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Gene Action for Yield and Yield Component Traits in Bread Wheat (*Triticum aestivum* l.) Under late Sown Conditions

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ABSTRACT

The present work was conducted during the two wheat growing seasons of 2013/2014 and 2014/2015 respectively, at the Experimental Farm of South Valley University to study the gene action under normal sowing date (30th November) and late sowing dates (10th January). Five parents were crossed in ahalf diallel cross mating design. The F_1´s hybrids and their parents were raised under normal and late sowing dates. The analysis of the F_1 generations and their parents revealed that additive gene effects was manifested for all traits studies in the first sowing date, but the reverse was true in the second sowing date. However, over-dominance type of gene action was recorded for grain yield in the first sowing date and partial dominance in the second sowing date. As to the number of kernels/spike partial dominance was displayed in the first sowing date and over dominance in the second sowing date. Narrow sense heritability estimates ranged from 0.49 in the first sowing date to 0.69 in the second sowing date for grain yield. Meanwhile, narrow sense heritability was 0.58 for 1000-grain weight and 0.69 for grain yield in the second sowing date.

INTRODUCTION

Wheat (*Triticum aestivum* L) is the most widely consumed cereal crop worldwide especially in Egypt and is the world's most widely adapted crop, being grown on wide range of environmental condition. Eighty percent wheat crop is sown late, which is ultimately exposed to high temperature combined with lack of water during filling and hence grain yield are reduced substantially (Anonymous, (2007), Hussain *et al*., (2010) and Mahmood *et al*., (2010). Heat stress reducing grain quality and grain was reported by (Stone and Nicolas, 1994). Also, heat stress is major yield limiting factor and genetic management is the most apposite solution. Diallel analysis of the genetic traits is a valuable aid in selection and development of high yielding and wheat varieties. Grain yield is highly affecting by environmental stress like drought stress and heat stress because over 50% of the total wheat is sown late which results in terminal heat stress (Kaur and Behi, 2010). Breeder´s evaluate many lines during selection for heat tolerance because identification of a plant with all the required genes is difficult (Ortiz-Ferrera *et al*., 1993). Twelve lines and four testers were crossed in an L X T mating design by (Punia *et al*., 2011). The 44 crosses and their parents were raised under normal (21 November 2002) and late sawn (1, January 2003) seasons at the Experimental Farm of Ragathan College of Agriculture. Their results indicated that the parents like C306, k´sama, K9708, DWR195 and Kailash could be utilized in multiple crossing programs and further biparental mating for selection of high yielding progenies for heat tolerance. Additive gene action was found to be involved in controlling spike length (Chowdhry *et al*., 2005). Over dominance was reported by (Khan and Dar, 2010) for number of grains per spike and grain yield per plant. Dominance was observed for spike length and grain yield. It showed potential for availability of transgressive segregates in late generation (Sadia *et al*., 2013). Muhammad *et al*., (2012a) analyzed F_1 progenies of 7 X 7 diallel fashion crosses comprising four high temperatures and three susceptible spring wheat parental genotypes were evaluated under normal and heat stress conditions. Analysis of variance under both conditions indicated additive gene action with partial dominance. A full diallel cross study comprising of five bread wheat (*Triticum aestivume* L.) cultivars was carried out with parents and their F_2 progeny to determine gene action for grain yield, plant height and their complements under irrigated and water deficient stress was investigated by (Behnam *et al*., (2015). Estimates of the genetic components of variation as well as ratio of GCA/SCA showed that all the characters were predominantly controlled by additive gene action. The results of Natasa *et al*., (2014) indicated significant differences among the parents. However, highly significant differences for general (GCA) and specific (SCA) combining ability in F_1 generation denoted that spike length had resulted from the genes with additive and non-additive. Heritability is one of the determinants for measuring percent improvement to be expected for in a segregating population. Broad sense heritability estimates for days to heading, plant height and 1000-grain weight varied from low to moderate.

Information used in this study on various morphological traits and genetic aspects play an important role for the development of thermo-tolerant varieties and yield stability. Increasing the genetic potential for grain yield of wheat is the main goal of breeding. Yield is a complex trait and is the result of money quantitative traits which are controlled by numerous genes each having small effects. Improving direct and some other indirect components, grain yield can be improved (Zečević ***et al*., (2005**). Therefore, the aim of this work is to study the genetic system controlling grain yield, number of kernels, 1000-grain weight and spike length under normal and late sewing dates which represent heat stress in order to elucidate the influence of the environmental on the type of gene action.

MATERIAL AND METHODS

Plant Materials: Five parental genotypes of wheat ie. Giza-168, Sids-112, Shandaweel-1, Qena-25 and Sakha-

94 were used in this study. The seeds were grown in the Experimental Farm of South Valley University.

Field Experiment condition: In 30th November, 2013/2014 wheat growing season the five parental genotypes of wheat were planted into the Field of the Expermental Farm South Valley University Experimental and crossed in ahalf diallel in order to obtain a total of 10 F_1 crosses. In 2014/2015 the five parents and their 10 F_1 hybrids of the five-parent half diallel cross were sown in the field in the two sowing dates, the first sowing date 30th November, were the sowing condition are favorable and the second sowing date 10th January which allow the plants to be subjected to the heat stress resulting from the rise of temperature late in the growing season. The experimental layout in each date was a complete Randomized Block Design with three replications. The parents were represented by one row of plants per block each row contain 40 plants, while four rows per block were used for each of the 10 F_1 hybrids. Each row was 4.0 meter long, spaced 10 cm apart with plants spaced 20 cm within rows.

Yield and other measurements: Measurements were recorded on a random sample of ten guarded plants for parents and their F_1 hybrids in each replicate in the two experiments. The following characters were recorded for each plant: grain yield, 1000 grain weight, number of kernels/spike and spike length.

Statistical analysis: Means of ten plants for parents and their F_1 hybrids for each of the characters studied were used for statistical analysis (Steel and Torrie, 1980). The collected data were analyzed using diallel analysis as developed by Hayman [1954] and Jinks [1954].

RESULTS AND DISCUSSION

F_1 performance: The data in Table 1 showed that the highly significant among the different entries of F_1 diallel of the four studied traits. Similar results were obtained by Messias and Antonio (2001) and Muhammad *et al*., (2012b). The means of grain yield/plant ranged from 1.2 (g) for P_5 to 2.73 (g) for P_3 in the first season, while in the second season ranged from 0.45 (g) for P_5 to 1.87 (g) for P_4. Regard to F_1´s the means ranged from 1.41 (g) for (P_3 X P_5) to 3.18 (g) for (P_3 X P_4) in the first sowing date and ranged from 0.39 (g) for (P_3 X P_5) to 2.08 (g) for (P_3 X P_4) in the second sowing date, (Table 2). As to the number of kernels/spike the means of parents ranged from 45 for P_5 to 61.67 for P_3 in the first sowing date, in contrast the means ranged from 38.33 for P_3 and P_5 to 51.33 for P_4. However, the means of F_1´s crosses ranged from 41.67 for (P_2 X P_5) to 59.33 for (P_3 X P_4) in first sewing date, but in the second sowing date the means ranged from 31.67 for (P_2 X P_5) to 46.33 for (P_3 X P_4), (Table 3). Here too, the means of 1000-grain weight ranged from 26.73 (g) for P_5 to 44.44 (g) for P_3 in early sowing date, also the mean of parents ranged from 11.17 (g) for P_5 to 39.95 (g) for P_3 at the late sewing date which represent heat stress. Finally, for spike length the means of parents ranged from 8.67 (cm) for P_5 to 12 (cm) for P_3, but in the second sewing date the means ranged from 5.67 (cm) for P_5 to 8.67 (cm) for P_1 (Table 5). (P_1 X P_3) F_1´s gave the highest mean performance and P_2 X P_4 gave the lowest mean of spike length in the first sewing date. In contrast, the P_3 X P_4 gave the highest mean (10.0), while the (P_1 X P_3) displayed the lowest mean value of spike length.

Table 1. The analysis of variance of four studied traits of 2014/2015 wheat growing season among the different entries of diallel Table.

Item	sowing dates	d.f	grain yield	1000 grain weight	number of kernel/spike	spike lenght
Blocks	1st	2	0.0484	143.555	90.508	1.120
	2nd	2	0.0539	4.9726	22.807	4.004
Genotypes	1st	14	0.7522**	114.291**	155.050**	4.10**8
	2nd	14	0.7712**	109.47**	317.37**4	3.396**
Error	1st	28	0.0478	19.546	17.581	0.429
	2nd	28	0.00705	6.4733	3.476	0.155

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

Table 2. The means of grain yield (g) of F_1 diallel cross grown of 2014/2015 wheat growing season.

Parents	sowing dates	P_1	P_2	P_3	P_4	P_5
P_1 (Giza-168)	1st	2.00	2.08	2.49	2.21	1.75
	2nd	1.22	0.95	1.53	0.86	0.49
P_2 (Sids-112)	1st		1.43	1.60	1.95	2.05
	2nd		0.59	0.95	1.22	0.62
P_3 (Shandweel 1)	1st			2.73	3.18	1.41
	2nd			1.53	2.08	0.39
P_4 (Qena 25)	1st				2.23	2.04
	2nd				1.87	1.20
P_5 (Sakha-94)	1st					1.20
	2nd					0.45

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

Table 3. the means of Number of Kernels / spike of F1 diallel cross of 2014/2015 wheat growing season.

Parents	sowing dates	P_1	P_2	P_3	P_4	P_5
P_1 (Giza-168)	1st	52.00	43.67	58.67	55.33	48.33
	2nd	44.00	26.33	43.33	37.00	33.67
P_2 (Sids-112)	1st		46.33	43.00	50.33	41.67
	2nd		37.00	36.33	40.33	31.67
P_3 (Shandweel -1)	1st			61.67	59.33	47.33
	2nd			38.33	46.33	32.67
P_4 (Qena-25)	1st				53.00	52.33
	2nd				51.33	39.00
P_5 (Sakha-94)	1st					45.00
	2nd					38.33

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

Table 4. the means of 1000 grain weight of F1 diallel cross of 2014/2015 wheat growing season.

Parents	sowing dates	P_1	P_2	P_3	P_4	P_5
P_1 (Giza-168)	1st	38.53	48.47	42.88	39.78	36.18
	2nd	27.78	36.16	35.21	23.12	14.50
P_2 (Sids-112)	1st		31.11	37.26	38.61	49.62
	2nd		16.01	26.18	30.41	19.51
P_3 (Shandweel -1)	1st			44.44	53.68	30.04
	2nd			39.95	44.89	11.82
P_4 (Qena-25)	1st				42.19	39.25
	2nd				36.44	30.67
P_5 (Sakha-94)	1st					26.73
	2nd					11.17

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

The F_1 diallel analysis: The diallel analysis of variance of the grain yield, number of kernels/spike, 1000-grain weight and spike length per plant for each of the two sowing dates are given in Table 6. The analysis revealed highly significant additive and non additive gene effects over the two sowing dates as indicated by the significance of "a" and "b" items. The additive mean square was greater in magnitude than non additive for the first sowing date for all studied traits, but the reverse was true for the second sowing date for 1000-grain weight. These results are in harmony with results of Muhammad *et al*., (2012b) who indicated gene action with partial dominance for grain yield and number of kernels/spike suggesting these traits might be useful for the development of terminal heat tolerant Varieties by pedigree selection. Sadia *et al*., (2013) found that dominance controlling on grain yield and spike length. Also, generation means analysis by Muhammad *et al*., (2012c) revealed additive, dominance and epistatic genetic effects were operating of the plant character under both conditions. Ahmadi *et al*. (2003) found that the general combining ability (GCA) were highly significant for number of grains/spike, 1000-kernels weight and grain yield, while Specific combining ability (SCA) effects were highly significant for all studied traits. On partitioning the non-additive effects item "b" into its component, it was evident from the significance of item "b" that F_1 hybrids exhibited dominance for higher grain yield/plant, number of kernels/spike and 1000 grain weight in the first sowing date, but the reverse was true in the second sowing date "heat stress". The average of the F_1 exceeded that of the parents by 7% for grain yield/plant, 12.02% for number of kernels/spike and by 11.98 for 1000-grain weight in the first sowing date, but in the second sowing date the F_1 exceeded that of parents by 0.05 for spike length. The significant "b2" item indicated assymetrical gene distribution of genes affecting grain yield, number of kernels/spike, 1000-grain weight and spike length in the two sowing dates at loci showing dominance, while the significant of "b3" item indicated further dominance effects due to specific combinations. These results were in same line with these obtained by Pumia *et al*., (2011) who showed that the crosses K9708 X PBN-51 for proline content and heat injury and C309 with kaitash for heat injury had desirable significant SCA effects.

Table 5. the means of spike length of F1 diallel cross of 2014/2015 wheat growing season.

Parents	sowing dates	P_1	P_2	P_3	P_4	P_5
P_1 (Giza-168)	1st	12.67	11.00	12.50	11.50	11.33
	2nd	8.67	8.67	6.50	7.83	8.17
P_2 (Sids-112)	1st		11.00	10.33	9.33	9.33
	2nd		7.00	7.33	7.50	6.67
P_3 (Shandweel -1)	1st			12.00	12.33	10.17
	2nd			8.17	10.00	7.17
P_4 (Qena-25)	1st				11.67	10.17
	2nd				8.17	8.83
P_5 (Sakha-94)	1st					8.67
	2nd					5.67

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

Table 6. The diallel analysis of variance of four studied traits of the F_1 diallel cross grown in the two wheat sowing dates of 2014/2015 season.

Item	d.f	grain yield		Number of kernel/spike		1000 -grain weight		spike length	
		1st growing data	2nd growing data	1st growing data	2nd growing data	1st growing data	2nd growing data	1st growing data	2nd growing data
a	4	2.348114**	3.214518**	517.4297**	358.9727**	179.7305**	1125.711**	19.22656**	6.43335**
b	10	0.8660584**	0.5652695**	67.32813**	119.1391**	300.2281**	311.4125**	2.167969**	5.57666**
b1	1	0.2845923**	0.1331413**	30.72	316.2134	297.6842**	11.50134*	1.92**	1.3333**
b2	4	0.2168675**	0.1214447**	97.52832**	86.9043**	96.35547**	120.7388**	2.60669**	2.802765**
b3	5	1.501704**	1.006755**	50.4896*	105.512**	463.8351**	523.9337**	1.866586**	8.644442**
B x a	8	0.0748**	0.0214**	31.586	11.41	22.49	7.077	0.9567	0.16333
B x b	20	0.0296	0.00835	34.28	10.97	33.20	5.51	0.647	0.3057
B x b1	2	0.0341	0.00660	3.64	0.693	10.44	5.90	0.28	0.243
B x b2	8	0.0428	0.00254	13.59	7.86	9.62	1.69	0.547	0.169
B x b3	10	0.024	0.0133	56.96*	15.51	56.61	8.49	0.800	0.428*
Block interaction	28	0.0248	0.00705	19.5459	6.4733	17.58	3.48	0.429	0.1545868

**** : P< 0.01**
All items were tested against the block interaction M.S

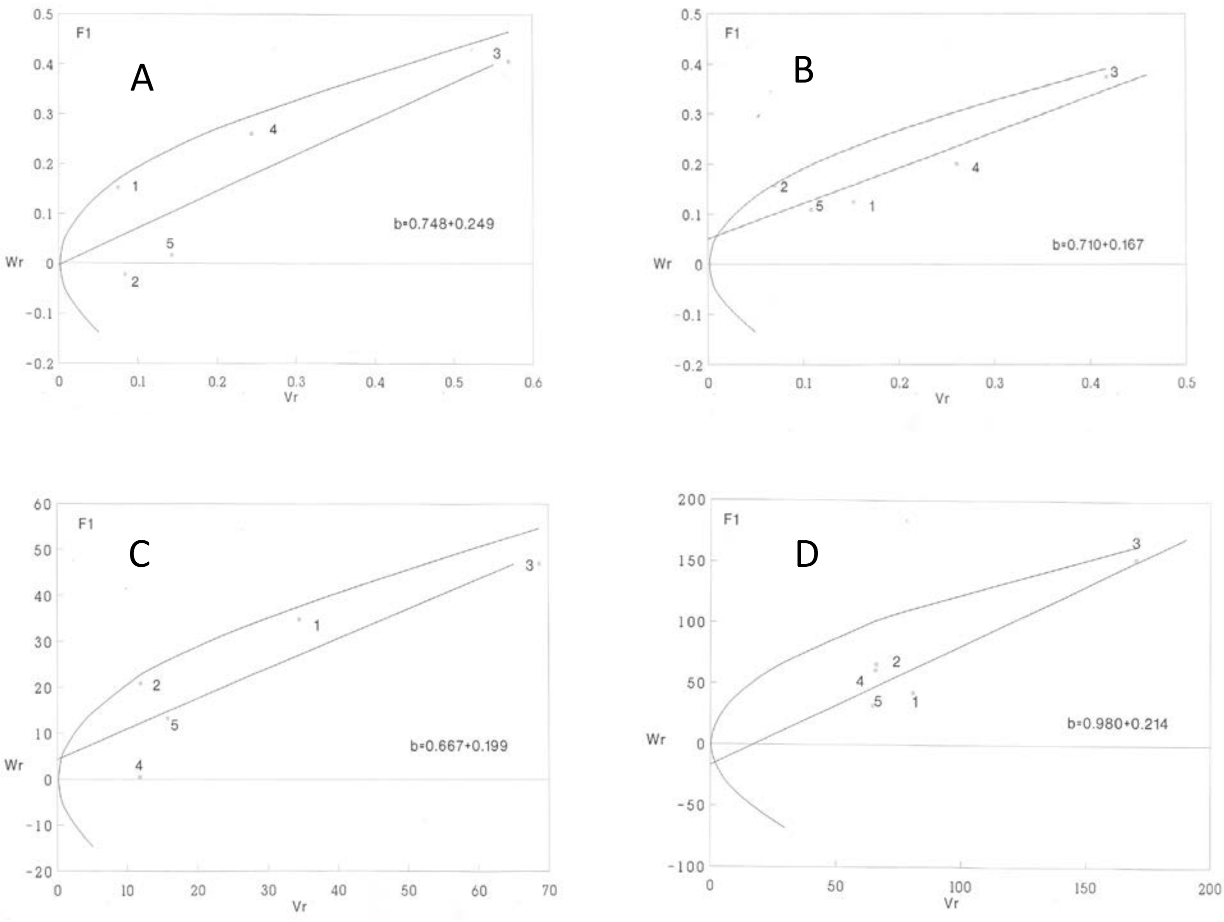

Fig.1. Wr, Vr graphs of F_1 diallel cross for grain yield in first sowing date (A), for grain yield in second sowing date (B), number of kernels/spike in first sowing date (C) and 1000-grain weight in second sowing date (D)

The analysis of variance of (Wr + Vr) and (Wr – Vr) are shown in Table 7, which revealed highly significant differences for (Wr + Vr) and (Wr – Vr) for grain yield in the two sowing dates indicated the presence of non-additive gene and epistatic effects. While, the analysis of (Wr + Vr) and (Wr – Vr) for number of kernels/spike revealed non significant for the (Wr + Vr) in the second sowing date and highly significant (Wr – Vr) in the second sowing date. Evidently, additive gene and epistatic effects were presented in the second sowing date. As to the 1000-grain weight the analysis of variance revealed highly significant of (Wr +Vr) in the second sowing date indicate the presence of non additive gene effects and also highly significant (Wr –Vr) in the two sowing dates. Regards spike length/plant the analysis of (Wr + Vr) and (Wr – Vr) showed significant of (Wr + Vr) in the second sowing date confirming the non-additive gene effect. The slope of the Wr/Vr regression line [Fig. 1 (A and B)] was significantly deviated from zero, but not from unity for grain yield, in the two sowing dates. While, for number of kernels/spike the slope of Wr/Vr was significantly deviated from zero, but not from unity. and in the second sowing date for 1000-grain weight. Evidently additive – dominance model of gene action was operating. The regression coefficient of Wr/Vr was not significantly different from zero for number of kernels/spike in the second sowing date, 1000-grain weight in the first sowing date indicating that non-allelic gene interaction was manifested. Array No. 3 as commen parent represented the extreme recessive genotype which was located at the end of the regression line for grain yield in the two sowing dates, also for number of kernels/spike in the first sowing date and 1000-grain weight in the second sowing date (Fig 1: A, B and C). Meanwhile, array No. 2 represent the extreme dominant gene type which was located near the origin point of regression line for grain yield in the two sowing dates (Fig 1,A and B). For number of kernels/spike array No. 4 represented the extreme dominant genotype which was located near the origin point of regression line. Similar results were also reported by Farooq *et al*., (2010) and Nazeer *et al*., (2011).

Table 7. Analyses of variance of Wr + Vr and Wr –Vr values for all studied traits of F_1 hybrids.

Source of variation	d.f	sowing dates	Grain yield		Number of kernel/spike		1000 grain weight		Spike lenght	
			Wr+Vr	Wr -Vr	Wr+Vr	Wr-Vr	Wr + Vr	Wr - Vr	Wr + Vr	Wr - Vr
Blocks	2	1st	0.0126	0.0026	179.004	1605.25	3591.73	7578.11**	1.402	1.063**
		2nd	0.0205	0.00007	528.164	299.114*	2411.63	93.437	0.137	0.1313
Array	4	1st	0.4094**	0.0284**	6357.95*	950.145	4349.63**	3774.12	1.362	0.242
		2nd	0.1765**	0.0101**	843.018	747.22**	24790.3**	885.909**	2.951*	1.1036
Errer	8	1st	0.0136	0.0026	1871.71	508.194	1332.59	562.462	0.476	0.177
		2nd	0.0039	0.00032	739.145	67.152	863.31	100.500	0.514	9.3876

1st: first sowing date 30th November and 2nd : the second sowing date 10th January

Genetic parameters: The estimates of various components of the genetic variation for grain yield/plant, number of kernels/spike and 1000-grain weight in the first and second sowing dates are given in Table 8. The "D" parameter estimating the additive effect was smaller than "H_1" confirming that over dominance was operating in the first sowing date and partial dominance in the second sowing date for grain yield/plant. As to the number of kernels/plant the "D" parameter estimating the additive effect was much greater than the "H_1" confirming the partial dominance was operating in the first sowing date, but over-dominance was manifested in the second sowing date for 1000-grain weight. The results of Farhad *et al*., (2011) revealed that significant additive "D" and dominant genetic variations for number of grains/spike, 1000 grain weight and grain yield/plant under early planting. Similarly, under the late planting date significant additive (D) and dominant (H) genetic variation were observed for number of grains/spike and grain yield/plant, which for 1000-grain weight only additive "D" genetic component was significant. Rashid *et al*., (2012) using 6 × 6 wheat dialell crosses, indicated that grain yield was controlled by additive gene effects. They also emphasized that selection of genotypes in early generations has higher efficiency in breeding programs. The same results were reported for wheat spike length (SL),number of spikelets/spike (SN) and grain yield /plant (GY) (Anwar *et al*., 2011, Nazir *et al*. 2005, Mahmood and Chowdhry 2002). Also, similar results were obtained by Mahdiyeh and Bahram (2014) who pointed that SCA revealed that selection among progenies of cross ad1 X Darab2 cross would be efficient for increasing grain yield/plant (Gy). The GCA estimates revealed that the cross ad1 and Marvdasht for grain yield /plant (Gy) were the best combiner. The average degree of dominance measured by $(H1/D)^{½}$ ratio reached 1.20 and 0.88 for grain yield in the first and second sowing dates, respectively. As to the number of kernels/spike the $(H1/D)^{½}$ reached 0.11 in the first sowing date, but it reached 1.15 for 1000-grain weight in the second sowing date. The "F" value was positive and significant for grain yield in the first and second sowing dates indicating unequal of dominant and recessive alleles among parents. In contrast, The F value was negative in the first sowing date for number of kernels/spike indicating an excess of dominant than recessive alleles. The UV values were less than 0.25 indicating unequal distribution of the dominant and recessive alleles among the five parents which has been indicated before from the significant "b_2". Narrow sense heritability estimates ranged from 0.58 for 1000-grain weight and number of kernel to 0.69 for grain yield in the second sowing date. High estimates of narrow sense heritability for these traits suggest that genetic improvement for heat tolerance (second sowing date) may be achieved through selection breeding. The results of Abd-Allah *et al*., (2007) indicated that Narrow sense heritability estimates ranged from 0.0% for number of spikes/plant in the third cross to 0.71% for 1000 kernel weight in the first cross under optimum sowing date, and from 31.14% for number of spike/plant in the second cross to 78.21% before maturity date in the first cross under late sowing date. Also Amein, (2007) found that the parent of spring regression heritability, under optimum sowing date ranged from 31.99 for number of spikes/plant in the third cross to 77.19 for grain yield/plant in the first cross and grain yield/plant in the third cross under late sewing date. The results revealed that selection among progenies of the F_1 hybrids in late generations would be efficient in breeding programs to improve these studied traits.

Table 8. Components of the genetic variation for grain yield, number of kernels/spike and 1000-grain weight of 2014/2015 of wheat growing season.

Character	Grain yield X ± S. E		Number of kernels/spike X ± S. E		1000-grain weight X ± S. E	
Item	1st growing data	2nd growing data	1st growing data	2nd growing data	1st growing data	2nd growing data
D	0.36 ± 0.032	0.36 ± 0.013	24.14 ± 14.26	29.23 ± 5.18	38.37 ± 14.99	153.04 ± 6.34
F	0.08 ± 0.081	0.05 ± 0.028	-29.25 ± 35.6	-2.55 ± 12.95	30.16 ± 37.47	26.40 ± 15.83
H_1	0.56 ± 0.087	0.38 ± 0.030	13..57 ± 38.50	79.98 ± 13.99	173.71 ± 40.51	222.71 ± 17.12
H_2	0.53 ± 0.079	0.36 ± 0.0.028	7.36 ± 34.92	66.99 ± 12.69	166.39 ± 36.74	200.93 ± 15.53
E	0.02 ± 0.013	0.007 ± 0.005	19.55 ± 5.82	6.47 ± 2.12	17.58 ± 6.12	3.48 ± 2.59
$(H1/D)^{½}$	1.20	0.88	0.11	0.95	1.45	1.15
UV	0.24	0.24	0.14	0.21	0.24	0.23
Broad- sense hb.s	0.92	0.98	0.62	0.86	0.12	0.97
Narrow-sense hn.s	0.49	0.69	0.58	0.49	0.74	0.58

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فعل الجين لصفات المحصول ومكوناتة تحت ظروف الزراعة المتاخرة فى قمح الخبز

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أجريت هذه الدراسة خلال موسمى زراعة القمح ٢٠١٤/٢٠١٣ و ٢٠١٥/٢٠١٤ فى تجربة حقلية بمزرعة كلية الزراعة بجامعة جنوب الوادى لدراسة طبيعة فعل الجين لصفات المحصول ومكوناتة تحت ظروف الزراعة الطبيعية (٣٠ نوفمبر) والزراعة المتأخرة (١٠ يناير). واستخدمت فى هذه التجربة خمس أصناف من القمح المصرى حيث تم زراعة هذه الاصناف فى موسم زراعة القمح ٢٠١٤/٢٠١٣ وتم اجراء التهجين بين الاباء فى اتجاه واحد للحصول على بذور ١٠ هجن منها فى الجيل الاول. وفى موسم ٢٠١٥/٢٠١٤ تم زراعة الاباء وهجن الجيل الاول فى تجربة قطاعات كاملة العشوئية وتم تحليل بيانات الاباء والجيل الاول لصفات محصول القمح وهى وزن المحصول وعدد الحبوب فى كل سنبلة ووزن الالف حبة وطول السنبلة. أظهرت النتائج أن جميع الصفات محل الدراسة محكومة وراثيا بالطراز المضيف والسيادى لفعل الجين كما كان تاثير فعل الجين المضيف اكثر اهمية لجميع الصفات الوراثية محل الدراسة فى الميعاد الطبيعى (٣٠ نوفمبر). وبالنسبة لصفة المحصول ظهر تاثير السيادة الفائقة من فعل الجين فى الميعاد الطبيعى بينما ظهر تأثير السيادة الجزئية فى الميعاد الثانى. بالاضافة الى ذلك كانت درجة التوريث بمعناها الضيق والواسع عالية لجميع الصفات محل الدراسة مما يشير الى إمكانية التربية والتحسين لهذه الصفات من خلال برامج الانتخاب فى الاجيال الانعزالية المتقدمة.