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Combining Ability, Heterosis and Gene Action Estimation by Using Line X Tester Analysis in Bread Wheat (*Triticum astivum*, L)

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ABSTRACT

In order to investigate the combining ability, gene action and heterosis morphological, yield and its components traits in wheat F_1 crosses using line x tester analysis. Experiment was conducted with sixty three genotypes consisting of fifteen lines, L_1,L_2, L_3, L_4, L_5, L_6, L_7, L_8, L_9, L_{10}, L_{11}, L_{12}, L_{13}, L_{14}, L_{15} and three testers namely; Gemmeiza 9 (T_1), Giza 171 (T_2) and Gemmeiza 11 ((T_3) and heir forty five crosses made in line x tester mating at experimental Research Farm, Faculty of Agric., Tanta University during the winter successive growing seasons 2014/15 and 2015/16. A significant difference was found among lines, testers and line x testers for all the studied traits. Analysis of genetic revealed that GCA and SCA variances were significant for all traits, indicating the importance of both additive and non-additive components in the inheritance of thesis traits. The non-additive was more important for all the studied traits except days to heading and No. of grains/spike in which the additive was more important.The best general combining ability for earliness (Number of days to heading and maturity) were L_5, L_7, L_9, L_{10} and $L_{14}$for short plant were L_2, L_6, L_{10}, L_{12} andL_{13} for spikes numbers/plant, grains numbers/spike and grain yield/plant were the parental lines L_{11} and L_{12}. The best crosses for heterosis relative to mid parent and better parent were T_1 x L_7 and T_1 x L_9 for number of days to heading and maturity, while the cross T_3 x L_{11} for spikes numbers/plant, grains number/spike and grain yield/plant.Heritability in broad sense were greater than the corresponding values of narrow sense for all the studied traits. Higher value for narrow sense 10.22% was obtained for days to maturity, while the lowest value 3.96 was detected for No. of grains/spike. The lines had higher contribution to the total variance than both testers and lines x testers, also the line x testers contribution were higher than the testers for all the studied characters excluding number of days to heading.

INTRODUCTION

Bread wheat (*Triticumaestivum* L.) is a chief food crop in the world. In Egypt, wheat used as a steady food grain for urban, rural and bedewing societies and as a main source of straw for animal nourishing. There is requirement to have knowledge about the nature of gene action complicated in the appearance of carefully significant quantitative as well as qualitative traits and also concerning the nature of combining ability of obtainable parents to be rummage-sale in the hybridization programme to improve yield potential of wheat (Hassan *et al.* (2007). In order to develop the genetically greater high yielding cultivars, identification of greater parents is an important pre-requisite, Prasad (2014). Chaudhry *et al.* (1992) exposed that both general and specific combining ability were involved for yield and its attributes. For effective improvement in yield of wheat, one can use combining ability analysis to examination the performance of designated parents in dissimilar cross combinations and can describe the nature and magnitude of gene properties in the expression of various yield donating characters.

Hybrid vigor is the phenomenon depending on the equilibrium of additive, dominance and their interrelating characters as well as delivery of genes in parental lines and distinct the advantage of the hybrid over the mid-parent (heterosis) and better parent (heterobeltiosis) (Allard, 1960). Such information will lead to isolation of potential cross combinations and the selection of superior parental lines for the use in plant breeding programs. by crossing good general combining lines for grain yield and selecting transgressive sergeants from resulting hybrids Breeders could develop of productive wheat varieties, Abdel Nour *et al.* (2011). In order to keep the above in view, the present line × tester analysis was planned to estimation general and specific combining ability effects to identify better parents as well as superior cross combinations for further improvement in wheat.

MATERIALS AND METHODS

Study was assigned out at El–Gemmeiza Res. Station, ARC, Egypt during 2014/15and 2015/16 seasons, Egypt. In 2014/15 season, line x tester mating design was performed through 15 genotypes (lines) plus to three testers to produce the hybrid seeds of 45 crosses. Parents of the beforementioned genotypes are listed in Table 1. In 2015/16, the 18 parents along with the 45 F_1'S were grown in RCBD with three replications. Each genotype was sown in 2 rows of 3m length with 30 cm wide and plants within row were 10 cm apart.. The recommended cultural practices were followed to raise a good crop, stand all. The recommended cultural practices were applied at the proper time. Data were recorded on a sample of ten plants for apiece replication in each genotype for Number of days to heading, days to 50% flowering on plant height (cm), no. of spikes per plant, no. of grains per spike, 1000 grain weight and grain yield per plant. However, number of days to 75% heading and days to maturity were logged per plot basis. The data for each trait depicting significant difference were further analyzed for line x tester according to Singh and Chaudhry (1979).

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance of ordinary and line x testers mating design for studied characters are obtainable in Table (2). Analysis of variance revealed highly significant for genotypes and their partitions; parents, crosses and parents vs. crosses for studied traits except thousand grain weight for parent vs. crosses, indicating the wide diversity among the genotypes, which is considered adequate for further biometrical assessment significant parents vs. crosses mean squares as an suggesting the presence of significant heterosis over all crosses for all the studied traits except thousand grains weight.

Crosses mean squares and their partitions; lines, testers and line x testers were highly significant for all the studied traits, indicating that both lines and testers were significantly different from one to another in top crosses. These consequences are in arrangement with those of Abd El-Aty (2002), Abd El-Atyand Katta (2002), Nour *et al.* (2011) and Kumar *et al.* (2015).

Table 1. Pedigrees and name of the parental genotypes.

NO.	Pedigree	Origin
L_1	OUASSOU-20ICW01-00114-0AP-3AP-0AP-0AP-6AP/MOR-0AP/MOR-0AP	ICARDA
L_1	MON'S'/ALD'S'//ALDAN'S'/IAS58/3/SAFI-1/4/ZEMAMRA-1ICW01-21120-2AP12AP0AP-0AP-18AP3AP-0AP	ICARDA
L_1	BOW #1/FENGKANG 15/NESMA*2/261-9/3/DUCULAICW02-20369-22AP-0AP-0AP-0AP-5AP-0AP	ICARDA
L_1	HUBARA-5/3/SHA3/SERI//SHA4/LIRAICW03-0014-10AP/0TS-0AP-0AP13AP-0AP	ICARDA
L_1	HUBARA-3/ANGI-2//SOMAMA-3ICW02-20005-4AP-20AP/0TS-0AP-0AP-15AP-0AP	ICARDA
L_2	CNO79//PF0354/MUS/3/PASTOR/4/BAV92/FRET2/KUKUNA//CMSA05Y01011T-040M-040ZTP0Y-040ZTM-040SY-5ZTM-01Y-0B	CIMMYT
L_3	SW89-5124*2/FASAN/3/ALTAR 84/AE.SQ//2*OPATACMSA04M00335S-040ZTP0Y-040ZTM-040SY-16ZTM-04Y-0B	CIMMYT
L_4	GOUBARA-1/2*SOKOLLCMSA04M01020T-050Y-040ZTP0M-040ZTY-040ZTM-040SY-12ZTM-02Y-0B	CIMMYT
L_5	SAUAL/YANAC/SAUALCMSS06Y00783T-099TOPM-099Y-099ZTM-099NJ-3WGY-0B	CIMMYT
L_6	BECARD/KACHUCMSS06B00169S-0Y-099ZTM-099Y-099M-21WGY-0B	CIMMYT
L_7	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/7/CAL/NH//H567.71/3/CMSS05B00579S-099Y-099M-099Y-099ZTM-10WGY-0B	CIMMYT
L_8	KAUZ//ALTAR 84//AOS/3/MILAN/KAUZ/4/HUITES/7/CAL/NH//CMSS05B00581S-099Y-099M-99Y-099ZTM-2WGY-0B	CIMMYT
L_9	TRCH/SRTU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITESCGSSO5B00191T-099TOPY-099M-099NJ-099NJ-7WGY-0B	CIMMYT
L_{10}	ATTILA*2/PBW65//KIRITATI/3/WAXWING/KIRITATICGSS05B00299T-099TOPY-099M-099Y-099ZTM-019WGY-0B	CIMMYT
L_{11}	PBW343*2/KUKUNA/PARUS/3/PBW343*2/KUKUNACGSS05B00256T-099TOPY-099M-099NJ-099NJ-3WGY-0B	CIMMYT
L_{12}	OUASSOU-20ICW01-00114-0AP-3AP-0AP-0AP-6AP/MOR-0AP/MOR-0AP	ICARDA
L_{13}	MON'S'/ALD'S'//ALDAN'S'/IAS58/3/SAFI-1/4/ZEMAMRA-1ICW01-21120-2AP12AP0AP-0AP-18AP3AP-0AP	ICARDA
L_{14}	BOW #1/FENGKANG 15/NESMA*2/261-9/3/DUCULAICW02-20369-22AP-0AP-0AP-0AP-5AP-0AP	ICARDA
L_{15}	HUBARA-5/3/SHA3/SERI//SHA4/LIRAICW03-0014-10AP/0TS-0AP-0AP13AP-0AP	ICARDA
T1	GEMMEIZA # 9- ALD"S"/HUAC//CMH74A-630/SX	Egypt
T2	GIZA #171- Sakha 93 / Gemmeiza9- GZ003-101-1GZ-1GZ-2GZ-0GZ	Egypt
T3	GEMMEIZA # 11- BOW"S"/KVS"S"//7C/SERI82/3/GIZA168/SAKHA61- GM-7892-2GM-1GM2GM-1GM-0GM	Egypt

Table 2. The analysis of variance for morphological characters in line x tester including parents.

Source of variation	Df	No. of days to heading	No. of days to maturity	Plant height	Spikes Numbers /plant	Grains numbers /spike	1000- Grain weight	Grain yield/plant
Replication	2	8.53*	34.55**	8.79	28.02*	91.92*	2.01	0.18
Treatments	62	92.91**	39.02**	45.27**	34.64**	221.64**	41.02**	322.18**
Parents	17	169.85**	61.51**	51.55**	24.79**	452.93**	45.81**	192.17**
Crosses	44	64.71**	21.59**	43.01**	37.96**	133.01**	39.99**	368.60**
Parentsvs. crosses	1	25.70**	423.35**	38.23*	56.47**	189.34**	4.87	489.61**
Line	14	166.48**	49.75**	100.28**	77.35**	258.65**	75.50**	707.51**
Tester	2	171.83**	30.89**	84.14**	21.61*	122.41**	56.96**	378.08**
Line x Tesrer	28	6.18**	6.85**	11.43*	19.43**	70.95**	21.04**	198.47**
Error	124	2.09	1.83	7.09	6.19	21.46	6.58	10.59

The sign of *and ** significant at 0.05 and 0.01 respectively

Mean performance of genotypes

The mean concert of parents (lines and testers) and their crosses are presented in Tables (3 and 4). A wide range of performance among the parental cultivars was shown. Also, significant differences were detected among the F_1 hybrids for all characters. The parental lines L_9, L_{10} and L_{11}gave the lowest values (earliest) of days to heading and maturity, while the parents L_3 and L_6 were the latest. For plant height the parents L_7 and L_9 gave the highest values, while the parental lines L_1 and L_6 gave the lowest values. On the other hand the parental T_3 was the earliest tester also, it had the shortest plants. The parental L_1, L_5 and L_{13} gave the highest mean values for spike length; meanwhile the parental T_1 gave the highest mean value for this trait.

Table 3. Mean performance of parents (lines and testers) for all studied traits.

Parents	No. of days to heading (DH)	No. of days to maturity (DM)	Plant height (cm)	Spikes No. /plant	Grains No. /spike	1000- Grain weight	Grain yield /plant
L1	106.33	151.67	101.60	18.67	62.57	45.48	46.91
L2	100.17	147.33	102.20	14.03	79.53	48.40	41.99
L3	109.17	153.00	108.27	13.97	81.63	44.32	39.84
L4	96.33	147.67	102.50	12.07	87.47	47.11	47.55
L5	100.50	148.00	107.10	18.97	79.13	51.82	41.24
L6	111.00	156.67	100.90	17.20	65.40	42.48	35.24
L7	100.83	145.50	115.97	14.10	74.33	56.19	37.32
L8	100.67	146.33	108.63	16.93	73.63	44.78	38.83
L9	91.00	141.50	113.70	12.90	62.37	55.75	42.25
L10	84.67	142.50	105.60	10.63	61.87	51.13	30.82
L11	82.83	139.50	107.20	12.50	58.87	48.31	31.10
L12	97.00	146.00	107.43	16.43	66.30	50.48	44.40
L13	104.17	148.67	103.33	20.50	68.53	52.70	50.44
L14	97.83	144.00	102.83	17.43	85.20	51.03	55.52
L15	102.83	150.33	103.13	13.73	87.83	48.80	38.87
T1	106.33	155.17	105.53	19.63	104.03	48.88	58.32
T2	101.67	146.33	108.83	16.63	84.13	53.00	54.78
T3	96.00	149.33	102.70	18.00	89.23	45.05	49.32
Average lines	99.02	147.24	106.03	15.34	72.98	49.25	41.49
Average testers	101.33	150.28	105.69	18.09	92.47	48.98	54.14
LSD 5%	0.88	0.82	1.83	1.66	3.10	1.68	2.19
LSD 1%	1.17	1.08	2.42	2.19	4.11	2.22	2.90

Combining ability

With respect to No. of grains/spike, four parental lines L_3, L_4, L_4 and L_{15} had higher No. of grains/spike, also the parental T_1 gave the highest mean value for this trait. The parental lines L_7 and L_9 also the parental T_2 were superior in 1000 grain weight 56.19, 55.75 and 53.00, respectively.

Concerning to the grain yield/plant the parental lines L_{13} and L_{14} as well as parental T_1 had the highest and desirable mean values for this trait.

The mean recital values of the F_1 crosses for all the studied traits are presented in Table (3). The two crosses T_2 x L_{10} and T_3 x L_{10}were the earliest flowering date. As the regard to plant height, three of the F_1 crossesT_1 X L_7, T_2 X $L_7$and T_3 X L_7were taller than their parental means. Four crosses had the highest values for the No. of spikes/plant, namely; T_2 X L_{11}, T_3 X $L_{11,}$ T_1 X $L_{12,}$ and T_2 X L_{12}. Four crosses had higher No. of grains/spike, 89.00, 89.30, 91.53 and 91.73, namely; T_2 X L_7, T_3 X $L_{11,}$ T_3 X $L_{12,}$ and T_1 X L_{12}, respectively. Similar findings are in line with conclusions of Saeed *et al.* (2001).

Eight crosses were superior in 1000 grain weight, the heaviest cross T_2 X L_5 (55.68 g) while, the lowest weight was found in T_3 X L_3 (40.32 g). Concerning the grain yield/plant, ten crosses were higher in the grain yield/plant; the crosses were higher in the grain yield/plant, where the heaviest crosses, 71.98, 70.68, 79.27 and 73.43 g/plant, namely; T_2 X $L_{11,}$ T_3 X L_{11}, T_1 X $L_{12}$and T_2 X L_{12} respectively. While, the lowest weight was found in cross T_2 X L_{14} (32.32 g). These results were coincident with these obtained by Khalifa *et al.* (1998), Abd El-Aty and Katta (2002), Nour *et al.* (2011), Kumar *et al.* (2015), Rajput and Kandalkar *et al.* (2018).

Table 4. Mean performance of hybrids (line x tester) for all studied traits.

Crosses	Days to heading (DH)	No. of days to maturity (DM)	Plant height (cm)	Spikes No. /plant	Grain No. /spike	1000- Grain weight	grain yield
T1 X L1	107.13	153.50	109.07	14.87	72.40	49.41	42.33
T2XL1	108.47	153.00	105.23	16.57	79.63	45.15	38.39
T3XL1	104.97	154.50	103.90	16.90	71.37	45.15	36.23
T1X L2	102.80	151.50	106.40	16.83	71.07	48.50	47.51
T2XL2	98.30	150.33	104.93	16.23	83.53	53.19	51.04
T3XL2	100.30	147.00	102.17	13.97	73.57	52.32	36.57
T1XL3	106.63	152.83	110.00	15.60	85.33	48.68	44.65
T2XL3	105.80	152.50	105.77	23.40	82.23	42.64	60.07
T3X L3	102.80	154.83	103.80	15.60	79.17	40.32	44.43
T1XL4	102.30	153.50	110.60	13.20	84.83	50.17	40.71
T2XL4	101.33	149.67	108.20	18.17	85.03	52.22	45.23
T3X L4	100.33	152.67	103.30	13.23	83.57	47.15	51.62
T1XL5	102.33	150.00	109.13	15.70	75.97	54.25	39.00
T2XL5	98.17	146.50	111.17	13.00	73.40	55.68	45.44
T3X L5	95.33	150.00	105.93	18.77	68.90	51.14	57.11
T1XL6	110.33	156.67	101.07	20.10	76.57	47.77	40.55
T2XL6	107.67	153.33	105.03	18.77	71.70	47.01	46.20
T3X L6	102.67	155.00	101.43	19.50	74.20	43.62	34.67
T1XL7	101.33	149.50	114.57	16.10	71.87	54.46	41.84
T2XL7	96.73	149.17	117.23	21.72	89.00	50.88	57.53
T3X L7	95.23	149.83	113.27	18.07	86.30	49.88	60.48
T1XL8	104.07	152.17	108.03	16.63	68.43	53.24	43.37
T2XL8	100.90	150.17	107.10	17.67	70.07	46.62	40.11
T3X L8	100.40	151.00	107.60	13.83	74.83	48.51	34.78
T1XL9	96.23	147.50	111.83	13.03	78.40	52.41	43.34
T2XL9	95.57	146.50	111.23	13.60	84.07	53.33	50.83
T3X L9	94.23	148.00	106.67	13.17	77.60	51.41	40.52
T1XL10	94.57	149.50	105.87	14.80	68.60	47.71	38.73
T2XL10	90.90	149.00	100.43	17.40	80.90	50.31	57.25
T3X L10	90.73	149.50	100.20	13.67	73.33	53.32	38.36
T1XL11	94.73	150.00	109.00	17.23	71.93	45.39	47.08
T2XL11	94.90	153.00	106.77	26.03	85.20	49.28	71.98
T3X L11	93.90	156.00	103.97	23.67	91.53	48.16	70.68
T1XL12	103.07	154.00	102.00	24.87	91.73	44.52	79.27
T2XL12	104.57	154.17	105.10	23.00	83.13	42.23	73.43
T3X L12	99.07	152.50	103.80	21.17	89.30	46.09	56.09
T1XL13	104.23	153.83	103.67	20.40	72.40	53.23	50.75
T2XL13	102.90	148.33	104.53	15.63	69.40	49.37	36.83
T3X L13	99.40	150.00	106.53	17.30	74.17	44.71	45.32
T1XL14	101.40	148.00	108.93	13.57	85.70	47.92	42.79
T2XL14	97.40	146.67	108.73	9.63	83.67	51.69	32.32
T3X L14	96.07	148.00	109.23	15.20	83.73	48.04	41.80
T1XL15	100.73	151.83	109.97	17.40	76.33	46.88	39.14
T2XL15	101.23	149.33	110.60	16.20	80.07	50.72	50.89
T3X L15	97.90	153.00	109.47	13.90	75.70	43.60	34.87
Average L x T	100.22	151.06	106.97	17.01	78.44	48.85	47.16
LSD 5%	0.88	0.82	1.83	1.66	3.10	1.68	2.19
LSD 1%	1.17	1.08	2.42	2.19	4.11	2.22	2.90

Effects of general combining ability (GCA (ĝi)).

General combining ability estimation of for parents (lines and testers) are presented in Table (5). The recorded results showed that five parental lines; L_5, L_7, L_9, L_{10} and L_{14} showed significant negative (ĝi) effects (desirable) for number of days to heading and maturity earliness in maturity is essentially a prerequisite in breeding program of a crop.

Regarding to plant height, tall plants are preferred for straw purpose while dwarf plants are more lodging resistant thus preference depends upon the breeding objective. Therefore, the parental lines L2, L6, L10, L12 and L13 can be defined as good general combiner for dwarfness as they showed highly significant negative GCA (ĝi), while the parental lines, L7, L9 and L15 considered as good general combiner for tallness as they showed highly significant positive (ĝi) effects. The number of spikes/plants, the parental lines L6, L11 and L12 showed highly significant positive (ĝi) effects. On the other hand four parental lines L4, L9 and L10 and L14 exhibited highly significant negative (undesirable) (ĝi) effects.

Table 5. General combining ability estimation effects of parents for studied characters.

Parent/Line	No. of days to heading	No. of days to maturity	Plant height	Spikes No. /plant	Grains No. /spike	1000- Grain weight	Grain yield
L1	6.63**	2.60**	-0.90	-0.90	-3.97*	-2.28**	-8.17**
L2	0.24	-1.45**	-2.47**	-1.33	-2.39	2.49**	-2.12
L3	4.85**	2.33**	-0.44	1.19	3.80*	-4.97**	2.56*
L4	1.10*	0.88*	0.40	-2.14*	6.04**	0.99	-1.31
L5	-1.61**	-2.23**	1.78	-1.18	-5.69**	4.84**	0.02
L6	6.67**	3.94**	-4.45**	2.45**	-4.29**	-2.71**	-6.68**
L7	-2.46**	-1.56**	8.06**	1.62	3.95*	2.89**	6.12**
L8	1.57**	0.05	0.61	-0.96	-7.33**	0.60	-7.74**
L9	-4.88**	-3.73**	2.95**	-3.74**	1.58	3.53**	-2.26*
L10	-8.16**	-1.73**	-4.80**	-1.72*	-4.16**	1.59	-2.38*
L11	-5.71**	1.94**	-0.39	5.30**	4.45**	-1.24	16.09**
L12	2.01**	2.49**	-3.33**	6.00**	9.61**	-4.57**	22.44**
L13	1.95**	-0.34	-2.05*	0.77	-6.45**	0.25	-2.86*
L14	-1.93**	-3.51**	2.00*	-4.21**	5.93**	0.36	-8.19**
L15	-0.27	0.33	3.05**	-1.17	-1.07	-1.78*	-5.53**
LSD 5%	0.88	0.82	1.83	1.66	3.10	1.68	2.19
LSD 1%	1.17	1.08	2.42	2.19	4.11	2.22	2.90
Tester							
Gemmeiza 9(T1)	1.90**	0.56**	1.04*	-0.32	-1.67*	0.79*	-1.76**
Giza 171 (T2)	0.10	-0.95**	0.51	0.79*	1.63*	0.50	3.35**
Gemmeiza 11 (T3)	-2.00**	0.39*	-1.55**	-0.48	0.04	-1.29**	-1.59**
LSD 5%	0.39	0.37	0.82	0.74	1.39	0.75	0.98
LSD 1%	0.52	0.48	1.08	0.98	1.84	0.99	1.30

***and ** significant at 0.05 and 0.01 respectively**

With respect to No. of grains/spike six parental lines; L3, L4, L7, L11, L12 and L14 showed highly significant positive GCA effects, these parents defined as decent combiner for this trait of No. of grains/spike is an important yield contributing trait.

For 1000 grains weight, four the parental lines; L2, L5, L7 and L9 showed highly significant positive (ĝi) effects.1000 grain weight is an important indirect selection criterion for the selection of grain yield, thus significant positive GCA values considered as good general combining ability effects.

Regarding grain yield/plant; four parental lines L3, L7, L11 and L12 exhibited highly significant positive (ĝi) effects.These results are in agreement with the earlier studies carried out by Abd El-Aty and Katta (2002), Akbar*et al*. (2009), Nour *et al* (2011), Attia*et al*. (2014), Kumar *et al* (2015) and Tabassum and parasad (2017).

Specific combining ability

The results of SCA effects (Sij) of single crosses for all the studied traits are presented in Table (6).

Four crosses, T_1 x L_1, T_2 x L_2, T_3 x L_6 and T_1 x L_{11} showed significant negative (desirable) Sijeffectsfor days to heading and days to maturity, which indicated that one or more of these combinations could be helpful for selecting early maturity wheat lines.

For plant height, only the cross T_3 x L_{13} showed significant positive Sij effects (tall plant), it could be a good combiner for straw production.

For No.of spikes/plant, five out of forty five crosses; T_2 x L_3, T_3 x L_5, T_2 x L_{11}, T_1 x L_{13} and T_3 x L_{14} showed significant positive (desirable) SCA (Sij). These crosses can be used for increasing No. of tillers/plant.

Regarding No.of grains/spike, two crosses; T_2 x L_2 and T_3 x L_{11} exhibited significant positive Sij effects.

1000-grain weight, six crosses out of forty-five crosses namely; T1 x L3, T1 x L8, T3 x L10, T3 x L12, T1 x L13 and T2 x L15 showed significant positive Sijeffectsand they considered as good specific combiner for 1000 grain weight.

For grain yield/plant, fifteen crosses out of forty-five crosses exhibited highly significant positive Sij effects (desirable), they consider the best combiner for this trait.

Heterosis

The percentage of increase or decrease of wheat hybrids over mid parent and better parent for all studied traits are shown in Table (7).

It could be noticed that positive heterosis considered as desirable for all the studied traits, except for earliness days to heading and days to maturity.

For days to heading, nine crosses out of forty five crosses showed significant and highly significant negative heterosis relative to mid parent which ranged from -4.46% for T2 x L7 to -2.36% for T2 x L15. Twenty seven crosses showed highly significant negative heterosis relative to better parent, which ranged from -11.07% for T1 x L10 to -2.19% for T3 x L11.

Concerning days to maturity, none of the crosses exhibited significant negative heterotic relative to mid parent, meanwhile eight crosses exhibited highly significant negative heterosis relative to better parents, which ranged from -4.94% for T_1 x L_9 to -2.36% for T_1 x L_2. The negative estimates of heterosis for No. of days to heading and maturity may be favorable traits for wheat breeding.

Concerning to plant height, five crosses expressed significant positive heterotic effects relative to mid parent.

However, three crosses gave significant positive heterotic effects relative to mid parent, and ranged from -6.33% for T_2 x L_{10} to -4.21% for T_1 x L_{13}. On the other hand, two crosses out of forty five crosses showed highly significant positive heterosis relative to mid parent.

For No. of spikes/plant, nineteen crosses out of forty-five crosses had significant positive heterosis relative to mid parent and ranged from 5.26% for T_2 x L_8 to 78.72% for T_2 x L_{11}, meanwhile fifteen crosses expressed highly significant positive heterosis relative to better parent and ranged from 4.33% for T_2 x L_8 to 56.51% for T_2 x L_{11}.

Table 6. Estimates of specific combining ability effects of crosses for studied traits.

crosses	Days to heading	Days to maturity	Plant height (cm)	No. of spike /plant	No. of grain /spike	1000- Grain weight	grain yield
T1 X L1	-1.63*	-0.73	1.96	-0.93	-0.40	2.06	5.10**
T2XL1	1.51	0.29	-1.34	-0.34	3.54	-1.92	-3.94*
T3XL1	0.11	0.44	-0.62	1.27	-3.14	-0.13	-1.17
T1X L2	0.43	1.33	0.86	1.47	-3.32	-3.62*	4.22*
T2XL2	-2.27**	1.67*	-0.07	-0.24	5.85*	1.35	2.66
T3XL2	1.83*	-3.00**	-0.79	-1.23	-2.53	2.27	-6.88**
T1XL3	-0.35	-1.11	2.43	-2.28	4.76	4.02**	-3.31
T2XL3	0.62	0.06	-1.26	4.41**	-1.64	-1.74	7.01**
T3X L3	-0.28	1.05	-1.17	-2.12	-3.12	-2.27	-3.70
T1XL4	-0.93	1.00	2.19	-1.35	2.03	-0.46	-3.39
T2XL4	-0.09	-1.33	0.33	2.51	-1.07	1.87	-3.97*
T3X L4	1.01	0.33	-2.52	-1.16	-0.95	-1.41	7.36**
T1XL5	1.82*	0.61	-0.65	0.20	4.88	-0.23	-6.43**
T2XL5	-0.54	-1.38	1.92	-3.62*	-0.98	1.49	-5.09**
T3X L5	-1.28	0.77	-1.26	3.42*	-3.90	-1.26	11.52**
T1XL6	1.54*	1.11	-2.49	0.96	4.08	0.85	1.83
T2XL6	0.68	-0.71	2.02	-1.48	-4.08	0.37	2.38
T3X L6	-2.22**	-0.39	0.47	0.52	0.00	-1.22	-4.21*
T1XL7	1.66*	-0.56	-1.50	-2.21	-8.85**	1.93	-9.69**
T2XL7	-1.13	0.62	1.71	2.29	4.98	-1.36	0.90
T3X L7	-0.53	-0.06	-0.21	-0.08	3.87	-0.57	8.79**
T1XL8	0.37	0.50	-0.59	0.91	-1.01	3.00*	5.71**
T2XL8	-0.99	0.01	-0.98	0.83	-2.67	-3.34*	-2.66
T3X L8	0.61	-0.50	1.57	-1.73	3.68	0.35	-3.05
T1XL9	-1.01	-0.39	0.88	0.08	0.05	-0.76	0.20
T2XL9	0.12	0.12	0.82	-0.46	2.42	0.44	2.59
T3X L9	0.89	0.27	-1.70	0.38	-2.47	0.32	-2.79
T1XL10	0.60	-0.39	2.66	-0.17	-4.01	-3.52*	-4.30*
T2XL10	-1.27	0.62	-2.24	1.32	4.99	-0.64	9.13**
T3X L10	0.67	-0.23	-0.42	-1.14	-0.99	4.16**	-4.83*
T1XL11	-1.68*	-3.56**	1.38	-4.76**	-9.29**	-3.01*	-14.41**
T2XL11	0.29	0.95	-0.32	2.93*	0.68	1.17	5.39**
T3X L11	1.39	2.61**	-1.06	1.83	8.60**	1.84	9.03**
T1XL12	-1.07	-0.11	-2.68	2.17	5.35	-0.55	11.43**
T2XL12	2.23**	1.56*	0.96	-0.81	-6.55*	-2.55	0.49
T3X L12	-1.17	-1.45*	1.71	-1.37	1.20	3.10*	-11.92**
T1XL13	0.15	2.55**	-2.29	2.94*	2.08	3.34*	8.21**
T2XL13	0.62	-1.44*	-0.88	-2.94*	-4.22	-0.24	-10.81**
T3X L13	-0.78	-1.11	3.17*	0.00	2.13	-3.10*	2.61
T1XL14	1.21	-0.11	-1.08	1.08	3.00	-2.08	5.58**
T2XL14	-0.99	0.06	-0.74	-3.96**	-2.33	1.97	-9.99**
T3X L14	-0.22	0.05	1.81	2.88*	-0.68	0.11	4.42*
T1XL15	-1.13	-0.11	-1.09	1.88	0.64	-0.97	-0.74
T2XL15	1.18	-1.10	0.08	-0.43	1.07	3.15*	5.91**
T3XL15	-0.05	1.22	1.00	-1.46	-1.71	-2.18	-5.17**
SCA 0.05	1.53	1.42	3.17	2.87	5.38	2.91	3.80
SCA 0.01	2.02	1.88	4.19	3.80	7.12	3.85	5.03

***and ** significant at 0.05 and 0.01 respectively**

Regarding No. of grains/spike, twelve crosses showed highly significant positive heterosis relative to mid parent and ranged from 7.71% for T_1 x L_{13} to 23.61% for T_3 x L_{11}, while, none of the crosses showed significant positive hetoresis relative to better parent.

For 1000 grain weight the results showed that fifteen crosses out of forty five were significant positive heterosis relative to mid parent and ranged from 3.66% for T_1 x L_7 to 13.68 % for T_1 x L_8, while six crosses exhibited highly significant positive heterosis relative to better parent.

With respect to grain yield/plant, sixteen cross combinations expressed highly significant positive heterosis relative to mid-parent. While eleven crosses exhibited significant positive relative to better-parent. The cross T_3 x L_{11} gave the highest value of heterotic effects comparative to mid-parent (75.80%) and better-parent (43.33%). These results were coincident with these reported by Abd El-Aty and Katta (2002), Nour *et al* (2011), Kumar *et al*. (2015), Tabassum and Parasad (2017) and Rajput and Kandalkar (2018).

Genetic components

The knowledge of gene action helps in the selection of parents for usage in the hybridization programs and in the choice of appropriate breeding procedure for the genetic improvement quantitative traits.

The estimates of genetic parameters and dominance degree ratio were calculated, for all the studied traits as presented in table (8).

Table 7. Estimates of heterosis over mid parent and better parents of crosses for DH, DM ,PH, NS/P, NG/S, TWG and GY/P

crosses	Days to heading [DH]			Days to maturity[DM]			Plant height [PH] (cm)		
	MP	BP	Pr	MP	BP	Pr	MP	BP	Pr
T1 X L1	0.75	0.75	0.00	0.05	-1.07	0.05	5.31**	3.35	2.80
T2XL1	4.29**	2.01	1.91	2.68**	0.88	1.50	0.02	-3.31	0.00
T3XL1	3.76**	-1.29	0.74	2.66**	1.87	3.43	1.71	1.17	3.18
T1X L2	-0.44	-3.32**	-0.15	0.17	-2.36*	0.06	2.44	0.82	1.52
T2XL2	-2.59**	-3.31**	-3.49	2.38**	2.04*	7.00	-0.55	-3.58	-0.18
T3XL2	2.26*	0.13	1.06	-0.90	-1.56	-1.33	-0.28	-0.52	-1.13
T1XL3	-1.04	-2.32*	-0.79	-0.81	-1.50	-1.15	2.90	1.60	2.27
T2XL3	0.36	-3.08**	0.10	1.89*	-0.33	0.85	-2.56	-2.82	-9.82
T3X L3	0.21	-5.83**	0.03	2.43**	1.20	2.00	-1.60	-4.13	-0.60
T1XL4	0.95	-3.79**	0.19	1.38	-1.07	0.56	6.33**	4.80*	4.34
T2XL4	2.36*	-0.33	0.87	1.81*	1.35	4.00	2.40	-0.58	0.80
T3X L4	4.33**	4.15**	25.00	2.81**	2.23*	5.00	0.68	0.58	7.00
T1XL5	-1.05	-3.76**	-0.37	-1.04	-3.33**	-0.44	2.65	1.90	3.60
T2XL5	-2.89**	-3.44**	-5.00	-0.45	-1.01	-0.80	2.96	2.14	3.69
T3X L5	-2.97**	-5.14**	-1.30	0.90	0.45	2.00	0.99	-1.09	0.47
T1XL6	1.53	-0.60	0.71	0.48	0.00	1.00	-2.08	-4.23	-0.93
T2XL6	1.25	-3.00**	0.29	1.21	-2.13*	0.35	0.16	-3.49	0.04
T3X L6	-0.81	-7.51**	-0.11	1.31	-1.06	0.55	-0.36	-1.23	-0.41
T1XL7	-2.17*	-4.70**	-0.82	-0.55	-3.65**	-0.17	3.45	-1.21	0.73
T2XL7	-4.46**	-4.85**	-10.84	2.23*	1.94	7.80	4.30*	1.09	1.36
T3X L7	-3.23**	-5.55**	-1.32	1.64	0.33	1.26	3.60	-2.33	0.59
T1XL8	0.55	-2.13	0.20	0.94	-1.93	0.32	0.89	-0.55	0.61
T2XL8	-0.26	-0.75	-0.53	2.62**	2.62*	0.00	-1.50	-1.59	-16.33
T3X L8	2.10*	-0.26	0.89	2.14*	1.12	2.11	1.83	-0.95	0.65
T1XL9	-2.47*	-9.50**	-0.32	-0.56	-4.94**	-0.12	2.02	-1.64	0.54
T2XL9	-0.80	-6.00**	-0.14	1.80*	0.11	1.07	-0.03	-2.17	-0.01
T3X L9	0.78	-1.84	0.29	1.78*	-0.89	0.66	-1.42	-6.19**	-0.28
T1XL10	-0.98	-11.07**	-0.09	0.45	-3.65**	0.11	0.28	0.25	9.00
T2XL10	-2.43*	-10.59**	-0.27	3.17**	1.82	2.39	-6.33**	-7.72**	-4.20
T3X L10	0.44	-5.49**	0.07	2.46**	0.11	1.05	-3.79	-5.11*	-2.72
T1XL11	0.16	-10.91**	0.01	1.81*	-3.33**	0.34	2.48	1.68	3.16
T2XL11	2.87**	-6.66**	0.28	7.06**	4.56**	2.95	-1.16	-1.90	-1.53
T3X L11	5.01**	-2.19*	0.68	8.02**	4.46**	2.36	-0.94	-3.02	-0.44
T1XL12	1.38	-3.07**	0.30	2.27*	-0.75	0.75	-4.21*	-5.06*	-4.72
T2XL12	5.27**	2.85*	2.24	5.47**	5.35**	48.00	-2.81	-3.43	-4.33
T3X L12	2.66**	2.13	5.13	3.27**	2.12*	2.90	-1.21	-3.38	-0.54
T1XL13	1.38	-3.07**	0.30	2.27*	-0.75	0.75	-4.21*	-5.06*	-4.72
T2XL13	5.27**	2.85*	2.24	5.47**	5.35**	48.00	-2.81	-3.43	-4.33
T3X L13	2.66**	2.13	5.13	3.27**	2.12*	2.90	-1.21	-3.38	-0.54
T1XL14	-0.97	-1.97	-0.94	1.26	-0.86	0.59	-0.73	-1.77	-0.70
T2XL14	-0.02	-1.22	-0.01	0.56	-0.22	0.71	-1.46	-3.95	-0.56
T3X L14	-0.68	-4.58**	-0.17	0.67	0.45	3.00	3.41	3.10	11.11
T1XL15	-0.67	-4.64**	-0.16	-1.06	-4.62**	-0.28	4.56*	3.22	3.52
T2XL15	-2.36*	-4.20**	-1.23	1.03	0.23	1.29	2.74	-0.09	0.97
T3XL15	-0.88	-1.81	-0.93	0.91	-0.89	0.50	6.29**	6.22**	97.00

***and ** significant at 0.05 and 0.01 respectively**

Recorded results showed that the non-additive genetic variance was larger than the additive genetic variance for the studied characters, indicating importance of non-additive genetic variance in the inheritance of these traits. The GCA variance were lower than SCA variance in terms in contrast to Titan *et al* (2012). They observed that SCA variance were lower than GCA variance. Also, Sharma *et al* (2006) noticed that gca variance was of greater importance than sca variance for some traits. The difference in the results reported by investigators may be attributed to alterations of parental materials used hybridization and to G × E.

The ratio GCA/SCA varies depending on the allele frequencies between parental populations (Reif *et al*., 2007; Longin *et al*., 2013). The lines selected from different gene pools had favorable GCA/SCA ratio because of their high GCA ($\hat{g}i$) (Labate *et al*.,1997). The low ratios of GCA/SCA, O^2A/O^2D and low narrow sense heritability supported the involvement of non-additive effects with predominance of non-additive type of gene actions (Table 5). Lines and the interaction of line × testers contributed more to variation of the expression of studied traits.

Ratio of GCA/SCA variances were found to be lower than unity for all the studied traits, Similar values were obtained for the average degree of dominance Ơ^{2}A/Ơ^{2}D, indicating the presence of partial dominance. Similar results were in accordance with these of Abd-Elaty (2000), Abd-Elaty and Katta (2002) and Nour *et al.* (2011).

The results of heritability in bread and narrow senses are presented in Table (7). Heritability values in brood sense were larger than the corresponding values of narrow sense for all the studied traits. The highest value for brood sense was observed for grain yield/plant (85.93%), while the lowest value was 21.40% for plant height, while for narrow sense heritability, it ranged from 3.96 to 62.59 for grains numbers/spike and number of days to heading, respectively.

Table 7. Con.

crosses	No. of spike/plant (NS/P)			No. of grain/spike (NG/S)			1000- Grain weight (TWG)		
	MP	BP	Pr	MP	BP	Pr	MP	BP	Pr
T1 X L1	-22.37**	-24.28**	-8.86	-13.09**	-30.41**	-0.53	4.73**	1.09	1.31
T2XL1	-6.14**	-11.25**	-1.07	8.57*	-5.35	0.58	-8.31**	-14.82**	-1.09
T3XL1	-7.82**	-9.46**	-4.30	-5.97	-20.02**	-0.34	-0.26	-0.74	-0.54
T1X L2	0.00	-14.26**	0.00	-22.57**	-31.69**	-1.69	-0.28	-0.77	-0.57
T2XL2	5.87**	-2.40	0.69	2.08	-0.71	0.74	4.91**	0.35	1.08
T3XL2	-12.80**	-22.41**	-1.03	-12.82**	-17.56**	-2.23	11.99**	8.11**	3.34
T1XL3	-7.14**	-20.54**	-0.42	-8.08*	-17.98**	-0.67	4.47*	-0.41	0.91
T2XL3	52.94**	40.68**	6.08	-0.78	-2.26	-0.52	-12.38**	-19.56**	-1.39
T3X L3	-2.40	-13.33**	-0.19	-7.34*	-11.28**	-1.65	-9.77**	-10.50**	-11.96
T1XL4	-16.72**	-32.77**	-0.70	-11.40**	-18.46**	-1.32	4.53*	2.64	2.46
T2XL4	26.60**	9.22**	1.67	-0.89	-2.78	-0.46	4.31*	-1.48	0.73
T3X L4	-11.97**	-26.48**	-0.61	-5.41	-6.35	-5.42	2.31	0.07	1.03
T1XL5	-18.65**	-20.03**	-10.80	-17.05**	-26.98**	-1.25	7.75**	4.70*	2.66
T2XL5	-26.97**	-31.46**	-4.11	-10.09**	-12.76**	-3.29	6.25**	5.06*	5.52
T3X L5	1.53	-1.05	0.59	-18.15**	-22.79**	-3.03	5.59**	-1.31	0.80
T1XL6	9.14**	2.38	1.38	-9.62**	-26.40**	-0.42	4.58*	-2.26	0.65
T2XL6	10.94**	9.11**	6.53	-4.10	-14.78**	-0.33	-1.53	-11.30**	-0.14
T3X L6	10.80**	8.33**	4.75	-4.03	-16.85**	-0.26	-0.32	-3.16	-0.11
T1XL7	-4.55*	-18.00**	-0.28	-19.42**	-30.92**	-1.17	3.66*	-3.08	0.53
T2XL7	41.32**	30.56**	5.01	12.33**	5.78	1.99	-6.80**	-9.44**	-2.33
T3X L7	12.56**	0.37	1.03	5.52	-3.29	0.61	-1.45	-11.22**	-0.13
T1XL8	-9.02**	-15.28**	-1.22	-22.96**	-34.22**	-1.34	13.68**	8.91**	3.13
T2XL8	5.26**	4.33*	5.89	-11.18**	-16.72**	-1.68	-4.66*	-12.05**	-0.55
T3X L8	-20.80**	-23.15**	-6.81	-8.10*	-16.14**	-0.85	8.01**	7.70**	27.33
T1XL9	-19.88**	-33.62**	-0.96	-5.77	-24.64**	-0.23	0.19	-5.99**	0.03
T2XL9	-7.90**	-18.24**	-0.63	14.77**	-0.08	0.99	-1.92	-4.34*	-0.76
T3X L9	-14.78**	-26.85**	-0.90	2.37	-13.04**	0.13	2.01	-7.78**	0.19
T1XL10	-2.20	-24.62**	-0.07	-17.30**	-34.06**	-0.68	-4.60*	-6.70**	-2.04
T2XL10	27.63**	4.61*	1.26	10.82**	-3.84	0.71	-3.38	-5.09*	-1.88
T3X L10	-4.54*	-24.07**	-0.18	-2.93	-17.82**	-0.16	10.87**	4.27*	1.72
T1XL11	7.26**	-12.22**	0.33	-11.68**	-30.86**	-0.42	-6.59**	-7.13**	-11.16
T2XL11	78.72**	56.51**	5.55	19.16**	1.27	1.08	-2.71	-7.02**	-0.58
T3X L11	55.19**	31.48**	3.06	23.61**	2.58	1.15	3.19	-0.30	0.91
T1XL12	37.89**	26.66**	4.27	7.71*	-11.82**	0.35	-10.39**	-11.81**	-6.44
T2XL12	39.11**	38.28**	64.67	10.53**	-1.19	0.89	-18.38**	-20.32**	-7.55
T3X L12	22.94**	17.59**	5.04	14.83**	0.07	1.01	-3.51	-8.70**	-0.62
T1XL13	37.89**	26.66**	4.27	7.71*	-11.82**	0.35	-10.39**	-11.81**	-6.44
T2XL13	39.11**	38.28**	64.67	10.53**	-1.19	0.89	-18.38**	-20.32**	-7.55
T3X L13	22.94**	17.59**	5.04	14.83**	0.07	1.01	-3.51	-8.70**	-0.62
T1XL14	1.66	-0.49	0.77	-16.09**	-30.41**	-0.78	4.81**	1.02	1.28
T2XL14	-15.80**	-23.74**	-1.52	-9.08**	-17.51**	-0.89	-6.59**	-6.86**	-22.72
T3X L14	-10.13**	-15.61**	-1.56	-5.98	-16.88**	-0.46	-8.51**	-15.15**	-1.09
T1XL15	-26.80**	-30.90**	-4.52	-9.42**	-17.62**	-0.95	-4.08*	-6.10**	-1.90
T2XL15	-43.44**	-44.74**	-18.50	-1.18	-1.80	-1.88	-0.63	-2.48	-0.33
T3XL15	-14.21**	-15.56**	-8.88	-3.99	-6.16	-1.73	0.00	-5.86**	0.00

***and ** significant at 0.05 and 0.01 respectively**

Results indicated that Ơ2GCA/Ơ2SCA portion was lower than one and (Ơ2A/Ơ2D) portion, indicating that non-additive genetic effects are controlling the inheritance of studied traits whereas dominancy degree, lower than one (Table 7). It was understood that selection for the traits inherited with this manner should be performed in the further generations like F4 or F5.Non-additive gene action was importance for the plant height, spike length, no. of fertile tillers, thousand kernel weight and kernel yield, Fellahi *et al* (2013). They optional that selection of superior plants would be postponed to later generations due to preponderance of non-additive type of gene actions for studied characters. Results of predominance of non-additive gene action for all studied traits were similar with the results showed by Verma *et al* (2007) for barley. The efficiency of the selection is related with the size of narrow sense heritability in the segregating populations. The heritability degrees were very low for the studied traits (Table 7). Indicating that the additive variance is very low in this population and the selection must be applied in the further generations. These findings proved that in the present study, both non-aditive and additive components are important expression of the studied traits. Similar results were previously reported by Khalifa *et al* (1998), Abd El-Aty (2000), Abd El-Aty and Katta (2002).

Table 7. Con.

crosses	Grain yield/plant (GY/P)		
	MP	BP	Pr
T1 X L1	-19.54**	-27.41**	-1.80
T2XL1	-24.49**	-29.92**	-3.17
T3XL1	-24.71**	-26.54**	-9.89
T1X L2	-5.27*	-18.54**	-0.32
T2XL2	5.49*	-6.83*	0.42
T3XL2	-19.90**	-25.85**	-2.48
T1XL3	-9.02**	-23.44**	-0.48
T2XL3	26.98**	9.66**	1.71
T3X L3	-0.34	-9.92**	-0.03
T1XL4	-23.09**	-30.20**	-2.27
T2XL4	-11.60**	-17.44**	-1.64
T3X L4	6.58**	4.67	3.61
T1XL5	-21.65**	-33.13**	-1.26
T2XL5	-5.36*	-17.06**	-0.38
T3X L5	26.14**	15.80**	2.93
T1XL6	-13.32**	-30.48**	-0.54
T2XL6	2.65	-15.66**	0.12
T3X L6	-17.99**	-29.69**	-1.08
T1XL7	-12.51**	-28.26**	-0.57
T2XL7	24.94**	5.02	1.31
T3X L7	39.62**	22.64**	2.86
T1XL8	-10.71**	-25.63**	-0.53
T2XL8	-14.31**	-26.79**	-0.84
T3X L8	-21.08**	-29.48**	-1.77
T1XL9	-13.82**	-25.69**	-0.86
T2XL9	4.77*	-7.22**	0.37
T3X L9	-11.50**	-17.84**	-1.49
T1XL10	-13.11**	-33.60**	-0.42
T2XL10	33.76**	4.50	1.21
T3X L10	-4.27	-22.22**	-0.18
T1XL11	5.30*	-19.27**	0.17
T2XL11	67.64**	31.40**	2.45
T3X L11	75.80**	43.33**	3.35
T1XL12	54.35**	35.92**	4.01
T2XL12	48.07**	34.04**	4.59
T3X L12	19.71**	13.73**	3.75
T1XL13	54.35**	35.92**	4.01
T2XL13	48.07**	34.04**	4.59
T3X L13	19.71**	13.73**	3.75
T1XL14	-6.67**	-12.97**	-0.92
T2XL14	-29.99**	-32.77**	-7.26
T3X L14	-9.14**	-10.15**	-8.14
T1XL15	-24.83**	-26.63**	-10.11
T2XL15	-41.40**	-41.79**	-61.71
T3XL15	-20.27**	-24.72**	-3.42

***and ** significant at 0.05 and 0.01 respectively**

Table 8. The partitioning of the genetic components for morphological, yield and its components.

Genetic components	No. of days to heading	No. of days to maturity	Plant height	Spikes No. /plant	Grains No. /spike	1000- Grain weight	Grain yield/plant
σ^2gca	0.75	0.19	0.40	0.24	0.79	0.24	2.17
σ^2sca	1.47	1.77	1.27	4.39	16.33	4.87	62.51
σ^2gca/ σ^2sca	0.51	0.11	0.31	0.05	0.048	0.049	0.03
σ^2 A	1.49	0.38	0.80	0.47	1.58	0.48	4.33
σ^2 D	1.47	1.77	1.27	4.39	16.33	4.87	62.51
σ^2 A/ σ^2 D	1.01	0.22	0.63	0.11	0.097	0.099	0.07
Cov. H.S. (line)	17.81	4.77	9.87	6.44	20.86	6.05	56.56
Cov. H.S. (tester)	2.39	0.28	0.97	-0.13	0.22	0.35	1.17
Cov. H.S. (average)	0.79	0.20	0.43	0.26	0.86	0.26	2.37
Cov. (F.S.)	27.94	7.05	14.45	9.15	34.97	11.59	115.55
h^2 (n.s)	31.52	10.22	8.30	4.24	3.96	4.10	5.57
H^2 (B.S)	62.59	58.55	21.40	43.74	44.92	45.45	85.93
Average degree of dominance (ā)	1.40	3.07	1.78	4.31	4.55	4.49	5.37
Cont. of Line	81.86	73.32	74.20	64.84	61.87	60.06	61.07
Cont. of tester	12.07	6.50	8.89	2.59	4.18	6.47	4.66
Cont. of L x T	6.08	20.18	16.91	32.57	33.94	33.47	34.26

Proportional contribution of lines, testers and their interaction to the total variance.

The relative contribution lines, testers and line x testers for all the studied traits are presented inTable 6.The results indicated that the lines had higher contribution to the total variance than both testers and lines x testers for all the studied traits. However the line x testers contribution were higher than the testers for all the studied traits except days to heading this explain why F_1 hybrid was superior for these traits than their parents.

REFERENCES

Abd El-Aty,M.S.M. (2000) Estimates of heterosis and combining ability in diallel wheat crosses (*Triticum aestivum* L.). J. Agric. Tanta Univ. 26(3)486-498.

Abd El-Aty, M.S. and Y.S. Katta (2002) Genetic analysis and heterosis grain yield and related traits in bread wheat (Triticum aestivum L.). J. Agric. Res. Tanta Univ., 28 (2) 2002.

AbdelNour, N. A. R.; H. S.A. EL-Fateh and A.K.Mostafa (2011). Line x Tester analysis for yield and its traits in bread wheat. Egypt. J. Agric. Res., 89 (3):979-992.

Akbar, M.; A. Rehman; M.H. Chaudhry and M. Hussain (2009). Line×tester analysis in bread wheat (*Triticum aestivum* L.). J Agri Res. 47(1): 411-420.

Allard, R. W. (1960). Principles of Plant Breeding. John Willey and Sons, New York, London.

Attia, S.A.A, Abed N.R, El–Hameid and A.A. Haiba (2014).Heterosis, combining ability analysis of some bread wheat crosses and the genetic relationship among the included studied cultivars. *J App Sci Res.* 9(10): 6394-6403.

Chaudhry, M.A.; M.S. Akhtarand; M.T. Ahmad (1992). Combining ability analysis for flag leaf area, yield and its components in spring wheat.*J. of Agri. Research,* 30(1):17-23.

Fellahi, Z.E.A., A. Hannachi, H. Bouzerzour and A. Boutekrabt (2013). Line×tester mating desing analysis for grain yield and yield related traits in bread wheat (*Triticum aestivum L.*). Int. J. of Agro.:9.

Hassan, G.; F. Mohammad; S.S. Afridi and I. Khalil (2007).Combining ability in the F1 generations and yield components in Wheat.Sarhad. J. Agric., 23(4): 937-942.

Khalifa, M.A.; A.A.Ismail; G.R. El-Nagar and I.A. (1998).Genetical studies of earliness and grain yield and its components of bread wheat. Assuit J. of Agric. Sci. vol. 29 No. 5, 59-69.

Kumar, A., Harshwardhan; A. Kumar and B. Prasad (2015). Combining ability and gene interaction study for yield, its attributing traits and quality in common wheat. J. of Applied and Nat. Sci., 7(2): 927-934.

Labate, J.A.; K. R. Lamkey; M. Lee and W. L. Woodman (1997). Molecular genetic diversity after reciprocal recurrent selection in BSSS and BSCB1 maize populations. Crop Sci. 37: 416-423.

Longin, C.F.;M. Gowda; J. Mühleisen; E. Ebmeyer; E. Kazman; R. Schachschneider; J. Schacht; M. Kirchhoff; Y. Zhao and J. C. Reif. (2013). Hybrid wheat: quantitative genetic parameters and consequences for the design of breeding programs. Theor. Appl. Genet. 126(11):2791-801.

Nour, A.; A.R.Nadya;H.S.A. El-Fateh and A.K. Mostafa (2011).Line x Tester analysis for yield and its traits in bread wheat. Egypt J. Agric. Res., 89 (3):979-990.

Prasad, B. (2014). Heteroticvigour studies in forage sorghum hybrid by multiple critera. J. of Hill Agri.,5(2):182-185.

Rajput, R.S. and V.S. Kandalkar (2018). Combining ability and heterosis for grain yield and its attributing traits in bread wheat (*Triticum aestivum* L.). J. of Phar. And Phyt. 7(2):113-119.

Reif, J.C.; F. Gumpert; S. Fischer and A. E. Melchinger (2007). Impact of genetic divergence and dominance variance in hybrid populations. Genetics 176: 1931-1934.

Saeed, A.; M.A. Chowdhry, N. Saeed I. Khaliq and M.Z. Johar (2001) Line x Tester Analysis for some Morpho-Physiological Traits in Bread Wheat. Int. J. Agri. Biol., 3(4):444-447.

Sharma, H.C.; M.K. Dhillan and B. V. S. Reddy (2006). Expression of resistance to *Atherigonasoccata*in F1 hybrids involving shoot fly-resistant and susceptible cytoplasmic male-sterile and restorer lines of sorghum. Plant breeding 125: 473-477.

Singh, R. K. and B. D. Chaudhry (1979). Biometrical methods in quantitative genetics analysis. 191-199. 2nd Ed. Kalyan: Publishers, New Delhi, India.

Tabassum, A.K. and B. Parasad (2017). Study of combining ability and nature of gene action for yield and its contributing traits in bread wheat (Triticumaestivum L. enThell). Int. J. Curr. Microbial. App. Sci. 6(10): 3562-3573).

Titan, P.; V. Meglic and J. Iskra (2012).Combining ability and heterosis effect in hexaploid wheat group.Genetika 44: 595-609.

Verma, A. K.; S. R. Vishwakarma and P. K. Singh (2007). Line x Tester analysis in barley (Hordeumvulgare L.) across environments. Barley Genetics Newsletter 37: 29-33.

تقدير القدرة الائتلافية والفعل الجينى وقوة الهجين باستخدام تحليل السلالة xالكشاف فى قمح الخبز

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بهدف هذا البحث دراسة القدرة الائتلافية والفعل الجيني وقوة الهجين للصفات المورفولوجية والمحصول ومكوناته في الجيل الاول لقمح الخبز باستخدام طريقة تحليل السلالة x الكشاف، حيث ضمت التجربة ثلاثة وستون تركيبا وراثيا وهى عبارة عن خمسة عشر سلالة وهى سلالة1، سلالة 2 ، سلالة 3، سلالة4 ،سلالة 5 ،سلالة 6، سلالة 7، سلالة8، سلالة 9، سلالة 10 ،سلالة 11 ،سلالة 12، سلالة 13، سلالة 14، سلالة 15، وثلاثة اصناف كشاف وهى جميزة 9 ، جيزة 171، جميزة 11 بالإضافة الى خمسة واربعون هجينا تمثل الجيل الاول بينهما بنظام التزاوج السلالة x الكشاف في تصميم قطاعات كاملة العشوائية ذات الثلاث مكررات في المزرعة البحثية لكلية الزراعة جامعة طنطا، خلال موسمي الزراعة 2015/2014 ، 2015/ 2015 يمكن تلخيص أهم النتائج فيما يلى:1- وجدت اختلافات عالية المعنوية بين السلالات الابوية وبين الكشافات وكذلك الهجن الناتجة منهما لجميع الصفات المدروسة.2- كانت تقديرات القدرة العامة والقدرة الخاصة على الائتلاف عالية المعنوية لجميع الصفات المدروسة، مما يوضح أهمية كلا من الفعل الجينى المضيف والغير مضيف فى توريث هذه الصفات.3- كان التباين غير المضيف أعلى (أكثر أهمية) من التباين المضيف لجميع الصفات عدا صفنى عدد الايام حتى الطرد وعدد حبوب السنبلة حيث كان التباين المضيف هو الاكثر اهمية فى توريث هاتين الصفتين.4- كانت التراكيب سلالة 5، سلالة 7، سلالة 9، سلالة 10، سلالة 14 احسن الاباء للقدرة العامة على الائتلاف لصفة التبكير والاباء سلالة 2 ، سلالة 6 و سلالة 10 وسلالة 12 كانت الافضل لصفة قصر النبات فى حين كانت الاباء سلالة 11 وسلالة 12 الافضل لصفات عدد السنابل وعدد حبوب السنبلة ومحصول الحبوب للنبات.5- اظهرت الهجن T_3 x L_{11} و T_1 x L_9 قوة هجين عالية بالنسبة لمتوسط الابوين والاب الافضل لصفتى التزهير والنضج فى حين كان الهجين T_3 x L_{11} هو الافضل بالنسبة لصفات عدد سنابل للنبات ، عدد حبوب السنبلة ومحصول الحبوب للنبات.6- كان قيم درجة التوريث بالمعنى الواسع أعلى من قيم درجة التوريث بالمعنى الضيق 62.59% لصفة التزهير فى حين كانت 3.96 لصفة عدد حبوب السنبلة.7- كانت المساهمة النسبية للسلالات فى التباين الكلى اعلى من مساهمة السلالات x الكشافات لجميع الصفات المدروسة وكذلك كانت مساهمة تفاعل السلالات x الكشافات اعلى من مساهمة السلالات فى كل الصفات عدا صفة عدد الايام حتى التزهير.