

## Selection response for grain yield and its components in one segregating population of bread wheat (*Triticum aestivum*. L).

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**Abstract** - The present study was carried out during the three successive seasons i.e., 2019/2020, 2020/2021 and 2021/2022 at Fac. Agric. Farm, Assiut University, Egypt. The objective of this study was to estimate observed and expected responses to selection for grain yield and its components in two cycles of pedigree line selection and one cycle of late selection in one segregating population of bread wheat (*Triticum aestivum*. L). The results showed that the observed direct responses of pedigree line selection for grain yield/plant (selection criterion) were 11.94, 27.50 and 28.67% after one, 30.82, 22.21 and 29.07% after two cycles of early pedigree line selection and 40.96, 31.68 and 39.08% after one cycle of late selection as accounted relative to unselected bulk sample, better parent and mid parents, respectively. The final direct responses for grain yield/plant after two early cycles and one late cycle were larger than cycle one of pedigree line selection, except for better parent and mid parents in early selections.

**Keywords:** bread wheat, pedigree selection, Selection response.

### 1- INTRODUCTION

Wheat is considered the source of calories and protein for 82 % and 85% approximately of global population, respectively. And is the most important grain crop in Egypt as a source of human food and. Egypt's total wheat production of grain reached about 8.5 million tons resulted from 3.4 million faddens while the consumption of wheat grains is about 22 million tons [1], the importance of wheat is further emphasized through its role in human nutrition, since it accounts for around 20% of our carbohydrate and 20% of our protein intake [2], the local production is not sufficient to face the annual requirements, therefore improvement of wheat productivity is the most important way to minimize the gap between production and consumption, which can be achieved through the great

attention to increase the area and productivity per unit area of wheat [3], the direct selection responses for plant height, spike length, 1000-kernel weight and grain yield/plant in wheat were accompanied by an increase in grain yield, which accounted 36.34, 1.98, 13.45 and 12.6% respectively, after three cycles of selection calculated as a deviation from the better parent [4].

## 2 -MATERIAL AND METHODS

The present study was carried out during the three successive seasons i.e., 2019/2020, 2020/2021 and 2021/2022 at Fac. Agric. Farm, Assiut University, Egypt. The started breeding materials used in this study were 500 F3- families traced back to random F2- plants from one crosses:(Misr 2 × Sakha 94) population. The pedigree and origin of the parents are given in Table 1.

**Table 1. The pedigree and source for the parents of the one wheat population.**

Parental name	Pedigree	Origin
Misr 2	SKAUZ/BAV 92	Egypt
Sakha 94	Opta / Rayon // KAVZ	Egypt

**The following characters were recorded:**

- 1- Plant height (PH)**, cm: the distance from ground surface to the base of the spike of the main culm.
- 2- Spike length (SL)**, cm: was measured from the base of the main spike to its tip excluding awns.
- 3- Number of spikes/plant (NSP)**: number of spikes of the plant
- 4- Number of spikelets/spike (NSES)**: number of spikelets of main spike/plant.
- 5- Weight of spikes/plant (WSP)**, g: weight of spikes of the plant
- 6- Biological yield/plant (BYP)**, g: was recorded as the air dry weight of the up ground growth/plant.
- 7- Grain yield/plant (GYP)**, g: was recorded as the weight of grains of each guarded plant.
- 8-Seed index (SI)**, g: was recorded as the mean weight of random 100-kernel samples.
- 9- Harvest index % (HI)**: the ratio of GYP to BYP.

**10- Threshing index % (TI):** the ratio of GYP to WSP.

### Statistical analysis:

The observed response to selection was measured as the deviation percentage of the mean of the selected families from mid-parent, better parent and bulk sample.

Comparing the observed response to selection was calculated using R.L.S.D.

*Where;*

L.S.D = Least significant differences between means of parents, bulk and selected families or only selected families mean as R.L.S.D.  $\alpha = t_{\alpha} * Sd$

Selected Families Score of Selection Response (SFSSR) was calculated as an average of direct selection response yielded from grain yield/plant and correlated selection responses from the rest traits for each selected F5 family in relative to bulk, better parent and mid-parents in early and late selections according the following formula:

$$SFSSR = \frac{[\sum (DR \ GYP)_{B,BP,MP} + \sum_{1}^{n-1} (InDR \ Rest \ traits)_{B,BP,MP}]}{n}$$

*Where:*

- DR GYP: direct response of selection for grain yield/plant,
- InDR Rest traits: Indirect responses of selection for rest studied traits,
- B, BP and MP: Bulk, better parent and Mid-parents, respectively, and
- n: number of studied traits.

## 3-RESULTS AND DISCUSSION

**1-1-** Observed direct response over the cycle one (50 F<sub>4</sub> early selected families) and cycle two (10 F<sub>5</sub> early selected families) of early pedigree line selection as well as one cycle of late selection (10 F<sub>5</sub> late selected families) for grain yield/plant.

The observed direct responses of pedigree line selection for grain yield/plant (selection criterion) were 11.94, 27.50 and 28.67% after one cycle (50 F<sub>4</sub> selected families) and 30.82, 22.21 and

29.07% after two cycle (10 F<sub>5</sub> early selected families) of pedigree line selection and 40.96, 31.68 and 39.08% after one cycle of late selection (10 F<sub>5</sub> late selected selection) as accounted from unselected bulk sample, better parent and mid parents, respectively (Table 2). It is remarkable results that the estimates of direct response for grain yield/plant after two cycles of pedigree line selection (10 F<sub>5</sub> early selected families) as well as one cycle of late selection (10 F<sub>5</sub> late selected selection) were larger than cycle one (50 F<sub>4</sub> selected families), except for better parent and mid parents in early selection. Furthermore, the direct response of selection of late selection (10 F<sub>5</sub> late selected selection) exceeded the early one (10 F<sub>5</sub> early selected families), indicating to the effectiveness of direct selection giving more importance to late one for improvement the grain yield in bread wheat. These results are in line with those obtained by [5], [6] and [7], who observed increase in grain yield/plant over the bulk sample by more than 25.00%. Moreover, [8] increased grain yield after two cycles of pedigree selection relative to the better parent by 14.14 and 15.97% in two populations. Consequently, the pedigree selection procedure has been proposed as an effective method to develop high yielding genotypes of wheat. [9], stated actual gains for grain yield/plant and its components were higher than the predicted one across selection cycles in two populations, indicating that the dominance gene effects controlling yield and its components. Furthermore, the high values of selection response for grain yield and its correlated traits in wheat were found by [10], [11], [12], [13], [14], [15], and [16].

**1.1.2-** The correlated responses over the cycle one (50 F<sub>4</sub> early selected families) and cycle two (10 F<sub>5</sub> early selected families) of early pedigree line selection as well as one cycle of late selection (10 F<sub>5</sub> late selected families) for grain yield/plant.

The correlated responses after cycle one (F<sub>4</sub>) and cycle two (F<sub>5</sub>) of selection for grain yield/plant in relation to the unselected bulk sample, better parent and mid parents presented in Table 2. It is clear that the four traits i.e. biological yield/plant, weight of spikes/plant, seed index and harvest index had the highest positive values of correlated response in cycle one (50 F<sub>4</sub> selected families) and cycle two (10 F<sub>5</sub> early selected families) as well as late selection (10 F<sub>5</sub> late selected families) comparing to the bulk, better parent and mid parents. The estimates of selection responses for biological yield/plant were 6.58, 25.00 % and 25.11% after one cycle (50 F<sub>4</sub> selected families), 17.34, 10.14% and 19.34% after two cycles of pedigree line selection (10 F<sub>5</sub> early selected families) and 26.03, 18.30% and 28.18% after one cycle of late selection (10 F<sub>5</sub> late selected families) comparing to the bulk, better parent and mid parents, respectively. The estimates of selection

responses for weight of spikes/plant were 12.73, 34.74% and 35.70 % after one cycle (50 F<sub>4</sub> selected families), 27.63, 21.26% and 31.98% after two cycles of pedigree line selection (10 F<sub>5</sub> early selected families) and 39.63, 32.66% and 43.84% after one cycle of late selection (10 F<sub>5</sub> late selected families) comparing to the bulk, better parent and mid parents, respectively. Same results of families for harvest index. It is obvious results that the selection responses for selected families of late selection in F<sub>5</sub> (10 F<sub>5</sub> late selected families) increased comparing to the F<sub>4</sub> (50 F<sub>4</sub> selected families) in relative to unselected bulk sample and both parents as well as in early selection (10 F<sub>5</sub> early selected families) in relative to unselected bulk sample for biological yield/plant, weight of spikes/plant and harvest index. Moreover, same result obtained for harvest index comparing to better parent and mid-parents in early 10 F<sub>5</sub> selections. Furthermore, the selection responses were highest in late (10 F<sub>5</sub> selected families) than early one (10 F<sub>5</sub> early selected families) for biological yield/plant, weight of spikes/plant and harvest index, but vice versa for seed index. The correlated responses for the rest correlated traits were negative or neglected positive values, indicating the different genetic makeup for all correlated traits across the selection in different generations of current studied population.

Some researchers found different correlated response for various traits when selection was done for grain yield/plant in wheat. [17], accounted genetic advance range of 2.05 to 18.61% for plant height, spike length, number of spikelets/spike and harvest index. The increased range was 22.67 to 47.45% for the same traits [18], [19], valued correlated response range of 2.44 to 16.20% for biological yield/plant and number of spikes/plant, respectively. Moreover, the values of correlated responses for plant height were 7.49% [20], 25.29% [21], 18.89 [22], and 13.09% [23]. Number of spikes/plant recorded correlated response of 5.29 and 7.92% in two populations [24]. High correlated response recorded for spike length [25]. Otherwise, pedigree line selection was an efficient method in increasing grain yield/plant with adverse effects across the correlated traits of wheat [26].

**1.1.3-** The direct response for selected families in cycle two (of early pedigree line selection (10 F<sub>5</sub> early selected families) as well as one cycle of late selection (10 F<sub>5</sub> late selected families) for grain yield/plant.

Average, direct and correlated response of studied traits for selected families in cycle two of early pedigree line selection (10 F<sub>5</sub> early selected families) relative to bulk, better parent and mid parents presented in Table 3.

Direct responses in cycle two of early pedigree line selection (10 F<sub>5</sub> early selected families) for grain yield/plant exhibited that all selections (10 F<sub>5</sub> early selected families) obtained in cycle two of selection surpassed significantly the bulk, better parent (Sakha 94) and mid parents, except families no. 141 and no. 461 relative to parent Sakha 94 and mid parent were increased insignificantly. These direct responses for grain yield/plant varied from 17.12 to 45.01 with an average of 30.84% over the bulk sample, from 9.41 to 35.47 with an average 22.34% over the better parent and from 15.56 to 43.08% with an average 29.09% over the mid-parent. Family no 131 recorded the highest selection response for grain yield/plant with values of 45.01, 35.47 and 43.08% comparing to the bulk, better parent and mid parents, respectively. Otherwise, the lowest selection response yielded from Fam. no. 461. Moreover, the selection response for grain yield/plant of superior eight F<sub>5</sub> early selected families exceeded significantly in ranking the better parent (Sakha 94) in values of 35.47 (no. 131), 31.25 (no. 250), 30.04 (no. 373), 26.31 (no. 440), 24.59 (no. 140), 23.59 (no. 321), 18.83 (no. 1) and 13.24 (no. 455) (Table 3), reflecting the effectiveness of pedigree line selection to increase the grain yield in wheat.

Furthermore, average, direct and correlated response of studied traits for selected families in F<sub>5</sub> of late selection (10 F<sub>5</sub> late selected families) relative to bulk, better parent and mid parents presented in Table 8. Direct responses of late selection (10 F<sub>5</sub> late selected families) for grain yield/plant revealed that all selections (10 F<sub>5</sub> late selected families) exceeded significantly the bulk, better parent (Sakha 94) and mid parents. The direct responses for grain yield/plant ranged from 32.28 to 60.23 with an average of 40.94% over the bulk sample, from 23.58 to 49.68 with an average 31.66% over the better parent and from 30.52 to 58.09% with an average 39.05% over the mid-parent. Family no 500 yielded the highest selection response for grain yield/plant with values of 60.23, 49.68 and 58.09% comparing to the bulk, better parent and mid parents, respectively. Otherwise, the lowest response yielded from Fam. no. 321. It is clear result that the selection response for grain yield/plant of superior 10 F<sub>5</sub> late selected families exceeded significantly in ranking the better parent (Sakha 94) in values of 49.68 (no. 500), 36.37 (no. 431), 35.47 (no. 131), 33.42 (no. 130), 31.26 (no. 250), 30.05 (no. 373), 26.32 (no. 440), 25.89 (no. 380), 24.58 (no. 140) and 23.58% (no.321) (Table 4), reflecting the effectiveness of late selection to improve the grain yield.

The obtained results proposed that the both early pedigree line selection and late selection are remarkable and powerful methods for improving the grain yield of wheat and getting high yielding lines. Moreover, it is obvious conclusion that the late selection can be more effective

comparing to the early pedigree line selection, where the late selection recorded the highest response to selection of 40.94, 31.66 and 39.05% comparing the early pedigree line selection of 30.84, 22.23 and 29.09%, giving 32.75, 42.42 and 34.24% advantage in favor of late selection comparing to the early one for the grain yield/plant as relative to bulk, better parent and mid-parents, respectively. The increasing of selection response in late selection refer in ranking to the families no. 500, 431, 130 and 380, which were different compare to the early selection. The rest families shared in late and early selection. Therefore, it can be recommended to apply late selection to improve the grain yield of wheat.

Same conclusion was proven by many authors such as [27] Moreover, [28], accounted realized genetic gain of 12.9% for grain yield/plant after two cycles of pedigree line selection in wheat. It was in range of 25 to 39% in three populations.

**1.1.4-** The correlated response for selected families in cycle two of early pedigree line selection (10 F<sub>5</sub> early selected families) as well as one cycle of late selection (10 F<sub>5</sub> late selected families) for grain yield/plant.

Average and correlated response of studied traits for selected families in cycle two of early pedigree line selection (10 F<sub>5</sub> early selected families) and one cycle of late selection (10 F<sub>5</sub> late selected families) relative to bulk, better parent and mid parents presented in Tables 3 and 4.

It is remarkable results on general average, the 10 F<sub>5</sub> early selected families for four traits i.e. biological yield/plant, weight of spikes/plant, seed index and harvest index, out of the rest traits, possessed the highest and significant positive correlated response comparing to the bulk, better parent and mid-parents. The estimates of general average for correlated response were 17.34, 10.13 and 19.34% for biological yield/plant, 27.61, 21.14 and 31.47% for weight of spikes/ plant, 9.92, 8.45 and 9.30% for seed index, and 11.52, 5.27 and 8.14% for harvest index relative to bulk, better parent and mid parents, respectively (Table 3). Furthermore, the previous estimates for correlated responses were significant positive and increased to 26.03, 18.30 and 28.18% for biological yield/plant, 39.65, 32.67 and 43.86% for weight of spikes/plant, and 11.65, 5.39 and 8.26 for harvest index with 10 F<sub>5</sub> late selected families, but slightly decreased to 9.12, 7.66 and 8.51% for seed index, compared to bulk, better parent and mid parents, respectively (Table 4). It is appeared from the values of correlated response that late selection was more efficiency comparing to early selection. Consequently, the obtained results of correlated selection responses as direct response

strongly supported the effectiveness of late selection compared to the early one.

In addition to, the highest positive and significant early selected families for correlated response were no. 373 for biological yield/plant (26.79, 19.01 and 28.95%), no. 131 for weight of spikes/plant (47.82, 40.44 and 52.28%), no. 440 for seed index (17.83, 16.26 and 17.04%), and no.1 for harvest index (35.10, 27.53 and 31.01%) relative to bulk, better parent and mid parents, respectively (Table 3). Furthermore, the highest positive and significant late selected families for correlated response were no. 130 equal no. 431 for biological yield/plant (36.19, 27.83 and 38.51%), no. 130 for weight of spikes/plant (64.60, 56.38 and 69.56%), no. 440 for seed index (17.83, 16.26 and 17.04%), and no.500 for harvest index (22.63, 15.75 and 18.91%) relative to bulk, better parent and mid parents, respectively (Table 4). Looking at the other correlated response for the rest traits possessed less or negative trend over general average or for most families of early and late selection in F<sub>5</sub> (Tables 3 and 4). The obtained results concluded that the superiority of grain yield/ plant depending on the selection for grain yield *per se* and main correlated traits. High genetic advances were recorded for plant height, number of spikelets/spike, spike length and yield/plant.

Table 2. Direct and correlated selection response (SR) for grain yield /plant and correlated traits in 10 F<sub>5</sub> early and late selected families.

	Mean	PH	SL	NSP	NSES	BYP	WSP	GYP	SI	HI	TI
10 F <sub>5</sub> Early Selected Families											
10 F <sub>5</sub> Early Selected Families	Families	108.17	12.35	8.37	8.73	65.85	35.94	23.22	4.87	35.49	35.30
	Bulk	114.50	12.15	9.52	9.73	56.12	28.16	17.75	4.43	31.82	36.57
	Misr 2	114.69	11.57	8.45	8.80	50.57	25.03	16.98	4.42	33.71	31.76
	Sakha 94	118.55	13.09	8.39	8.65	59.79	29.64	19.00	4.49	31.92	35.77
Selection response (SR)	<b>Bulk</b>			-	-						
		<b>-5.53</b>	<b>1.65</b>	<b>12.08</b>	<b>10.28</b>	<b>17.34</b>	<b>27.63</b>	<b>30.82</b>	<b>9.93</b>	<b>11.53</b>	<b>-3.47</b>
	<b>Better parent</b>	<b>-8.76</b>	<b>-5.65</b>	<b>-0.95</b>	<b>-0.80</b>	<b>10.14</b>	<b>21.26</b>	<b>22.21</b>	<b>8.46</b>	<b>5.28</b>	<b>-1.31</b>
	<b>Mid parents</b>	<b>-7.25</b>	<b>0.16</b>	<b>-0.59</b>	<b>0.06</b>	<b>19.34</b>	<b>31.48</b>	<b>29.07</b>	<b>9.32</b>	<b>8.15</b>	<b>4.55</b>
10 F <sub>5</sub> Late Selected Families											
10 F <sub>5</sub> Late Selected Families	Families	107.83	12.49	8.26	8.60	70.73	39.32	25.02	4.83	35.53	36.18
	Bulk	114.50	12.15	9.52	9.73	56.12	28.16	17.75	4.43	31.82	36.57
	Misr 2	114.69	11.57	8.45	8.80	50.57	25.03	16.98	4.42	33.71	31.76
	Sakha 94	118.55	13.09	8.39	8.65	59.79	29.64	19.00	4.49	31.92	35.77
Selection response (SR)	<b>Bulk</b>			-	-						
		<b>-5.83</b>	<b>2.80</b>	<b>13.24</b>	<b>11.61</b>	<b>26.03</b>	<b>39.63</b>	<b>40.96</b>	<b>9.03</b>	<b>11.66</b>	<b>-1.07</b>
	<b>Better parent</b>	<b>-9.04</b>	<b>-4.58</b>	<b>-2.25</b>	<b>-2.27</b>	<b>18.30</b>	<b>32.66</b>	<b>31.68</b>	<b>7.57</b>	<b>11.31</b>	<b>1.15</b>
	<b>Mid parents</b>	<b>-7.54</b>	<b>1.30</b>	<b>-1.90</b>	<b>-1.43</b>	<b>28.18</b>	<b>43.84</b>	<b>39.08</b>	<b>8.42</b>	<b>8.27</b>	<b>7.15</b>

Table 3. Direct and correlated responses for selected families in early (10 F5 early selected families) line pedigree line selection comparing to bulk, better parent and mid parent.

	Mean	PH	SL	NSP	NSES	BYP	WSP	GYP	SI	HI	TI
10 F5 Early Selected Families											
10 F5 Early Selected Families	Families	108.17	12.35	8.37	8.73	65.85	35.94	23.22	4.87	35.49	35.30
	Bulk	114.50	12.15	9.52	9.73	56.12	28.16	17.75	4.43	31.82	36.57
	Misr 2	114.69	11.57	8.45	8.80	50.57	25.03	16.98	4.42	33.71	31.76
	Sakha 94	118.55	13.09	8.39	8.65	59.79	29.64	19.00	4.49	31.92	35.77
Selection response (SR)	<b>Bulk</b>	<b>-5.53</b>	<b>1.65</b>	<b>12.08</b>	<b>10.28</b>	<b>17.34</b>	<b>27.63</b>	<b>30.82</b>	<b>9.93</b>	<b>11.53</b>	<b>-3.47</b>
	<b>Better parent</b>	<b>-8.76</b>	<b>-5.65</b>	<b>-0.95</b>	<b>-0.80</b>	<b>10.14</b>	<b>21.26</b>	<b>22.21</b>	<b>8.46</b>	<b>5.28</b>	<b>-1.31</b>
	<b>Mid parents</b>	<b>-7.25</b>	<b>0.16</b>	<b>-0.59</b>	<b>0.06</b>	<b>19.34</b>	<b>31.48</b>	<b>29.07</b>	<b>9.32</b>	<b>8.15</b>	<b>4.55</b>
10 F5 Late Selected Families											
10 F5 Late Selected Families	Families	107.83	12.49	8.26	8.60	70.73	39.32	25.02	4.83	35.53	36.18
	Bulk	114.50	12.15	9.52	9.73	56.12	28.16	17.75	4.43	31.82	36.57
	Misr 2	114.69	11.57	8.45	8.80	50.57	25.03	16.98	4.42	33.71	31.76
	Sakha 94	118.55	13.09	8.39	8.65	59.79	29.64	19.00	4.49	31.92	35.77
Selection response (SR)	<b>Bulk</b>	<b>-5.83</b>	<b>2.80</b>	<b>13.24</b>	<b>11.61</b>	<b>26.03</b>	<b>39.63</b>	<b>40.96</b>	<b>9.03</b>	<b>11.66</b>	<b>-1.07</b>
	<b>Better parent</b>	<b>-9.04</b>	<b>-4.58</b>	<b>-2.25</b>	<b>-2.27</b>	<b>18.30</b>	<b>32.66</b>	<b>31.68</b>	<b>7.57</b>	<b>11.31</b>	<b>1.15</b>
	<b>Mid parents</b>	<b>-7.54</b>	<b>1.30</b>	<b>-1.90</b>	<b>-1.43</b>	<b>28.18</b>	<b>43.84</b>	<b>39.08</b>	<b>8.42</b>	<b>8.27</b>	<b>7.15</b>

Table 3. continued.

Families. no.	Plant height, cm				Spike length, cm				Spikes number/plant			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
1	115.67	1.02	-2.43	-0.82	11.27	-7.27	-13.93	-8.62	9.07	-4.76	7.30	7.68
131	102.53	-10.45	-13.51	-12.08	13.07	7.54	-0.18	5.97	6.47	-32.07	-23.47	-23.20
140	110.80	-3.23	-6.54	-4.99	13.80	13.58	5.42	11.92	7.40	-22.27	-12.43	-12.11
141	109.40	-4.45	-7.72	-6.19	10.93	-10.01	-16.48	-11.33	9.67	1.54	14.40	14.81
250	96.33	-15.87	-18.74	-17.40	13.33	9.74	1.86	8.14	5.67	-40.48	-32.94	-32.70
321	109.60	-4.28	-7.55	-6.02	10.93	-10.01	-16.48	-11.33	10.27	7.84	21.50	21.93
373	106.87	-6.67	-9.86	-8.36	11.40	-6.17	-12.91	-7.54	10.20	7.14	20.71	21.14
440	106.27	-7.19	-10.36	-8.88	13.80	13.58	5.42	11.92	7.67	-19.47	-9.27	-8.95
455	115.87	1.19	-2.26	-0.65	13.80	13.58	5.42	11.92	8.87	-6.86	4.93	5.30
461	108.40	-5.33	-8.56	-7.05	11.13	-8.37	-14.95	-9.71	8.40	-11.76	-0.59	-0.24
<b>Average</b>	<b>108.08</b>				<b>12.91</b>				<b>7.94</b>			
Bulk	114.5				12.15				9.52			
P1	114.69				11.57				8.45			
P2	118.55				13.09				8.39			
Mid-parents	116.62				12.33				8.42			
Gen. R.L.S.D. <sub>0.05</sub>	4.26				0.92				1.23			
Gen. R.L.S.D. <sub>0.01</sub>	5.83				1.25				1.68			
Fam. R.L.S.D. <sub>0.05</sub>	4.62				0.99				1.38			
Fam. R.L.S.D. <sub>0.01</sub>	6.59				1.42				1.97			

amilies. no.	Spikelets number/spike				Biological yield/plant, g				Weight of spikes/plant, g			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
1	9.40	-3.39	6.82	7.74	52.56	-6.34	-12.09	-4.75	31.20	10.80	5.26	14.14
131	6.60	-32.17	-25.00	-24.36	67.81	20.84	13.42	22.89	41.63	47.82	40.44	52.28
140	7.80	-19.84	-11.36	-10.60	68.39	21.86	14.38	23.93	41.09	45.90	38.62	50.31
141	10.00	2.77	13.64	14.61	66.11	17.80	10.56	19.80	33.65	19.51	13.54	23.11
250	5.93	-39.02	-32.58	-32.00	65.59	16.87	9.70	18.86	38.94	38.28	31.38	42.45
321	10.53	8.26	19.70	20.73	63.17	12.57	5.66	14.49	33.47	18.87	12.93	22.46
373	10.47	7.57	18.94	19.96	71.15	26.79	19.01	28.95	35.69	26.75	20.42	30.58
440	7.93	-18.47	-9.85	-9.07	70.23	25.14	17.46	27.27	37.93	34.68	27.96	38.75
455	9.27	-4.76	5.30	6.21	69.15	23.22	15.66	25.32	34.41	22.21	16.10	25.89
461	9.33	-4.08	6.06	6.97	64.31	14.60	7.57	16.55	31.35	11.32	5.76	14.68
<b>Average</b>	<b>8.73</b>				<b>65.85</b>				<b>35.94</b>			
Bulk	9.73				56.12				28.16			
P1	8.8				50.57				25.03			
P2	8.65				59.79				29.64			
Mid-parents	8.73				55.18				27.34			

Gen. R.L.S.D. 0.05	1.3				5.81				3.82			
Gen. R.L.S.D. 0.01	1.78				7.95				5.23			
Fam. R.L.S.D. 0.05	1.47				5.9				4.09			
Fam. R.L.S.D. 0.01	2.1				8.43				6.09			

Table 3. continued.

Families. no.	Grain yield/plant, g				Seed index, g				Harvest index, %				Threshing index, %			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
1	22.58	27.20	18.83	25.50	4.72	6.65	5.23	6.05	42.99	35.10	27.53	31.01	27.36	-25.20	-23.52	-18.98
131	25.74	45.01	35.47	43.08	4.83	9.07	7.62	8.46	37.96	19.29	12.60	15.67	41.12	12.44	14.95	21.78
140	23.67	33.37	24.59	31.59	4.99	12.61	11.11	11.98	34.64	8.86	2.75	5.56	42.22	15.45	18.03	25.04
141	20.81	17.26	9.54	15.69	4.61	4.03	2.64	3.45	31.51	-0.99	-6.54	-3.99	38.12	4.25	6.58	12.91
250	24.94	40.49	31.25	38.61	5.17	16.77	15.21	16.12	38.09	19.69	12.98	16.06	35.81	-2.07	0.12	6.06
321	23.48	32.29	23.59	30.52	4.79	8.05	6.61	7.44	37.16	16.79	10.25	13.25	29.86	-18.35	-16.52	-11.57
373	24.71	39.20	30.04	37.34	4.92	11.00	9.52	10.38	34.96	9.87	3.71	6.54	30.75	-15.92	-14.04	-8.94
440	24.00	35.21	26.31	33.40	5.22	17.83	16.26	17.04	34.18	7.41	1.39	4.15	36.63	0.15	2.39	8.47
455	21.52	21.22	13.24	19.60	4.58	3.48	2.10	2.90	31.09	-2.29	-7.77	-5.25	37.44	2.38	4.67	10.89
461	20.79	17.12	9.41	15.56	4.86	9.62	8.16	9.01	32.28	1.45	-4.23	-1.62	33.73	-7.77	-5.71	-0.11
<b>Average</b>	<b>23.22</b>				<b>4.87</b>				<b>35.49</b>				<b>35.30</b>			
Bulk	17.75				4.43				31.82				36.57			
P1	16.98				4.42				33.71				31.76			
P2	19				4.49				31.92				35.77			
Mid-parents	17.99				4.46				32.82				33.77			
Gen. R.L.S.D. 0.05	2.04				0.26				3.22				6.74			
Gen. R.L.S.D. 0.01	2.79				0.37				4.41				9.65			
Fam. R.L.S.D. 0.05	2.58				0.24				3.74				7.76			
Fam. R.L.S.D. 0.01	3.92				0.34				5.34				10.75			

Table 4. Direct and correlated responses for selected families in late (10 F5 late selected families) line pedigree line selection comparing to bulk, better parent and mid parent.

Families. no.	Plant height, cm				Spike length, cm				Spikes number/plant			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
130	116.13	1.42	-2.04	-0.42	13.60	11.93	3.90	10.30	9.20	-3.36	8.88	9.26
131	102.53	-10.45	-13.51	-12.08	13.07	7.57	-0.15	6.00	6.47	-32.04	-23.43	-23.16
140	110.80	-3.23	-6.54	-4.99	13.80	13.58	5.42	11.92	7.40	-22.27	-12.43	-12.11
250	96.33	-15.87	-18.74	-17.40	13.33	9.71	1.83	8.11	5.67	-40.44	-32.90	-32.66
321	109.60	-4.28	-7.55	-6.02	10.93	-10.04	-16.50	-11.35	10.27	7.88	21.54	21.97
373	106.87	-6.66	-9.85	-8.36	11.40	-6.17	-12.91	-7.54	10.20	7.14	20.71	21.14
380	108.47	-5.27	-8.50	-6.99	11.93	-1.81	-8.86	-3.24	7.27	-23.63	-13.96	-13.66
431	111.87	-2.30	-5.63	-4.07	11.87	-2.30	-9.32	-3.73	10.73	12.71	26.98	27.43
440	106.27	-7.19	-10.36	-8.87	13.80	13.58	5.42	11.92	7.67	-19.43	-9.23	-8.91
500	109.40	-4.45	-7.72	-6.19	11.13	-8.40	-14.97	-9.73	7.73	-18.80	-8.52	-8.19
<b>Average</b>	<b>107.83</b>				<b>12.49</b>				<b>8.26</b>			
Bulk	114.5				12.15				9.52			
P1	114.69				11.57				8.45			
P2	118.55				13.09				8.39			
Mid-parents	116.62				12.33				8.42			
Gen. R.L.S.D. <sub>0.05</sub>	5.51				1.05				1.09			
Gen. R.L.S.D. <sub>0.01</sub>	7.87				1.5				1.56			
Fam. R.L.S.D. <sub>0.05</sub>	6.18				1.14				1.1			
Fam. R.L.S.D. <sub>0.01</sub>	8.99				1.63				1.57			

Table 4. continued.

Families. no.	Spikelets number/spike				Biological yield/plant, g				Weight of spikes/plant, g			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
130	9.47	-2.67	7.61	8.54	76.43	36.19	27.83	38.51	46.35	64.60	56.38	69.56
131	6.60	-32.17	-25.00	-24.36	67.81	20.83	13.41	22.89	41.63	47.83	40.45	52.30
140	7.80	-19.84	-11.36	-10.60	68.39	21.86	14.38	23.94	41.09	45.92	38.63	50.32
250	5.93	-39.05	-32.61	-32.03	65.59	16.87	9.70	18.87	38.94	38.28	31.38	42.45
321	10.53	8.22	19.66	20.69	63.17	12.56	5.65	14.48	33.47	18.86	12.92	22.44
373	10.47	7.61	18.98	20.00	71.15	26.78	19.00	28.94	35.69	26.74	20.41	30.57
380	7.53	-22.61	-14.43	-13.70	75.11	33.84	25.62	36.12	40.23	42.86	35.73	47.17
431	11.27	15.83	28.07	29.17	76.43	36.19	27.83	38.51	37.95	34.77	28.04	38.83
440	7.93	-18.50	-9.89	-9.11	70.23	25.14	17.46	27.27	37.93	34.69	27.97	38.76
500	8.47	-12.95	-3.75	-2.92	72.99	30.06	22.08	32.28	39.96	41.90	34.82	46.19
<b>Average</b>	<b>8.60</b>				<b>70.73</b>				<b>39.32</b>			
Bulk	9.73				56.12				28.16			
P1	8.8				50.57				25.03			
P2	8.65				59.79				29.64			
Mid-parents	8.73				55.18				27.34			
Gen. R.L.S.D. <sub>0.05</sub>	1.13				6.28				4.37			
Gen. R.L.S.D. <sub>0.01</sub>	1.62				8.98				6.24			
Fam. R.L.S.D. <sub>0.05</sub>	1.11				6.56				4.65			
Fam. R.L.S.D. <sub>0.01</sub>	1.59				9.68				6.76			

Table 4. continued.

Families. no.	Grain yield/plant, g				Seed index, g				Harvest index, %				Threshing index, %			
	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents	Mean	Bulk	Better parent	Mid parents
130	25.35	42.82	33.42	40.91	4.62	4.29	2.90	3.70	33.28	4.59	-1.28	1.42	45.23	23.68	26.45	33.96
131	25.74	45.01	35.47	43.08	4.83	9.03	7.57	8.42	37.96	19.30	12.61	15.68	41.12	12.44	14.96	21.78
140	23.67	33.35	24.58	31.57	4.99	12.64	11.14	12.01	34.64	8.86	2.76	5.56	42.22	15.45	18.03	25.04
250	24.94	40.51	31.26	38.63	5.17	16.70	15.14	16.05	38.09	19.70	12.99	16.07	35.81	-2.08	0.11	6.06
321	23.48	32.28	23.58	30.52	4.79	8.13	6.68	7.52	37.16	16.78	10.23	13.24	29.86	-18.35	-16.52	-11.57
373	24.71	39.21	30.05	37.35	4.92	11.06	9.58	10.44	34.96	9.87	3.71	6.54	30.75	-15.91	-14.03	-8.93
380	23.92	34.76	25.89	32.96	4.67	5.42	4.01	4.83	31.91	0.28	-5.34	-2.76	40.36	10.36	12.83	19.53
431	25.91	45.97	36.37	44.02	4.62	4.29	2.90	3.70	34.06	7.04	1.04	3.79	31.03	-15.15	-13.25	-8.10
440	24.00	35.21	26.32	33.41	5.22	17.83	16.26	17.04	34.18	7.42	1.39	4.16	36.63	0.16	2.40	8.49
500	28.44	60.23	49.68	58.09	4.51	1.81	0.45	1.23	39.02	22.63	15.75	18.91	28.80	-21.25	-19.49	-14.70
<b>Average</b>	<b>25.02</b>				<b>4.83</b>				<b>35.53</b>				<b>36.18</b>			
Bulk	17.75				4.43				31.82				36.57			
P1	16.98				4.42				33.71				31.76			
P2	19				4.49				31.92				35.77			
Mid-parents	17.99				4.46				32.82				33.77			
Gen. R.L.S.D. <sub>0.05</sub>	1.84				0.27				3.49				5.9			
Gen. R.L.S.D. <sub>0.01</sub>	2.58				0.4				5.2				8.59			
Fam. R.L.S.D. <sub>0.05</sub>	2.15				0.29				3.99				6.32			
Fam. R.L.S.D. <sub>0.01</sub>	2.97				0.43				5.99				9.19			

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**2. 1 -** Selected families score of selection response (SFSSR) in early pedigree line selection (10 F5 early selected families) and late selection (10 F5 late selected families) over all studied traits.

Selected families score of selection response (SFSSR) both direct and correlated in early (10 F5 early selected families) and late selection (10 F5 late selected families) over all studied traits presented in Tables 5 and 6.

The selected family score for selection response (SFSSR) was calculated as an average of direct selection response yielded from grain yield/plant and correlated selection responses from the rest traits for each selected F5 family in relative to bulk, better parent and mid-parents in early and late selections. The results revealed that the general mean of selected family score for selection response (SFSSR) over all selected families were accounted 21.13 points for the 10 F5 early selected selections and increased to 30.25 points for the 10 F5 late selected selections, which represents an increase of 43.16% higher than the early selection as remarked in Table 5 and 6, respectively. Moreover, the general mean of selected family score for selection response (SFSSR) over all the 10 F5 late selected families represents an increase of 45.99, 58.03 and 33.26% higher than the 10 F5 early selection in relative to bulk, better parent and mid-parents, respectively. This result may be due to those selected families no. 130, 380, 431 and 500 which matched only in the 10 F5 late selections and not matched the 10 F5 early selection and possessed high selection response such as grain yield/plant, biological yield/plant and weight of spikes/plant. Moreover, highest average of SFSSR recorded for selected family no. 140 (32.36 points) among the early F5 selections and family no. 130 (56.33 points) out of the late F5 selections.

The lowest values of SFSSR were yielded from family no. 461 (6.38 points) in early selections and family no. 250 (12.66 points) in late selections, revealing to the less direct and correlated response across both early and late selection.

The superior selected families no. 130, 131, 431 and 500, which yielded grain yield/plant more than 25.35 g exhibited to be in grate order improvement as a new genotypes exerted from the current population of wheat.

Table 5. Average of direct and correlated selection responses score of early pedigree line selection (10 F5 early selections) over all studied traits.

<b>Families no.</b>	<b>Bulk</b>	<b>Better parent</b>	<b>Mid parents</b>	<b>Total</b>	<b>Rank</b>
<b>140</b>	10.63	8.46	13.26	<b>32.36</b>	<b>1</b>
<b>373</b>	9.96	8.55	13.01	<b>31.55</b>	<b>2</b>
<b>440</b>	8.89	6.77	11.41	<b>27.08</b>	<b>3</b>
<b>131</b>	8.73	6.23	11.05	<b>26.03</b>	<b>4</b>
<b>321</b>	7.20	5.97	10.19	<b>23.37</b>	<b>5</b>
<b>455</b>	7.34	5.74	10.21	<b>23.29</b>	<b>6</b>
<b>141</b>	5.17	4.02	8.29	<b>17.47</b>	<b>7</b>
<b>250</b>	4.44	1.82	6.42	<b>12.66</b>	<b>8</b>
<b>1</b>	3.38	1.90	5.90	<b>11.18</b>	<b>9</b>
<b>461</b>	1.68	0.29	4.40	<b>6.38</b>	<b>10</b>
<b>Average</b>	<b>6.74</b>	<b>4.98</b>	<b>9.41</b>	<b>21.13</b>	

Table 6. Average of direct and correlated selection responses score of late selection (10 F5 late selections) over all studied traits.

<b>Families no.</b>	<b>Bulk</b>	<b>Better parent</b>	<b>Mid parents</b>	<b>Total</b>	<b>Rank</b>
<b>130</b>	18.35	16.41	21.57	<b>56.33</b>	<b>1</b>
<b>431</b>	13.71	12.30	16.96	<b>42.96</b>	<b>2</b>
<b>140</b>	10.63	8.46	13.27	<b>32.36</b>	<b>3</b>
<b>373</b>	9.97	8.57	13.02	<b>31.55</b>	<b>4</b>
<b>500</b>	9.08	6.83	11.50	<b>27.41</b>	<b>5</b>
<b>440</b>	8.89	6.77	11.42	<b>27.08</b>	<b>6</b>
<b>131</b>	8.74	6.24	11.06	<b>26.03</b>	<b>7</b>
<b>321</b>	7.20	5.97	10.19	<b>23.37</b>	<b>8</b>
<b>380</b>	7.42	5.30	10.03	<b>22.75</b>	<b>9</b>
<b>250</b>	4.43	1.82	6.42	<b>12.66</b>	<b>10</b>
<b>Average</b>	<b>9.84</b>	<b>7.87</b>	<b>12.54</b>	<b>30.25</b>	

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