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Heterosis and Combining Ability Studies for Grain Yield and some Contributing Traits in Bread Wheat (*Triticum aestivum* L.) under Normal and Late Sowing Conditions.

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ABSTRACT

Seven parental cultivars of bread wheat (*Triticum aestivum* L.) were used in a half diallel mating design at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt, during the two successive seasons of 2013/2014 and 2014/2015 to study combining ability and heterosis and their interactions under two sowing dates , 15th November (normal sowing date) and 15th December (late sowing date) in two adjacent experiments, for days to heading, No. of spikes/plant, 1000- grain weight and grain yield/plant. Sowing dates mean squares was highly significant for all studied traits. Genotypes mean squares was highly significant for all studied traits at the two sowing dates and their combined. The overall means of genotypes were (88.98, 83.76 and 86.37days) for days to heading; (13.87, 10.00 and 11.94) for No. of spikes/plant; (47.26, 35.41 and 41.34g) for 1000-grain weight and (39.43, 24.58 and 32.01g) for grain yield/plant on the normal, late sowing dates and their combined, respectively. Late sowing date (heat stress) caused reduction for days to heading (5.87%), No. of spikes/plant (27.90%), 1000-grain weight (25.07%) and grain yield/plant (37.66 %), compared with normal sowing date (favorable). Interaction of sowing dates with genotypes was highly significant for all studied traits. General combining ability (GCA) and specific combining ability (SCA) mean squares was significant for all studied traits at the both sowing dates and their combined, except general combining ability mean squares for 1000-grain weight and grain yield/plant for the combined data. Genetic analyses of these traits confirm the participation of both additive and non-additive gene effects in controlling their inheritance. The interactions of sowing dates with general combining ability were found to be not-significant for all studied traits, whereas the interactions of sowing dates with specific combining ability were found to be significant for all studied traits. The ratio of GCA to SCA variance (predictability ratio) was closer to 1 for all studied traits, except for No. of spikes/plant and grain yield/plant at normal sowing date that revealed the predominance of additive gene action in the inheritance. The parental line (P_5) proved to be the good general combiner for grain yield/plant at the two sowing dates and their combined. Hybrid combination ($P_1 \times P_4$) showed highly significant desirable SCA effects for days to heading, No. of spikes/plant, 1000-grain weight and grain yield/plant. Six cross combinations ($P_1 \times P_2$), ($P_1 \times P_4$), ($P_1 \times P_6$), ($P_2 \times P_4$), ($P_4 \times P_5$) and ($P_4 \times P_6$), exhibited significant desired heterosis for grain yield/plant which varied from (10.8%) to (35.38%) relative to their better parents at both normal and late sowing date levels.

Keywords: *wheat, diallel crosses, Combining ability, heterosis, sowing dates, Heritability.*

INTRODUCTION

Wheat is considered as one of the most fundamental crops, widely cultivated all over the world, with main objective of human consumption, supporting almost 35% of the world's population and 95 % of wheat cultivated today is hexaploid (2n=6x), which is utilized in bread making and other bakery outputs (Debasis and Khurana, 2001). The area and production of wheat status 1st globally between the cereal crops. It accounts for more than 1/3rd of the total world's cereal crops and is the main origin of calories for more than 1.5 billion people in the world (Reynolds *et al.,* 1999). In Egypt, breeding efforts are directed mainly towards producing high yielding cultivars in order to face the rapid increase in wheat consumption, and consequently decrease wheat import. Furthermore, increasing food demands have led to implant wheat under secondary conditions which recognized by many abiotic stresses. So, adaptability of agricultural crops to face the such new environment limited factors for increasing yield (Evans,1980). Late sowing date is seriously affect wheat production due to last heat stress especially during anthesis and grain filling stages. Net reduction in grain yield due to late sowing date was registered as 33%, suggesting non-adaptation of wheat genotypes to stress faced due to late sowing date (Khalil, 2016). Optimum sowing date range of different cultivars varies with regions depending on growing conditions of a specific tract that could be assessed by sowing them at different times (Zia *et al.,* 2014). The other crucial factor is wheat cultivars which are mainly selected for higher yields, greater tolerance to adverse conditions and shorter maturity (Kumar *et al.,* 2013). These two factors limit wheat productivity, because every crop cultivar has its own requirements for particular environmental conditions for maximum growth, which could be facilitated by proper sowing date. The highest values of some vegetative characters, yield attributes and grain yield, as well as enhancement in biological and economical yield occurred when wheat planted earlier (Qasim *et al.,* 2008). The reduction in wheat grain and its attributes with delaying sowing date was the result of exposure of plants to high temperature, which reduces season length.

Combining ability analysis of Griffing, 1956 is most widely used as a biometrical tool for evaluating parental lines in terms of their ability to combine well in hybrid combinations. According to this method, the resulting of total genetic variation is partitioned into effects of general combining ability, as a measure of additive gene action and specific combining ability, as a measure of non- additive gene action. Several investigators have notified general and specific combining ability effects for different wheat genotypes (Sheikh *et al.,* 2000, Rehman *et al*., 2002, Ahmad *et al.,* 2011 and Abdallah *et al.,* 2015). All these studies exposed that a large part of genetic variability for yield and its components was equally associated with general and specific combining ability, which is a measure of additive and non-additive genetic variance, respectively suggesting the importance of both additive and non-additive genetic variability for yield components.

Heterosis is a complex genetical phenomenon, which depends on the balance of different combinations of gene effects as well as on the distribution of plus and minus alleles in the parents of a mating. In self- pollinated crops like wheat the scope for utilization of heterosis depends mainly upon the direction and magnitude of heterosis. Heterosis over the better parent may be useful in identifying the best hybrid combinations but these hybrids can be immense practical value if they involve the best cultivars of the area (Prasad *et al.,* 1998). Environmental vacillation is highly influence the phenotypic expression of quantitative traits. Genotypic x environment interaction, depending upon their nature and quantity, leads to bias estimates of gene effects and combining ability for various sensitive characters to environmental modification. Heritability is widely used in the establishment of breeding programs and formation of selection indexes. It provides an estimate of genetic advance a breeder can expect from selection applied to a population in a given experiment, and is essential for an effective crop-breeding program by predicting the behavior of succeeding generations by devising the appropriate selection criteria and assessing the level of genetic improvement.

Estimates of heritability alone do not provide an idea about the expected gain in the next generation, unless considered in conjunction with estimates of selection response or genetic advance. The utility of heritability therefore increases when used to calculate selection response, which indicates the degree of gain in a character obtained under particular selection pressure (Kumar *et al.,* 2013). Therefore, the objectives of the present research were to study:

1- The magnitude of both general and specific combining ability and their interactions with two sowing dates.
2- The type of gene action administers these materials and its employment in a breeding program.
3- The potentiality of heterosis of grain yield and some of its components in a seven parental diallel crosses under two sowing dates and their combined.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt, during the two successive seasons 2013/2014 and 2014/2015. Seven wheat genotypes differed in their genetic diversity namely; CROC-1/AE.SQUARROSA(224)//OPATA (P_1), PREW (P_2) from ICARDA; Giza 168 (P_3) and Seds1 (P_4) from Egypt; TRI 5641(P_5) and TRI 5643 (P_6) from Iran, and TRI 12736 (P_7) from Russia) were selected for the study. In 2013/ 2014 growing season the seven parents were crossed in all possible combinations excluding reciprocals, to obtain a total of 21 F_1 hybrids. The parental cultivars and their possible twenty-one crosses were sown in 2014/ 2015 season under two sowing dates; 15th November (normal sowing date) and 15th December (late sowing date) in two adjacent experiments. Each experiment was laid-out in a randomized complete block design (RCBD) with three replications. Each plot was two rows, 3 meters long with 30 cm between rows. Plants within rows were 10 cm. apart. Days to heading was recorded as number of days from sowing to the first appearance of awns from the flag leaf sheaths of 50% of the plants in a plot. At maturity, twenty guarded plants were selected at random to measure No. of spikes/plant, 1000-grain weight (g) and grain yield/plant (g). Separate and combined analyses of variance were performed according to Gomez and Gomez, 1984. Estimates of both general and specific combining ability were calculated according to Griffing, 1956 method 2, model 1. The ratio of GCA to SCA variance (predictability ratio) was computed by following the method of Baker (1978) Predictability ratio = 2 MS gca /(2 MS gca + MS sca). If this ratio equals to 1, it means that all effects are the result of additive effect (Baker, 1978). If this ratio equals to 0.5, it means that variance of additive effects and non-additive effects are equal, and if it is less than 0.5 it shows the superiority of non-additive gene effects (dominance, over dominance and epistasis) in controlling the traits of interest (Farshadfar *et al.,* 2012). The values of heterosis were calculated as the percentages deviation from the $F_{1's}$ hybrids over the average of the mid-parents ($\overline{M.P}$) and above the better-parent ($\overline{B.P}$) as follows:

$$\text{H (M.P) \%} = \frac{\overline{F}_1 - \overline{M.P}}{\overline{M.P}} \times 100$$

$$\text{H (B.P) \%} = \frac{\overline{F}_1 - \overline{B.P}}{\overline{B.P}} \times 100$$

Where: **H (M.P) % : Heterosis over mid-parents, H (B.P) % : Heterosis over better-parent, ($\overline{M.P}$) : Mean mid-parent value, ($\overline{B.P}$) : Mean better parent value and $\overline{F}_1$: mean performance of the hybrid. The significance of heterosis was tested, using the least significant difference (LSD) according to the formula of Steel and Torrie, 1980 as fallows :**

LSD for heterosis relative to mid-parents

$$= t \times \sqrt{\frac{3MSe}{2r}}$$

LSD for heterosis relative to better-parent

$$= t \times \sqrt{\frac{2MSe}{r}}$$

Where: **t: is the tabulated t value at a stated level of probability for the experimental error degree of freedom, r: is the number of replications and MSe = Error mean square.**

Simple correlation was calculated according to Pearson, 1920.

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance (Table 1) indicated significant difference ($p \leq 0.01$) between the two sowing dates for all studied traits. Mean squares of genotypes were significant ($p \leq 0.01$) for all studied traits for separate and combined analyses, indicating wide genetic variability among them. These results agree with those obtained by Anwar *et al.,* 2009 and Rizkalla *et al.,* 2012. In addition, mean squares of G X D interaction was significant ($p \leq 0.01$) for all studied traits, revealing that these genotypes were inconsistent from date to another. Similar findings were reported by Ahmad *et al.,* 2011, Nadim *et al.,* 2012, Nazir *et al.,* 2014, Abdallah *et al.,* 2015 and Khalil, 2016.

Mean performance

Mean performance of the parents and their F_1 hybrids are given in Table 2. The genotype (P_1) ranked the fourth for No. of spikes/plant and the fifth for 1000- grain weight. The genotype (P_2) ranked the second for days to heading and the fifth for No. of spikes/plant. The genotype (P_3) ranked the third for No. of spikes/plant, 1000- grain weight and grain yield/plant. The genotype (P_4) ranked the first for days to heading and the fourth for 1000-grain weight. The genotype (P_5) ranked the first for No. of spikes/plant and grain yield/plant and the second for 1000-

grain weight. The genotype (P_6) ranked the fourth for grain yield/plant and the fifth for days to heading and 1000-grain weight. The genotype (P_7) ranked the first for 1000-grain weight and the second for days to heading, No. of spikes/plant and grain yield/plant. Early heading date was found in crosses (P_4 x P_7), (P_4 x P_5), (P_1 x P_4), (P_2 x P_4) and (P_3 x P_4) at normal and late sowing dates as well as the combined analysis. For No. of spikes/plant, the best five crosses (P_5 x P_7), (P_1 x P_7), (P_2 x P_5), (P_3 x P_5) and (P_1 x P_4) were found at the two sowing dates and their combined data. For 1000- grain weight, the best five crosses (P_4 x P_6), (P_4 x P_5), (P_4 x P_7), (P_1 x P_4) and (P_1 x P_6) were found at the two sowing dates and their combined data. The best five crosses for grain yield/plant were (P_4 x P_5), (P_1 x P_4), (P_4 x P_7), (P_1 x P_6) and (P_4 x P_6). at the two sowing dates and their combined. The results showed that the means at normal sowing date (15th November), were higher than those at late sowing date (15th December). Generally, all studied characteristics were reduced in the late sowing compared with the normal sowing date. This could be due to that high temperature reduced season length and higher risk of disease attacks. These results are in agreement with those of Hamam and Khaled,2009 and Abdallah, *et al.,* 2015 who mentioned that late sowing date caused reduction in spike length and yield, spike grain weight, No. of spikes per square meter and 1000-grain weight. The overall mean of genotypes were (88.98, 83.76 and 86.) for days to heading; (13.87, 10.00 and 11.94) for No. of spikes/plant; (47.26, 35.41 and 41.34g) for 1000-grain weight and (39.43, 24.58 and 32.01g) for grain yield/plant (g) at the normal, late sowing dates and their combined, respectively. Late sowing date (heat stress) caused reduction for days to heading (5.87%), No. of spikes/plant (27.90%), 1000-grain weight (25.07%) and grain yield/plant (37.66 %) compared with normal sowing date (favorable). For days to 50% heading (Table 2) of wheat genotypes was significantly reduced at the late sowing (83.76 days) as compared to normal sowing date (88.98 days). This trait showed (5.87%) reduction. At normal sowing date, three genotypes, viz. P_4, (P_4 × P_7) and (P_4 × P_5) headed after (70.78, 81.31 and 81.62 days, respectively), whereas (P_3 × P_6), P_3 and (P_2 × P_6) headed after (93.44, 93.65 and 94.86 days, respectively). Days to heading ranged from (70.78 days) for genotype (P_4) to (94.86 days) in genotype (P_2 × P_6) at normal sowing, while, it ranged from (66.22 days) in genotype (P_4) to (89.78 days) in genotype (P_1 × P_2) in late sowing date. Reduction in days to heading was previously reported by Sial *et al.,* 2005, Hamam and Khaled, 2009 and Abdallah, *et al.,* 2015 who manifested 12.54% decreasing due to the late sowing dates compared with normal sowing date. The parental cultivar (P_4) was the earliest genotype in both sowing dates (66.22 days at the late sowing and 70.78 days at the normal sowing date). This could be attributed to differences in stability of genotypes.These findings are in agreement with kumar *et al.,* 2013.

Table 1. Mean squares for all studied traits under normal (N), late (L) sowing dates and their combined data.

S.V	D.F		Days to heading			No. of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
	S	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
Dates (D)	---	1	---	---	1145.27**	---	---	629.03**	---	---	5888.51**	---	---	9263.28**
Replications (R)	2	---	15.97	16.96	---	0.60	0.51	---	11.42	10.32	---	6.96	8.46	---
R/D	---	4	---	---	16.47	---	---	0.56	---	---	10.87	---	---	7.71
Genotypes (g)	27	27	86.94**	76.75**	160.32**	10.79**	11.77**	21.11**	74.04**	48.61**	113.34**	37.34**	43.17**	64.63**
G x D	---	27	---	---	3.37**	---	---	1.46**	---	---	9.31**	---	---	15.88**
Error	54	108	1.57	0.10	1.28	0.003	0.04	0.02	1.12	2.79	1.95	0.59	2.66	1.63

***, ** Significant at 5% and 1% levels of probability, respectively**
N= normal sowing date (15th November). L = late sowing date (15th December). Comb.= combined

Data in Table 2 show that delay sowing date diminished No. of spikes/plant for all parents and hybrids. The reduction caused by late sowing was (27.90%). The highest No. of spikes/plant was recorded at normal sowing (17.48) for (P_5) followed by (16.25) for (P_5 × P_7). These results were also confirmed by the earlier findings of Tahir *et al.,* 2009 and Hozayn and Abd El-Monem, 2010.

Mean 1000-grain weight was significantly reduced at late sowing (35.41g) as compared to normal sowing (47.26 g). The wheat cultivar (P_5) had the highest values at the normal sowing date (52.28g) and at the late sowing date (27.82g). For hybrids, it ranged from (36.47) in (P_1 × P_7) to (56.20) in (P_4 × P_6) at the normal sowing date and from (28.66) in (P_6 × P_7) to (43.06) in (P_4 × P_5) at the late sowing date. It could be concluded that 1000-grain weight was drastically reduced with late sowing, because late sown crop is in danger of disease, drought and high temperature shocks. These results of 1000-grain weight are in agreement with those reported by Hamam and Khaled, 2009, Ali, 2011 and Abdallah *et al.,* 2015. Data presented in Table 2, show that grain yield/plant of bread wheat genotypes was significantly decreased with the late sowing dates (37.66%). The parental wheat genotype (P_5) had the highest mean values of grain yield/plant at the normal and late sowing dates (42.13 and 26.93 g, respectively), as well as cross combination (P_4 × P_5) at the normal sowing date and (P_3 × P_7) at the late sowing dates (47.95 and 34.43 g, respectively). Moreover, the genotype (P_2) gave the lowest grain yield/plant at the normal and late sowing dates (33.16 and 16.91 g respectively), as well as the hybrids (P_6 × P_7) on the normal sowing date and (P_2 × P_4) on the late sowing date (34.03 and 21.23 g, respectively). Similar results were obtained by Hamam and Khaled, 2009. Naceur *et al.,* 1999 reported that the spikes population or mean grain weight in late planting could not compensate the decrease in yield compared to normal sowing due to high temperature at the anthesis stage and shortage season length. furthermore, the low temperature of late sowing date (15th December) reduced germination of seeds and early vegetative growth.

Table 2. Mean performances of seven parents and their F_1 hybrids for all studied traits under normal (N), late (L) sowing dates and their combined data.

Traits	Days to heading				No. of spikes/plant			
Genotypes	N	L	Reduction%	Comb.	N	L	Reduction%	Comb.
(P_1)	92.90	87.93	5.35	90.42	14.38**	11.11**	22.74	12.74**
(P_2)	83.31**	80.05**	3.91	81.68**	14.16**	8.92	37.01	11.54
(P_3)	93.65	87.88	6.16	90.77	14.93**	11.65**	21.97	13.29**
(P_4)	70.78**	66.22**	6.44	68.50**	7.87	4.74	39.77	6.31
(P_5)	88.58**	83.70**	5.51	86.14**	17.48**	12.99**	25.69	15.23**
(P_6)	92.58	87.66	5.31	90.12	11.51	8.65	24.85	10.08
(P_7)	85.38**	82.28**	3.63	83.83**	16.03**	13.80**	13.91	14.92**
P_1 x P_2	94.57	89.78	5.07	92.18	13.06	8.40	35.68	10.73
P_1 x P_3	93.42	85.21	8.79	89.31	15.04**	9.83	34.64	12.44**
P_1 x P_4	82.63**	77.40**	6.33	80.01**	15.37**	9.39	38.91	12.38**
P_1 x P_5	90.45**	83.34**	7.86	86.90**	13.38	9.35	30.12	11.37
P_1 x P_6	92.65	88.79	4.17	90.72	13.28	8.98	32.38	11.13
P_1 x P_7	88.68**	86.45	2.51	87.56**	15.60**	13.32**	14.62	14.46**
P_2 x P_3	92.88	87.23	6.08	90.06	13.94*	9.57	31.35	11.76
P_2 x P_4	84.30**	77.98**	7.50	81.14**	10.41	5.58	46.40	7.99
P_2 x P_5	91.90	83.40**	9.25	87.65**	16.14**	11.45**	29.06	13.80**
P_2 x P_6	94.86	89.63	5.51	92.25	13.38	8.89	33.56	11.14
P_2 x P_7	90.33**	85.52	5.32	87.93**	13.06	10.42*	20.21	11.74
P_3 x P_4	86.52**	82.48**	4.67	84.50**	13.20	11.00**	16.67	12.10
P_3 x P_5	90.56**	84.56	6.63	87.56**	15.04**	10.45**	30.52	12.75**
P_3 x P_6	93.44	88.11	5.70	90.77	12.95	9.65	25.48	11.30
P_3 x P_7	88.60**	83.27**	6.02	85.93**	13.94	9.93	28.77	11.94
P_4 x P_5	81.62**	77.55**	4.99	79.59**	14.16**	10.32	27.12	12.24**
P_4 x P_6	90.91**	85.29	6.18	88.10**	12.91	9.71	24.79	11.31
P_4 x P_7	81.31**	77.53**	5.81	79.42**	13.38	10.41*	22.20	11.90
P_5 x P_6	92.62	88.41	4.55	90.52	14.38**	9.71	32.48	12.05
P_5 x P_7	91.34*	83.41**	8.68	87.38**	16.25**	12.60**	22.46	14.43**
P_6 x P_7	90.57**	84.09**	7.15	87.33**	13.06	9.12	30.17	11.09
Means	88.98	83.76	5.87	86.37	13.87	10.00	27.90	11.94
$LSD_{0.05}$	2.05	0.52	-	1.83	0.09	0.33	-	0.23
$LSD_{0.01}$	2.72	0.69	-	2.42	0.12	0.43	-	0.30

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

Table 2 .Cont.

Traits	1000 grain weight (g)				Grain yield/plant (g)			
Genotypes	N	L	Reduction%	Comb.	N	L	Reduction%	Comb.
(P_1)	37.97	27.82	26.73	32.90	34.33	19.59	42.94	26.96
(P_2)	43.11	30.07	30.25	36.59	33.16	16.91	49.01	25.04
(P_3)	46.83	39.42**	15.82	43.13	38.55	26.77	30.56	32.66
(P_4)	47.80	37.91	20.69	42.86	34.91	17.51	49.84	26.21
(P_5)	52.28**	39.52**	24.41	45.90**	42.13**	26.93	36.08	34.53*
(P_6)	49.53*	37.31	24.67	43.42	36.90	22.79	38.24	29.85
(P_7)	50.36**	41.72**	17.16	46.04**	41.08*	26.59	35.27	33.84
P_1 x P_2	44.27	33.01	25.43	38.64	37.79	22.53	40.38	30.16
P_1 x P_3	46.86	34.91	25.50	40.89	40.03	23.94	40.19	31.98
P_1 x P_4	52.19**	39.55**	24.22	45.87**	44.76**	26.52	40.75	35.64**
P_1 x P_5	41.74	32.43	22.30	37.09	37.58	22.68	39.65	30.13
P_1 x P_6	50.59**	38.06	24.77	44.33**	43.01**	26.88	37.50	34.94**
P_1 x P_7	36.47	31.96	12.37	34.21	36.57	30.98**	15.29	33.78
P_2 x P_3	49.13*	33.71	31.39	41.42	38.31	21.65	43.49	29.98
P_2 x P_4	49.48*	34.59	30.099	42.03	38.82	21.23	45.31	30.02
P_2 x P_5	46.07	35.69	22.539	40.88	41.47**	27.33*	34.10	34.40*
P_2 x P_6	48.02	34.72	27.70	41.37	39.85	23.30	41.53	31.58
P_2 x P_7	43.50	30.41	30.09	36.95	37.23	21.69	41.74	29.46
P_3 x P_4	46.72	35.52	23.97	41.12	39.57	26.68	32.57	33.13
P_3 x P_5	48.87	35.43	27.50	42.15	41.61**	24.30	41.60	32.96
P_3 x P_6	48.51	34.51	28.86	41.51	39.42	23.34	40.79	31.38
P_3 x P_7	45.64	34.29	24.87	39.96	39.82	34.43**	13.53	37.13**
P_4 x P_5	55.34**	43.06**	22.19	49.20**	47.95**	29.49**	38.50	38.72**
P_4 x P_6	56.20**	39.34**	30.00	47.77**	43.44**	25.58	41.11	34.51*
P_4 x P_7	54.87**	41.38**	24.59	48.13**	44.13**	26.10	40.85	35.12**
P_5 x P_6	40.54	29.95	26.12	35.25	35.61	24.02	32.55	29.82
P_5 x P_7	49.71**	36.65	26.27	43.18	42.07**	26.55	36.90	34.31*
P_6 x P_7	40.55	28.66	29.32	34.61	34.03	21.94	35.52	27.99
Means	47.26	35.41	25.07	41.34	39.43	24.58	37.66	32.01
LSD $_{0.05}$	1.73	2.73	-	2.26	1.25	2.66	-	2.06
LSD $_{0\cdot01}$	2.30	3.63	-	2.98	1.67	3.54	-	2.73

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

Combining ability analysis

Mean squares of general and specific combining abilities were significant (Table 3) for all studied traits under the both sowing dates and their combined data, except for the combined data of 1000-grain weight and grain yield/plant. Genetic analysis confirmed the participation of both additive and non-additive gene action in controlling these traits. The ratio of GCA to SCA variance (predictability ratio) was closer to one (more than 0.7) for all studied traits, except for No. of spikes/plant and grain yield/plant at normal sowing date that reveals additive effects play more significant roles. Low ratio of GCA to SCA variance in normal sowing dates of No. of spikes/plant and grain yield/plant (0.62 and 0.69, respectively) indicates the role of additive and non-additive effects in controlling them. These results are in line with those noted by Ahmad *et al.,* 2011, Yao *et al.,* 2011, Nazir *et al.,* 2014, Abdallah *et al.,* 2015 and Jatav *et al.,* 2017. However, Kashif and Khan, 2008 in which they found preponderance of non-additive effects for 1000-grain weight and grain yield/plant under both normal and late sowing conditions. While, Sheikh *et al.,* 2000 and Singh *et al.,* 2003 reported that both additive and non-additive genetic effects were found for grain yield and its components. Moreover, the interactions of GCA X D mean squares were not significant for all studied traits indicating the insensitivity of the additive genetic effects to the sowing dates conditions. However, the interaction of SCA X D mean squares were significant for all studied traits except for days to heading , reflecting the effect of sowing dates on non-additive gene actions. The ratios of GCA X D / SCA X D mean squares were more than one for all studied traits except for days to heading, revealing that the magnitudes of additive gene action fluctuated from normal to late sowing date. These findings are in agreement with those obtained by Hamada, 2003 and Koumber *et al.,* 2006.

Table 3. Analysis of variance of combining ability for all studied traits under normal (N), late (L) sowing dates and their combined data.

	D.F		Days to heading			No. of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
S.V	**S**	**Comb.**	**N**	**L**	**Comb.**	**N**	**L**	**Comb.**	**N**	**L**	**Comb.**	**N**	**L**	**Comb.**
GCA	6	6	103.82**	92.62**	195.65**	10.38**	11.07**	20.55*	41.25**	28.70**	65.60	13.57**	14.39**	29.46
SCA	21	21	7.58**	6.43**	12.81**	1.66**	1.88**	3.18**	19.94**	12.63**	29.83**	12.09**	2.84**	19.28*
GCA x D	---	6	---	---	0.85	---	---	0.9	---	---	4.36	---	---	8.36
SCA x D	---	21	---	---	1.20**	---	---	0.37**	---	---	2.74**	---	---	4.42**
Error	54	108	0.52	0.33	0.43	0.001	0.01	0.01	0.37	0.93	0.65	0.20	0.89	0.54
GCA/SCA	---	---	0.96	0.97	0.97	0.62	0.94	0.93	0.81	0.82	0.82	0.69	0.91	0.75
GCA x D /SCA x D	---	---	---	---	0.71	---	---	2.47	---	---	1.59	---	---	1.89

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

Combining ability effects :

a-General combining ability effects (GCA)

Estimates of the general combining ability effects (GCA) for each parent under two sowing dates and their combined data for all studied traits are presented in Table 4. The results showed that, the parents (P4) and (P7) were the best general combiners for earliness at the two sowing dates and their combined data. The parental genotypes (P1), (P3), (P5) and (P7) were the best general combiners at the both sowing dates and their combined data for No. of spikes/plant. The parents (P4) and (P5) were good general combiners for 1000 grain weight at the two sowing dates and their combined data. Regarding to grain yield/plant, the parental genotype (P5) was found to be the best general combiner at the two sowing dates and their combined data. Moreover, the parents (P3) and (P7) were good general combiners for the same trait at the late sowing date and combined data. Therefore, these excellent parents proved to be good general combiners for improving these traits and could be utilized in a future breeding to develop high yielding cultivars. Similar results were obtained by Yadav and Singh, 2004, Motawea, 2006 and Kumar *et al.,* 2011.

Table 4. Estimates of general combining ability effects (GCA) of the parents for all studied traits at normal (N), late (L) sowing dates and their combined data.

Parents	Days to heading			No. of spikes/plant			1000 grain weight (g)			grain yield/plant (g)		
	N	**L**	**Comb.**	**N**	**L**	**Comb.**	**N**	**L**	**Comb.**	**N**	**L**	**Comb.**
P_1	1.82**	1.87**	7.37**	0.40**	0.17**	1.12**	-3.33**	-1.97**	-10.61**	-0.79**	-0.44	-2.45**
P_2	0.41	0.4	1.61**	-0.30**	-0.87**	-2.33**	-1.26**	-2.34**	-7.20**	-1.74**	-2.79**	-9.06**
P_3	2.32**	1.8**	8.33**	0.34**	0.42**	1.51**	0.15	0.43	1.17**	0.05	1.25**	2.59**
P_4	-7.00**	-6.6**	-27.19**	-1.75**	-1.57**	-6.63**	3.6**	2.89**	12.96**	1.45**	-0.67	1.55**
P_5	0.43	-0.22	0.41**	1.49**	1.1**	5.17**	0.98**	0.99*	3.94**	1.68**	1.29**	5.93**
P_6	3.16**	3.29**	12.89**	-0.89**	-0.74**	-3.25**	0.60*	-0.38	0.44**	-0.70**	-0.67	-2.73**
P_7	-1.14**	-0.58*	-3.43**	0.71**	1.49**	4.41**	-0.73*	0.39	-0.70**	0.06	2.02**	4.17**
SE (g_i)	0.24	0.19	0.04	0.01	0.04	0.01	0.20	0.32	0.05	0.15	0.31	0.05
LSD $_{0.05}$	0.58	0.46	0.09	0.03	0.09	0.01	0.49	0.77	0.13	0.36	0.75	0.13
LSD $_{0.01}$	0.88	0.70	0.14	0.04	0.14	0.02	0.74	1.17	0.20	0.54	1.14	0.20

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

b- Specific combining ability effects (SCA)

Estimates of specific combining ability effects (SCA) for the twenty-one crosses at the two sowing dates and their combined data are presented in Table 5. The results illustrated that, three crosses (P_1 x P_3), (P_1 x P_5) and (P_6 x P_7) exhibited significant negative desirable

(SCA) effects for days to heading, suggesting that these specific crosses have good genes for earliness. Eight crosses (P_1 x P_4), (P_1 x P_7), (P_2 x P_5), (P_2 x P_6), (P_3 x P_4), (P_4 x P_5), (P_4 x P_6) and (P_4 x P_7) showed significant positive desirable (SCA) effects for No. of spikes/plant. The three hybrid combinations (P_1 x P_4), (P_1 x P_6) and (P_4 x P_5) exhibited significant positive desirable (SCA) effects for 1000 grain weight. Three crosses (P1 x P6), (P_2 x P_5) and (P_4 x P_5) showed significant desirable (SCA) for grain yield/plant. It is of interest to mention that, combination (P_1 x P_4) showed significant ($p\leq$ 0.01%) desirable (SCA) effects for days to heading, No. of spikes/plant, 1000-grain weight and grain yield/plant. Also, the cross combination (P_4 x P_5) had a desirable (SCA) effect for No. of spikes/plant, 1000-grain weight and grain yield/plant. Meanwhile, the cross (P_1 x P_6) had a desirable (SCA) effect for days to heading, 1000-grain weight and grain yield/plant. These promising crosses could be used in a breeding program to improve both earliness and grain yield and som of its components.

Table 5. Estimates of specific combining ability effects (SCA) of crosses for all studied traits at normal (N), late (L) sowing dates and their combined data.

Crosses	Days to heading			No. of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
P_1 x P_2	3.37*	3.76**	3.57**	-0.91**	-0.90**	-0.90**	1.61	1.90	1.77**	0.88	1.18	1.03**
P_1 x P_3	0.3	-2.26*	-0.98**	0.44**	-0.75**	-0.16**	2.79**	1.04	1.93**	1.34	-1.46	-0.06
P_1 x P_4	-1.17	-1.62	-1.4**	2.86**	0.79**	1.82**	4.67**	3.23*	3.95**	4.66**	3.05	3.85**
P_1 x P_5	-0.77	-2.061*	-1.42**	-2.36**	-1.92**	-2.14**	-3.16**	-2.01	-2.58**	-2.74**	-2.75	-2.75**
P_1 x P_6	-1.3	-0.12	-0.71**	-0.10	-0.44*	-0.27**	6.06**	5.00**	5.53**	5.06**	3.40*	4.2291**
P_1 x P_7	-0.99	1.41	0.21*	0.62**	1.66**	1.14**	-6.73**	-1.87	-4.30**	-2.14**	4.82**	1.34**
P_2 x P_3	1.17	1.23	1.21**	0.03	0.03	0.03	3.00**	0.20	1.59**	0.58	-1.39	-0.41**
P_2 x P_4	1.92	0.42	1.17**	-1.42**	-1.98**	-1.70**	-0.11	-1.37	-0.74**	-0.32	0.104	-0.107
P_2 x P_5	2.09	-0.54	0.78**	1.08**	1.22**	1.15**	-0.90	1.62	0.36*	2.10**	4.25**	3.18**
P_2 x P_6	2.324	2.186*	2.26**	0.70**	0.50*	0.60**	1.42	2.03	1.73**	2.86**	2.18	2.52**
P_2 x P_7	2.09	1.94*	2.013**	-1.23**	-0.20	-0.71**	-1.77	-3.05	-2.41**	-0.52	-2.13	-1.33**
P_3 x P_4	2.22	3.48**	2.85**	0.75**	2.15**	1.45**	-4.28	-3.22	-3.75**	-1.35	1.52	0.08
P_3 x P_5	-1.17	-0.82	-0.99**	-0.65**	-1.06**	-0.86**	0.491	-1.41	-0.46**	0.46	-2.82	-1.18**
P_3 x P_6	-1.02	-0.78	-0.9**	-0.37**	-0.03	-0.20**	0.50	-0.96	-0.23	0.65	-1.8	-0.59**
P_3 x P_7	-1.57	-1.75	-1.66**	-0.98**	-1.97**	-1.48**	-1.035	-1.944	-1.49**	0.28	6.68**	3.43**
P_4 x P_5	-0.78	0.61	-0.09	0.56**	0.79**	0.67**	3.513**	3.77**	3.64**	5.40**	4.29**	4.85**
P_4 x P_6	5.77**	4.84**	5.31**	1.68**	2.01**	1.85**	4.749**	1.431	3.09**	3.26**	2.34	2.80**
P_4 x P_7	0.465	0.95	0.7063**	0.55**	0.48*	0.52**	4.754**	2.70	3.73**	3.19**	0.16	1.68**
P_5 x P_6	0.061	1.585	0.823**	-0.09	-0.65**	-0.37**	-8.29**	-6.07**	-7.18**	-4.80**	-1.18	-3.00**
P_5 x P_7	3.08*	0.46	1.77**	0.19**	0.02	0.10**	2.21	-0.15	1.03**	0.90	-1.35	-0.22
P_6 x P_7	-0.43	-2.38*	-1.4**	-0.64**	-1.64**	-1.14**	-6.57**	-6.76**	-6.67**	-4.77**	-4.00*	-4.38**
SE(Sij)	1.16	0.92	0.09	0.05	0.19	0.01	0.98	1.55	0.13	0.71	1.51	0.13
LSD $_{0.05}$ (S_{ij}-S_{ik})	2.41	1.92	0.19	0.11	0.39	0.03	2.04	3.22	0.27	1.48	3.14	0.27
LSD $_{0.01}$ (S_{ij}-S_{ik})	3.28	2.61	0.26	0.14	0.52	0.04	2.77	4.38	0.37	2.01	4.27	0.37

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

Estimates of heterosis :

a- Heterosis over mid parents

Estimates of heterosis over mid parents for all studied traits are given in Table 6. The results showed that the cross combinations (P_1 × P_5), (P_3 × P_5) and (P_3 × P_7) were significantly earlier than their mid parents at each sowing date and combined data. Also the cross combination (P_1 × P_3) exhibited significant negative desirable (SCA) effects for this traits at the late sowing date and combined data. Regarding No.of spikes/ plant, the cross combinations (P_1 × P_4), (P_1 × P_7), (P_2 × P_5), (P_3 × P_4), (P_4 × P_5), (P_4 × P_6) and (P_4 × P_7) exhibited significant ($p\leq$ 0.01%) desirable heterosis over their mid parents at the both sowing dates and their combined data. The maximum heterotic effect for No. of spikes/plant was obtained from the cross (P_1 × P_4) 38.16% under normal sowing date. While, the cross (P_4 × P_6) gave high estimate of heterosis (45.03% and 38.01%) under late sowing date and combined data, respectively. Moreover, all these hybrids showed significant positive desirable (SCA) effects for this trait at both sowing dates and their combined data. As for 1000-grain weight, the cross combinations (P_1 × P_2), (P_1 × P_4), (P_1 × P_6) and (P_4 × P_5), manifested highly significant desirable heterosis at the both sowing dates and their combined data. The cross combination (P_1 × P_4) recorded the maximum heterotic of 21.70%, 20.34% and 21.09% for 1000-grain weight under normal, late sowing dates and their combined data; respectively. The cross combinations (P_1 × P_4) and (P_1 × P_6) exhibited significant positive desirable (SCA) effects for 1000-grain weight at both sowing dates and their combined data. Concerning grain yield/plant, ten out of twenty-one cross combinations showed significant ($p\leq$ 0.01%) desirable heterosis over their mid parents toward increasing yield at both sowing dates and their combined data. Three crosses of them (P_1 × P_6), (P_2 × P_5) and (P_4 × P_5) appeared significant positive desirable (SCA) effects for grain yield/plant at both sowing dates and their combined data. It could be noticed that the cross (P_1 × P_4) gave high heterotic values of 29.29%, 42.96% and 34.06% under normal, late sowing date and their combined data, respectively. These results agree with those obtained by El-Hossary *et al.,* 2000, Hamada *et al.,* 2002, Koumber *et al.,* 2006 and Moussa and Morad, 2009.

Table 6. Estimates of heterosis over mid parents for all studied traits under normal (N), late (L) sowing date and their combined data.

Crosses	Days to heading			No. of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
P_1 x P_2	7.34	6.89	7.12	-8.48^{**}	-16.13^{**}	-11.61^{**}	9.20^{**}	14.04^{**}	11.21^{**}	11.99^{**}	23.45^{**}	16.00^{**}
P_1 x P_3	0.16^{**}	-3.07^{**}	-1.42^{**}	2.63^{**}	-13.62^{**}	-4.42^{**}	10.52^{**}	3.84	7.56^{**}	9.85^{**}	3.28	7.28^{*}
P_1 x P_4	0.97^{**}	0.42^{**}	0.69^{**}	38.16^{**}	18.49^{**}	29.97^{**}	21.70^{**}	20.34^{**}	21.09^{**}	29.29^{**}	42.96^{**}	34.06^{**}
P_1 x P_5	-0.32^{**}	-2.88^{**}	-1.56^{**}	-16.01^{**}	-22.41^{**}	-18.70^{**}	-7.50^{**}	-3.68	-5.86^{*}	-1.70	-2.49	-2.00
P_1 x P_6	-0.10^{**}	1.13	0.50^{**}	2.59^{**}	-9.11^{**}	-2.45^{**}	15.63^{**}	16.87^{**}	16.17^{**}	20.76^{**}	26.85^{**}	23.01^{**}
P_1 x P_7	-0.52^{**}	1.58	0.50^{**}	2.60^{**}	6.95^{**}	4.56^{**}	-17.42^{**}	-8.08^{*}	-13.33^{**}	-3.01^{*}	34.17^{**}	11.12^{**}
P_2 x P_3	4.97	3.89	4.45	-4.16^{**}	-6.95^{**}	-5.28^{**}	9.25^{**}	-2.98	3.91	6.85^{**}	-0.87	3.92
P_2 x P_4	9.42	6.62	8.06	-5.49^{**}	-18.30^{**}	-10.48^{**}	8.85^{**}	1.77	5.80^{*}	14.06^{**}	23.36^{**}	17.15^{**}
P_2 x P_5	6.93	1.86	4.46	2.02^{**}	4.52^{**}	3.10^{**}	-3.41^{*}	2.57	-0.88	10.16^{**}	24.68^{**}	15.49^{**}
P_2 x P_6	7.86	6.89	7.39	4.25^{**}	1.20	3.05^{**}	3.67^{*}	3.06	3.41	13.76^{**}	17.38^{**}	15.07^{**}
P_2 x P_7	7.10	5.37	6.25	-13.48^{**}	-8.27^{**}	-11.26^{**}	-6.92^{**}	-15.28^{**}	-10.57^{**}	0.30	-0.28	0.07
P_3 x P_4	5.24	7.05	6.11	15.79^{**}	34.23^{**}	23.47^{**}	-1.26	-8.13^{**}	-4.36	7.73^{**}	20.51^{**}	12.55^{**}
P_3 x P_5	-0.61^{**}	-1.43^{**}	-1.01^{**}	-7.19^{**}	-15.18^{**}	-10.59^{**}	-1.38	-10.24^{**}	-5.31^{*}	3.15^{*}	-9.50^{**}	-1.89
P_3 x P_6	0.35^{**}	0.39^{**}	0.36^{**}	-2.04^{**}	-4.93^{**}	-3.29^{**}	0.68	-10.05^{**}	-4.08	4.49^{**}	-5.81	0.40
P_3 x P_7	-1.02^{**}	-2.13^{**}	-1.57^{**}	-9.95^{**}	-21.96^{**}	-15.35^{**}	-6.08^{**}	-15.48^{**}	-10.37^{**}	0.01	29.05^{**}	11.67^{**}
P_4 x P_5	2.43^{*}	3.46	2.94	11.72^{**}	16.41^{**}	13.65^{**}	10.59^{**}	11.22^{**}	10.86^{**}	24.48^{**}	32.72^{**}	27.49^{**}
P_4 x P_6	11.30	10.85	11.08	33.23^{**}	45.03^{**}	38.01^{**}	15.48^{**}	4.60	10.73^{**}	20.99^{**}	26.95^{**}	23.12^{**}
P_4 x P_7	4.14	4.42	4.27	11.97^{**}	12.30^{**}	12.11^{**}	11.80^{**}	3.93	8.28^{**}	16.15^{**}	18.37^{**}	16.97^{**}
P_5 x P_6	2.25^{*}	3.19	2.71	-0.79^{**}	-10.26^{**}	-4.78^{**}	-20.36^{**}	-22.04^{**}	-21.07^{**}	-9.88^{**}	-3.38	-7.36^{**}
P_5 x P_7	5.01	0.51^{**}	2.82	-3.01^{**}	-5.94^{**}	-4.28^{**}	-3.14^{*}	-9.77^{**}	-6.07^{**}	1.12	-0.78	0.37
P_6 x P_7	1.79^{*}	-1.04	0.41^{**}	-5.16^{**}	-18.75^{**}	-11.28^{**}	-18.81^{**}	-27.47^{**}	-22.62^{**}	-12.72^{**}	-11.14^{**}	-12.11^{**}
LSD $_{0.05}$	1.77	0.45	1.58	0.08	0.28	0.20	1.50	2.36	1.96	1.09	2.31	1.79
LSD $_{0.01}$	2.36	0.59	2.09	0.10	0.38	0.26	1.99	3.14	2.58	1.44	3.07	2.36

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

b- Heterosis over better parent

The heterotic values over the better parent for all studied traits are presented in Tables 7. The results indicated that the cross combinations (P_1 × P_3) and (P_1 × P_5) exhibited negative significant heterotic values in relation to better parents for days to heading. The results indicated that the cross combination (P_4 × P_6) was the best hybrid for No. of spikes/plant with positive significant desirable heterotic values of 12.16%, 12.25% and 12.20% over better parent at normal, late sowing dates and combined data; respectively. Concerning 1000-grain weight, only three out of twenty-one crosses revealed significant desirable heterosis values over better parent under normal date and combined data. The maximum heterotic values over better parent for this trait were 13.47% and 10.02% for the cross (P_4 × P_6) under normal date and combined data, respectively. As for grain yield/plant, six crosses out of twenty-one crosses were significantly better yielding than their better parents under the both two sowing dates and their combined data. The cross combination (P_1 × P_4) was the best for the same trait with heterotic values of 28.22%, 35.38% and 32.20% at normal, late sowing dates and their combined data; respectively. These results are in harmony with those obtained by Chowdhry *et al.,* 2001 and Farooq *et al.,* 2005.

In general, the promising crosses in this study which gave desirable heterotic values over mid and better parents reflect high degree of genetic diversity among the parental genotypes and supporting the important role of non-additive gene action in the inheritance of these traits. The crosses which gave desirable heterotic values over better parents viz. (P_1 x P_5) for days to heading, (P_4 x P_6) for No. of spikes/plant and 1000-grain weight and (P_1 x P_4) for grain yield/plant. It is considered a superior cross combinations can be used in breeding programs to get better transgressive segregants.

Genetic parameters:

Estimates of gene action for all studied traits under the two planting dates and their combined data are presented in Table 8. The results showed that the magnitudes of additive gene action were higher than those of non-additive gene action for No. of days to heading and No. of spikes/plant under both planting dates and their combined data, suggesting the important role of additive gene effects in the inheritance of these traits. On the other hand, the additive variance was lower than that of non-additive for 1000 grain weight and grain yield/plant under both planting dates and their combined data, confirming that the non-additive gene action played the major role in the inheritance of these traits. The interaction of σ^2 g x D variances were lower than those of σ^2 s x D variance for all studied traits under both sowing dates and their combined data, reflecting that non additive gene effects were more affected by planting dates than additive ones. Concerning heritability values, the estimate of broad sense heritability (h^2 $_{BS}$) were higher than those of narrow sense heritability for all studied traits under the both two sowing dates and their combined data. Narrow sense heritability estimates (h^2 $_{NS}$) were more than 50% for number of days to heading and No. of spikes per plant under the two sowing dates and their combined data. Whereas, the estimate of narrow sense heritability was less than 50% for 1000 grain weight per plant and grain yield per plant under the both sowing dates and their combined data. Subhani and Chowdhry, 2000 observed that high estimates of narrow sense heritability for heading dates and 1000-grain weight. Moreover, additive genetic effects were more prevalent than non-additive genetic effects under both environments for all traits.

Table 7. Estimates of heterosis over better parent for all studied traits under normal (N), late (L), sowing dates and their combined data.

Crosses	Days to heading			No. of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
P_1 x P_2	13.52	12.15	1.95**	-9.18**	-24.39**	-15.78**	2.69	9.78*	5.60	10.08**	15.01*	11.87**
P_1 x P_3	0.56**	-3.04**	-1.23**	0.74*	-15.62**	-6.40**	0.06	-11.44**	-5.19	3.84*	-10.57*	-2.08
P_1 x P_4	16.74	16.88	-11.51	6.88**	-15.48**	-2.83**	9.18**	4.33	7.02*	28.22**	35.38**	32.20**
P_1 x P_5	2.11**	-0.43**	-3.89**	-23.46**	-28.02**	-25.34**	-20.16**	-17.94**	-19.19**	-10.80**	-15.78**	-12.74**
P_1 x P_6	0.08**	1.29	0.33**	-7.65**	-19.17**	-12.64**	2.14	2.01	2.10	16.56**	17.95**	17.05**
P_1 x P_7	3.87	5.07	-3.16	-2.68**	-3.48**	-3.08**	-27.58**	-23.39**	-25.70**	-10.98**	16.51**	-0.18
P_2 x P_3	11.49	8.97	-0.78**	-6.63**	-17.85**	-11.51**	4.91**	-14.49**	-3.96	-0.62	-19.13**	-8.21*
P_2 x P_4	19.10	17.76	-0.66**	-26.48**	-37.44**	-30.76**	3.51	-8.76*	-1.94	11.20**	21.25**	14.54**
P_2 x P_5	10.31	4.18	1.75**	-7.67**	-11.86**	-9.39**	-11.88**	-9.69**	-10.94**	-1.57	1.49	-0.38
P_2 x P_6	13.86	11.97	2.36*	-5.51**	-0.34	-3.47**	-3.05	-6.94	-4.72	7.99**	2.24	5.80
P_2 x P_7	8.43	6.83	4.89	-18.53**	-24.49**	-21.31**	-13.62**	-27.11**	-19.74**	-9.37**	-18.43**	-12.94**
P_3 x P_4	22.24	24.55	-6.91	-11.59**	-5.58**	-8.95**	-2.26	-9.89**	-4.66	2.65	-0.34	1.44
P_3 x P_5	2.24*	1.03	-3.54	-13.96**	-19.55**	-16.28**	-6.52**	-10.35**	-8.17**	-1.23	-9.77	-4.55
P_3 x P_6	0.93**	0.51**	0.72**	-13.26**	-17.17**	-14.97**	-2.06	-12.46**	-4.40	2.26	-12.81*	-3.92
P_3 x P_7	3.77	1.20	-5.33	-13.04**	-28.04**	-19.97**	-9.37**	-17.81**	-13.21**	-3.07*	28.61**	9.72**
P_4 x P_5	15.32	17.11	16.19	-18.99**	-20.55**	-19.63**	5.85**	8.96*	7.19**	13.81**	9.51*	12.13**
P_4 x P_6	28.44	28.80	-2.24*	12.16**	12.25**	12.20**	13.47**	3.77	10.02**	17.72**	12.24*	15.61**
P_4 x P_7	14.88	17.08	-5.26	-16.53**	-24.57**	-20.24**	8.96**	-0.81	4.54	7.42**	-1.84	3.78
P_5 x P_6	4.56	5.63	0.44**	-17.73**	-25.25**	-20.88**	-22.46**	-24.22**	-23.20**	-15.48**	-10.81*	-13.64**
P_5 x P_7	6.98	1.37	1.44**	-7.04**	-8.70**	-5.25**	-4.92**	-12.15**	-6.21*	-0.14	-1.41	-0.64
P_6 x P_7	6.08	2.20	-3.10	-18.53**	-33.91**	-25.67**	-19.48**	-31.30**	-24.83**	-17.16**	-17.49**	-17.29**
LSD $_{0.05}$	2.05	0.52	1.83	0.09	0.33	0.23	1.73	2.73	2.26	1.25	2.66	2.06
LSD $_{0.01}$	2.72	0.69	2.42	0.12	0.43	0.30	2.30	3.63	2.98	1.67	3.54	2.73

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

Table 8. Estimates of genetic parameters for all studied traits under normal (N), late (L) sowing dates and their combined data .

Traits	Days to heading			No of spikes/plant			1000 grain weight (g)			Grain yield/plant (g)		
Components	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
σ^2 g	21.39	19.15	20.56	1.94	2.04	1.88	4.74	3.57	3.80	0.33	2.57	0.70
σ^2 s	7.06	6.10	5.81	1.66	1.87	1.41	19.57	11.70	13.55	11.89	1.95	7.43
σ^2 $g_{x D}$	---	---	-0.08	---	---	0.12	---	---	0.36	---	---	0.88
σ^2 $s_{x D}$	---	---	0.77	---	---	0.36	---	---	2.09	---	---	3.88
Error	0.52	0.33	0.43	0.001	0.01	0.01	0.37	0.93	0.65	0.20	0.89	0.54
h^2_{NS}	73.83	74.87	74.79	53.86	52.07	49.74	19.19	22.04	18.58	2.65	47.47	5.21
h^2_{BS}	98.2	98.70	95.93	99.97	99.69	87.04	98.49	94.27	84.84	98.41	93.84	60.54

σ2 g, σ2 s are GCA and SCA Variances respectively.

Estimates of correlation coefficient

Assessment of correlation coefficient among all studied traits are given in Table 9. The results showed that grain yield/plant was significantly and positively correlated with No. of spikes/plant at normal and late sowing dates (0.34 and 0.56, respectively), and with 1000 grain weight at normal and late sowing dates (0.82 and 0.50, respectively). 1000 grain weight was significantly and negatively correlated with days to heading at normal and late sowing dates (-0.28 and -0.37, respectively), but not significantly correlated with No. of spikes/plant at normal and late sowing dates (-0.02 and 0.17, respectively). No. of spikes/plant was significant and positively correlated with days to heading at normal and late sowing dates (0.39 and 0.36, respectively). These results are in agreement with those reported by Saleem *et al.,* 2006, Khan *et al.,* 2008 and Tahmasebi *et al.,* 2013, except 1000 grain weight was significantly and negatively correlated with No. of spikes/plant.

Table 9 . Estimates of correlation coefficient among all studied traits under normal and late sowing dates.

Traits	No of spikes/plant		1000 grain weight (g)		grain yield/plant (g)	
	N	L	N	L	N	L
Days to heading	0.39**	0.36**	-0.28**	-0.37**	-0.12	0.09
No. of spikes/plant			-0.02	0.17	0.34**	0.56**
1000 grain weight (g)					0.82**	0.50**

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

In conclusion, mean squares of G X D interaction were found to be highly significant for all studied traits, indicating that these genotypes were inconsistent from environment to another. The promising crosses in this study which gave desirable heterotic values over mid and better parents reflect high degree of genetic diversity among the parental genotypes. The estimate of genetic parameters in this study presented the evidence of the important role of additive gene action for number of days to heading and No. of spikes per plant under each sowing date and combined data. Whereas, that non additive gene action played a major role in controlling of 1000 grain weight per plant and grian yield per plant under each planting date and combined data. The results showed that the estimates of σ^2 g x D interaction were lower than those of σ^2 s x D variance for all studied traits under each environments and their combined data, reflecting that non additive gene effects were more affected by planting dates than additive ones.

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دراسات على قوة الهجين والقدرة على التآلف لمحصول الحبوب وبعض مكوناته فى قمح الخبز تحت ظروف ميعادى الزراعه العاديه والمتأخره

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أُجريت هذه الدراسة على سبعة أصناف من قمح الخبز بعمل كل التهجينات الممكنه بينهما بنظام التهجين النصف دائرى بدون الهجن العكسية وذلك فى مركز التجارب بكلية الزراعه جامعة سوهاج خلال موسمين متتالين 2014/2013 و 2015/2014 لدراسة القدره على التآلف وقوة الهجين والتفاعل تحت ظروف ميعادين للزراعة 15 نوفمبر (موعد الزراعه العادى) و 15 ديسيمبر (موعد الزراعه المتأخر) فى تجربتين متجاورتين وذلك لدراسة عدد الأيام من الزراعه حتى طرد السنابل ، عدد سنابل النبات ، وزن 1000 حبه ومحصول حبوب النبات . أظهرت النتائج أن متوسط مربع الانحرافات لمواعيد الزراعه كانت عاليه المعنوية بالنسبة لكل الصفات تحت الدراسة وكانت قيمها عاليه فى ميعاد الزراعه العادى مقارنة بميعاد الزراعه المتآخر . أظهر متوسط مربع الانحرافات للتراكيب الوراثية اختلافات معنوية عاليه لكل الصفات تحت الدراسة فى كلا ميعادى الزراعه والتحليل المشترك على الترتيب. كان المتوسط العام للتراكيب الوراثية (88.98 ، 83.76 و 86.37 يوم) لصفة عدد الايام حتى طرد السنابل ، (13.87 ، 10.00 و 11.94) لصفة عدد سنابل النبات ، (47.26 ، 35.41 و 41.34 جم) لصفة وزن 1000 حبه و (39.43 ، 24.58 و 32.01 جم) لصفة محصول حبوب النبات ، لموعد الزراعه العادى والمتأخر والتحليل المشترك بينهما على الترتيب. تسبب موعد الزراعه المتأخر (الاجهاد الحرارى) فى نقص عدد الايام حتى طرد السنابل وقدره (5.87%) ، عدد سنابل النبات وقدره (27.90%) ، وزن 1000 حبه وقدره (25.07%) ووزن حبوب النبات وقدره (37.66%) مقارنة بموعد الزراعه العادى (المناسب). كان متوسط مربع الانحرافات الخاص بالقدرة العامه والخاصه على التآلف معنويًا لجميع الصفات تحت الدراسة فى كلا ميعادى الزراعه والتحليل المشترك وأكد التحليل الوراثى لهذه الصفات مساهمة كل من الفعل المضيف والغير مضيف للجينات فى التحكم فى وراثة هذه الصفات . كان التفاعل بين ميعادى الزراعه والقدرة العامه على الائتلاف غير معنوى بينما كان التفاعل بين ميعادى الزراعه والقدرة الخاصة على الائتلاف معنويًا لكل الصفات تحت الدراسة . أظهرت النتائج اقتراب نسبة GCA/SCAمن الواحد الصحيح لكل الحالات عدا عدد سنابل/النبات ومحصول حبوب/النبات فى موعد الزراعه العادى مما يشير الى سيطرة الفعل الجينى المضيف على وراثة كل هذه الحالات . أظهر الأب (P_5) أفضل قدره عامه على الائتلاف لمحصول حبوب النبات فى كلا ميعادى الزراعه والتحليل المشترك . أظهر الهجين ($P_4 \times P_1$) تأثير معنوى عالى ومرغوب للقدرة الخاصه على الائتلاف لصفات عدد الأيام من الزراعه حتى الطرد ، عدد سنابل النبات ، وزن 1000 حبه ومحصول حبوب النبات . أظهرت ستة هجن ($P_2 \times P_1$) ، ($P_4 \times P_1$) ، ($P_6 \times P_1$) ، ($P_4 \times P_2$)، ($P_5 \times P_4$) و ($P_6 \times P_4$) تأثيرات معنوية مرغوبة لقوة الهجين بالنسبه للأب الأفضل تراوحت من 10.8% الى 35.38% وذلك فى كلا ميعادى الزراعه والتحليل المشترك .