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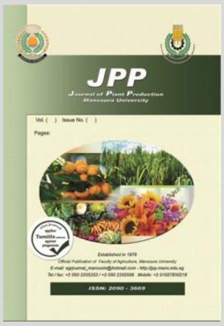
Estimation of Combining Ability for Earliness and Morpho-Physiological Traits of some Bread Wheat Genotypes under Optimum and Late Sowing Dates

Nour Y. Elsherbini[1]; M. A. Abdel-Moneam[1*]; M. N. A. El-Hawary[2] and Soad H. Haffez[1]

[1] Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt.
[2] Wheat Research. Department, Field Crop Research Institute., Agricultural Research center, Egypt



ABSTRACT

Using a half-diallel model, six genotypes of bread wheat were crossed during 2021/2022 season, to determine the genetic effects. Parents and their F_1 were examined utilizing a randomized complete block design (RCBD) with 3 replications under optimum and late sowing dates in the 2022/2023 season on the research farm of the agronomy division, faculty of agriculture, Mansoura University,Dakahlia Governorate, Egypt. Data were taken on the earliness and physiological characteristics. Results revealed that the variance of sowing dates were significant for every examined attribute except for total chlorophyll content.The sowing date × genotypes interactions were found to be significant for every attribute except for grain filling rate.The variance of general (GCA) and specific (SCA) combining ability were significant for every examined attribute at each sowing date except for days to maturity, grain filling period, grain filling rate under late sowing date, and chlorophyll content under late sowing date due to SCA. GCA/SCA ratio was more than unity for days to heading, days to anthesis and flag leaf area under optimum sowing date, days to maturity and chlorophyll under content late sowing date, grain filling period, grain filling rate under optimum and late sowing date, it means that the control of these traits was more dependent on additive genetic impact.Results showed that crosses P_1xP_3, P_3xP_4 and P_5xP_6 exhibited significant and negative SCA effects, heterosis and heterbeltiosis for most earliness traits under study.Therefore, we can recommend introducing these hybrids into the wheat breeding program to increase productivity, whether in early or late planting.

Keywords: Wheat (*Triticum aestivum* L.), sowing dates, combining ability, heterosis.

INTRODUCTION

Among the most important harvests of cereals ensuring worldwide food security is wheat (*Triticum aestivum*). However, in order to satisfy the predicted 10 billion people by 2050, an extra190 million tons of wheat grain must be produced (Abasi *et al.*, 2024). 222 million hectares of wheat were planted in 2021–2022, yielding 779 million metric tons of grain worldwide. Diseases and pests that are constantly changing and expanding to new places due to changes in agricultural practices, climate, and international trade pose a threat to wheat production worldwide (Pequeno *et al.*, 2024). Plant growth and development are harmed by rising temperatures and consequent climatic changes, which results in a devastating decline in wheat production. Statistics indicate that for every degree that the temperature rises, wheat yield collapses by 6%. Elevated temperatures adversely affect various physiological, biological, and biochemical processes in wheat; Heat stress impacts seed germination, grain filling duration, grain number, Rubisco enzyme activity, photosynthetic capacity, assimilate translocation rate, leaf senescence, amount of chlorophyll, and total yield Late planting of wheat significantly affects spikes plant^{-1}, spikelets spike^{-1}, and grain weight which eventually results in decreased yield (It is approximate that delayed planting (late December) causing around loss of 38% decline in the grain yield (Ul-allah *et al.*, 2021). Genetic diversity analysis is one of the greatest techniques to identify the best donors for heat tolerance in crop improvement breeding in order to handle the problem of heat stress in wheat programs (Jaiswal *et al.*, 2024). Heterosis is the ability of a hybrid to outperform the mid-parent value or better parents. Wheat breeders working on different aspects of hybrid wheat discovered that the conventional heterotic effect for grain yield ranged from 6% to 41% on a large plot basis (Baloch *et al.*, 2024). Similarly, the most widely used biometric technique for identifying the genotypes of the parents based on their ability to blend into hybrids is the combining ability analysis (Griffing, 1956). It separates the genetic variation into two categories: specific combining ability (SCA), which evaluates the dominance of one gene effect, and general combining ability (GCE), which evaluates additive gene effects. In many crop species, heterosis has been effective but crucial in enhancing agricultural plant's productivity. Nowadays, it is a well-established fact that heterosis does arise with suitable parental combinations; In wheat, hybrid vigor has a direct association with the effective selection of potential parents. Wheat breeders working on different aspects of hybrid wheat discovered that the conventional heterotic effect for grain yield ranged from 6% to 41% on a broad plot basis (Baloch *et al.*, 2024) This information would be valuable to plant breeders for types of genetic variants in the attributes (Ali 2018). The purpose of this study was to estimate the combining ability effects under normal and late planting dates, besides to evaluate the heterotic amounts for the

*** Corresponding author.**
E-mail address: maaelmoneam@mans.edu.eg
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earliness and physiological characters under normal and late sowing dates.

MATERIALS AND METHODS

Six genotypes for bread wheat were selected as parents in this investigation, indicating a variety of variability in various parameters. Table (1) contains the names of the parents, as well as their pedigree and origin. during the 2021/2022 season, planted the parental genotypes at different dates to compensate for discrepancies in flowering time. All feasible parallel combinations, avoiding reciprocals, formed between the six parents, resulting fifteen hybrids.

Table 1. Parents names, pedigree and origin.

No	Genotype	Pedigree	Origin
P_1	SIDS 14	BOW"S"/VEE"S"//BOW"S"/TSI/3/BANI SEWEF 1 SD293-1SD-2SD-4SD-0SD	Egypt
P_2	SAKHA 94	OPATA/RAYON//KAUZ CMBW90Y3180-0TOPM-3Y-010M- 010M-010Y-l0M-0I5Y-0Y-0AP-0S.	Egypt
P_3	SAKHA 95	PASTOR//SITE/MO/3/CHEN/ AEGILOPSSQUARROSA(TAUS)//BCN/4/WBLL1 CMSA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S.	Egypt
P_4	GIZA 168	MRL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B.	Egypt
P_5	LINE 1	CBSME4SA-BV05 CMSW96WM00910S-3DNB-010B-4DNB-015B-03DNB-0Y	CIMMYT*
P_6	MISR 3	Rohf 07*2/KiritiCGSS 05 B00123T-099T-0PY-099M-099NJ-6WGY-0B-0BGY-0GZ.	Egypt

In 2022/2023 season, the 21 entries (6 parents and 15 F_1) were examined in 2 distinct planting dates tests. the first experimental was sown on the optimum planting date of 12th November while, the second experiment was sown on late planting date of 12th December.

Table (2) showed the average, minimum and maximum temperatures at Mansoura during the 2022/2023 season (2) https://eg.freemeteo.com/weather/egypt.

Table 2. Mean, Maximum, and Average temperature (℃) at Mansoura during 2022/2023 season.

Months	Min	Max	Temperature (℃) Mean Read 1	Read 2	Read 3
November	15	27	21.75 (1 Nov-10 Nov)	21.55 (11 Nov- 20 Nov)	19.55 (21 Nov- 30 Nov)
December	10	26	19.25 (1 Dec-10 Dec)	20.15 (11 Dec-20 Dec)	17.09 (21 Dec-31 Dec)
January	9	24	17.25 (1 Jan-10 Jan)	15.6 (11 Jan-20 Jan)	16.82 (21 Jan-31 Jan)
February	8	24	12.8 (1 Feb-10 Feb)	13.9 (11 Feb-20 Feb)	16.5 (21 Feb-28 Feb)
March	11	31	17.95 (1 Mar-10 Mar)	17.65 (11 Mar- 20 Mar)	17.82 (21 Mar-31 Mar)
April	11	30	19.90 (1 Apr-10 Apr)	18.60 (11 Apr-20 Apr)	19.65 (21 Apr- 30 Apr)
May	16	33	20.70 (1 May-10 May)	21.25 (11 May-20 May)	23.45 (21 May-31 May)

During soil preparation, both of the 2 investigations received fertilization with 15 kg P_2O_5/fad, 24 kg K_2O/fad in single dose, and 75 kg N/fad supplied in two equal doses. Following 27 days from planting, the first dose was 30% with planting and the second was 70% with the first irrigation. The two investigations were carried out in the experimental farm of the agronomy department, faculty of agriculture, Mansoura University, Dakahlia Governorate, Egypt, utilizing RCBD with three replications.

Every replication had 21 rows (genotypes) beside two rows (borders) that were 4 m long and 25 cm apart, with a 20 cm spacing among plants. Each row was sown with twenty grains, which were then manually drilled. All other cultural techniques, with the exception of planting dates, were followed as indicated for wheat cultivation. To reduce border impact, removed the two outside plants and the two exteriors of each row in each plot for each character, ten plants were used to determine the attributes.

The studied characters were, days to heading (DH), days to anthesis (DA), days to maturity (DM), grain filling period (GFP), grain filling rate (GFR, g/day), flag leaf area (FLA, cm^2), total chlorophyll content (T.Chlo.), plant height (PH, cm).

Plot mean analysis was performed on the collected data for each trait in the parents and F_1. To examine the association between genotypes and sowing date conditions, all collected data were analyzed statistically using the randomized complete block design method, as explained by Gomez and Gomez (1984). A combined analysis of the two investigations was carried out (optimum and late deficit sowing dates) to indicate the sowing dates effects according to Snedecor and Cochran (1980). Treatments were compared using the least differences values (LSD) at 5% and 1% level of probability.

The Griffing (1956) method 2 model 1 was utilized in an ordinary analysis to measure the impacts of general combining ability (GCA) and specific combining ability (SCA).

For individual crosses, heterosis was defined as the percentage difference between the F1 means and the mid-parent means (MP) and better parent (BP), as defined by Mather and Jinks (1982).

RESULTS AND DISCUSSION

Analysis of variance

The combined analysis of the examined attributes was performed in Tables (3) and (4). Results revealed that sowing dates mean squares were significant for every attribute except total chlorophyll content which indicated significant differences between the optimum and late sowing date condition for these attributes.

Table 3. Combined analysis of variance for earliness studied characters over both sowing dates.

Source of Variation	d.f	Days to heading	Days to Anthesis	Days to maturity	Grain filling period	Grain filling rate
Sowing dates	1	3630.91**	2257.62**	1074.77**	6447.8**	1.22**
Error	4	26.07	40.47	30.87	51.12	0.05
Genotype	20	111.33**	119.52**	21.8**	118.65**	0.1**
S.D X Geno	20	35.57**	57.99**	15.85**	27.78**	0.004
Error	80	2.07	2.96	2	4.75	0.005

***,** significant at 0.05 and 0.01, probability levels, respectively.**

Table 4. Combined analysis of variance for physiological characters.

Sourceof Variation	d.f	Flag leaf area	Total chlorophyll content	Plant height
Sowing dates	1	7208.39**	12.68	771.75*
Error	4	230.21	8.28	38.48
Genotype	20	171.09**	25.22**	70.36**
S.D X Geno	20	41.56*	14.22**	18.95**
Error	80	23.06	3.74	5.58

***,** significant at 0.05 and 0.01, probability levels, respectively.**

The sowing date × genotypes interactions were found to be significant for all traits except for grain filling rate.

Analysis of variance for the examined traits are performed in Tables (5) and (6). The results revealed that mean squares of genotypes, parents, and crosses were significant for most examined attributes under optimum and late sowing dates. Mean squares for the interaction between parents and their F_1's were significant for all traits under each condition except days to maturity under late sowing date, grain filling rate at late sowing date condition, grain filling period at both sowing dates, flag leaf area at optimum sowing date, total chlorophyll content at both sowing dates. These outcomes agreed with the findings published by (Duby *et al.*, 2019), (Ahmed 2021).

Table 5. Estimated mean squares of earliness studied characters for different optimum and late sowing dates.

Source of Variation	d.f	Days to heading		Days to Anthesis		Days to maturity	
		Optimum	Late	Optimum	Late	Optimum	Late
Blocks	2	47.47**	4.67*	69.5**	11.43**	50.29**	11.44**
Genotypes	20	121.33**	25.57**	162.92**	14.59**	30.2**	7.45**
Parents	5	296.41**	14.41**	390.07**	15.82**	56.67**	6.07*
F1's	14	65.29**	29.95**	83.67**	14.84**	18.94**	8.4**
P. vs F1's	1	30.35**	20.08**	136.7**	5.05*	55.5**	1.19
Error	40	2.7	1.44	4.75	1.16	1.91	2.09

***,**significant at 0.05 and 0.01,probability levels, respectively.**

Continued 5.

Source of Variation	d.f	Grain filling period		Grain filling rate	
		Optimum	Late	Optimum	Late
Blocks	2	89.68**	12.56	0.04**	0.07**
Genotypes	20	120.75**	25.67**	0.05**	0.04**
Parents	5	292.74**	39.93**	0.16**	0.11**
F1's	14	66.67**	22.32**	0.018**	0.03**
P. vs F1's	1	18	1.34	0.01*	0.0001
Error	40	5.59	3.92	0.003	0.007

***,**significant at 0.05 and 0.01,probability levels, respectively.**

Table 6. Estimated mean squares of physiological studied characters for different optimum and late sowing dates.

Source of Variation	d.f	Flag leaf area		Total chlorophyll content		Plant height	
		Optimum	Late	Optimum	Late	Optimum	Late
Blocks	2	401.63**	58.79	9.57	6.98	16.22	60.73**
Genotypes	20	91.35**	121.29**	20.00**	19.43**	52.54**	36.77**
Parents	5	143.73**	88.910*	16.14**	49.66**	89.07**	38.29**
F1's	14	79.10**	106.87**	22.64**	9.94*	29.58**	18.18**
P. vs F1's	1	0.974	485.18**	2.37	1.26	191.31**	289.41**
Error	40	19.44	26.68	3.42	4.07	5.66	5.50

***,** significant at 0.05 and 0.01, probability levels, respectively.**

Combining ability:

The mean squares of general and specific combining ability presented in Tables (7) and (8) were significant or highly significant for every examined attribute at optimum and late sowing date except for days to maturity, grain filling period, grain filling rate under, chlorophyll content under late sowing date caused by SCA.

The data obtained showed that, for each sowing dates, the ratio of GCA/SCA was greater than unity for days to heading, days to anthesis and flag leaf area under optimum sowing date, days to maturity, and chlorophyll under content late sowing date, grain filling period, grain filling rate under optimum and late sowing date. This indicates that additive gene activity is mostly responsible for controlling these attributes. Thus, it could be concluded that, In the early segregation generations, selection processes based on the cumulative of additive impact might be higher successful. While for, days to heading, days to anthesis, and flag leaf area under late sowing date, days to maturity and chlorophyll content under optimum sowing date, plant height under optimum and late sowing dates, were mainly controlled by non-additive gene action. So, selection for these traits would be more successful in the late segregation generation. These findings are in agreement with (Aboshosha *et al.*, 2018), (Emad *et al.*, 2018), (Shaban *et al.*, 2019), (Hassan *et al* 2020) and (Meghawal *et al.*, 2021), (Hussien and Zataar., 2024).

Table 7. Mean squares of general combining ability (GCA) and specific combining ability (SCA) and their ratio for earliness characters under optimum and late sowing dates.

Source of Variation	d.f	Days to heading		Days to Anthesis		Days to maturity		Grain filling period, day		Grain filling rate, g/day	
		Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late
GCA	5	127.37**	15.71**	164.61**	13.02**	19.75**	6.02**	144.25**	30.11**	0.063**	0.051**
SCA	15	11.47**	6.13**	17.54**	2.14**	6.84**	1.31	5.59**	1.37	0.003**	0.003
Error	40	0.90	0.48	1.58	0.39	0.64	0.70	1.86	1.31	0.001	0.002
GCA/SCA	-	1.50	0.34	1.28	0.90	0.39	1.09	4.78	55.38	3.18	16.17

***,** significant at 0.05 and 0.01, probability levels, respectively.**

Table 8. Mean squares of general combining ability (GCA)and specific combining ability (SCA)and their ratio for physiological characters under optimum and late sowing dates.

Source of Variation	d.f	Flag leaf area, cm^2		Chlorophyll content		Plant height, cm	
		Optimum	Late	Optimum	Late	Optimum	Late
GCA	5	77.54**	87.66**	8.54**	19.01**	38.68**	19.00**
SCA	15	14.75*	24.69**	6.05**	2.30	10.46**	10.01**
Error	40	6.48	8.89	1.14	1.36	1.89	1.83
GCA/SCA	-	1.07	0.62	0.19	2.34	0.54	0.26

***,** significant at 0.05 and 0.01, probability levels, respectively.**

Combining ability effects:

The estimation of GCA impacts for parents for every examined attribute at optimum and late sowing dates were performed in Tables (9) and (10).

Significant negative GCA values would be the best for every examined attribute except for grain filling rate, flag leaf area and chlorophyll content where significantly positive effects would be useful according to GCA estimation, it could be indicated that the top combiners for days to heading were Giza 168 and line 1 at each dates, Misr 3 under optimum sowing date; for days to anthesis were Giza 168 and line1 at both dates and Misr 3 under optimum sowing; for days to maturity were Sids 14 and line 1 at optimum sowing date and Sakha 95 under late sowing date; for grain filling period were Sakha 94 at each condition and Sakha 95 at optimum sowing date. While for grain filling rate was Sakha 95 at both sowing dates; for flag leaf area were Sids 14 under late sowing date and Giza 168 at optimum and late sowing dates; for total chlorophyll content were Sakha 94 under late sowing date, Line1 and Misr 3 at each condition; for plant height were Giza 168 under optimum and late sowing, Misr 3 under optimum sowing date these findings suggested that these genotypes might be regarded as effective combiners for developing these attributes.

Estimation of SCA effects of hybrids for all examined attributes at optimum and late sowing dates are presented in Tables (11) and (12).

Table 9. Estimates of general combining ability effects for parent genotypes for earliness characters under optimum and late sowing dates.

Parents	Days to heading		Days to Anthesis		Days to maturity		Grain filling period		Grain filling rate	
	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late
Sids 14 (P1)	-0.32	1.03**	-0.59	0.98**	-1.38**	0.48	-0.80	-0.50	-0.01	0.00
Sakha 94 (P2)	4.63**	1.92**	4.02**	1.47**	0.53*	-0.49	-3.49**	-1.96**	0.03*	0.02
Sakha 95 (P3)	4.83**	0.31	6.77**	0.23	1.67**	-0.76**	-5.09**	-0.99	0.16**	0.13**
Giza 168 (P4)	-5.18**	-2.00**	-5.36**	-2.12**	1.46**	1.55*	6.82**	3.67**	-0.07**	-0.06**
Line 1 (P5)	-1.91**	-0.93**	-2.68**	-0.69**	-2.29**	-0.44	0.39	0.25	-0.09**	-0.11**
Misr 3 (P6)	-2.05**	-0.33	-2.17**	0.13	0.01	-0.34	2.17**	-0.47	-0.03*	0.01
S.E (gi)	0.31	0.22	0.41	0.20	0.26	0.27	0.44	0.37	0.01	0.02
S.E (gi-gj)	0.47	0.35	0.63	0.31	0.40	0.42	0.68	0.57	0.02*	0.02

***,** significant at 0.05 and 0.01,probability levels, respectively.**

Table 10. Estimates of general combining ability effects for parental genotypes for physiological characters under optimum and late sowing dates.

Parents	Flag leaf area (cm^2)		Chlorophyll content		Plant height, cm	
	Optimum	Late	Optimum	Late	Optimum	Late
Sids 14 (P1)	0.76	4.10**	-0.30	-0.77*	1.82*	2.41**
Sakha 94 (P2)	-3.31**	-2.72**	-0.36	1.84**	0.23	0.90*
Sakha 95 (P3)	1.87*	-1.13	-1.05**	-2.08**	2.51**	-1.03*
Giza 168 (P4)	4.91**	4.29**	-0.77*	-1.13**	-2.90**	-1.93**
Line 1 (P5)	-2.55**	-1.70	1.65**	1.18**	0.70	0.28
Misr 3 (P6)	-1.67*	-2.83**	0.84*	0.96*	-2.37**	-0.62
S.E (gi)	0.82	0.96	0.34	0.38	0.44	0.44
S.E (gi-gj)	1.27	1.49	0.53	0.58	0.69	0.68

***,** significant at 0.05 and 0.01,probability levels, respectively.**

Table 11. Estimates of specific combining ability effects for F_1 crosses for earliness characters under optimum and late sowing dates.

Crosses	Days to heading		Days to Anthesis		Days to maturity		Grain filling period		Grain filling rate	
	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late
P1XP2	-2.81**	-0.72	-2.22	-0.54	-2.94**	0.18	-0.71	0.72	-0.04	-0.07
P1XP3	-3.05**	-0.80	-6.28**	-0.31	-3.67**	0.00	2.61*	0.31	-0.09**	-0.05
P1XP4	0.07	1.12	0.68	0.29	-0.42	2.52**	-1.11	2.23**	0.03	-0.02
P1XP5	0.44	-0.51	1.25	-0.56	0.65	-0.99	-0.60	-0.43	0.01	0.01
P1XP6	1.59	0.53	1.57	0.82	2.93**	-0.24	1.35	-1.06	0.04	0.10*
P2XP3	1.96*	2.33**	4.31**	0.92	3.20**	0.35	-1.11	-0.58	-0.02	-0.02
P2XP4	-3.67**	-0.25	-4.10**	-1.08	-2.16**	-0.31	1.94	0.77	0.02	0.04
P2XP5	-0.69	-0.70	-3.47**	0.88	-0.50	0.78	2.96*	-0.10	-0.05	-0.02
P2XP6	0.05	1.86**	0.69	0.89	-1.88*	-0.40	-2.57*	-1.29	0.03	0.04
P3XP4	-3.81**	-5.09**	-4.75**	-2.51**	-3.79**	-2.31**	0.97	0.19	-0.06*	-0.03
P3XP5	-1.08	0.13	-3.44**	-0.10	-2.16**	-0.37	1.28	-0.27	-0.04	0.00
P3XP6	-1.79*	-0.01	-4.08**	-0.21	-0.87	0.43	3.21*	0.64	-0.08*	-0.03
P4XP5	7.87**	1.34*	6.58**	0.73	2.92**	0.66	-3.65**	-0.07	0.02	-0.01
P4XP6	2.51**	1.36*	1.51	1.78**	-0.19	-0.11	-1.71	-1.88	0.00	0.01
P5XP6	-4.16**	-5.95**	-2.24	-3.68**	-0.04	-1.48	2.20	2.20*	0.06*	0.06
S.E (Sij)	0.84	0.61	1.12	0.55	0.71	0.74	1.21	1.01	0.03	0.04
S.E (Sij-Sik)	1.26	0.92	1.67	0.82	1.05	1.11	1.81	1.51	0.04	0.06
S.E (Sij-Skj)	1.16	0.85	1.54	0.76	0.98	1.02	1.67	1.40	0.04	0.06

***,** significant at 0.05 and 0.01,probability levels, respectively.**

Significant negative SCA values would be the best for all studied traits except for flag leaf area, chlorophyll content, grain filling rate where significantly positive effects would be useful based on SCA estimation, it could be inferred that the most effective crosses for days to heading were Sids14 × Sakha 94 (P_1×P_2), Sids 14 × Sakha 95 (P_1×P_3) and Sakha 94 × Giza168 (P_2×P_4) at optimum sowing date, Sakha 95 × Giza 168 (P_3×P_4) and Line 1× Misr 3 (P_5×P_6) at optimum and late sowing dates; for days to anthesis were Sids14×Sakha 95 (P_1×P_3), Sakha94 × Giza168 (P_2×P_4), Sakha 94 × Line 1 (P_2×P_5), Sakha 95× Line1 (P_3×P_5) and Sakha 95 × Misr 3 (P_3×P_6) at optimum sowing date, Sakha 95 × Giza168 (P_3×P_4) at optimum and late sowing dates, Line 1 × Misr 3 (P_5×P_6) at late sowing date; for days to maturity were Sids14 × Sakha 94 (P_1×P_2), Sids14 × Sakha 95 (P_1×P_3), Sakha 94 × Giza 168 (P_2×P_4), Sakah95 × Giza 168 (P_3×P_5) under optimum sowing date, Sakha95 × Giza 168 (P_3×P_4) under both sowing dates; for grain filling period were Giza 168 × Line 1 (P_4×P_5) at optimum sowing date. While, for grain filling rate significant values were for Sids14 × Misr3 (P_1×P_6) under late sowing date and Line1× Misr3 (P_5×P_6) under optimum sowing date; for flag leaf area were Sids14×Line1 (P_1×P_5), Sakha 94 × Sakha 95 (P_2×P_3) at late sowing date and Line1×Misr3 (P_5×P_6) at optimum sowing date. While, for total chlorophyll content were Sakha94×Line1 (P_2×P_5) and Giza168 × Line1 (P_4×P_5) at optimum sowing date; However, for plant height significant negative values were for Sids 14×Giza 168 (P_1×P_4) under normal sowing date. These outcomes agreed with those presented by (Aboshosha *et al.*, 2018), (Emad *et al.*, 2018), (Shaban *et al.*, 2019), (Hassan *et al.*, 2020) and (Hassan and Aziz., 2023).

Table 12. Estimates of specific combining ability effects for F_1 crosses for physiological characters under optimum and late sowing dates.

Crosses	Flag Leaf Area		Chlorophyll content		Plant height	
	Optimum	Late	Optimum	Late	Optimum	Late
P1×P2	0.53	-0.39	-1.29	1.63	1.33	0.69
P1×P3	-4.41	-2.75	0.68	0.10	2.66	1.73
P1×P4	0.42	5.17	-1.36	1.75	-2.82*	1.14
P1×P5	4.70*	9.94**	1.50	-0.40	-0.42	3.81
P1×P6	-1.55	-0.80	1.18	-1.30	-0.68	0.37
P2×P3	4.76*	7.94**	-0.40	1.31	3.64	-0.98
P2×P4	-1.24	0.08	2.07*	1.40	0.66	-0.18
P2×P5	-2.26	0.05	3.40**	-1.06	-0.66	-0.17
P2×P6	-0.83	0.08	-0.57	0.02	2.63	3.00
P3×P4	2.96	2.62	-1.12	0.75	-1.61	-0.20
P3×P5	-3.09	0.57	-4.33**	1.32	-1.16	-0.47
P3×P6	-3.56	-2.15	1.92*	-0.92	0.96	4.45
P4×P5	-6.38**	2.36	4.68**	-0.25	4.02	3.21
P4×P6	4.21	3.20	-1.42	-1.36	2.93	2.64
P5×P6	6.91**	0.39	-3.11**	-1.65	5.05	1.28
S.E (Sij)	2.26	2.64	0.95	1.03	1.22	1.20
S.E (Sij-Sik)	3.37	3.95	1.41	1.54	1.82	1.79
S.E (Sij-Skj)	3.12	3.65	1.31	1.43	1.68	1.66

***,** significant at 0.05 and 0.01,probability levels, respectively.**

Heterosis percentage:

The estimations of heterosis over mid and better parents for earliness characters at optimum and late conditions for earliness and physiological characters are presented in Tables (13) and (14).

The highest value of negative and desirable significant heterosis and heterobeltiosis for days to heading and days to anthesis was obtained by crosse (P_1×P_2) over their mid-parent under optimum sowing date and for days to maturity over their mid and better parents under optimum sowing date; for the crosse (P_1×P_3) negative and significant values were calculated for days to heading and days to anthesis under optimum sowing date over their mid parent under optimum sowing date and for days to heading over the mid and better parent under late sowing date and for days to anthesis over their mid parent under optimum and late sowing date and for days to maturity over mid and better parent under optimum sowing date; while the crosse (P_2×P_4) negative and significant values were calculated for days to heading, days to anthesis and days to maturity under over their mid-parent optimum sowing date, for days to anthesis over the mid-parent under late sowing date and for days to maturity over the better parent under optimum sowing date. For the crosse (P_2×P_5) negative and significant values were estimated for days to heading, days to anthesis and days to maturity over their mid-parent under late sowing date. For the crosse (P_3×P_4) negative and significant values were estimated for days to heading, days to anthesis and days to maturity over their mid parent under optimum sowing date, for days to heading over the mid and better parent under late sowing date and for days to maturity over the better parent under optimum sowing date and over the mid parent under late sowing date. For the crosse (P_3×P_5) negative and significant values were determined for days to heading over mid and better parent under late sowing date, for days to anthesis over the mid parent under late sowing date and days to maturity over the mid parent under optimum sowing date. For the crosse (P_3×P_6) negative and significant values were calculated for days to heading over the mid and better paent under optimum sowing date, for days to anthesis and days to maturity over the mid parent under optimum sowing date. For the crosse (P_5×P_6) negative and significant values were calculated for days to heading over the mid and better parent under optimum and late sowing date and for days to anthesis over the mid and better parent under late sowing date and for days to maturity over the mid parent under late sowing date. For the grain filling period negative and significant value was estimated by the crosse (P_2×P_6) over the mid parent under the late sowing date while for the plant height it was obtained by the crosse (P_1×P_4) over the better parent under the optimum sowing date.

Table 13. Percentages of heterosis over mid -parent (M.P) and better -parent (B.P) for F1 crosses for earliness character under optimum and late dates.

Crosses	Days to heading				Days to Anthesis				Days to maturity			
	Optimum		Late		Optimum		Late		Optimum		Late	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P1XP2	-6.63**	0.38	-0.22	-0.02	-5.54*	-0.14	-0.39	-0.23	-3.52**	-2.02**	0.53	1.11
P1XP3	-7.71**	0.32	-2.13**	-2.08*	-12.41**	-1.78	-1.05	-0.74	-4.53**	-1.71*	-0.09	0.21
P1XP4	-0.19	11.13**	2.54**	4.4**	-0.79	8*	0.72	3.6**	-1.58*	0.51	0.01	3.29**
P1XP5	0.14	4.99*	0.01	-1.72	-0.42	3.64	-1.18*	-0.3	0.01	1.51*	-0.04	-0.59
P1XP6	0.29	3.64	-1.66*	0.97	-0.4	2.5	1.01	1.68*	1.5*	1.91*	0.17	-0.25
P2XP3	-1.56	-0.53	2.37**	2.7**	-0.47	5.26	1.2*	1.21	0.22	1.58*	-0.54	0.29
P2XP4	-6.08**	13.22**	0.81	3.79**	-6.8*	7.73*	0.02	2.54**	-2.93**	-2.4**	2.26**	1.56
P2XP5	-3.04	10.91**	-7.94**	-0.85	-11.7**	3.49	-3.8**	1.92**	-2.35**	2.08**	-2.02**	0.87
P2XP6	-2.29	8.79**	-2.62**	3.73**	-1.39	7.45*	-1.53*	2.33**	-2.14**	-1.01	-0.91	0.03
P3XP4	-7.13**	13.32**	-1.74*	-4.61**	-10**	10.84**	-0.98	-0.68	-4.56**	-3.8**	-0.38	-0.73
P3XP5	-3.3*	10.62**	-2.48**	-1.81*	-8.49**	7.26*	-1.51*	-0.64	-2.72**	1.7*	-0.74	-0.76
P3XP6	-5.61**	6.31**	-0.58	-0.59	-9.5**	4.76	-0.18	-0.36	-1.92**	0.56	0.31	-0.08
P4XP5	15.07**	21.89**	0.54	2.14*	8.82**	13.63**	1.74**	2.12**	1.63*	5.38**	-0.33	1.48
P4XP6	4.52*	12.37**	-0.15	2.94**	1.2	6.9	0.73	4.37**	-0.8	0.9	-0.25	0.68
P5XP6	-6.15**	-4.82*	-9.79**	-9.49**	-4.3	-3.24	-5.13**	-4.87**	0.13	2.04**	-1.73*	-1.59
LSD0.05	2.36	2.73	1.26	1.45	4.16	4.81	1.01	1.17	1.67	1.93	1.83	2.12
LSD 0.01	3.28	3.79	1.75	2.02	5.78	6.67	1.41	1.62	2.32	2.68	2.54	2.94

***,** significant at 0.05 and 0.01,probability levels, respectively.**

For the grain filling rate positive and significant values were obtained by crosses ($P_1 \times P_5$) over the mid-parent under late sowing date, ($P_1 \times P_6$) over the mid-parent under optimum and late sowing date and over better parent under late sowing date, for the crosse ($P_2 \times P_6$) over the mid parent under optimum and late sowing date and over the better parent under late sowing date, For the crosses ($P_3 \times P_5$) and ($P_3 \times P_6$) over the mid parent under late sowing date, for the crosse ($P_4 \times P_5$) for the crosse ($P_4 \times P_6$) over the mid parent under optimum and late sowing date and over the better parent under late sowing date, for the crosse ($P_5 \times P_6$) over the mid and better parent under optimum and late sowing date and over the mid and better parent under late sowing date. For the flag leaf area positive value was obtained by the crosses ($P_1 \times P_4$) over the mid parent under late sowing date and ($P_5 \times P_6$) over the mid and better parent under optimum sowing date, for the chlorophyll content positive and significant values were obtained by the hybrids ($P_2 \times P_4$), ($P_2 \times P_5$) and ($P_4 \times P_5$) over the mid parent under optimum sowing date. These outcomes are in concur with those published by (Aboshosha *et al.,* 2018), (Shaban *et al.,* 2018), (Fouda *et al.,* 2022) and (Al-Ashkar *et al.,* 2020) and (Fareed *et al.,* 2024).

Continued table 13.

Crosses	Grain filling period				Grain filling rate			
	Optimum		Late		Optimum		Late	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P1XP2	-0.37	4.34	2.5	4.76	-8.78**	-13.1**	-10.55**	-12.83**
P1XP3	9.33	23.03**	1.93	2.2	-19.16**	-35.68**	-9.7**	-21.49**
P1XP4	-2.47	12.9*	-1.5	17.12**	3.61**	-8.04**	-5.47**	-10.67**
P1XP5	0.59	2.41	2.08	2.86	0.41	-13.67**	4.02**	-13.86**
P1XP6	3.99	9.03	-1.54	-0.32	7.52**	-0.08	-17.06**	10.08**
P2XP3	1.57	8.81	-4.15	0.4	-10.83**	-26.29**	8.15**	-15.93**
P2XP4	1.88	24.28**	6.36	15.11**	1.95**	-13.26**	-3.58**	-5.9**
P2XP5	13.23**	13.78*	1.24	4.62	-31.46**	-25.22**	-6.73**	-18.65**
P2XP6	-3.21	6.5	0.33	-0.1	4.78**	-6.89**	-2.93**	0.89*
P3XP4	3.05	36.27**	0.83	11.79*	-15.36**	-38.29**	-2.81**	-23.97**
P3XP5	6.89	22.71**	0.81	2.64	-13.25**	-38.17**	0.51	-25.86**
P3XP6	10.41*	30.94**	1.2	3.07	-16.01**	-36.69**	-1.19*	-18.64**
P4XP5	-6.02	6.62	-4.03	9.05*	6.15**	2.35**	5.86**	-9.24**
P4XP6	-2.9	6.76	-2.22	3.52	4.18**	-0.89**	15.13**	2.41**
P5XP6	5.6	8.7	4.93	5.02	14.58**	5.3**	15.1**	2.59**
LSD 0.05	4.89	5.65	3.43	3.96	0	0	0.01	0.01
LSD 0.01	6.79	7.84	4.76	5.5	0	0	0.01	0.01

significant at 0.05 and 0.01, probability levels, respectively.

Table 14. Percentages of heterosis over mid -parent (M.P) and better –parent (B.P) for F1 crosses for physiological under optimum and late dates.

Crosses	Flag leaf area				Chlorophyll content				Plant height			
	Optimum		Late		Optimum		Late		Optimum		Late	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P1XP2	1.85	-8.8	8.37	-2.79	-0.93	-2.96	8.6	1.86	2.89	-0.19	2.98	2.82
P1XP3	-12.16	-15.76	2.98	-4.12	0.16	-0.54	3.94	-1.04	3.29	2.92	4.55	2
P1XP4	0.75	-7.48	23.85	18.91	-1.45	-4.41	8.64	7.25	-1.81	-6.47*	0.71	0.62
P1XP5	11.94	2.98	10.44	16.79	6.31	1.71	8.43	-9.03	1.15	-1.29	1.97	5.13
P1XP6	-0.86	-9.85	7.03	-3.68	2.43	-2.57	9.12	-14.69*	1.88	-4.17	4.64	1.13
P2XP3	10.57	-4.57	4.61	18.97	-1.23	-3.92	-1.24	-2.68	5.95*	3.14	6.27*	-1.59
P2XP4	-2.41	-18.92	19.67	-0.36	11.25*	10.16	8.94	0.22	3.14	1.22	4.53	-1.7
P2XP5	-20.56	-8.76	14.08	10.75	10.78*	6.7	6.69	-3.8	-0.1	2.06	2.54	0.36
P2XP6	2.09	0.36	11.46	1.1	-0.76	-7.44	4.43	-4.44	6.87**	3.52	2.49	2.47
P3XP4	4.43	-0.2	-0.82	6.85	-3.7	-7.22	-4.74	3.11	0.28	-4.15	8.39**	1.13
P3XP5	-9.78	-20.11	31.12	6.25	-13.01**	-16.22**	-1.35	-7.93	1.48	-0.63	7.22**	1.97
P3XP6	-7.75	-19.21	17.66	-1.44	1.7	-2.62	-0.54	-17.11**	4.42	-1.45	6.63**	6.93*
P4XP5	-15.06	-27.69	12.65	5.4	17.37**	9.08	-6.06	-9.59	6.06*	3.47	7.2**	4.64
P4XP6	13.05	-4.76	4.06	4.89	-3.5	-10.82*	-6.2	-15.76**	6.22*	4.82	5.03*	7.17*
P5XP6	23.54	21.98	8.24	3.8	-8.32*	-8.88	-9.17	-10.54	8.92**	4.88	6.01*	4.06
LSD 0.05	17.02	19.65	23.36	26.98	2.99	3.45	3.57	4.12	4.96	5.73	4.82	5.56
LSD 0.01	23.62	27.28	32.43	37.44	4.15	4.79	4.95	5.72	6.88	7.95	6.68	7.72

significant at 0.05 and 0.01, probability levels, respectively.

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تقدير القدرة على التألف لصفات التبكير والصفات الفسيولوجية لبعض التراكيب الوراثية لقمح الخبز تحت الزراعة المبكرة والمتأخرة

نور ياسر الشربينى[1]، مأمون أحمد عبد المنعم[1]، محمد نبيل الهوارى[2] وسعاد حسن حافظ [1]

[1] قسم المحاصيل – كلية الزراعة – جامعة المنصورة – مصر
[2] قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – مصر

الملخص

تم تهجين ستة تراكيب وراثية من قمح الخبز في نموذج نصف تبادلي خلال موسم 2022/2021، لتحديد التأثيرات الجينية. تم تقييم الآباء والسلالات الناتجة منها F_1 باستخدام تصميم القطاعات كاملة العشوائية (RCBD) فى ثلاث مكررات في مواعيد الزراعة المبكرة والمتأخرة في موسم 2023/2022 في مزرعة الأبحاث التابعة لقسم المحاصيل، كلية الزراعة، جامعة المنصورة، محافظة الدقهلية، مصر. تم أخذ البيانات عن صفات التبكير والصفات الفسيولوجية. أظهرت النتائج أن تباين مواعيد الزراعة كان معنويا لجميع الصفات المدروسة باستثناء محتوى الكلوروفيل الكلي. ووجد أن تفاعلات مواعيد الزراعة × التراكيب الوراثية كانت معنوية لجميع الصفات باستثناء معدل امتلاء الحبوب. وأيضاً كان تباين القدرة العامة على التألف (GCA) والخاصة (SCA) معنويا لجميع الصفات المدروسة في حالة الزراعة المبكرة والمتأخرة باستثناء عدد أيام النضج وفترة امتلاء الحبوب ومعدل امتلاء الحبوب ومحتوى الكلوروفيل تحت ميعاد الزراعة المتأخرة بسبب SCA. كانت نسبة GCA/SCA أكبر من الواحد بالنسبة لعدد أيام الطرد وعدد أيام التزهير ومساحة الورقة العلم في حالة الزراعة المبكرة وعدد أيام النضج والكلوروفيل في حالة الزراعة المتأخرة وفترة امتلاء الحبوب ومعدل امتلاء الحبوب في حالة الزراعة المبكرة والمتأخرة مما يعني أن التأثيرات الوراثية المضافة كانت أكثر أهمية في التحكم بهذه الصفات. أظهرت النتائج أن الهجن P_1xP_3 وP_3xP_4 وP_5xP_6 أظهرت تأثيرات معنوية وسلبية على SCA وقوة الهجين بالنسبة لمتوسط الابوين وبالنسبة لأفضل الأبوين لمعظم صفات التبكير تحت الدراسة. لذلك يمكننا أن نوصي بإدخال هذه الهجن في برنامج تربية القمح لزيادة الإنتاجية سواء في الزراعة المبكرة أو المتأخرة.