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Effect of Sowing Dates on Genetic Behavior for Some Bread Wheat Genotypes using Five Parameters Model.

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Abstract

This investigation was carried out at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center, Egypt, through the four seasons 2016/17 to 2019/20 growing seasons to determine the genetic behavior controlling inheritance of yield traits, heterosis expression and expected genetic advance under optimum (15November) and late (15 December) sowing date conditions. The parents and their five populations (P_1, P_2, F_1, F_2 and F_3) of three crosses; Line 1 × Line 2, Line 2 × Giza 171 and Misr 2 × Line 3 were layout in a randomized complete block design with three replications. Analysis of variance revealed significant differences among the population means under both sowing dates for most studied traits. Parents (Line 1 and Line2) and F_1 had the best tolerance to late planting conditions. Scaling test revealed the presence of epistasis for most studied traits in the three crosses. Also results revealed the importance of both additive and non-additive gene effects in the expression of the studied traits, The inheritance of the studied traits was mostly controlled by the dominance effect under optimum sowing date and the additive effect under late sowing date. Over-dominance towards the highest parent was detected for plant height, number of kernels/spike and grain yield/plant under both sowing dates and number of spikes/plant under optimum sowing date, however partial-dominance was detected for days to heading, days to maturity and100-kernel weight under optimum sowing date and number of spikes/plant under late sowing dates. Cross 2 (Line2 x Giza 171) under optimum sowing date displayed absence of inbreeding depression, recording highly significant and positive best-parent heterotic values in few cases. Narrow sense heritability estimates ranged from 29.75% to 89.42% under the optimum sowing date and 26.55%-93.45% under the late sowing date, indicating the low environmental influence The highest estimates of expected genetic advance (GA%) coupled with the highest narrow sense heritability (h_n^2) which revealed selection efficiency for the number of spikes/plant, number of kernels/spike, and grain yield/plant in these studied populations and help breeders in selecting high yielding genotypes, under optimum sowing date. The parents of Line 1, Line 2 and crosses (Line 1 × Line 2) and (Line2 × Giza 171) were considered tolerant to late sowing and could be used in breeding programs to improve bread wheat production

Key words: *Gene action, Genetic advance, Population, Heterosis, Heritability, sowing dates.*

Introduction

Globally, wheat (*Triticum aestivum* L.) is the most important food cereal crops all over the world, especially in Egypt. It is widely adapted crop for a wide range of environmental conditions. Meanwhile, wheat grain yield is highly influenced by environment and varied from sowing date to another because yield is a complex trait that is quantitatively inherited with low heritability value. Wheat crop that sown at late date maybe exposed to high temperature during grain filling stage, reducing its grain yield (Ibrahim, 2016). On the other side, grain yield is difficultly improved through breeding but it can be improved by making up of the interaction among different yield components with environment.

Population mean analysis is considered as the best evaluation quantitative biometrical method based on phenotypic performance of investigated traits (Sharma and Sain, 2004). This method is adequate to estimate main gene effects (additive, dominance and their interactions) about the performance of parental genotypes and their crosses to provide a guide for identifying the desirable genotypes, then designing a future breeding program (Abd El-Rahman 2013). Plant breeders are interested in the gene effect estimation to activate them for wheat yield traits improvement. Heritability estimates associated with high genetic advance can offer good indicator for genotype selection in optimum segregating populations (Memon *et al* 2005). Grain yield attributes in wheat may have more heritable than yield itself (Fethi and Mohamed 2010). High heritability estimates, coupling with other parameters can be used in predicting genetic gain follows by selection for these traits.

In this work, the five populations under study may help to obtain information about the genetic system controlling grain yield to help selection for wheat genotypes to be grown under optimum and late sowing conditions. Therefore, the aims of this work were to 1) investigate the genetic variation among different populations under optimum and late sowing dates, 2) assess the impact of lateness in wheat planting date to determine the best cross under optimum/late sowing and 3) estimate gene action, heritability and expected genetic advance from selection under contrasting sowing dates.

Materials and Methods

The field experiment was carried out at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center, Egypt, through four seasons; 2016/17, 2017/18, 2018/19 and 2019/20. Name, selection history and characteristics of these parental genotypes are presented in Table 1. In 2016/17 growing season, the parental genotypes were crossed to produce the three F_1 crosses. The studied crosses were intended as follows: cross 1: Line 1 × Line 2, cross 2: Line2 × Giza 171 and cross 3: Misr2 × Line3. A part of grains obtained from the F_1s' and F_2's grains of the three crosses were sown to generate F_2's and F_3's in 2017/18 and 2018/19, respectively.

Table 1. Parental name, pedigree and selection history of five bread wheat genotypes.

Parent	Name	Pedigree and selection history**	Characteristics for earliness
1	Line 1	WBLL*2/BRAMBLIMG//HUBRA-21 S.17017-056S-019S-1S-0S	Early
2	Line 2	SAKHA93/3/VEE/PJN//2*KAUZ/5/MAI"S"/PJ//ENU"S"/3/KITO/POTO.19// MO/JUP/4/K134(60)/VEE S.16412-01S-035-4S-0S	Early
3	Giza 171	Sakha 93/ Gemmeiza 9 Gz 2003-101-1Gz- 4Gz-1Gz-2Gz-0Gz	Intermediate
4	Misr 2	Skauz / Bav92 CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S	Late
5	Line 3	SITTA/CHIL//IRENA/6/GIZA168/5/MAI"S"/PJ//ENU"S"/3/ KITO/POTO.19//MO/JUP/4/K134(60)/VEE S.16616-018S-015S-2S-0S	Early

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In 2019/20, the parents, F_1, F_2 and F_3 populations of the three crosses were evaluated in the two sowing dates; the first date at 15th November was the optimum sowing date and the second date 15th December was the late sowing. The experimental plots were laid out in each date using the randomized complete block design (RCBD) with three replications. Each experimental plot consisted of 13 rows (one row for each of P_1, P_2 and F_1, five rows for each of F_2 and F_3) besides two border rows were planted to avoid the border effects. The rows were 3 m long, 20 cm apart and 10 cm among plants within row. All cultural practices were conducted during the growing season according to the recommendation. Data on 30 individual randomly selected plants from each parent and F_1 generation and 200 plants from F_2 and F_3 population were recorded to calculate the studied traits (Days to heading, days to maturity, plant height, number of spikes per plant, number of kernels per spike, 100-kernel weight and grain yield per plant) for all populations of the three crosses in the two sowing dates. The registered maximum and minimum temperatures at Sakha experimental site were recorded from November through May in the season 2019/20 are illustrated graphically in Fig. 1 (weather reports in Sakha, https://www.wunderground.com).

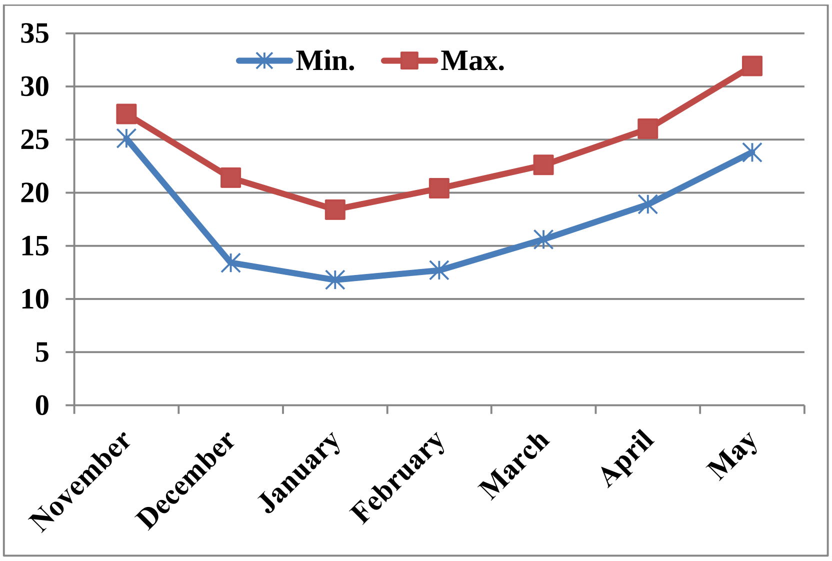

Fig. 1. The registered maximum and minimum temperature at Sakha experimental site from November to May of the studied season 2019/2020.

Biometrical and genetical methods:

Data were analyzed to test the differences among the five populations across the two sowing dates for grain yield/plant and the Reduction Index (RI) which was estimated to measure the reduction in grain yield under late planting. RI was calculated for each genotype according to the modified formula of Fisher and Maurer (1978): $RI = (1 – (Y_{LS}/Y_{ES}))/D$, where; RI = an index of late sowing reduction, Y_{LS} = yield from late sowing experiment for each genotype, Y_{ES} = yield from optimum sowing experiment for each genotype and D = late sowing intensity = 1 – (mean of Y_{LS} for all genotypes/ mean of Y_{ES} for all genotypes).

Scaling test for (C and D) was used to predict and test the epistasis. Suitable gene effect (five parameters) model was conducted according to Gamble (1962) as illustrated by Singh and Chaudhary (1985).

The scaling test variance, standard error and't' test were calculated to detect the interactions or to fit in simple additive- dominance model.

Populations mean analysis in this study used biometrical technique as developed by Mather and Jinks method (1982) to perform genetic parameters. Population mean of each trait was verified as follows: $Y = m + \beta_1 (d) + \beta_2 (h) + \beta_3 (i) + \beta_4 (1)$, where, Y: the mean of one population, m: the mean of all populations, d: the sum of additive effects, h: the sum of dominance effects, i: the sum of additive x additive interaction, 1: the sum of dominance x dominance interaction and β_1… and β_4 are the coefficients of gene effects. The significance of the measured gene effects (m, d, h, i, j and l) was tested by t-test for the studied traits according to Hayman model (1958) as described by Singh and Chaudhary (1985).

Both broad (h^2_b) and narrow (h^2_n) sense heritability and mean degree of dominance $(H/D)^{1/2}$, inbreeding depression (%) and heterosis above mid and better parents were estimated according to Mather and Jinks (1982). Expected genetic advance (GA %) as percentage of the F_2 mean was calculated as reported by Allard (1999).

Results and Discussion

Mean performance

Means and variances of the five populations of the three crosses under the two sowing dates are shown in Table 2. Data showed highly significant differences among the investigated populations and their respective parents for most the studied traits. In the first cross, P_2 and P_1 had the earliest heading and maturity plants, respectively under the two sowing dates. Parent (P_1) in the second cross recorded the earliest heading and maturity plants for each date. Meanwhile in the third cross P_2 revealed the earliest heading and maturity date under the optimum sowing date, whereas F_1 and P_2 had the earliest heading and maturity plants under the late sowing date. The first cross recorded the tallest plants for P_2 under optimum sowing date and P_1 under the late sowing date. Meanwhile, both second and third crosses had the tallest plants for P_2 under both sowing date, respectively.

Regarding the number of spikes per plant, F_2 and P_1 in the first and third cross (Line 1 and Misr2) showed the highest values under optimum and late sowing dates, respectively, whereas the second cross had the highest mean value for P_2 under both sowing dates. P_1 recorded the highest number of kernels per spike in the first cross under the two sowing dates, whereas P_2 (Giza 171) and F_2 in the second cross under both sowing date, while P_2 (Line3) under optimum sowing date, P_2 and F_2 under late sowing date in the third cross gave the highest number of kernels per plant.

On the other hand, F_3 recorded the highest hundred kernel weight in the first cross under both sowing dates, P_2 and F_3 in the second cross under both sowing date. Meanwhile, F_2 in the third cross under both sowing dates gave the highest 100- kernel weight. Concerning grain yield, the first cross had the heaviest grain yield for P_1 (Line 1) and P_2 (Line 2) under optimum sowing date, P_2 under late sowing date, meanwhile P_2 (Giza 171) and P_1 (Line 2) were the heaviest in the second cross under optimum sowing date and P_1 (Line 2) under late sowing date. Also, in the third cross, P_2 (Line 3) recorded the highest grain yield under both sowing dates

Obviously, it is noted that the optimum sowing date had the highest effects for most investigated traits, presenting the importance of optimum planting date. Reduction was characterized for number of spikes/plant, especially for F_2 and F_3 in the three crosses. Many researchers introduced some reasons for these reductions may be due to the environmental effect on forming tillers or spikes under late sowing date.

Table 2. Means (Ẍ) and variances (s^2) for all the studied traits using five populations for the three bread wheat crosses.

Crosses	Traits	Statistical parameters	Optimum swing date					Late sowing date				
			P_1	P_2	F_1	F_2	F_3	P_1	P_2	F_1	F_2	F_3
Cross1 Line1 × Line2	D.H	x	95.00^{a}	90.10^{b}	92.03^{ab}	95.47^{a}	97.66^{a}	89.20^{a}	85.27^{c}	87.23^{b}	89.03^{a}	89.25^{a}
		s2	0.55	0.85	0.59	42.24	47.73	1.2	1.1	1.1	33.84	47.83
	D.M	x	147.60^{b}	147.97^{ab}	147.68^{ab}	149.40^{ab}	151.11^{a}	133.27^{ab}	136.27^{a}	134.77^{ab}	141.38^{a}	135.24^{a}
		s2	1.01	0.59	0.28	6.97	9.02	1.65	1.24	1.34	49.22	57.24
	PH	x	97.67^{b}	105.50^{a}	100.83^{a}	110.92^{a}	102.40^{a}	98.50^{a}	90.00^{b}	94.25^{a}	89.90^{b}	81.14^{c}
		s2	25.4	26.47	15.66	295.61	421.6	14.05	0.01	3.51	141.86	233.21
	SP	x	20.60^{ab}	17.43^{c}	18.43^{bc}	22.64^{a}	20.59^{ab}	12.73^{a}	10.70^{c}	11.72^{b}	12.54^{a}	12.09^{ab}
		s2	10.73	4.39	5.5	84.94	103.62	2.06	1.11	1.25	29.93	31.75
	K/SP	x	58.20^{a}	56.27^{bc}	57.60^{b}	48.63^{cd}	42.23^{d}	54.47^{a}	41.53^{d}	48.00^{c}	52.27^{b}	51.32^{b}
		s2	27.41	14.2	12.04	166.55	216.27	2.12	3.71	2.62	112.28	131.63
	KW	x	4.30^{b}	4.93^{b}	5.02^{ab}	4.97^{ab}	7.29^{a}	4.70^{a}	4.35^{b}	4.53^{ab}	4.73^{a}	4.81^{a}
		s2	0.37	0.21	0.44	1.43	1.5	0.35	0.17	0.21	1.16	1.17
	GY	x	49.77^{a}	48.10^{b}	51.52^{a}	44.98^{b}	37.24^{c}	32.77^{c}	45.77^{a}	39.27^{b}	33.49^{c}	22.95^{d}
		s2	33.63	13.61	18.32	388.3	313.56	4.6	6.67	5.03	130.56	141.57
Cross2 Line 2 × Giza 171	D.H	x	90.20e	105.00a	97.00^{d}	99.92^{b}	97.94c	85.20^{c}	99.17^{a}	92.18^{b}	95.04^{ab}	91.83^{b}
		s2	0.99	0.9	1.45	25.85	41.76	1.13	1.45	1.13	31.17	45.94
	D.M	x	147.97^{c}	151.00^{ab}	150.06^{b}	153.07^{a}	151.26^{ab}	136.10^{a}	138.13^{a}	137.12^{a}	138.35^{a}	137.84^{a}
		s2	0.59	0.97	0.19	10.91	15.49	1.2	1.09	1.12	36.29	44.36
	PH	x	105.33^{c}	116.33^{a}	110.50^{b}	103.63^{d}	116.48^{a}	90.33^{c}	97.83^{a}	94.08^{b}	83.13^{d}	96.12^{a}
		s2	30.92	22.3	17.41	69.34	96.03	18.85	13.25	11.42	80.26	123.77
	SP	x	17.43^{d}	22.20^{a}	19.82^{c}	20.88^{b}	18.31^{c}	11.23^{c}	14.57^{a}	12.90^{b}	13.41^{ab}	13.29^{ab}
		s2	5.5	5.75	11.03	57.35	56.22	3.5	2.81	2.8	30.14	40.72
	K/SP	x	56.80^{d}	72.87^{a}	64.58^{c}	69.24^{b}	54.46^{d}	42.47^{d}	58.97^{b}	50.72^{c}	71.91^{a}	57.12^{b}
		s2	24.72	6.74	50.5	164.93	231.41	6.33	6.24	3.53	115.88	157.96
	KW	x	5.09^{a}	5.18^{a}	4.86^{b}	$5.02a^{b}$	5.05^{ab}	3.91^{c}	5.05^{a}	4.48^{b}	4.41^{b}	5.10^{a}
		s2	0.59	1.16	1.11	2.44	1.97	0.17	1.22	0.39	1.18	1.03
	GY	x	48.13^{c}	59.37^{a}	53.79^{a}	51.81^{b}	43.69^{d}	45.63^{a}	32.63^{c}	39.32^{b}	36.18^{b}	29.07^{d}
		s2	15.84	9.27	23.87	402.95	388.73	7.55	4.45	4.61	80.11	101.06
Cross3 Misr2 × Line3	D.H	x	108.13^{a}	97.00^{c}	102.00^{b}	103.70^{b}	103.62^{b}	101.17^{a}	93.17^{b}	87.23^{c}	98.32^{a}	97.81^{a}
		s2	1.09	1.52	1.38	19.66	27.86	1.59	1.52	1.1	122.77	89.17
	D.M	x	155.13^{a}	149.50^{c}	152.47^{ab}	153.24^{a}	152.11^{ab}	140.13^{a}	139.07^{a}	139.60^{a}	139.79^{a}	139.83^{a}
		s2	1.29	0.88	2.05	11.31	15.51	1.15	1.72	1.18	148.84	70.22
	PH	x	111.00^{a}	99.17^{c}	105.08^{b}	108.60^{ab}	112.66^{a}	86.17^{c}	95.00^{a}	90.58^{b}	81.98^{d}	85.48^{c}
		s2	40.34	19.11	17.02	381.69	373.43	18.42	15.52	11.07	291.18	240.6
	SP	x	21.17^{a}	16.33^{c}	18.90^{b}	21.35^{a}	21.15^{a}	15.03^{a}	10.07^{c}	12.55^{b}	13.53^{ab}	13.42^{ab}
		s2	9.18	4.71	5.9	90	78.1	8.65	2.13	3.89	45.14	43.9
	K/SP	x	61.20^{c}	70.07^{a}	66.27^{b}	58.03^{d}	61.84^{c}	60.43^{c}	68.00^{ab}	64.22^{b}	64.15^{b}	70.49^{a}
		s2	9.82	13.58	75.32	203.13	274.88	6.74	3.59	3.1	179.06	159.34
	KW	x	2.99^{c}	5.05^{b}	4.08^{d}	6.30^{a}	4.81^{bc}	3.00^{d}	4.41^{a}	3.70^{c}	4.45^{a}	4.04^{b}
		s2	0.22	0.8	0.12	4.73	4.98	0.15	0.28	0.11	2.71	1.85
	GY	x	26.53^{e}	52.80^{a}	40.17^{c}	38.32^{d}	47.03^{b}	29.43^{d}	45.40^{a}	37.42^{b}	30.88^{c}	33.02^{cd}
		s2	5.57	8.44	7.7	455.39	440.76	48.87	8.66	19.74	136.96	128.26

Means in rows followed by the same letter (s) are not significantly differed (Duncan, 1955).

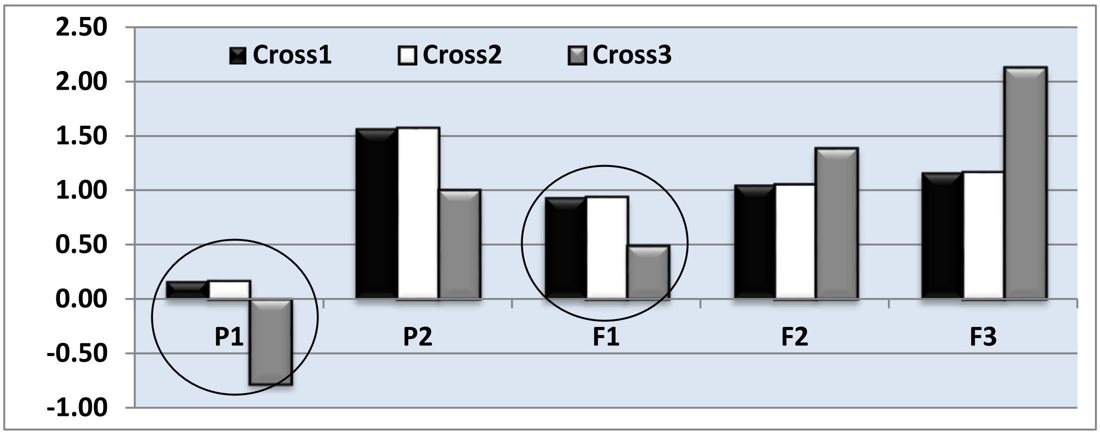

Fig. 2: Reduction index (RI) for grain yield of five populations in the three studied crosses.

Reduction index (RI) for grain yield of the five populations in the three crosses is illustrated in Fig. (2). The (RI) was used as a parameter to provide a measure of lateness tolerance based on minimization of yield, losses under late sowing compared to relatively optimum sowing date. Low Reduction index (RI < 1) was recorded for P_1 and F_1 populations, in the three crosses, indicating that parents (Line 1, Line2 and Misr2) and F_1 had highest tolerance to late planting. In this connection, many researchers reported that there was a wide range of responses to late sowing tolerance in bread wheat genotypes as those reported by Abdel-Nour and Zakaria (2010), Abdel-Nour (2011) and Abd-Allah and Amin (2013).

Scaling test and gene effects:

Scaling test estimates of the investigated traits in the three crosses under the two sowing dates are presented in Table (3). At least one of the estimated values of C and D scaling test recorded significance in all cases under both sowing dates except for 100-kernel weight in the first cross under late sowing date, second cross under optimum sowing date and number of spikes/plant in the 2^{st} and 3^{nd} crosses under late sowing date. These significant scaling test values indicated the existence of non-allelic interactions and the importance of epistasis in the inheritance of these traits (Mather and Jinks, 1982). These results are in agreement with those obtained by Zaazaa *et al*. (2012), Amin (2013), Abd-Allah and Amin (2013), Hamam (2014), El-Hawary (2016), Al-Bakry *et al. (2017)*, kumar *et al*. (2017), Abd El-Rady (2018) and Abd El-Hamid and Ghareeb (2018) for most traits.

Result of the five genetic parameter model explained the nature of gene action under the two sowing dates as shown in Tables (3). Results indicated that the estimates of F_2 mean effects (m) were highly significant for all the studied traits in the three wheat crosses under the two sowing dates, indicating that these traits are quantitatively inherited. Similar results were obtained by Amin (2013), Abd-Allah and Amin (2013), Hamam (2014), El-Hawary (2016), Abd El-Rady (2018) and Abd El-Hamid and Ghareeb (2018).

Additive gene effects (a) recorded positive and highly significant values for days to heading and number of spikes/plant in the first cross under both sowing dates. Additive also was significant for plant height, number of kernels/spike and 100-kernel weight in the first cross under late sowing date, grain yield/plant in the second cross under late sowing date, days to heading, days to maturity and number of spikes/plant in the third cross under both sowing dates and plant height in the third cross under optimum sowing date. These results indicated the great importance of additive gene effects in the inheritance of these traits and the ability to get further improvement of these traits by selection, Whereas, negative and highly significant estimates were obtained for days to maturity in the first cross under both sowing dates, plant height and 100-kernel weight in the first cross under optimum sowing date, grain yield/plant in the first cross under late sowing date, all traits in the second cross under both sowing dates except for 100-kernel weight under optimum sowing date and grain yield/plant under late sowing date. Meanwhile, number of kernels/spike, 100-kernel weight and grain yield/plant in the third cross under both sowing dates and plant height under late sowing date. These results are in accordance with those obtained by Amin (2013), Abd-Allah and Amin (2013), Hamam (2014), El-Hawary (2016), Kumar et al. (2017) Abd El-Rady (2018), Abd El-Hamid and Ghareeb (2018) and Yassin and Ghareeb (2019) whose reported that the additive gene effects mostly recorded significant positive values for number of spikes/plant, number of kernels/spike and grain yield/plant while significant negative values were detected for days to heading ,days to maturity, and 100- kernel weight.

Table 3. Estimates of scaling test and gene effects of all the studied traits under optimum and late sowing date for the three bread wheat crosses.

Crosses	Traits	Treats	Scaling test		Genetic Components				
			c	D	m	a	d	aa	dd
Cross 1 Line1x Line2	DH	optimum	13.71**	15.60**	95.47**	1.95**	-8.13**	-4.21**	2.52
		Late	7.19**	4.47*	89.03**	1.97**	-1.78	2.15	-3.62
	DM	optimum	7.65**	11.08**	149.40**	-0.68**	-5.71**	-7.48**	4.58*
		Late	26.45**	-11.35**	141.38**	-1.50**	11.98**	8.98**	-50.41**
	PH	optimum	38.85**	-15.41*	110.92**	-3.92**	16.01**	8.91*	-72.34**
		Late	-17.40**	-43.76**	89.90**	4.25**	26.27**	34.77**	-35.15**
	SP	optimum	15.66**	-0.97	22.64**	1.58**	2.68	6.43**	-22.18**
		Late	3.29*	-0.17	12.54**	1.02**	0.66	2.70*	-4.62
	K/SP	optimum	-35.15**	-42.81**	48.63**	0.97	23.05**	24.61**	-10.21
		Late	17.08**	4.74	52.27**	6.47**	-0.31	12.62**	-16.45*
	100-KW	optimum	0.59	4.00**	4.97**	-0.32**	-2.17**	-3.20**	4.55**
		Late	0.83	0.71	4.73**	0.18**	-0.33	-	-
	GY	optimum	-20.98**	-38.89**	44.98**	0.83	25.01**	24.09**	-23.88
		late	-23.11**	-53.73**	33.49**	-6.50**	31.97**	18.97**	-40.84**
Cross 2 Line 2 x Giza 171	DH	optimum	10.58**	-3.2	99.92**	-7.45**	3.35*	-11.00**	-18.37**
		late	11.34**	-7.18	95.04**	-6.95**	6.65**	-7.22**	-24.70**
	DM	optimum	13.18**	-0.08	153.07**	-1.52**	2.82**	-0.79	-17.67**
		late	4.77**	0.24	138.35**	-0.93**	0.55	-1.23	-6.04
	PH	optimum	-28.31**	36.81**	103.63**	-5.42**	-29.67**	-40.09**	86.83**
		late	-43.50**	30.38**	83.13**	-3.92**	-27.33**	-35.33**	98.50**
	SP	optimum	4.25	-8.17**	20.88**	-2.38**	6.16**	1.39	-16.57**
		late	2.55	1.08	13.41**	-1.93**	-0.03	-	-
	K/SP	optimum	18.64**	-49.78**	69.24**	-8.30**	36.31**	19.70**	-91.23**
		late	85.69**	-15.83**	71.91**	-8.72**	25.30**	7.40**	-135.36**
	100-KW	optimum	0.24	0.07	5.02**	-0.13	-0.21	-	-
		late	-0.7	2.19**	4.41**	-0.35**	-1.80**	-2.28**	3.86**
	GY	optimum	-7.8	-36.33**	51.81**	-5.63**	22.97**	11.65*	-38.04**
		late	-12.33**	-34.47**	36.18**	6.57**	21.04**	34.06**	-29.52**
Cross 3 Misr2 x Line3	DH	optimum	15.67**	11.95**	103.70**	10.57**	-0.92	15.78**	-4.96
		late	32.48**	8.39**	98.32**	8.00**	-6.11*	15.82**	-32.12**
	DM	optimum	13.39**	7.31**	153.24**	7.82**	2.51**	12.99**	-8.12**
		late	8.74**	4.25	139.79**	4.53**	2.62	7.69**	-5.99
	PH	optimum	14.05*	26.31**	108.60**	5.92**	-15.20**	-3.37	16.35
		late	-34.43**	-3.12	81.98**	-4.42**	-3.66	-12.49**	41.76**
	SP	optimum	10.08**	8.09*	21.35**	2.42**	-3.56	1.12	-2.65
		late	3.9	3.05	13.53**	2.48**	-1.38	3.58	-1.13
	K/SP	optimum	-31.68**	0.03	58.03**	-4.43**	-4.67	-14.17**	42.28**
		late	-0.27	25.41**	64.15**	-3.78**	-16.98**	-24.55**	34.23**
	100-KW	optimum	9.01**	-1.40*	6.30**	-1.03**	2.49**	0.38	-13.88**
		late	3.00**	0.1	4.45**	-0.71**	0.43	-0.98**	-3.87**
	GY	optimum	-6.41	32.16**	38.32**	-13.13**	-22.01**	-48.77**	51.42**
		late	-26.15**	-4.53	30.88**	-7.98**	-1.34	-17.30**	28.82**

DH: Days to heading, DM: days to maturity, PH: plant height, SP: number of spikes per plant, K/SP: number of kernels per spike, KW: 100-kernel weight and GY: grain yield per plant

Regarding the dominance gene effects (d),highly significant and positive dominance estimates were detecting in the first cross for plant height and grain yield/plant under both sowing dates, in addition number of kernels/spike under optimum sowing date and days to maturity under late sowing date; in the second cross for days to heading, number of kernels/spike and grain yield/plant under both sowing dates, also days to maturity, number of spikes/plant, under optimum sowing date, days to maturity and 100-kernel weight in the third cross under optimum sowing date, while none trait showed positive significant dominance in the third cross under the late sowings date. On the other side, negative and significant or highly significant dominance effects were recorded in the first cross for days to heading, days to maturity and 100- kernel weight under optimum sowing date; while in the second cross for plant height under both sowing dates and 100- kernel weight under late sowing date, in the third cross for plant height and grain yield/plant under optimum sowing date, days to heading and number of kernels per spike under late sowing date. These attained results established the importance of dominance gene effects in the inheritance of these traits similar results were obtained by Abd-Allah and Amin (2013), Hamam (2014) and Ibrahim (2016). Kumar *et al*. (2017), and Amin (2013).

With regard to additive × additive gene interaction (aa) values in Tables (3) revealed positive and significant or highly significant values in the first cross for plant height, number of spikes/plant; number of kernels/spikes and grain yield/plant under both sowing dates, also days to maturity under late sowing date, in the second cross for number of kernels/spikes and grain yield under both sowing dates and the third cross for days to heading and days to maturity under both sowing dates. Therefore, selection for these traits (having increasing genes) could be effective in early generations for wheat breeding program. These results were agreeing the findings of Abd-Allah and Amin (2013), Hamam (2014), Kumar *et al*. (2017), Abd El-Rady (2018) and Yassin and Ghareeb (2019). Meanwhile, negative and highly significant values of additive × additive gene action were obtained in the first cross for days to heading, days to maturity and 100-kernel weight under optimum sowing date, the second cross for days to heading, plant height under both sowing dates, also 100-kernel weight under late sowing date and in the third cross for number of kernels/spike under both sowing dates, grain yield under optimum sowing date, and plant height and100-kernel weight under late sowing date. So, selection for these traits will not be effective in the early generations.

Dominance × dominance (dd) gene effects were significant or highly significant and positive in the first cross for days to maturity and 100-kernel weight under optimum sowing date, in the second cross for plant height under both sowing dates and 100-kernel weight under late sowing date; in the third cross for number of kernels/spike and grain yield under both sowing dates, also plant height under late sowing date. These results proved the importance of dominance × dominance gene interaction in the genetic control of these traits with delaying selection to later generation. Significant or highly significant negative dominance × dominance gene effects were attained in the first cross for plant height under both sowing dates, number of spikes/plant under optimum sowing date, days to maturity, number of kernels per spike and grain yield per plant under late sowing date, in the second cross for days to heading, number of kernels/spike and grain yield under both sowing dates, also days to maturity, number of spikes/plant under optimum sowing date, in the third cross for 100-kernel weight under both sowing dates, days to maturity and days to heading under optimum and late sowing date, respectively. These results pointed to the gene effect reduction in the expression of these traits that agreeing mostly with those obtained by Hamam (2014), Kumar *et al*. (2017) and Abd El-Rady (2018).

Results in Table (3) showed the type of epistasis for the studied traits of the three crosses under both sowing dates. Dominance (d) and dominance × dominance (dd) gene effects recorded significant values with different signs for all significant traits in the three crosses under both sowing dates indicating that these traits were controlled by duplicate epistasis, however only days to heading in the third cross under late sowing date had significant values with the same sign for dominance (d) and dominance × dominance (dd), indicated that the gene effects were controlled by complementary epistasis.

This indicated that duplicate epistasis of greater importance than complementary epistasis for most studied traits, these findings are in harmony with those previously obtained by Abd El-Aty et al 2005 and Abd El-Aty and Katta 2007.

Heritability and genetic advance:

Both broad and narrow-sense heritability and genetic advance estimates are given in Tables 4. Broad-sense heritability (h_b^2) includes different types of genetic variances, whereas plant breeders concern on narrow-sense heritability (h_n^2) which estimate the additive portion of genetic variance. The h_n^2 exhibited values lower than h_b^2 ones, then difference between h_b^2 and h_n^2 confirm the involvement of the dominance effect in the genetic constitution of these traits. Estimates of (h_b^2) were high for the investigated traits in the three crosses under both sowing dates and ranged from 78.30 % for 100-kernel weight to 98.32% days to heading and from 80.51 % for 100-kernel weight to 97.29% for number of kernel/spike in the first cross under optimum and late sowing date, respectively. In the second cross, (h_b^2) ranged between (62.66% for 100 kernel weight to 96.52% for grain yield per plant under optimum sowing date and 36.23% for 100 kernel weight to 96.88% for days to maturity under late sowing date. Meanwhile, h_b^2

values in the third cross ranged from 86.18 % for number of kernels per spike to 98.35% for grain yield per plant and from 84.31% for grain yield per plant to 99.03% for days to maturity under optimum and late sowing date, respectively.

Table 4. Genetic parameters of all the studied traits for the three bread wheat crosses under optimum and late sowing dates

Crosses	Treats	Genetic parameters	D.H	D.M	Ph	SP	K/SP	KW	GY
Cross 1 Line 1× Line2	optimum	h_b^2	98.32	91.18	92.05	92.64	89.81	78.3	94.9
	late		96.68	97.22	96.9	95.37	97.29	80.81	95.6
	optimum	h_n^2	57.87	63.72	73.89	60.51	63.7	43.53	34.34
	late		75.85	59.38	93.45	51.45	60.27	39.7	53.53
	optimum	GA%	13.79	3.32	29.39	77.68	49.1	38.86	85.65
	late		13.01	9.94	26.45	85.71	40.63	37.94	67.19
Cross 2 line 2 × Giza 171	optimum	h_b^2	96.04	93.79	68.1	88.27	88.15	62.66	96.52
	late		95.88	96.88	88.19	92.1	95.75	36.23	93.7
	optimum	h_n^2	89.42	74.45	57.62	44.8	74.89	29.75	46.37
	late		79.58	63.22	88.11	70.8	72.15	26.55	63.95
	optimum	GA%	10.07	4.17	11.27	65.95	33.68	40.2	77.04
	late		11.6	8.69	19.58	77.7	29.53	18.34	47.76
Cross3 Misr2 × line3	optimum	h_b^2	93.01	88.72	93.74	93.19	86.18	89.75	98.35
	late		98.83	99.03	94.8	90.69	97.63	92.5	84.31
	optimum	h_n^2	74.65	70.37	51.97	71.69	72.06	49.35	47.13
	late		53.69	68.07	60.06	75.41	67.19	48.88	38.36
	optimum	GA%	8.19	4.01	34.74	85.32	43.6	63.8	112.84
	late		22.94	17.8	40.65	92.8	41.95	70.46	65.82

DH: Days to heading, DM: days to maturity, PH: plant height, SP: number of spikes per plant, K/SP: number of kernels per spike, KW: 100-kernel weight and GY: grain yield per plant

Narrow sense heritability (h_n^2) values were moderate in most traits ranged in the first cross between 34.34% for grain yield per plant to 73.89% for plant height and 39.70% for 100 kernel weight to 93.45% for plant height under optimum and late sowing date, respectively. In the second cross the values ranged from 29.75% for 100 kernel weight to 89.42% for days to heading and 26.55% for 100 kernel weight to 88.11% for plant height under optimum and late sowing date, respectively. In addition to the third cross traits had values ranged from 47.13% for grain yield per plant to 74.65% for days to heading and from 38.36% for grain yield per plant to 75.41% for number of spikes per plant under optimum and late sowing date, respectively. The results indicated that these traits were greatly controlled by additive and non-additive effects and there is effective amount of heritable variation. Therefore, the selection for these traits will be easier and low environmental influence. These results are in line with El-Aref et al. (2011), Amin (2013), Mohamed (2014), El- Hawary (2016) and Abd El-Rady (2018).

The expected genetic advance, as a percentage of F_2 (GA%) under the two sowing dates are shown in (Tables $5_{a,b}$). The results revealed that GA% estimates under optimum sowing date ranged from 3.32% for days to maturity in the first cross to 112.84 % for grain yield/ plant in the third cross. Meanwhile, GA% recorded values ranged from 9.94% for days to maturity in the first cross to 92.80% for number of spikes/ plant in the third cross under late sowing date. The highest estimates of expected genetic advance (GA%) coupled with highest narrow sense heritability (h_n^2) were detected for number of spikes/plant and number of kernels/spike in the first and third cross and grain yield/plant and number of spikes/plant in the second cross under optimum sowing date. Whereas, under late sowing date, number of kernels/spike and grain yield/plant in the first cross, number of spikes/plant and grain yield/plant in the second cross and number of spikes/plant and number of kernels/spike in the third cross.

These results indicated the existence amount of variability for the improvement of those traits and the selection could be effective in the optimum populations. Then, selection for number of spikes/plant, number of kernels/spike and grain yield/plant in these studied populations help breeders in selecting of high yielding genotypes especially, under optimum sowing date.

Generally, most of the obtained parameters detected the first cross (Line 1 x Line 2) and third cross (Misr2 x Line3) for planting under optimum sowing date, Meanwhile, the first (Line 1 x Line 2) and second (Line2 x Giza 171) crosses were detected for planting under late date, which had the lowest values for reduction index (RI) under the late sowing date. Therefore, breeding programs establishment for genetic improvement of bread wheat could be include the crosses (Line 1 x Line 2) and (Line2 x Giza 171) for late sowing date.

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تأثير ميعاد الزراعة على السلوك الوراثى لبعض التراكيب الوراثية من قمح الخبز بإستخدام نموذج العشائر الخمسة

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

**** المعمل المركزي للتصميم وللتحليل الاحصائي – مركز البحوث الزراعية – مصر**

أجريت هذه التجربة في المزرعة البحثية بمحطة البحوث الزراعية بسخا، مركز البحوث الزراعية مصر خلال أربع مواسم زراعية من 2017/2016 إلي 2020/2019 لتحديد السلوك الوراثى المتحكم فى توارث صفات االمحصول وقوة الهجين والتحسين الوراثى المتوقع تحت ظروف ميعاد الزراعة العادي والمتاخر، تم زراعة الآباء والعشائر الخمسة لثلاثة هجن من قمح الخبز، وهي سلالة 1 x سلالة 2 ، و سلالة 2 x جيزة 171 ، و مصر 2 x سلالة 3 بتصميم القطاعات الكاملة العشوائية. أظهر تحليل التباين اختلافات معنوية بين متوسطات الأجيال لمعظم الصفات المدروسة بكلا ميعادى الزراعة. وقد سجل كلا من الابوين سلالة 1 و سلالة 2 مع الجيل الأول للهجن الثلاثة أعلى تحمل لظروف التاخير فى الزراعة. أوضح اختبار Scaling–test أن معظم الصفات المدروسة للهجن الثلاثة تشير إلى وجود تفاعلات غير أليلية. كما أظهرت النتائج أهمية تأثير الفعل الجيني المضيف وغير–المضيف فى تعبير الصفات المدروسة ، وغالبا كان التأثير السيادى للجينات هو المتحكم فى التوارث تحت ميعاد الزراعة العادي ، بعكس زيادة التأثير المضيف تحت ميعاد الزراعة المتأخر. وكان هناك سيادة فائقة تجاه الأب الأعلى لصفة طول النبات، وعدد حبوب السنبلة، ومحصول حبوب النبات تحت ميعاد الزراعة العادي ، فى حين كانت السيادة جزئية لصفة عدد الأيام حتى طرد السنابل ، وعدد الأيام حتى النضج ، ووزن–100 حبة تحت ميعاد الزراعة العادي، عدد سنابل النبات تحت ميعاد الزراعة المتأخر. وقد اظهر الهجين الثانى (سلالة 2 x جيزة 171) غياب تأثير التربية الداخلية تحت ميعاد الزراعة العادي؛ مسجلا قيما موجبة عالية المعنوية لحالات قليلة لقوة الهجين للأب الأفضل. وقد تراوحت قيم كفاءة توريث بالمعنى الضيق بين 29.75% الى 89.42% للصفات تحت ميعاد الزراعة العادي ومن 26.55% الى 93.45% تحت ميعاد الزراعة المتأخر، مشيرا لانخفاض التأثير البيئى وسهولة الانتخاب فى هذه الصفات. أشارت قيم التحسين الوراثي المتوقع العالية والمقترنة بأعلى كفاءة توريث بالمعنى الضيق الى أن الانتخاب لصفة عدد سنابل النبات ، وعدد حبوب السنبلة، ومحصول حبوب النبات خلال العشائر المدروسة تساعد مربى النبات فى انتخاب التراكيب الوراثية عالية المحصول ؛ خاصة تحت ميعاد الزراعة العادي. وعليه؛ فإن الأبوان سلالة 1 و سلالة 2 وهجينى سلالة 1 x سلالة 2 ، و سلالة 2 x جيزة 171 يعتبرا تراكيبا وراثية بديلة ومبشرة خلال برامج التربية لتحسين قمح الخبز للتحمل تحت تأخير ميعاد الزراعة.