatively reflected on grain yield (Gupta *et al.*, 2015). Therefore, wheat breeding programs must be aimed to developing high yielding and heat-tolerance cultivars. Selection is one of the important tools in crop improvement. But, the success of breeding program depends on the selection method and criteria utilized to achieve genetic improvement during selection. Many wheat breeders reported that pedigree selection method is effective in improving grain yield of wheat and identifying the highest yielding genotypes in a cultivar breeding program (Ali, 2011; Mahdy *et al.*, 2012; Moustafa, 2015; Abd El-Rady, 2016 and 2017; Khames et al., 2017; Koubisy, 2020 and Soliman and Feltaous, 2020). However, selection for grain yield under stress and non-stress environments is a problem which continues to confuse plant breeders. Some researchers prefer selection under non-stress conditions (Betran *et al.,* 2003), other have trust in selection under stress condition (Rathjen, 1994), while other yet have preferred a mid-point and trust in selection under stress and non-stress conditions (Byrne *et al.,* 1995). Environmental sensitivity decreased when selection and environment effects were in reverse direction, but it increased when selection and environment effects were in the same direction (Jinks and Connolly, 1973 and 1975; Jinks and Pooni, 1982 and Falconer, 1990). Heat susceptibility index, an index for evaluating heat stress, is a major requirement for traditional breeding. Correlation and path coefficient analysis give a good understanding of the relationship between grain yield and various traits. The objective of this research was to study; 1) the relative merit of pedigree selection for grain yield plant^{-1} under normal and late planting conditions, 2) heat susceptibility index and the sensitivity test of the selected families to heat stress, and 3) the correlation and path coefficient for yield and its components in the base population and after two cycles of selection under normal and late planting conditions.

Materials and Methods:

The current investigation was conducted at Shandaweel Agric. Res. Station, Sohag, Egypt during 2018/2019 to 2020/2021 growing seasons. The breeding material was consisted of one F_2 durum wheat population originated from the cross between the two durum wheat varieties Cirno C2008 and Bani suef 5 (Table 1). Pedigree selection for grain yield plant^{-1} was practiced separately for two cycles under each of normal and late planting dates and the evaluation was in the F_4 generation under both planting dates.

Table 1. The pedigree, selection history and origin of the two parents .

Parents	Pedigree and selection history	Origin
Cirno C2008 (P_1)	SOOTY-9/RASCON-37//CAMAYO CGS02Y00004S-2F1-6Y-0B-1Y-0B.	Mexico
Bani suef 5 (P_2)	DIPPERZ /BBUSHEN3 CDSS92B128-1M-0Y-0M-0Y-3B-0Y-0SD	Egypt

In 2018/19 season, 500 F_2 plants of the durum wheat population were sown in non replicated plots under both normal (20th November) and late

(30th December) planting dates. The plot included 25 rows that were 2 m long, 30 cm apart, and 10 cm between plants within a row. In addition, the two parents of the population were sown in separate plots under each planting date. All agricultural practices were applied as recommended. After maturity, data were collected on 400 random guarded plants under each of the two planting dates and the highest 40 plants in grain yield were selected in each treatment to be raised as F_3 families. An equal number of grains from each plant (400 plant) under both environments were bulked to consist F_3 bulk sample.

In 2019/20 season (F_3 generation); the 40 F_3 families selected under normal planting conditions, the two parents and unselected bulk sample were sown under normal planting date (20th November). On the other hand, the 40 F_3 families selected under late planting conditions, the two parents and unselected bulk sample were grown under late planting date (30th December). The experimental design was a randomized complete block with three replications. The experimental plot was one row, 2.5 m long, 30 cm apart and 10 cm between plants within a row. Data were recorded on 20 guarded plants from each family. The best high yielding plant from each of the best 10 high yielding families were selected under each of planting dates and retained to be raised as F_4 families. In 2020/21 season (F_4 generation); the highest high yielding 10 F_4 families selected under normal planting environment + the highest yielding 10 F_4 families selected under late planting environment + the two parents + the bulk sample were evaluated under both environments. The experimental design, number of replications, agricultural practices and data recorded were the same in the previously mentioned.

The studied traits:

Days to 50% heading (DH), days to 50% maturity (DM), plant height (PH, cm), number of spikes plant^{-1} (NSP^{-1}), 100-kernel weight (100-KW) in g., number of kernels spike^{-1} (NKS^{-1}), biological yield plant^{-1} (BYP^{-1}) in g. and grain yield plant^{-1} (GYP^{-1}) in g.

Statistical analysis:

The analysis of variance was performed according to Steel and Torrie (1980). Two analyses of variance were done, one for (families + parents + bulk sample) and one for the selected families to calculate heritability and genotypic and phenotypic variance. The revised Least Significant Difference (R.LSD) test was used to compared genotype means at the 5 and 1% level of probability, as reported by El-Rawi and Khalafala (1980). According to Walker (1960), The phenotypic (σ^2p) and genotypic (σ^2g) variances as well as heritability in broad sense ($H_{b.s}$%) were calculated. The phenotypic (PCV%) and genotypic (GCV%) coefficients of variability were computed as outlined by Burton (1952), Realized heritability h^2= R/S was calculated according to Falconer (1989); where S = selection differential and R = response to selection. Heat susceptibility index (HSI) was calculated according to Fischer and Maurer (1978). The relative merit of selection and the sensitivity test of selected families were calculated according to

Falconer (1990). The relative merit = (change of mean by antagonistic selection) / (change of mean by synergistic selection). Synergistic selection is selection upwards in a good environment or downwards in a bad, while antagonistic selection is selection upwards in a bad environment or downwards in a good.

The phenotypic correlation coefficients between all studied traits were calculated in the base population (F_2) and in the second cycle of selection (F_4) according to Al- Jibouri *et al.* (1958), as follows: Phenotypic correlation rpxy = cov pxy / (σ px . σ py).

Path coefficient analysis was done according to the procedure followed by Dewey and Lu (1959) for yield and its components under normal and late planting dates in the base population and the second cycle of selection. The contributions of number of spikes plant^{-1} (NSP^{-1}), 100-kernel weight (100-KW), number of kernels spike^{-1} (NKS^{-1}), grain yield plant^{-1} (GYP^{-1}) as well as residual factors (X) were included in the path coefficient analysis as shown in the following diagram:

$r_{14}= P_{14}+ r_{12} P_{24} + r_{13} P_{34}$
$r_{24}= P_{24}+ r_{12} P_{14} + r_{23} P_{34}$
$r_{34}= P_{34}+ r_{13} P_{14} + r_{23} P_{24}$
$1= P^2_{X4}+ P^2_{14}+ P^2_{24}+ P^2_{34}+ 2 P_{14} r_{12} P_{24}+2 P_{14} r_{13} P_{34}+ 2 P_{24} r_{23} P_{34}$

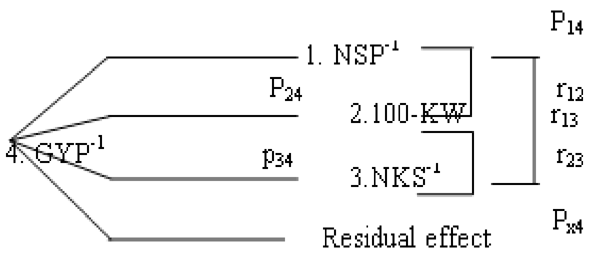

Fig.1: Direct and indirect of NSP^{-1}, 100-KW, NKS^{-1} and GYP^{-1}

Results and Discussions:

Differences in temperatures through the growing seasons are recorded in (Table 2). Accordingly, the two planting dates used in the study showed a range of variation in seasonal climate. The reduction caused by late planting (heat stress) in the F_2 population was 13.07, 17.85, 17.06, 9.28, 17.36 and 37.59% for PH, NSP^{-1}, 100-KW, NKS^{-1}, BYP^{-1} and GYP^{-1}, respectively (Table 3). These results appears that terminal heat stress under late planting indirectly reduced yield by directly affecting different yield components. Therefore, grain yield as a selection criterion to select against heat stress remains the most reliable yardstick. Similar results were reported by Zakeria (2004), Ali (2011) and Salous *et al.* (2014). Soliman and Feltaous (2020) found that delaying sowing date reduced yield and its components.

1. Description of the base population; season 2018/2019

Summary of all the studied characters of the F_2 generation and the two Parents under both planting dates are presented in Table 3. Bani suef 5 was the higher than Cirno C2008 in all studied traits except number of spikes plant^{-1} under both planting dates.

Table 2. Min., max. and mean monthly temperature in Celsius through the growing seasons 2018/2019 - 2020/2021.

Season		Month						
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
2018/2019	Min.	16.93	13.29	9.19	11.71	14.19	18.97	26.00
	Max.	27.37	21.29	20.52	22.71	26.00	31.30	39.29
	Mean	22.15	17.29	14.86	17.21	20.10	25.14	32.65
2019/2020	Min.	15.73	9.26	6.52	9.17	14.06	17.40	22.58
	Max.	29.70	23.03	18.77	22.66	28.74	32.53	37.97
	Mean	22.72	16.15	12.65	15.92	21.40	24.97	30.28
2020/2021	Min.	14.00	12.10	9.81	9.86	13.97	20.60	27.00
	Max.	25.07	24.45	23.00	24.25	29.52	34.20	39.68
	Mean	19.54	18.28	16.41	17.06	21.75	27.40	33.34

Comparing the population mean with the mean of the two parents, grain yield plant^{-1} indicated over-dominance than the highest parent Bani suef 5 under normal and late planting dates. The coefficient of variability ranged from 4.86 to 41.00% under normal planting date and from 11.22 to 53.14% under late planting date; for plant height and grain yield plant^{-1}, respectively. These results indicate feasibility of selection for grain yield in the F_2 generation. Similar results were obtained by Zakaria *et al.* (2008), Ali (2011), Soliman *et al.* (2015) and Soliman and Feltaous (2020). Broad sense heritability ranged from 42.65% for plant height to 87.53% for biological yield plant^{-1} under normal planting date and from 71.50% for 100-kernel weight to 89.23% for biological yield plant^{-1} under late planting date and it was higher under late planting than under normal planting for all studied traits except number of spikes plant^{-1}. Such estimates of heritability coupled with high phenotypic variances resulted in very high expected genetic advance from selection of superior 10% plants from the F_2-population under both planting dates. The expected genetic advance ranged from 3.65 for plant height to 56.65% for grain yield plant^{-1} under normal planting date and from 17.05 for 100-kernel weight to 77.67% for grain yield plant^{-1} under late sowing date. These results was in line with those stated by Zakaria. (2004), Ali (2011), Mahdy (2012) and Soliman and Feltaous (2020).

Table 3. Mean, reduction%, phenotypic variance(σ^2ph), heritability in broad sense ($H_{b.s}$%) and expected genetic advance (ΔG/mean%) of the base population (F_2) under normal and late planting dates for the studied traits.

Item	Normal planting date						Late planting date					
	PH	NSP^{-1}	100-KW	KS^{-1}	BYP^{-1}	GYP^{-1}	PH	NSP^{-1}	100-KW	NKS^{-1}	BYP^{-1}	GYP^{-1}
F_2 Population Mean ± SE	103.07 ±0.25	9.86 ±0.18	5.98 ±0.03	36.76 ±0.36	65.68 ±1.20	21.63 ±0.44	89.60 ±0.50	8.10 ±0.16	4.96 ±0.03	33.35 ±0.48	54.28 ±1.07	13.50 ±0.36
Reduction%							13.07	17.85	17.06	9.28	17.36	37.59
σ^2 ph	25.14	12.47	0.41	52.86	574.59	78.63	101.01	9.88	0.45	93.21	458.93	51.49
CV%	4.86	35.83	10.67	19.78	36.50	41.00	11.22	38.79	13.55	28.95	39.47	53.14
$H_{b.s\%}$	42.65	84.02	58.54	44.36	87.53	78.51	88.43	80.10	71.50	82.10	89.23	83.05
Δ G/mean%	3.65	52.98	10.99	15.44	56.22	56.65	17.46	54.68	17.05	41.83	61.99	77.67
Cirno C2008 Mean ± SE	90.25 ±0.78	8.60 ±0.34	5.15 ±0.08	43.79 ±0.93	60.35 ±1.85	19.22 ±0.67	76.05 ±0.73	6.95 ±0.29	4.50 ±0.08	37.50 ±0.90	37.90 ±1.62	11.64 ±0.49
Reduction%							15.73	19.19	12.62	14.36	37.20	39.44
σ^2 ph	12.20	2.25	0.14	17.28	68.13	9.06	10.68	1.63	0.12	16.12	52.62	4.80
CV%	3.87	17.45	7.34	9.49	13.68	15.66	4.30	18.36	7.78	10.71	19.14	18.82
Bani suef 5 Mean ± SE	104.00 ±0.91	7.95 ±0.29	6.01 ±0.10	44.11 ±1.44	66.55 ±1.94	21.03 ±1.11	83.50 ±0.80	6.75 ±0.34	4.99 ±0.08	38.97 ±0.93	43.70 ±1.52	13 ±0.80
Reduction%							19.71	15.09	16.97	11.65	34.34	38.18
σ^2 ph	16.63	1.73	0.19	41.53	75.21	24.73	12.68	2.30	0.13	17.26	46.22	12.66
CV%	3.92	16.56	7.35	14.61	13.03	23.65	4.27	22.48	7.36	10.66	15.56	27.37

Results in Table 4 revealed positive and highly significant phenotypic correlations between grain yield plant^{-1} and each of PH, NSP^{-1}, NKS^{-1} and BYP^{-1} under both planting dates and 100-KW under late planting date. Plant height showed positive and significant or highly significant correlation with all studied traits either under normal or late planting dates. Number of spikes plant^{-1} showed positive and significant or highly significant correlation with biological yield plant^{-1} under both conditions, number of kernels spike^{-1} under normal planting and 100-kernel weight under late planting, while it showed negative and insignificant correlation with number of kernels spike^{-1} under late planting and 100-kernel weight under normal planting. The correlation of 100-kernel weight with number of kernels spike^{-1} was negative and significant ($P<0.01$) under normal planting, while it was positive and non significant under late planting. The correlation between100-kernel weight and biological yield plant^{-1} was positive and non significant under normal planting and positive and highly significant under late planting. Number of kernels spike^{-1} showed positive and significant correlation with biological yield plant^{-1} under both planting dates. Generally, it could be concluded that selection for number of spikes plant^{-1} and number of kernels spike^{-1} may be effective in improving grain yield plant^{-1} under both environments. Abd El-Rady (2017) and Soliman and Feltaous (2020) obtained the same conclusion.

Table 4. phenotypic correlation among the studied traits in the F_2 generation under normal planting date (above diagonal) and late planting date (below diagonal).

Trait	PH	NSP^{-1}	100-KW	NKS^{-1}	BYP^{-1}	GYP^{-1}
PH		0.248^{**}	0.180^{**}	0.168^{**}	0.342^{**}	0.320^{**}
NSP^{-1}	0.120^{*}		-0.007	0.116^{*}	0.869^{**}	0.910^{**}
100-KW	0.503^{**}	0.194^{**}		-0.458^{**}	0.077	0.027
NKS^{-1}	0.333^{**}	-0.009	0.005		0.237^{**}	0.435^{**}
BYP^{-1}	0.308^{**}	0.726^{**}	0.222^{**}	0.127^{*}		0.884^{**}
GYP^{-1}	0.398^{**}	0.780^{**}	0.380^{**}	0.536^{**}	0.666^{**}	

* and** Significant at 5 and 1% levels of probability, respectively.

2. Selection for grain yield plant^{-1}

2.1. Variability and heritability estimates:

The analysis of variance for grain yield plant^{-1} and other studied traits (Table 5) showed significant ($p< 0.05$) or highly significant ($p< 0.01$) differences among the F_3 and F_4 selected families under both planting dates. These results indicate the presence of variability for further cycles of selection. These results are in line with those found by Mahdy (2012), Salous *et al*. (2014), Abd El-Rady (2017), Koubisy (2020) and Soliman and Feltaous (2020).

The effect of selection for two cycles on variability and heritability estimates of grain yield plant^{-1} is presented in Table 6. The phenotypic σ^2p and genotypic σ^2g variances in grain yield plant^{-1} were larger under normal planting date than under late planting date in C_0, C_1 and C_2 and dropped rapidly after cycles one (C_1) and two (C_2). This may be due to the increase of homozygosity in the F_4 generation. The phenotypic and genotypic coefficient of variability for grain yield plant^{-1} under normal planting date were (41.00 and 36.33%) in the base population and decreased to (12.50 and 11.42%) after C_1 and to (10.78 and 10.04%) after C_2, respectively. Likewise, the phenotypic and genotypic coefficients of variability under late planting date were slightly more than that under normal planting date and showed the same trend, this may be due to higher mean of grain yield under normal planting date than under late planting date. The close estimates of the phenotypic and genotypic variability resulted in high estimates of broad sense heritability in the two cycles of selection. It is of interest to note that heritability estimates for grain yield plant^{-1} were 78.51 and 83.05% in the base population (F_2) and increased to 83.47 and 88.22% after C_1 and 86.73 and 89.03% after C_2 under normal and late planting dates, respectively. The realized heritability increased from C_1 (37.75 and 57.75%) to C_2 (40.63 and 83.48%) under normal and late planting conditions, respectively. Similar results reported by Zakaria (2004), Ahmed (2006), Ali (2011), Mahdy (2012), Salous *et al.* (2014) and Koubisy (2020). Soliman and Feltaous (2020) noted broad sense of heritability of grain yield plant^{-1} of 90.27 and 73.83% and realized heritability of 28.05 and 66.76% after two cycles of selection for grain yield under normal and late sowing conditions, respectively.

Table 5. Mean squares (MS) for the selected families for high grain yield plant^{-1} and correlated traits in the F_3 and F_4 generations under normal (N) and late planting dates (L).

Ite	ng	S. O. V.	d.f	MS							
				GYP^{-1}	DH	DM	PH	NSP^{-1}	100-KW	NKS^{-1}	BYP^{-1}
F_3	N	Rep.	2	3.69	0.23	50.11**	3.43	0.75	0.12	17.30*	30.61
		Families	39	22.49**	9.06*	13.14**	64.98**	2.82**	0.38**	39.79**	197.90**
		Error	78	3.72	5.39	4.63	10.62	0.85	0.06	4.71	37.68
	L	Rep.	2	0.91	19.15**	7.56	55.95**	0.13	0.28**	5.53	4.88
		Families	39	16.68**	7.34**	6.56**	40.31**	1.91**	0.14**	33.91**	34.89**
		Error	78	2.02	2.47	2.46	8.85	0.62	0.03	4.29	17.78
F_4	N	Rep.	2	3.28	1.95	4.55	47.00**	0.09	0.16*	1.05	18.36
		Families	19	20.15**	13.61**	9.87**	51.36**	2.29**	0.25**	36.82**	206.20**
		Error	38	2.68	2.06	2.92	6.73	0.58	0.05	3.46	28.82
	L	Rep.	2	2.08	8.82*	20.06**	0.923	0.89	0.07	2.51	0.47
		Families	19	11.79**	10.38**	8.96**	58.07**	2.65**	0.50**	24.39**	156.88**
		Error	38	1.29	2.03	3.58	6.55	0.45	0.06	3.55	32.00

*and** Significant at 5 and 1% levels of probability, respectively.

Table 6. Variability and heritability estimates of grain yield/plant under normal (N) and late planting dates (L) in C0, C1 and C2, respectively.

Selection cycle	σ^2_p		σ^2_g		P.C.V. %		G.C.V. %		$H_{b.s}$ %		R heritability	
	N	L	N	L	N	L	N	L	N	L	N	L
C_0	78.63	51.49	61.73	42.76	41.00	53.14	36.33	48.43	78.51	83.05	---	---
C_1	7.50	4.02	6.26	3.54	12.50	17.17	11.42	16.13	83.47	88.22	37.75	57.75
C_2	6.72	3.93	5.83	3.50	10.78	14.92	10.04	14.07	86.73	89.03	40.63	83.48

2.2. Means and direct observed gains under normal planting date:

In the third season (F_4 generation), each group of the selected families for high grain yield plant^{-1} from the previous two cycles, either under normal planting date or late planting date was evaluated under both planting dates (Table 7). The group of F_4 families selected for high grain yield plant^{-1} under normal planting date and evaluated under normal planting date ranged from 19.01 for family No. 114 to 28.29 for family No. 160 with an average of 23.08 g plant^{-1}. The average direct observed gain from selection significantly ($P<0.05$) out-yielded the unselected bulk sample by 12.59% and insignificant ($P>0.05$) from the better parent by 7.45%. Six of these families had significant or highly significant observed gain from the unselected bulk sample and ranged from 12.68 to 38.00%, three of them, i.e., families No. 88, 157 and 160 showed significant or highly significant observed gain from the better parent by 13.69, 21.32 and 31.70%, respectively.

Means of the F_4 families group selected for high grain yield plant^{-1} under late planting date and evaluated under normal planting date ranged from 22.51 for family No. 105 to 28.50 for family No. 281 with an average of 25.02 g plant^{-1}. The average direct observed gain from selection significantly ($P<0.01$) than the unselected bulk sample and the better parent by 22.05 and 16.48%, respectively. Eight of these selected families gave significant or highly significant observed gain from the unselected bulk sample and ranged from

14.54 to 39.02%, seven of them showed significant or highly significant observed gain from the better parent ranged from 11.87% for family No. 93 to 32.68% for family No.281.

2.3. Means and direct observed gains under late planting date:

Grain yield plant^{-1} of the F_4 families group selected under normal planting date and evaluated under late planting date ranged from 10.70 for family No. 114 to 14.92 for family No. 160 with an average of 12.22 g plant^{-1} (Table 7). The average direct observed gain from selection was highly significant (25.33%) from the unselected bulk sample, while it was not significant (2.69%) from the better parent. Moreover, six of these selected families appeared significant or highly significant observed gain from the unselected and ranged from 19.69 to 53.03%, two families No. 157 and 160 gave significant or highly significant observed gain of 17.65 and 25.38 % from the better parent, respectively.

Table 7. Mean and observed gain from the bulk sample (OG% Bulk) and the better parent (OG% BP) for the selected families after two cycles of selection for grain yield plant^{-1} under normal and late planting dates.

Item		Fam. No.	Environment of evaluation					
			Normal planting date			Late planting date		
			Mean	OG% Bulk	OG% BP	Mean	OG% Bulk	OG% BP
Environment of selection	Normal planting date	12	20.66	0.78	-3.82	12.57	28.92**	5.63
		78	21.10	2.93	-1.77	11.72	20.21*	-1.51
		88	24.42	19.12**	13.69*	13.50	38.46**	13.45
		113	23.61	15.17*	9.92	11.18	14.67	-6.05
		114	19.01	-7.27	-11.50	10.70	9.74	-10.08
		157	26.06	27.12**	21.32**	14.00	43.59**	17.65*
		160	28.29	38.00**	31.70**	14.92	53.03**	25.38**
		188	23.86	16.39*	11.08	11.25	15.38	-5.46
		271	23.10	12.68*	7.54	11.67	19.69*	-1.93
		355	20.67	0.83	-3.77	10.73	10.05	-9.83
		Average	**23.08**	**12.59***	**7.45**	**12.22**	**25.33****	**2.69**
	Late planting date	64	23.48	14.54*	9.31	12.52	28.41**	5.21
		93	24.03	17.22**	11.87*	14.00	43.59**	17.65*
		105	22.51	9.80	4.80	13.82	41.74**	16.13*
		201	27.58	34.54**	28.40**	15.03	54.15**	26.30**
		223	26.16	27.61**	21.79**	16.10	65.13**	35.29**
		278	24.14	17.76**	12.38*	12.81	31.38**	7.65
		279	26.30	28.29**	22.44**	15.70	61.03**	31.93**
		281	28.50	39.02**	32.68**	17.77	82.26**	49.33**
		295	22.60	10.24	5.21	11.25	15.38	-5.46
		350	24.92	21.56**	16.01*	14.45	48.21**	21.43**
		Average	**25.02**	**22.05****	**16.48****	**14.35**	**47.18****	**20.59****
P1			**20.89**			**11.50**		
P2			**21.48**			**11.90**		
Bulk			**20.50**			**9.75**		
R.LSD $_{0.05}$			**2.54**			**1.78**		
R.LSD $_{0.01}$			**3.36**			**2.36**		

OG = observed gain, P1 = Cirno C2008, P2 = Bani suef 5 and *,** Significant at 5 and 1% levels of probability, respectively.

Means of grain yield plant^{-1} of the ten F_4 selected families under late planting date and evaluated under late planting date ranged from 11.25 for family No. 295 to 17.77 for family No. 281 with an average of 14.35 g plant^{-1}. The average of direct observed gain from selection, significantly ($P<0.01$) increased than the unselected bulk sample and the better parent by 47.18 and 20.59%, respectively. All the selected families except family No. 295 showed significant or highly significant observed gain from the unselected bulk sample ranged from 28.41 for family No. 64 to 82.26% for family No. 281, seven of them showed significant or highly significant observed gain from the better parent ranged from 16.3 for family No. 105 to 49.33% for family No.281. These results are in line with those reported by many investigators. After two cycles of selection for grain yield plant^{-1}, Kheiralla *et al.* (2006) achieved genetic gain of 20.21 and 7.62% from the unselected bulk sample and the better parent, respectively. Mahdy (2012) concluded that selection for three cycles for high grain yield plant^{-1} under drought stress was better than selection under normal irrigation either evaluation was practiced under normal irrigation or under drought stress. Soliman *et al*. (2015) and Abd El-Rady (2016 and 2017) came to the same conclusion. After two cycles of selection, Soliman and Feltaous (2020) found increase in grain yield plant^{-1} when selection was practiced under late planting date as compared when selection was done under normal planting date, either evaluation was under normal or late planting date, respectively.

2.4. Means and Correlated gains under normal planting date:

Direct selection for high grain yield plant^{-1} for the two cycles of selection under normal planting date and evaluation under normal planting conditions (Table 8) was accompanied by negative correlated gain for DH (-2.55%) and 100-KW (-0.36%), and positive correlated gain for DM (0.21%), PH (3.77%), NSP^{-1} (5.42%), NKS^{-1} (7.46%) and BYP^{-1} (1.84%) from the unselected bulk sample. In respect to the correlated gain from the better parent, negative correlated gain was obtained for PH (-0.48%) and 100-KW (-1.44%), while positive correlated gain was recorded for DH (3.80%), DM (2.07%), NSP^{-1} (0.44%), NKS^{-1} (1.40%) and BYP^{-1} (3.79%).

Table 8. Direct and correlated gains in the two cycles of selection for grain yield plant^{-1} in percentages from the bulk (OG%"Bulk") and the better parent (OG%"BP") under normal planting date.

Item		Trait							
		GYP^{-1}	**DH**	**DM**	**PH**	**NSP^{-1}**	**100-KW**	**NKS^{-1}**	**BYP^{-1}**
F_3 families (C1)		21.91	100.52	151.82	97.78	9.27	5.57	42.67	67.25
Cirno C2008		20.63	100.00	150.00	90.95	9.05	5.40	42.44	62.85
Bani suef 5		21.32	96.33	146.67	101.67	8.67	5.63	43.67	71.70
Bulk sample		18.75	98.67	147.00	92.53	8.94	5.53	38.13	56.6
OG% (Bulk)		16.85*	1.87	3.28*	5.67*	3.69	0.72	11.91	18.82*
OG% (BP)		2.77	4.35	3.51**	-3.83	2.43	-1.07	-2.29	-6.21
R.LSD 0.05		**3.00**	**4.72**	**3.82**	**5.10**	**1.62**	**0.37**	**3.50**	**9.60**
R.LSD 0.01		**3.94**	**6.52**	**5.10**	**6.69**	**2.16**	**0.48**	**4.59**	**12.58**
F_4 families (C2)	N	23.08	95.50	145.63	97.96	9.14	5.46	46.40	72.10
	L	25.02	95.10	144.77	97.95	9.69	5.34	48.60	73.81
Cirno C2008		20.89	96.67	148.33	90.23	9.10	5.15	44.63	66.44
Bani suef 5		21.48	92.00	142.67	98.43	8.50	5.54	45.76	69.47
Bulk sample		20.50	98.00	145.33	94.4	8.67	5.48	43.18	70.8
OG% (Bulk)	N	12.59*	-2.55*	0.21	3.77	5.42	-0.36	7.46*	1.84
	L	22.05**	-2.96**	-0.39	3.76	11.79	-2.55	12.55**	4.25
OG% (BP)	N	7.45	3.80**	2.07	-0.48	0.44	-1.44	1.40	3.79
	L	16.48**	3.37*	1.47	-0.49	6.51	-3.61	6.21	6.24
R.LSD $_{0.05}$		**2.54**	**2.36**	**3.04**	**4.21**	**1.36**	**0.33**	**3.05**	**8.15**
R.LSD $_{0.01}$		**3.36**	**3.12**	**4.12**	**5.57**	**1.85**	**0.44**	**4.03**	**10.78**

N= group selected under normal planting date, L= group selected under late planting date, OG = observed gain and *, **significant at 5 and 1% levels of probability, respectively.

Selection for high grain yield plant^{-1} for two selection cycles under late planting date and evaluation under normal planting conditions accompanied with decrease in DH (-2.96%), DM (-0.39%) and 100-KW (-2.55%) and increase PH, NSP^{-1}, NKS^{-1} and BYP^{-1} by 3.76, 11.79,12.55 and 4.25% for from the unselected bulk sample, respectively. However, positive correlated gains for all studied traits from the better parent were showed except PH (-0.49%) and 100-KW (-3.61%).

2.5. Means and correlated gains under late planting date:

Selection for high grain yield plant^{-1} for the two cycles of selection under normal planting date and evaluated under late planting conditions (Table 9) showed negative correlated gain for DH (-1.30%) and NKS^{-1} (-2.32%), while showed positive correlated gain for DM (1.34%), PH (8.97%), NSP^{-1} (19.64%), 100-KW (7.51%) and BYP^{-1} (1.84%) than the bulk sample. However, positive correlated gains for all studied traits from the better parent were obtained except NSP^{-1} (-6.00%) and NKS^{-1} (-5.71%).

Direct selection for high grain yield plant^{-1} for two cycles of selection under late planting date and evaluated under late planting conditions accompanied by increase in all studied traits from bulk sample except DH (-2.96%). Respect to the correlated gain from the better parent, negative correlated gain was obtained for PH (-1.80%), 100-KW (-1.59%) and NKS^{-1} (-2.01%), while positive correlated gain was recorded for DH (2.99%), DM (0.95%), NSP^{-1} (0.12.14%) and BYP^{-1} (3.85%). These results indicated that pedigree selection method was effective in isolating high yield genotypes and the direct selection for grain yield per se was effective. Generally, it can be concluded that selection for high grain yield $plant^{-1}$ for two cycles under late planting conditions in these materials was better than selection under normal planting date either evaluation was practiced under normal or late planting conditions. Similar results was found by Zakaria (2004) and Abd El- Rady (2016 and 2017).

2.6. Average observed gain from selection for grain yield $plant^{-1}$ in the two cycles:

The observed gain from selection for high grain yield $plant^{-1}$ under normal planting date (Table 8) was 16.85 and 2.77% in cycle 1 and it was 12.59 and 7.45% in cycle 2 from the bulk sample and the better parent, respectively. While, the observed gain from selection for high grain yield $plant^{-1}$ under late planting date (Table 9) was 23.91 and 6.31% for cycle 1 and it was 47.18 and 20.59% for cycle 2 from the unselected bulk sample and the better parent, respectively.

Table 9. Direct and correlated gains in the two cycles of selection for grain yield/plant in percentages from the bulk (OG%"Bulk") and the better parent (OG%"BP") under late planting date.

Item		Trait							
		GYP^{-1}	DH	DM	PH	NSP^{-1}	100-KW	NKS^{-1}	BYP^{-1}
F_3 families (C1)		11.97	86.74	124.38	75.58	6.81	4.83	36.30	40.75
Cirno C2008		11.19	90.00	125.33	69.11	6.50	4.61	37.36	36.80
Bani suef 5		11.26	85.00	121.33	77.89	5.89	4.76	40.38	48.99
Bulk sample		9.66	87.00	123.33	70.00	6.00	4.52	35.81	30.00
OG% (Bulk)		23.91*	-0.30	0.85	7.97*	13.50	6.86*	1.37	30.00*
OG% (BP)		6.31	2.05	2.51*	-2.97	4.77	1.47	-10.10*	-16.82*
R.LSD 0.05		**2.19**	**2.72**	**3.04**	**4.88**	**1.38**	**0.29**	**3.30**	**8.15**
R.LSD 0.01		**2.87**	**3.63**	**4.11**	**6.45**	**1.85**	**0.39**	**4.33**	**10.98**
F_4 families (C2)	N	12.22	91.13	129.03	79.55	6.58	4.58	40.80	45.40
	L	14.35	89.60	127.53	75.78	7.85	4.33	42.40	44.79
Cirno C2008		11.5	91.33	131.00	73.03	7.00	4.16	40.37	39.67
Bani suef 5		11.9	87.00	126.33	77.17	6.33	4.40	43.27	43.13
Bulk sample		9.75	92.33	127.33	73.00	5.50	4.26	41.77	44.58
OG% (Bulk)	N	25.33**	-1.30	1.34	8.97**	19.64*	7.51	-2.32	1.84
	L	47.18**	-2.96**	0.16	3.81	42.73**	1.64	1.51	0.47
OG% (BP)	N	2.69	4.75**	2.14	3.08	-6.00	4.09	-5.71	5.26
	L	20.59**	2.99*	0.95	-1.80	12.14	-1.59	-2.01	3.85
R.LSD $_{0.05}$		**1.78**	**2.19**	**3.56**	**4.01**	**1.07**	**0.37**	**3.14**	**8.99**
R.LSD $_{0.01}$		**2.36**	**2.89**	**4.92**	**5.31**	**1.43**	**0.50**	**4.16**	**12.03**

N= group selected under normal planting date, L= group selected under late planting date, OG = observed gain and *, ** significant at 5 and 1% levels of probability, respectively.

The second cycle of selection was evaluated under both planting dates. The observed gain for grain yield plant^{-1} under normal planting date evaluation (Table 8) was (12.59 and 22.05%) from bulk sample and (7.45 and 16.48%) from the better parent for normal and late planting selection groups, respectively. Meanwhile, it was (25.33 and 47.18%) from bulk sample and (2.6 and 20.59%) from the better parent under late planting date evaluation for normal and late planting selection groups (Table 9), respectively. It is obvious that selection under late planting date (heat stress) was better than selection under normal planting date either evaluation was practiced under normal or under heat stress conditions. In other words antagonistic selection for grain yield was better than synergistic selection. Similar results were found by Ali (2011), Mahdy (2012), Abd El-Rady (2016 and 2017) and Soliman and Feltaous (2020).

2.7. Heat susceptibility index and the sensitivity to environments:

The heat susceptibility index (HSI) and the sensitivity to environments of the selected families for grain yield plant^{-1} after the two cycles of selection are presented in Table 10. The results of the selected families under normal planting (normal group) when evaluated under both planting dates indicated that five families, i.e., No. 12, 78, 88, 114 and 157 showed heat susceptibility index (HSI) values less than unit. The two parents showed less susceptibility. However, the bulk sample was high susceptible. The heat susceptibility index of Fisher and Maurer (1978) of the selected families coincided with the sensitive test of Falconer (1990) which measures the difference in the performance of a family under two environments relative to the difference in a base population or in a contemporaneous unselected control. Three out of the five less susceptible families recorded lower values of sensitivity. These families could be used as source of heat tolerance. Moreover, it could be noticed that two superior families, No. 157 and 160 showed significant observed gain over the better parent under both planting dates. The results of families which selected under heat stress and evaluated under both environments showed that, six families, No. 93, 105, 223, 279, 281 and 350 gave heat susceptibility index of 0.98, 0.90, 0.90, 0.94, 0.88 and 0.99, indicating less susceptibility. All these families gave also values less than one in sensitivity test. It is of interest to indicate that the five superior families, i.e., No. 93, 223, 279, 281 and 350 were less susceptible and less sensitive to heat and showed significant observed gain over the better parent under both planting dates, so they could be promising families. The mean sensitivity to heat stress of the selected families for high grain yield plant^{-1} under normal planting conditions was 1.01, while it was 0.97 for the selected families under late planting conditions (Table 10).

Table 10. Means, heat susceptibility index (HSI) and the sensitivity (S) to environments of the selected families under normal and late planting dates after two cycles of selection for grain yield plant^{-1}.

Environment of selection									
Normal planting date selections					Late planting date selections				
Fam. No.	N	L	HSI	S	Fam. No.	N	L	HSI	S
12	20.66	12.57	0.83	0.75	64	23.48	12.52	1.09	1.02
78	21.10	11.72	0.95	0.87	93	24.03*	14.00*	0.98	0.93
88	24.42*	13.50	0.95	1.02	105	22.51	13.82*	0.90	0.81
113	23.61	11.18	1.12	1.16	201	27.58**	15.03**	1.07	1.17
114	19.01	10.70	0.93	0.77	223	26.16**	16.10**	0.90	0.94
157	26.06**	14.00*	0.98	1.12	278	24.14*	12.81	1.10	1.05
160	28.29**	14.92**	1.00	1.24	279	26.30**	15.70**	0.94	0.98
188	23.86	11.25	1.12	1.17	281	28.50**	17.77**	0.88	0.99
271	23.10	11.67	1.05	1.06	295	22.60	11.25	1.18	1.06
355	20.67	10.73	1.02	0.92	350	24.92*	14.45*	0.99	0.97
average	23.08	12.22		1.01	average	25.02**	14.35**		0.97
P1	20.89	11.50	0.96	0.87	P1	20.89	11.50	0.96	0.87
P2	21.48	11.90	0.95	0.89	P2	21.48	11.90	0.95	0.89
Bulk	20.50	9.75	1.11		Bulk	20.50	9.75	1.11	

P1 = Cirno C2008 P2 = Bani suef 5 N = normal planting date, L = late planting date and *, ** significant observed gain from the better parent at 5 and 1% levels of probability, respectively.

The relative merit after cycle two of selection for high grain yield plant^{-1} was 1.75 when selection was practiced under normal and late planting dates and evaluation under normal planting conditions, while it was 1.86 when selection was practiced under normal and late planting dates and evaluation under late planting conditions. These results indicate that the antagonistic selection was better than synergistic selection to increase grain yield plant^{-1} in these materials, either evaluation made under normal planting or under late planting conditions. Moreover, the antagonistic selection reduced sensitivity to heat stress, while synergistic selection increased it. These results are in agreement to those reported by Jinks and Connolly (1973 and 1975) on *Schizophyllum commune*, Jinks and Pooni (1982) on *Nicotiana rustica*., Ceccarelli and Grando (1991 a and b) on barley and Mohamed (2001) on cotton concluded that environmental sensitivity decreased when selection and environment change the character in the opposite direction (antagonistic selection), while it increased when selection and environment change the character in the same direction (synergistic selection). Kheiralla *et al.* (2006) and Salous *et al.* (2014) found that the synergistic selection increased the sensitivity of the selected families, while the antagonistic selection decreased it. Abd El-Rady (2016 and 2017) and Soliman and Feltaous (2020) came to the same conclusion.

2.8. The phenotypic correlation after two cycles of selection for grain yield plant^{-1}:

The phenotypic correlations among grain yield plant^{-1} and the studied traits under both planting dates after two cycles of selection are presented in Table 11. Positive and significant or highly significant phenotypic correlations were recorded between grain yield plant^{-1} and each of; number of spikes plant^{-1} (0.790 and 0.870), number of kernels spike^{-1} (0.508 and 0.486) and biological yield plant^{-1} (0.823 and 0.560) under normal and late planting dates, respectively. However, the phenotypic correlation of grain yield plant^{-1} with plant height turned to weak and insignificant (0.411 and 0.102) and turned to negative with 100-kernel weight (-0.096 and -0.030) under normal and late planting dates, respectively. This means that, selection played on the highest correlated trait with grain yield plant^{-1} in the base population; number of spikes plant^{-1}. The phenotypic correlation between grain yield plant and each of days to 50% heading and days to 50% maturity was weakened and insignificant under normal planting date, while it was negative and insignificant under late planting date. Positive correlation was recorded between grain yield plant^{-1} and each of number of spikes plant^{-1} and biological yield plant^{-1} by Ahmed, 2006; Sharma et al., 2006; Zakaria *et al.;* 2008, Anawar *et al.,* 2009; Mahdy, 2012 and Koubisy, 2020. Soliman and Feltaous (2020) found high and positive phenotypic correlation among grain yield plant^{-1} and each of NSP^{-1}, NKS^{-1} and BYP^{-1} in base population and after two cycles of selection under normal and late planting dates.

2.9. Path coefficient analysis in the base population (F_2) and after two cycles (F_4) of selection for grain yield plant^{-1}:

The Partitioning of phenotypic correlation into direct and indirect effects by path analysis (Table 12) indicated that the highest direct effect on grain yield plant^{-1} was recorded by number of spikes plant^{-1} in the base population (0.860 and 0.739) and cycle two of selection (0.890 and 0.893) under normal and late planting dates, respectively. Furthermore, the highest indirect effects were correlated also with number of spikes plant^{-1} across the base population 0.100 via number of kernels spike^{-1} under normal planting date and 0.143 via100-kernel weight under late planting date, and cycle two of selection (0.072 and 0.392) via number of kernels spike^{-1} under normal and late planting dates, respectively.

Table 11. Phenotypic correlation among the studied traits in the F_4 generation under normal sowing date(above diagonal) and late planting date (below diagonal).

Trait	DH	DM	PH	NSP^{-1}	100-KW	NKS^{-1}	BYP^{-1}	GYP^{-1}
DH		0.673^{**}	-0.101	0.067	-0.395	0.216	0.052	0.023
DM	0.795^{**}		0.123	0.253	-0.435	0.355	0.281	0.245
PH	0.513^{*}	0.566^{**}		0.247	0.204	0.162	0.466^{*}	0.411
NS/P	-0.095	-0.022	-0.035		-0.313	0.081	0.829^{**}	0.790^{**}
100-KW	-0.362	-0.179	0.087	-0.382		-0.466^{*}	-0.043	-0.096
NKS^{-1}	0.068	-0.006	0.153	0.440	-0.637^{**}		0.150	0.508^{*}
BYP^{-1}	-0.123	-0.075	0.461^{*}	0.395	0.200	0.156		0.823^{**}
	-0.269	-0.135	0.102	0.870^{**}	-0.030	0.486^{*}	0.560^{*}	

*, ** significant at 5 and 1% levels of probability, respectively.

These results suggested that number of spikes plant^{-1} has exhibited to be powerful traits as a yield component and must be given preference in selection to improve grain yield plant^{-1}. It is clear that the effect of residual factor was decreased from (0.130 and 0.210) in the base population to (0.077 and 0.071) in cycle two of selection under normal and late planting dates, respectively. These results indicated that the strong effects were found for current studied traits on grain yield plant^{-1}.

Different estimates of direct and indirect effects of yield components on grain yield of wheat revealed by many studies according to the studied populations such as Kashif and Khaliq (2004), Abd El-Mohsen and Abd El-Shafi (2014), Nasri *et al.* (2014), Khames *et al.* (2016). Abd El-Rady (2017) reported that the direct effect of number of spikes plant^{-1} exhibited superiority on grain yield plant^{-1} for selection in the base population and cycle two of selection followed by number of kernels spike^{-1} and 100-kernel weight.

Table 12. Partitioning of phenotypic correlation coefficients into direct and indirect effects by path coefficient analysis for base population (F_2) and cycle two (F_4) of pedigree selection for grain yield plant^{-1} under normal (N) and late (L) planting dates.

Correlation		Normal planting		Late planting	
		Base pop. (F_2)	Cycle two (F_4)	Base pop. (F_2)	Cycle two (F_4)
1- Number of spikes plant^{-1} vs. Grain yield plant^{-1}	r	0.910	0.790	0.780	0.870
Direct effect	P_{14}	0.860	0.890	0.739	0.893
Indirect effects via 100-kernel weight	$r_{12}P_{24}$	-0.002	-0.154	0.046	-0.237
Indirect effects via number of kernels spike^{-1}	$r_{13}P_{34}$	0.052	0.054	-0.005	0.214
	Total	0.910	0.790	0.780	0.870
2- 100-kernel weight vs. Grain yield plant^{-1}	r	0.027	-0.096	0.380	-0.030
Direct effect	P_{24}	0.237	0.493	0.234	0.622
Indirect effects via number of spikes plant^{-1}	$r_{12}P_{14}$	-0.007	-0.279	0.143	-0.341
Indirect effects via number of kernels spike^{-1}	$r_{23}P_{34}$	-0.203	-0.310	0.003	-0.311
	Total	0.027	-0.096	0.380	-0.030
3- Number of kernels spike^{-1} vs. Grain yield plant^{-1}	r	0.435	0.508	0.536	0.486
Direct effect	P_{34}	0.444	0.666	0.541	0.489
Indirect effects via number of spikes plant^{-1}	$r_{13}P_{14}$	0.100	0.072	-0.006	0.392
Indirect effects via 100-kernel weight	$r_{23}P_{24}$	-0.109	-0.230	0.001	-0.395
	Total	0.435	0.508	0.536	0.486
	$1-R^2$	0.983	0.994	0.956	0.995
Residual factor		0.130	0.077	0.210	0.071

References

Abd El-Mohsen, A.A. and M.A. Abd El-Shafi (2014). Regression and path analysis in Egyptian bread wheat. J. of Agri. Food and Applied Sci., 2 (5): 139-148.

Abd El-RadyA.G. (2016). Selection for grain yield under normal and deficit irrigation regimes in bread wheat. Bull. Fac. Agric. Cairo Univ., 67: 295-306.

Abd El-Rady, A.G. (2017). Selection efficiency for grain yield under normal irrigation and water stress conditions in bread wheat, Assiut J. Agric. Sci., 48 (5): 1-20.

Ahmed, T.A. (2006). Efficiency of late and early selection for grain yield under different selection criteria and DNA marker Polymorphism in wheat (*Triticum aestivum* L.). Assiut J. Agric. Sci., 37 (2): 1-16.

Ali, M.A. (2011). Response to pedigree selection for earliness and grain yield in spring bread wheat under heat stress.. Asian J. Crop Sci., 3 (3): 118-129.

Al-Jibouri, H.A., P.A. Miller and H.F. Robinson (1958). Genotypic and environmental variance and co-variance in an Upland cotton cross of interspecific origin. Agron. J., 50: 633-636.

Anwar, J., M.A. Ali, M. Hussain, W. Sabir, M.A. Khan, M. Zulkiffal and M. Abdullah (2009). Assessment of yield criteria in bread wheat through correlation and path analysis. The J. Anim. Pl. Sci., 19: 185-188.

Betran, F.J., D. Beck, M. Banziger and G.O. Edmeades (2003). Genetic analysis of inbred and hybrid grain yield under stress and non stress environments in tropical maize. Crop Sci. J., 43 (3): 807-817.

Burton, G.W. (1952). Quantitative inheritance in grasses. Proceeding of 6th International Grassland Congress, Vol. 1, Pennsylvania State College, 17-23 August 1952, 277-283.

Byrne, P.F., J. Bolanos, G.O. Edmeades and D.L Eaton (1995). Gains from selection under drought versus multiplication testing in related tropical maize populations. Crop Sci. J., 35 (1): 63-69.

Ceccarelli, S. and S. Grando (1991a). Selection environment and environmental sensitivity in barley. Euphytica, 57 (2): 157-167.

Ceccarelli, S. and S. Grando (1991b). Environment of selection and type of germplasm in barley breeding for low-yielding conditions. Euphytica, 57 (3): 207-219.

Dewey, D.R. and K.H. Lu. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51: 515-518.

El-Rawi, K.M. and A.M. Khalafala (1980). Design and Analysis of Agricultural Experiments. El-Mousel Univ. Iraq 19:487.

Falconer, D.S. (1989). Introduction to Quantitative Genetics. 3rd ed. Longman, Hong Kong, pp 438.

Falconer, D.S. (1990). Selection in different environment: effects on environmental sensitivity (reaction norm) and mean performance. Genetical Research 56 (1): 57-70.

Fischer, R.A. and R. Maurer (1978). Drought resistance in spring wheat cultivars. I. Grain yield response. Crop and Pasture Sci., 29 (5): 897-912.

Gupta, N. K., A. Khan, A. Maheshwari, S. Narayan, O.P. Chhapola, A. Arora and G. Singh (2015). Effect of post anthesis high temperature stress on growth, physiology and anti-oxidative defence mechanisms in contrasting wheat genotypes. Indian J. Plant Physio., 20(2): 103–110.

Jinks, J.L. and V. Connolly (1973). Selection for specific and general response to environmental differences. Heredity, 30: 33-40.

Jinks, J.L. and V. Connolly (1975). Determination of environmental sensitivity of selection lines by the selection environment. Heredity, 34 (3): 401-406.

Jinks, J.L. and H.S. Pooni (1982). Determination of the environmental sensitivity of selection lines of *Nicotiana rustica* by selection environment. Heredity, 49 (3): 291-294.

Kashif, M. and I. Khaliq (2004). Heritability, correlation and path coefficient analysis for some metric traits in wheat. Int. J. Agri. Bio., 6 (1): 138-142.

Khames, K.M., A. Abo-Elwafa, A.M. Mahmoud and A. Hamada (2016). Correlation, path-coefficient, normal and stepwise regression analyses via two cycles of pedigree selection in bread wheat (*Triticum* *aestivum* L).Assiut J. Agric. Sci., 47:84-108.

Khames, K.M., A. Abo-Elwafa, A.M. Mahmoud and A. Hamada (2017). Efficiency of two cycles of pedigree line selection in bread wheat (*Triticum aestivum L*) under late sowing date. Assiut J. Agric. Sci., 48:1-25.

Kheiralla, K.A., M.A. El-Morshidy, A.M. Tammam and M.M. Zakaria (2006). The efficiency of selection and environmental sensitivity for grain yield in wheat. Symposium: Status and Improvement Horizons of Field Crops in the Arab World. 30-31 October, 2006, Alepo Univ., Syria.

Koubisy, Y.S.I. (2020). Selection for grain yield in bread wheat (*Triticum aestivum* L.) under normal irrigation and water stress conditions. Assiut J. Agric. Sci., 51 (1): 26-41

Mahdy, E.E., A.E. El-Karamity, S.A. Mokadem and H.M. Fouad (2012). Selection for grain yield and its components in two segregating populations. Minia Int. Conf. Agric. Irrig. In the Nile Basin Coun., 26th-29th March 2012, p. 595-604.

Mahdy, Rasha, E. (2012). Response to selection for earliness and yield in bread wheat under normal and drought conditions. Ph.D. Thesis, Fac. Agric. Assiut Univ., Egypt.

Mohamed, A.A. (2001). Breeding for earliness and yield components in some Egyptian cotton crosses. PhD. Thesis Fac. Agric. Assiut Univ. Assiut, Egypt.

Moustafa, H.M.F, (2015). Single and multiple traits selection in bread wheat under normal and drought stress conditions. Ph.D. Thesis, Fac. of Agric., Minia Univ., pp. 166.

Nasri, R., A. Kashani, F. Paknejad, S.Vazan and M. Barary (2014). Correlation, path analysis and stepwise regression in yield and yield component in wheat (*Triticum aestivum* L.) under the temperate climate of Ilam Province, IRAN. Indian J. of Fundamental and Applied Life Sci. 14 (4): 188-198.

Rathjen, A.J. (1994). The biological basis of genotype environment interaction Its definition and management. In Proceedings of the Seventh Assembly of the Wheat Breeding Society of Australia, Adelaide, Australia.

Salous, M.SH., M.A. El-Morshidy, K.A. Kheiralla and M.Kh. Moshref (2014). Selection for grain yield in bread wheat (T*riticum aestivum L.*) Under normal and heat stress conditions. Assiut J. Agric. Sci., 45:1-18.

Sharma, V., I.S. Pawar and R. Munjal (2006). Variability parameters, correlation and path coefficients for yield, its components and quality traits in bread wheat. Nat. J. Pl. Improv., 8: 153-155.

Soliman, G.M.M., M.A. El-Morshidy, K.A. Kheiralla and I.A. Amin (2015). Selection efficiency under both normal irrigation and water deficit conditions in durum wheat. Egypt. J. Agric. Res., 93 (2): 335-351.

Soliman, G.M.M. and Y.M. Feltaous (2020). Selection efficiency and environmental sensitivity for agronomic traits in a bread wheat population under normal and late sowing dates conditions. J. Plant Prod., Mansoura Univ., 11 (8): 761-769.

Steel, R.G.D. and J.H. Torrie (1980). Principle and Procedures of Statistics. A Biometrical approach 2nd Ed., McGraw-Hill Book Company, New York. U.S.A.

USDA Foreign Agricultural Service, Global Agricultural Information

Network (2020). GAIN Report Number: EG 20002.

Walker, T.T. 1960. The use of a selection index technique in the analysis of progeny row data. Emp. Cott. Rev., 37: 81-107.

Zakaria, M.M. (2004). Selection for earliness and grain yield in bread wheat (*Triticum aestivum* L.) under different environmental conditions. Ph.D. Thesis, Fac.Agric. Assiut Univ., Egypt.

Zakaria, M.M., M.A. El-Morshidy, K.A. Khieralla and A.M. Tammam (2008). Direct selection for grain yield and correlated response in bread wheat under normal and late sowing dates. Assiut J. Agric. Sci., 39:1-16.

Assiut J. Agric. Sci., 52 (3) 2021 (1-21) *ISSN: 1110-0486*
*Website:*www.aun.edu.eg/faculty_agriculture/journals_issues_form.php **E-mail: ajas@aun.edu.eg**

الانتخاب لمحصول الحبوب تحت ظروف ميعادى الزراعة العادى والمتأخر فى قمح الديورم

أيمن جمال عبدالراضى

قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

الملخص

أجرى هذا البحث فى محطة البحوث الزراعية بشندويل – سوهاج – مصر خلال المواسم من 2019/2018 إلى 2021/2020. تم إجراء الانتخاب المنسب لمحصول الحبوب للنبات بشكل منفصل من الجيل الثانى الى الجيل الرابع تحت ميعادى الزراعة العادى والمتأخر وكان التقييم تحت كلا ميعادى الزراعة فى الجيل الرابع. كان التباين المظهري أكثر قليلا من التباين الوراثي وانخفض من الجيل الثانى إلى الجيل الرابع، كانت قيم كفاءة التوريث بالمعنى الواسع 83,47 ، 86,73% تحت الزراعة العادية مقارنة بـ 88,22 ، 89,03% تحت الزراعة المتأخرة بعد الدورة الأولى والثانية للانتخاب على التوالي. كان معامل التوريث المحقق 37,75، 40,63% تحت الزراعة العادية مقارنة بـ 57,75 ، 83,48% تحت الزراعة المتأخرة للدورة الأولى والثانية على التوالي. بعد دورتين من الانتخاب المنسب كان متوسط الزيادة المحققة في محصول الحبوب للنبات لمنتخبات الزراعة العادية 12,59، 25,33% بالنسبة لمخلوط العشيرة و 7,45، 2,69% بالنسبة للأب الأفضل، بينما كانت 22,05 ، 47,18% بالنسبة لمخلوط العشيرة 16,48، 20,59% بالنسبة للأب الأفضل لمنتخبات الزراعة المتأخرة عندما قيمت العائلات المنتخبة تحت ظروف الزراعة العادية والمتأخرة على التوالي .كان الانتخاب المتضاد أفضل من الانتخاب المتوافق في زيادة المتوسط و نقص الحساسية سواء كان التقييم تحت ظروف الزراعة العادية اوالمتأخرة. بناء على تحليل معامل المرور، كان لصفة عدد السنابل للنبات التأثير المباشر الأعلى على محصول الحبوب للنبات يليها عدد الحبوب للسنبلة ثم وزن الـ100 حبة فى عشيرة الأساس و بعد دورتين من الانتخاب تحت كلا ميعادى الزراعة.