Estimate of combining ability and correlation for yield and its components in bread wheat (*Triticum aestivum* L.)

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Abstract

The experiment was performed at the Experimental Farm of Agronomy Department, Faculty of Agricultural, Al-Azhar University (Assiut Branch), Assiut, Egypt during the three successive seasons of 2016/2017,2017/2018 and 2018/2019. Seven parents of bread wheat (*Triticum aestivum*, L.) of a wide diversity for some agronomic traits were selected for the study, namely Sids1 Sids12, Sids13, Shndaweel1, Giza 171, Gemmeiza 11 and Sakha 93. The parents were crossed in 2016/2017 and 2017/2018 growing seasons in a half diallel fashion. The parent and crosses were evaluated in 2018/2019. Results indicated that mean squares of genotypes, general and specific combining abilities were significant (p≤0.01) for all traits, except number of kernels /spike. The ratio of GCA/SCA genetic components were less than unity indicating the greater amount of non- additive gene action determining the performance of all traits. The crosses (Sids 12 × Sakha 93), (Giza 171 × Sakha 93), (Gemmeiza 11 × Sakha 93), (Shandaweel 1 × Sakha 93) and (Sids 12 × Giza 171) recorded greatest mean values for grain yield /plant. Sids1 and Giza171 were considered as the best general combiners for grain yield /plant. The best crosses showed significant (p≤0.01) SCA and heterotic effects for grain yield /plant were Sids 1 × Sids 13, Sids 12 × Shandaweel 1, Shandaweel 1 × Sakha 93, Giza 171 × Gemmeiza 11 and Giza 171 × Sakha 93 so, they could consider promising hybrids in breeding programs for crop improvement.

Keywords: *Triticum aestivum*, combining ability, correlation, yield.

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of great important food crops worldwide and in Egypt. Due to its high converting and various utilization, high nutritive value, with high crop production, it is used as major food for further one third of the global population. Improving high yielding cultivars is one of the main objectives of wheat breeding programs. Identifying the good combiners for yield and its components is of main interest for many breeders (Madic *et al*., 2005). For improving wheat yield, the study of the genetic structure and combining ability is of great significance for the wheat breeders. Half diallel mating is an effective strategy to assess genotypes used as parents for combining ability effects to select acceptable, parents for developing recently developed cultivars (Hayman, 1954a,b; Jinks, 1954). Successful breeding programs need to know the type of gene action and genetic system controlling the inheritance of the interest traits and the best breeding strategy to be used to improve them (Madic *et al.*, 2005). Several researchers like Khalifa *et al*. (1984), Hendawy (1990), El-Shal *et al.* (2014), Khaled and Abd El-dayem (2014), Samier and Ismail (2015) and Rahul and Kandalkar (2018) showed that both additive and non-additive gene actions played an equal role in the inheritance of grain yield, number of spikes /plants, number of kernels /spike and 100-kernal weight. El-Hennawy (1992), Darwish (1992), Abd El-Mageed (1995) and Mahmoud (1999) indicated that dominance and additive gene effects were significant for grain yield /plant,

number of kernels /spike and 100-kernal weight. Similar results were obtained by El-Sayed *et al*. (2000), Hamada and Tawfeleis (2001), El- Sayed (2004), Abdel-Nour Nadya *et al.* (2009), Moussa (2010) and El-Awady and Wafaa (2011). Significant heterotic effects were obtained for many traits by El-Beially and El-Sayed (2002), Hamada and El-Beially (2003), Megahed Eman *et al.* (2014) and Samier and Ismail (2015). The aim of this article was estimation both of general combining ability (GCA), specific combining ability (SCA) and heterosis for grain yield and its attributes in 21 wheat crosses and their parents.

2. Materials and methods

The experiments were carried out during the three growing seasons of 2016/2017, 2017/2018 and 2018/2019 at the Experimental Farm of Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. Seven varieties of bread wheat widely different in their agronomic characters were used as parents in this study. These varieties were Sids 1 (P_1) Sids12 (P_2), Sids13 (P_3) Shandaweel1 (P_4), Giza 171 (P_5), Gemmeiza11 (P_6) and Sakha93 (P_7) were crossed in a half diallel fashion. The description and origin of these varieties are shown in Table (1).

2.1 Experimental layout

In 2016/2017 season, the seven parents were sown in the field in two planting

dates with two weeks in between to obtain enough flowers for crossing. Parents were crossed in all possible combinations excluding reciprocals to produce 21 F_1 hybrids. In 2017/2018 season, parents were crossed again in to obtain more hybrid seeds (F_1's) for all combinations. In 2018/2019 season, the parents and their 21 F_1-hybrids were sown in a randomized complete block design (RCBD) with three replications. Planting was carried out on November 20th, 2018. Plants were grown in rows, 4 m long and 50 cm apart, in single seeded hill spaced 15 cm. Each parent and F_1-hybrid were represented by three rows /plot. The agricultural practices of irrigation and fertilization were carried out as recommended for wheat production. The data were recorded on the mean of ten guarded plants /plot for both of parents and F_1 hybrids. Mid parents heterosis (%) = (F_1 – mid parent/mid parent) x100. Better parents heterosis (%) = (F_1 – better parent/better parent) $\times$ 100. The analysis of combining ability was performed as outlined by Griffing (1956). The recorded characters were days to 50% blooming (day), plant height (PH, cm), number of spikes /plants (NS/P), spike length of (SL, cm), number of grain /spike (NG/S), 1000-grain weight (GW, gm) and grain yield /plant (GY/P, gm).

Table (1): The Pedigree and origin of the seven bread wheat parental varieties.

Parent	Pedigree	Origin
Sids 1	MRL/BUC/SER1	Egypt
Sids 12	BUC//7C/ALD/5/MAYA74/0N//1160 Egypt/47/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL -//CMH74A.63014*SX.SD7096-4SD-1SD-1SD-0SD.	Egypt
Sids 13	ALMAZ.19=KAUZ"S"//TSI/SNB"S"IICSBW1-0375-4AP-2AP-030AP-0APS-3AP-0APS-050AP-0AP-0SD	Egypt
Shandaweel 1	Site / / MO /Nac/th. Ac./3* pvn /3/Mir 10/Buc Cmss93Boo567s-72Y-010M-010Y-010M-OHTY	Egypt
Giza 171	Sakha93 /Gemmeiza9 GZ003 – 101-1GZ -1GZ – 2 GZ -0GZ	India
Gemmeiza 11	BOW,,s,,/KVZ/7C/SERI82/3/GIZA168/SAKHA61	Egypt
Sakha 93	SAKHA 92/ TR 810328:	Egypt

3. Results and Discussion

3.1 Analysis of variance and mean performance

The analysis of variance (Table 2) showed significant (p≤0.01) differences among genotypes for all traits, indicating a wide genetic variability in these materials and the genetic analysis could be performed. The analysis of variance in Table (2) emphasized that mean squares due to general and specific combing ability were significant (p≤ 0.01) for all the studied traits, indicating that the additive and non-additive effects were involved in the inheritance of these traits. The ratio of $\sum gi^2 / \sum sij^2$ was less than unity indicating the predominant effects of non-additive in the inheritance of these

traits. These results are in line with those reported by Tolba (2000), Ahmadi *et al.* (2003), Nazir *et al.* (2005) and Motawea (2006).

Table (2): Mean squares of genotypes, general combining ability (GCA), specific combining ability (SCA) and their ratios for yield and its components.

S.O.V	d.f	Days to 50% blooming	Plant height	Number of spikes/plant	Spike length	Number of grains/spike	1000-grain weight	Grain yield/plant
Replicates	2	1.063	0.210	8.570**	7.691**	0.373	34.84**	25.61**
Genotypes	27	4.472**	66.49**	7.261**	6.382**	85.10**	37.83**	21.19**
GCA	6	9.826**	118.6**	7.529**	5.474**	188.9**	84.66**	11.19**
SCA	21	2.943**	51.60**	7.185**	6.641**	55.45**	24.46**	24.04**
Error	54	0.785	0.948	0.494	0.373	1.370	1.228	1.025
$\sum gi^2/\sum sij^2$		0.40	0.26	0.12	0.09	0.38	0.39	0.05

Means of parents and their F_1 hybrids are presented in (Table 3). The parental means showed wide variability for all traits. Furthermore, means of the F_1-hybrids located outside the parental range indicating the presence of non-additive gene effects and/or transgressive segregation. These results agree with those reported by Fonseca *et al.* (1968), Afiah *et al.* (2000), El-Beially and El-Sayed (2002), El-Borhamy (2004), Farooq *et al.* (2010), Khaledand Abd El-dayem (2014), Samier and Ismail (2015) and Rahul and Kandalkar (2018).

Table (3): Mean performances for all studied characters of parents and F_1 crosses.

Traits / Genotypes	Days to 50% blooming	Plant height	Number of spikes/plant	Spike length	Number of grains/spike	1000-grain weight	Grain yield/plant
Sids1 (P1)	81.33	101.80	13.33	12.13	74.72	44.27	27.70
Sids12 (P2)	83.43	94.30	10.73	12.93	79.43	46.43	27.07
Sids13 (P3)	83.60	90.63	13.30	12.07	80.64	43.90	26.54
Shandaweel 1(P4)	81.90	94.77	11.33	13.67	76.47	46.43	27.13
Giza 171 (P5)	80.30	103.70	11.47	12.97	66.43	51.57	28.47
Gemmeiza (P6)	81.49	105.20	10.00	12.80	83.57	42.10	25.83
Sakha 93 (P7)	83.77	98.20	12.73	12.93	83.57	49.20	23.97
P± S.E	82.26 ± 0.51	98.37 ± 2.05	11.84 ± 0.49	12.79 ± 0.21	77.83 ± 2.28	46.27 ± 1.23	26.67 ± 0.55
P1×P2	80.13	105.60	14.17	15.13	81.17	49.23	30.83
P1×P3	81.50	104.80	16.50	13.97	84.57	48.33	30.30
P1×P4	81.30	104.90	14.47	16.53	79.07	50.93	30.53
P1×P5	80.47	108.30	14.30	14.63	76.93	53.87	32.07
P1×P6	79.53	107.20	13.97	15.30	84.63	47.17	30.30
P1×P7	83.53	105.30	14.33	15.40	88.50	53.23	31.47
P2×P3	83.97	101.20	14.27	14.67	85.50	49.93	29.77
P2×P4	81.03	100.90	12.10	16.41	85.53	51.57	31.77
P2×P5	81.37	107.30	11.67	15.63	83.93	55.30	32.57
P2×P6	81.83	109.60	15.30	15.63	92.60	49.67	28.67
P2×P7	81.57	102.40	16.20	15.37	86.13	53.20	35.27
P3×P4	81.70	107.90	14.53	16.63	84.40	49.80	29.60
P3×P5	82.53	105.50	14.87	15.87	81.27	53.60	31.27
P3×P6	81.87	107.50	14.50	14.70	84.57	48.33	29.87
P3×P7	82.10	101.10	13.93	15.27	90.70	52.33	28.40
P4×P5	81.53	105.90	12.67	16.70	79.43	54.53	31.40
P4×P6	82.37	107.50	13.97	17.27	87.43	50.57	29.50
P4×P7	81.43	100.70	14.20	16.47	84.10	52.40	31.80
P5×P6	73.03	107.80	14.53	15.63	88.07	55.00	32.90
P5×P7	82.30	106.60	14.40	15.50	85.87	55.30	33.83
P6×P7	82.30	108.40	14.40	15.50	85.87	51.90	23.97
F1± S.E	81.30 ± 0.47	105.54 ± 0.60	14.25 ± 0.24	15.63 ± 0.18	84.77 ± 0.82	51.72 ± 0.54	30.77 ± 0.50

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3.2 Combining ability analysis

3.2.1 General combining ability

Data in Table (4) revealed that P_5 (Geiza 171) has a desirable significant ($p \leq 0.01$) gca effects for all traits, except PH , P_5 could be considered a good general combiner in improving days to 50% blooming, NS/P , SL, NG/S, GW, and GY/P also, P3 has a desirable significant ($p \leq 0.01$) gca effects for all traits, except days to 50% blooming and P_7 was good combiner for all studied traits except days to 50% blooming and PH.

3.2.2 Specific combining ability

Specific combining ability effects are presented in Table (4). Five crosses showed favorable negative significant SCA effects for days to 50% blooming. These crosses involved one or the two parents of negative GCA effects. However, the crosses $P_1 \times P_7$ and $P_3 \times P_6$ gave positive significant SCA effects, and both involved one parent of negative GCA effects. The results of days to 50% blooming indicate that the performance of this trait depended on both additive and non-additive gene effects. The SCA effects for PH showed seventeen crosses were significant ($p \leq 0.05$-$p \leq 0.01$), nine of them involved P_3 or P_6 or both. Furthermore, four out of the nine crosses of P_6 showed significant SCA effects proving that P_6 can transfer favorable genes of PH. Fifteen hybrids showed positive significant ($p \leq 0.05$-$p \leq 0.01$)

SCA for NS/P, ten of them involved one of the parents had positive GCA, and two hybrids ($P_2 \times P_6$ and $P_4 \times P_6$) had two parents of negative GCA effects. This indicates that NS/P controlled by additive and non-additive gene effects. The SCA effects were significant ($p \leq 0.05$-$p \leq 0.01$) for 19, 13, 17 and 14 hybrids for spike length, NG/S, GW, and GY/P, respectively. All these hybrids except few cases include one of their parents showed significant GCA effects. Otherwise, the cross $P_4 \times P_6$ gave significant favorable SCA effects for all traits except GY/P despite of its parents showed negative GCA effects. Also, the cross P_1 x P_4 gave positive SCA effects for SL, GW and GY/P, the cross $P_2 \times P_4$ in SL, NG/S, GW and GY/P. These cases proved the presence of dominance and epistasis effects in the inheritance of these traits. It could be concluded that in the presence of non-additive the performance of the hybrids could not be predicted according to GCA effects. These results agree with the findings of Abdel-Moneam (2009), Peng *et al*. (2009), Sener (2009), Kundan *et al*. (2010), Ahmad (2010), Kumar and Gupta (2010), Padhar *et al*. (2010), Zaazaa *et al*. (2012), Khaledand Abd El-dayem (2014), Samier and Ismail (2015) and Rahul and Kandalkar (2018).

3.3 Heterosis analysis

Heterosis is interpreted by the effects of allelic and non-allelic interactions. In India, efforts on hybrid wheat were

initiated in sixties following cytoplasmic male sterility (CMS) and chemical hybridizing agent (CHA) approach in 1995. However no significant results were obtained. It is well known that heterozygous genotypes are more adapted and stable under a variety of environments. Wheat hybrids are found to be stable for their performance in different environments. However, many wheat breeders address heterosis in their work. But production of enough hybrid grains for commercial use is still a dream.

Table (4): Estimates of general (of the parents) and specific (of crosses) combining ability effects for the studied traits.

Traits / Genotypes	Days to 50% blooming	Plant height	Number of spikes/plants	Spike length	Number of grains/ spike	1000-grain weight	Grain yield/plant
Sids 1 (P1)	-0.540**	1.093**	0.579**	-0.457**	-2.276**	-1.28**	-1.938**
Sids 12(P2)	0.307**	-1.596*	-0.447*	-0.071	0.831* *	-0.124	0.225**
Sids 13 (P3)	0.737**	2.315**	0.668**	0.457**	0.993**	1.41**	0.965**
Shandaweel 1(P4)	-0.119*	-1.793**	-0.510*	-0.888**	-1.322**	-.1.742**	-0.234**
Giza 171(P5)	-0.684**	-2.081**	0.425**	0.662**	4.048**	3.094**	1.110**
Gemmeiza (P6)	-0.453*	3.152**	-0.28**	0.032	-3.022**	-1.784**	-0.386**
Sakha 93 (P7)	0.752**	-1.01**	0.41**	0.329**	0.748**	1.542**	0.258**
S.E gi	0.060	0.065	0.048	0.041	0.079	0.075	0.069
P1×P2	-1.384**	2.387**	0.386**	0.743**	-0.650	0.284	0.495
P1×P3	-0.447*	2.239**	1.605**	-0.038	2.912**	0.677*	2.952**
P1×P4	0.209	1.461**	0.749**	1.184**	-0.435	1.884**	0.654*
P1×P5	-0.052	1.409**	0.497**	0.110	0.158	1.699**	0.843**
P1×P6	-1.523**	-0.761**	0.019	0.807**	0.787**	-0.123	0.572*
P1×P7	1.571**	1.469**	-0.310*	0.936**	4.876**	2.918**	1.095**
P2×P3	1.172**	1.328**	0.397**	0.276*	0.576	1.114**	0.385
P2×P4	-0.906**	0.183	-0.592**	0.671**	2.763**	1.355**	1.654**
P2×P5	-0.006	3.065**	-1.110**	0.724**	3.889**	1.969**	1.110**
P2×P6	0.229	4.294**	2.379**	0.754**	5.485**	1.214**	-1.294**
P2×P7	-1.243*	1.257**	2.582**	0.517**	-0.759*	1.421**	-4.661**
P3×P4	0.387	7.835**	0.727**	1.284**	1.791**	0.881**	0.678*
P3×P5	0.586*	2.017**	0.975**	1.3494**	1.384**	1.562**	1.000**
P3×P6	1.189**	2.913**	0.464**	0.207*	-2.387**	1.173**	1.096**
P3×P7	-0.950**	0.643*	-0.799**	0.803**	3.969**	1.847**	-1.015**
P4×P5	-0.081	1.472**	-0.047	0.832**	1.704**	1.103**	0.402
P4×P6	-1.579**	2.002**	1.108**	1.428**	2.633**	2.014**	-0.002
P4×P7	0.483*	-0.602*	0.645**	0.658**	-0.478	0.521	1.654**
P5×P6	0.650**	-1.217**	1.590**	0.621**	5.993**	3.329**	2.054**
P5×P7	0.251	1.746**	0.760**	0.518**	4.015**	0.303	2.343**
P6×P7	0.513*	2.543**	0.616**	0.547**	-1.356*	1.781**	4.606**
S.E sij	0.211	0.254	0.133	0.100	0.368	0.330	0.275

Mid and best parent heterosis are available. However, the real feasibility of hybrids depends on the heterotic advantage over the best parent or the best common grown cultivar.The results of heterosis are presented in Tables (5) and (6). Eighteen and nine hybrids showed significant heterosis in PH over the mid and better parent, respectively. Five of them showed significant sca effects in PH. For days to 50% blooming, 13 hybrids gave negative favorable significant heteroses, only five of them depend on negative SCA.

Table (5): Heterosis in percentage of mid-parents (M.P) and better parent (B.P) in the F_1 crosses for Plant height, 50% blooming (day), number of spikes/plant and spike length.

Traits / Crosses	Days to 50% blooming		Plant height		Number of spikes/plant		Spike length	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P1×P2	-2.73**	-3.95**	7.70**	13.73**	17.78**	6.30	10.75**	17.01**
P1×P3	-1.16*	-2.51*	8.92**	2.94	23.96**	23.78	15.45**	15.16
P1×P4	-0.25	0.08	6.72	3.04	17.35*	8.55	12.13**	20.92**
P1×P5	-0.42	0.08	5.40	4.43	15.32*	7.27	16.57**	22.79**
P1×P6	-2.30**	-2.40	3.75	1.90	19.81**	4.80	22.79**	19.53*
P1×P7	1.18*	-0.28	5.30	3.43	9.97*	7.50	22.90**	19.10*
P2×P3	0.55*	0.44	9.45**	7.31*	18.81**	7.29	17.36**	13.45
P2×P4	-1.97**	-2.87**	6.73**	6.46*	9.70	6.79	23.38**	20.04*
P2×P5	-0.59**	-2.46*	8.38**	3.47*	4.19	1.74	20.69**	20.50
P2×P6	-0.76*	-1.91*	9.7**	3.88*	27.68**	42.59**	21.53**	20.88*
P2×P7	-2.21**	-2.41*	6.38**	4.27*	38.10**	27.25*	18.87**	18.87
P3×P4	-1.26*	-2.27*	6.39**	13.85**	18.03**	9.24	29.21**	21.65*
P3×P5	0.70*	-1.27*	8.58	1.73	20.11**	11.80	26.75**	22.35*
P3×P6	-0.81*	-2.06*	9.62**	1.89	24.26**	9.02	18.26**	13.68
P3×P7	-1.88**	-1.99*	7.08**	2.95	7.07	4.73	14.63**	11.70
P4×P5	0.53	-0.45	6.72**	2.12	11.14	10.46	26.22**	22.16*
P4×P6	0.83*	0.57	7.36**	1.89	21.05**	33.30**	29.84**	26.33*
P4×P7	-1.69*	-2.79*	4.37**	2.54	18.03**	11.54	23.83**	20.48*
P5×P6	-6.59**	-10.38**	3.05**	2.18	15.41*	26.67	11.35**	20.50**
P5×P7	0.32	-1.75*	5.59**	8.55**	19.0**	13.11	19.69**	19.50
P6×P7	-1.60*	-1.75*	6.43**	2.74**	26.76**	31.11**	20.52**	19.87

* Significant at 5% level of significance, ** significant at 1% level of significance.

Table (6): Heterosis in percentage of mid-parents (M.P) and better parent (B.P) in the F_1 crosses for number of grains /spikes, 1000grain weight and grain yield/plant (gm).

Traits / Crosses	Number of grains /spike		1000-grain weight		Grain yield/plant	
	M.P	B.P	M.P	B.P	M.P	B.P
P1×P2	5.31*	2.19	8.55	6.03	12.60**	11.29*
P1×P3	8.86**	4.87	6.64**	10.09**	11.72**	9.38*
P1×P4	4.60	3.40	12.30**	9.69*	11.38**	10.21*
P1×P5	13.26	2.95	12.41**	4.45	14.20**	12.64*
P1×P6	6.93**	11.26**	9.24**	6.55*	13.22**	9.16*
P1×P7	11.82**	5.89*	13.90**	8.19*	21.83**	13.61*
P2×P3	5.83**	9.02**	10.80**	7.53*	11.08**	9.97*
P2×P4	9.68**	7.64*	11.07**	11.07*	10.23**	17.10**
P2×P5	15.08	5.66	12.85**	7.23*	10.28**	14.40*
P2×P6	5.61*	10.80**	12.22**	6.97	8.39**	5.91
P2×P7	5.68*	3.06	11.27**	8.13	21.20**	30.29**
P3×P4	7.44**	4.66	10.27**	7.25	10.32**	9.10
P3×P5	10.52**	0.78	12.50**	3.93	13.70**	9.83*
P3×P6	3.00	1.19	12.39**	10.09*	14.09**	12.54*
P3×P7	10.47**	8.53*	12.41**	6.36	12.47**	7.00
P4×P5	11.16**	3.87	11.28**	5.73	12.94**	10.29*
P4×P6	9.26**	4.61	6.25**	8.91**	11.40**	8.77
P4×P7	5.09*	0.63	4.60*	6.50	14.26**	17.21**
P5×P6	17.42**	5.38	17.44**	6.65	21.17**	15.56*
P5×P7	14.49**	2.75	9.76**	7.23*	29.02**	18.82*
P6×P7	2.75	2.75	3.69	5.48	3.73	7.20

* Significant at 5% level of significance, ** significant at 1% level of significance.

Respect to the better parent heterosis in the other traits, results showed that three out of four hybrids for NS/P, nine out of 13 for SL, five out of six for NG/S, five out of ten for GW and five out of 16 hybris for GY/P showed significant better parent heterosis based on SCA. These results indicate that heterotic

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effects in these materials depend on both additive and non-additive gene effects. These results are supported with the findings of Ashoush *et al*. (2001), Jahanzeb and Ihsan (2004), El-Sayed and Moshref (2005), Abdel-Moneam (2009), Bertan *et al*. (2009), Peng *et al*. (2009), Kundan *et al*. (2010), Ahmad (2010), Zaazaa *et al*. (2012), Samier and Ismail (2015) and Rahul and Kandalkar (2018).

Table (7): Correlation among studied characters for genotypes.

Characters	Days to 50% blooming	Plant height	Number of spikes /plant	Spike length	Grain weight/spike	1000-grain weight	Grain yield/plant
Days to 50% blooming	--	-0.355**	-0.141	-0.003	-0.003	-0.376**	-0.328**
Plant height		--	-0.029	0.162	-0.022	0.278*	-0.373**
Number of spikes /plant			--	0.120	-0.339**	0.291*	0.356**
Spike length				--	0.421**	0.231	0.369**
Grain weight / spike					--	-0.367**	0.388**
1000-grain weight						--	-0.329**
Grain yield/plant							--

* Significant at 5% level of significance, ** significant at 1% level of significance.

3.4 Phenotypic correlation

The correlation values between each pairs of studied traits were shown in Table (7). Grain yield/plant showed significant (p≤0.01) correlation with NS/P, SL and NG/S, while it gave negative correlation with GW, PH, and days to 50% blooming. Therefore, selection for NS/P, SL and NG/S in these materials may result in high yielding early lines of short stature, and selection for SL could increase NG/S. These results are supported with the findings of Ashoush *et al*. (2001), El-Sayed and Moshref (2005), Abdel-Moneam (2009), Peng *et al*. (2009), Kundan *et al*. (2010), Ahmad (2010), Farooq *et al*. (2010), Khaled and Abd El-dayem (2014), Samier and Ismail (2015) and Rahul and Kandalkar (2018).

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