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RESEARCH ARTICLE

IMPROVING GRAIN YIELD OF RICE (*ORYZA SATIVA L.)* BY ESTIMATION OF HETEROSIS, GENETIC COMPONENTS AND CORRELATION COEFFICIENT

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ABSTRACT

The recent approach for rice production includes the improvement of yield is necessary to cater for consumer demand. Therefore, a field experiment (diallel analysis) was conducted at RiceResearch and Training Center, Egypt during 2014 and 2015growing season to estimate combining ability, heterosis and genetic parameters in ricefor improving the yield. The results indicated that, Sakha101 and Sakha105 were recorded highest mean values for most traits. The crosses (Giza177 × Sakha106, Sakha101 × Sakha104 and Sakha101 × Gz7576-10-3-2-1) were recorded highest mean values for grain yield plant^{-1}.Sakha106 and Sakha104 recorded the highest mean values for flag leaf area.It is evident from the result, a positive correlation was observed between flag leaf area and grain yield plant^{-1}as well as, the results were recorded positively correlation coefficient between number of days to heading, number of filled grains panicle^{-1} and 1000-grain weight. Special attention was paid to, the cross Sakha 101/Sakha 104, Sakha 104/Sakha 106, Sakha 105/BL1 and Sakha 106/BL1 were identified as themost promising cross for developing high yielding rice varieties and could be further benefits to isolate superior transgressivesegregants for breeding programs in rice.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the world's most important cereal crop with exceptional agricultural and economic importance as being a staple food for half of the world's population (Misratia *et al*., 2015). Rice is one of the world's most important staple cereal food crop growing in atleast 114 countries under diverse conditions. The phenomenon of heterosis has been a powerful force in the evolution of plants and it has been exploited extensively in crop production which is the greatest practical achievement of the science of genetics and plant breeding (Satheeshkumar and Saravanan, 2013). Heterosis in crops has contributed greatly to global crop production improvement in recent decades (Schnable and Springer, 2013). Heterosis describes improved performance of heterozygous F1 hybrids in terms of stature, biomass, size, yield, speed of development, fertility, resistance to diseases and insect pests, or to climatic rigors of any type compared to the average performance of their homozygous parental inbred lines (Birchler *et al*., 2006; Dan *et al*., 2013). This aim may be achieved by heterosis breeding by using desired lines/varieties. Heterosis breeding consider an important tool which can facilitate yield enhancement and helps enrich many other desirable quantitative traits in rice (Venkanna *et al*., 2014; Balakrishna and Satyanarayana, 2015). The ultimate goal of crop breeding is to develop varieties with high yield potential and desirable agronomic characteristics. Furthermore, In rice breeding, the most important qualities sought by breeders have been high yield potential (Khan *et al*., 2015).

Therefore, with keeping the above points in view, the present research work was undertaken to estimate the percentage of heterosis and heterobeltiosis among F1 hybrids produced by eight rice genotype. Broad and narrow sense heritability was estimated the phenotypic correlation coefficient was recorded among all possible pairs of the studied traits to understand the association among grain yield and its component characters for selecting suitable parents for hybrids development in rice breeding program.

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MATERIALS AND METHODS

Experimental design, treatment and parental lines used

This study was conducted at the research farm and Rice Biotechnology Lab of Rice Research and Training Center, Egypt during the three successive rice growing seasons 2014 and 2015. Eight Egyptian genotypes i.e., five commercial varieties (Giza177, Sakha101, Sakha104, Sakha105 and Sakha106), one promising lines (Gz7576-10-3-2-1) and two international deferential varieties (BL1 and Shien2). The eight genotypes were sown in the summer growing season of (2014) in three sowing dates. A half diallel design was conducted among the eight parents to produce twenty eight crosses. The hybridization technique of Jodon (1938) and modified by Butany (1961), was utilized. The parental varieties and the resulted crosses evaluated in a Randomized Complete Block Design (RCBD) experiment with three replications in 2015 growing season.

Data Collection: Each replication had twenty five individual plants from each genotype. Data have been collected on plant height, days to heading, No. of panicles plant^{-1}, grain yield plant^{-1}, 1000-grain weight, flag leaf area, Filled grains/panicle and panicle density.

Statistical analysis: The estimation of heterosis: heterosis of an individual cross for each trait was determined as the increase of the F_1 hybrid mean over either mid parents and better parent, these proposed by Mather (1949) and Mather and Jinks (1982). While, there are two formulas usually used for estimation of heterosis as follows: (1)-Mid-parents heterosis or heterosis over the mid-parents (MP %). (2)- Heterobeltiosis or heterosis over the better parent (BP %).

The estimates of correlation coefficients: Correlation coefficients (r) among all studied traits were computed using SPSS statistical package according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Mean performance

The mean performance of parental varieties and their 28 F1 hybrids for all studied traits are presented in (Table 1). Regarding plant height the shortest plant height is desirable. The two parents Shien2 and Sakha101 were recorded the lowest mean values (85.4 and 92.3 cm). The F1 generation had the highest values compared with parents indicated that the F1 generation, possess the over dominance for this trait. Concerning days to heading, the most desirable mean values towards the earliness were obtained from the parents Gz7576-10-3-2-1, Sakha 106 and shien2 which gave the lowest mean values of 92.0, 93.0 and 93.3 days, respectively. While, the results recorded that the crosses BL1×Shien 2 and Sakha101×Sakha105 gave the same mean values for No. of days to heading (earliness) with the mean values of 92.0 days. But, the crosses Sakha 105×Sakha 106, Sakha 106×Shien 2, Gz7576-10-3-2-1× BL1 and Gz7576-10-3-2-1×Shien2 recorded 93.0 days to heading. Meanwhile, the old variety sakha101 was the later parent for No. of days to heading. In the meantime, No. of panicles plant^{-1}, the highest mean values were obtained from the parents Sakha101 and Sakha105 (23.0 and 22.0 panicles), but Giza177 gave the lowest mean values 19.6 panicles plant^{-1}. Regarding to grain yield plant^{-1} the parents Sakha101 and Sakha105 were recorded the highest mean values (52.0 and 46.0 gram plant^{-1}) respectively. In the meantime, the highest mean values were observed in the crosses Giza177 × Sakha106, Sakha101 × Sakha104, Sakha101 × Gz7576-10-3-2-1, Sakha104 × Sakha106, Sakha105 × BL1 and Sakha106 × BL1 with mean values ranged from 81.85 to 87.20 gram plant^{-1}. But, the Crosses Sakha104×Gz7576-10-3-2-1and Gz7576-10-3-2-1 × BL1 gave the lowest mean values for grain yield plant^{-1} which were 57.37 and 56.33 gram plant^{-1}, respectively. Regarding to 1000-grain weight, the mean values of the parental varieties showed that Sakha101 and Sakha106 exhibited highest 1000-grain weight with the mean values (29.0, 28.5 (g), respectively. while, the parent Gz7576-10-3-2-1 gave the lowest mean value 26.2 (g).In the meantime. The hybrid combination Gz7576-10-3-2-1 × BL1 gave the highest 1000 grain weight 29.8g, But, Sakha101 × Shien^2 gave the lowest mean value 26.2 (g), for the same trait. Concerning flag leaf area (cm^2) the parental varieties Gz7576-10-3-2-1 and Giza177 recorded the lowest mean values of (22.3 and 23.2 cm^2) respectively, While, Sakha106 and Sakha104 scored the highest mean values of 31.2 and 30.8 cm2 respectively. From another side, we found the three crosses Sakha106 x BL1, Giza177 x Sakha101 and Sakha101 x BL1 exhibited the highest mean values of 44.0, 40.6 and 40.2 respectively. But , the three crosses Sakha101 x Sakha105, Giza177 x BL1 and Giza177 x Gz7576-10-3-2-1 gave the lowest mean values of 27.0, 29.3 and 30.8 cm2, respectively. Regarding to No. of filled grains panicle^{-1}, the parental varieties, Shien2 and BL1 recorded the lowest mean values of 119.01 and 121.00, respectively. While, the two rice varieties Sakha101 and Sakha104 recorded the highest mean values of 153.04 and 150.22, respectively. In this concern, The three hybrid crosses Sakha106 × BL1, Sakha105 × BL1 and Sakha101 x Sakha104 recorded the highest mean values of 155.32, 153.34 and 149.00, respectively. But, the lowest values were found in three crosses Giza177 × BL1, Giza177 × Shien2 and Sakha105× Sakha106 with values of 97.01, 97.92 and 102.80 filled grains panicle^{-1}, respectively. As for panicle density the parental varieties Sakha101 and Sakha104 exhibited the highest mean values of 6.89 and 6.83, respectively. While, Gz7576-10-3-2-1 and Sakha106 exhibited the lowest mean values of 6.21 and 6.23, respectively. In this concern, the crosses hybrids combination Giza177 x Shiein2 and Giza177 x BL1 had the lowest mean values of 4.23 and 4.28, respectively. But, Sakha101 x Sakha104, Sakha106 x BL1 and Sakha104 x Sakha106 recorded the highest mean values of 6.10, 5.92 and 5.91, respectively.

Heterosis

Useful heterosis expressed as the percentage deviations of F_1 mean performance from better-parent and mid-parent for all studied characters are presented in (Tables 2 and 3). High positive values of heterosis would be of interest in most traits under investigation; however for No. of days to heading, plant height and blast reaction, high negative values would be usefully from the breeder point of view.

Table 1. Mean performance of parental varieties and their F_1 crosses for all studied characters

No	Genotypes	plant height	days to heading	No-of Panicles/plant	Grain yield/plant	1000-grain weight	Flage Leaf areal	No .of filled grains /panicle	Panicle density
1	Giza 177	98.0	95	19.6	45.0	28.0	23.2	122	6.26
2	Sakha 101	92.3	110	23.0	52.0	29.0	25.8	153	6.89
3	Sakha 104	105.0	105	21.0	44.0	27.1	30.8	150	6.83
4	Sakha 105	95.0	95	22.0	46.0	28.0	27.9	135	6.29
5	Sakha 106	105.9	93	20.0	45.0	28.5	31.2	140	6.23
6	GZ 7576-10-3-2-1	102.2	92	21.0	37.0	26.2	22.3	128	6.21
7	BL 1	98.0	97	21.0	35.0	27.7	24.7	121	6.38
8	Shien 2	85.4	93	20.9	33.0	27.6	24.6	119	6.62
9	Giza 177×Sakha101	104.7	111	26.7	76.2	28.7	40.6	137	5.73
10	Giza 177× Sakha 104	111.1	96	25.6	75.3	27.7	33.8	125	5.59
11	Giza 177× Sakha 105	113.9	110	26.0	63.2	29.2	35.8	126	5.38
12	Giza 177× Sakha 106	112.3	98	27.0	83.9	28.7	32.3	125	4.78
13	Giza 177×GZ7576-10-3-2-1	108.1	97	26.8	69.3	28.8	30.8	110	4.82
14	Giza 177× BL 1	109.8	98	26.6	65.6	28.5	29.3	97	4.28
15	Giza 177× Shien 2	112.3	100	24.3	59.0	28.9	34.5	98	4.23
16	Sakha 101× Sakha 104	117.8	99	25.9	81.9	27.3	32.5	149	6.10
17	Sakha 101× Sakha 105	119.3	92	27.5	74.2	27.7	27.0	113	4.84
18	Sakha 101× Sakha 106	110.7	116	26.9	64.0	28.2	38.7	128	4.85
19	Sakha 101×GZ7576-10-3-2-1	109.6	113	25.1	87.2	26.6	36.3	120	4.76
20	Sakha 101× BL 1	110.1	111	29.4	74.0	28.0	40.2	109	4.56
21	Sakha 101×Shien 2	112.4	116	27.1	77.3	26.2	34.3	115	4.69
22	Sakha 104× Sakha 105	124.9	117	26.1	73.3	27.0	38.2	115	4.51
23	Sakha 104× Sakha 106	117.1	99	25.6	84.4	27.6	36.2	132	5.91
24	Sakha 104×GZ7576-10-3-2-1	122.0	112	23.6	57.4	28.6	35.0	138	5.77
25	Sakha 104× BL 1	115.9	104	23.0	73.5	27.1	36.3	134	5.17
26	Sakha 104× Shien 2	116.5	103	22.7	72.9	26.9	39.8	136	5.71
27	Sakha 105× Sakha 106	111.3	93	25.7	57.8	28.7	32.9	103	4.47
28	Sakha 105×GZ7576-10-3-2-1	112.1	94	26.1	68.0	28.4	35.3	112	4.68
29	Sakha 105× BL 1	117.0	97	27.2	83.6	28.3	39.5	153	5.67
30	Sakha 105× Shien 2	116.3	94	23.5	63.8	28.8	32.1	134	5.53
31	Sakha 106× GZ7576-10-3-2-1	115.4	92	28.0	58.2	28.8	36.0	108	4.56
32	Sakha 106 × BL 1	124.4	100	27.0	83.2	28.2	44.0	155	5.92
33	Sakha 106 × Shien 2	117.5	93	25.4	69.3	28.5	37.9	124	4.99
34	GZ7576-10-3-2-1× BL 1	116.5	93	26.5	56.3	29.8	34.9	128	5.39
35	GZ7576-10-3-2-1× Shien 2	115.7	93	27.3	79.4	27.8	36.1	119	5.17
36	BL 1× Shien 2	110.8	`92	23.8	57.3	27.4	33.9	109	4.79

Table 2. Estimates of heterosis relative to better parent and mid parent of parental varieties and their F_1 crosses for all studied characters

Crosses	Plant height (cm)		Days to heading		No. of panicle / plant		Grain yield plant^{-1}		1000-grain weight	
	H(BP)%	H(MP)%	H(BP)%	H(MP)%	H(BP)%	H(MP)%	H(BP)%	H(MP)%	H(BP)%	H(MP)%
Giza 177×Sakha101	13.47**	10.07**	16.84**	8.29**	16.09**	25.35**	46.44**	57.01**	-1.03*	0.70
Giza 177× Sakha 104	13.33**	9.43**	1.05*	-4.00**	21.90**	26.11**	67.39**	69.27**	-1.07*	0.54
Giza 177× Sakha 105	19.86**	18.00**	15.79**	15.79	18.18**	25.00**	37.32**	38.52**	4.29**	4.29**
Giza 177× Sakha 106	14.59**	10.15**	5.38**	4.26**	35.00**	36.36**	86.37**	86.37**	0.70*	1.59**
Giza 177×Gz 7576-10-3-2-1	10.31**	6.92**	5.80**	4.10**	27.62**	32.02**	54.01**	69.03**	2.86**	6.27**
Giza 177× BL 1	12.01**	12.01**	3.16**	2.08**	26.83**	31.20**	45.86**	64.09**	1.79**	2.33**
Giza 177× Shien 2	31.50**	22.46**	7.18**	6.21**	16.43**	20.16**	31.05**	51.21**	3.21**	3.96**
Sakha 101× Sakha 104	27.66**	19.45**	-5.71**	-7.91**	12.46**	17.58**	57.40**	70.51**	-5.86**	-2.67**
Sakha 101× Sakha 105	29.25**	27.39**	-3.16**	-10.24**	19.71**	22.37**	42.69**	51.43**	-4.48**	-2.81**
Sakha 101× Sakha 106	19.97**	11.74**	24.73**	14.29**	16.81**	24.96**	23.12**	32.00**	-2.76**	-1.91**
Sakha 101×Gz 7576-10-3-2-1	18.78**	12.73**	22.83**	11.88**	8.990**	13.94**	67.69**	95.96**	-8.28**	-3.62**
Sakha 101× BL 1	19.25**	15.68**	14.43**	7.25**	27.97**	33.79**	42.39**	70.21**	-1.38**	0.88*
Sakha 101×Shien 2	31.62**	26.51**	24.33**	14.12**	17.83**	23.46**	48.58**	81.80**	-9.66**	-7.42**
Sakha 104× Sakha 105	31.44**	24.87**	23.16**	17.00**	18.64**	21.40**	59.28**	62.81**	-1.43**	0.36
Sakha 104× Sakha 106	11.49**	11.02**	6.45**	0.00	21.90**	24.88**	87.61**	89.72**	-6.67**	-4.32**
Sakha 104×Gz 7576-10-3-2-1	19.34**	16.05**	21.74**	13.71**	12.38**	12.38**	30.38**	41.65**	5.54**	7.32**
Sakha 104× BL 1	18.23**	14.15**	7.22**	2.97**	9.520**	9.52**	66.97**	85.99**	-2.17**	-1.09**
Sakha 104× Shien 2	36.42**	22.37**	10.40**	3.88**	7.940**	8.19**	65.70**	89.37**	-2.54**	-1.65**
Sakha 105× Sakha 106	17.12**	10.77**	0.00	-1.06	16.97**	22.54**	25.56**	26.94**	0.70	1.59**
Sakha 105×Gz 7576-10-3-2-1	18.00**	13.69**	2.17**	0.53	18.64**	21.40**	47.83**	63.86**	1.43**	4.80**
Sakha 105× BL 1	23.12**	21.21**	2.11**	1.04	23.48**	26.36**	81.83**	106.52**	1.07*	1.62**
Sakha 105× Shien 2	36.18**	28.94**	0.75	-0.16	6.820**	9.56**	38.77**	61.60**	2.86**	3.60**
Sakha 106× Gz 7576-10-3-2-1	12.92**	10.91**	-0.36	-0.90	33.17**	36.42**	29.26**	41.87**	1.05*	5.30**
Sakha 106 × BL 1	26.97**	22.05**	7.89**	5.61**	28.57**	31.71**	84.98**	108.10**	-1.05*	0.36
Sakha 106 × Shien 2	37.63**	22.88**	0.00	-0.16	21.53**	24.21**	54.00**	77.69**	0.00	1.60**
Gz 7576-10-3-2-1× BL 1	18.91**	16.42**	1.09	-1.59*	26.19**	26.19**	52.25**	56.48**	7.58**	10.58**
Gz 7576-10-3-2-1× Shien 2	35.52**	23.38**	1.09	0.38	30.00**	30.31**	114.56**	126.82**	0.72	3.35**
BL 1× Shien 2	29.70**	20.79**	-90.14**	-3.31**	13.49**	13.76*	63.82**	68.64**	-1.08*	-0.90*
$LSD_{0.05}$	3.17	2.38	1.71	1.28	1.33	1.001	2.92	2.19	0.95	0.71
$LSD_{0.01}$	4.17	3.13	2.25	1.69	1.75	1.31*	3.84	2.88	1.25	0.94

Table 3. Estimates of heterosis relative to better parent and mid parent of parental varieties and their F_1 crosses for all studied characters

Crosses	Flag leaf area (cm^2)		No .of filled grains panicle^{-1}		Panicle density	
	H(BP)%	H(MP)%	H(BP)%	H(MP)%	H(BP)%	H(MP)%
Giza 177×Sakha101	57.39**	81.28**	-10.2**	-0.15	-16.78**	-12.80**
Giza 177× Sakha 104	9.85**	35.88**	-16.4**	-7.87**	-18.22**	-14.65**
Giza 177× Sakha 105	28.20**	52.52**	-6.52**	-1.79	-14.50**	-14.30**
Giza 177× Sakha 106	3.62*	28.80**	-11.0**	-4.91**	-23.64**	-23.46**
Giza 177×Gz 7576-10-3-2-1	37.97**	48.99**	-14.0**	-12.03**	-23.07**	-22.76**
Giza 177× BL 1	18.69**	34.17**	-20.4**	-20.16**	-32.90**	-32.26**
Giza 177× Shien 2	40.38**	58.41**	-19.7**	-18.73**	-36.16**	-34.38**
Sakha 101× Sakha 104	5.41**	14.72**	-2.61	-1.65	-11.43**	-11.04**
Sakha 101× Sakha 105	-3.35*	0.43	-26.1**	-21.55**	-29.82**	-26.62**
Sakha 101× Sakha 106	24.04**	35.79**	-16.1**	-12.45**	-29.64**	-26.10**
Sakha 101×Gz 7576-10-3-2-1	40.83**	51.07**	-21.7**	-14.78**	-30.92**	-27.34**
Sakha 101× BL 1	55.75**	59.14**	-29.0**	-20.71**	-33.83**	-31.29**
Sakha 101×Shien 2	32.95**	36.11**	-24.9**	-15.59**	-31.90**	-30.54**
Sakha 104× Sakha 105	24.13**	30.27**	-23.3**	-19.35**	-33.92**	-31.20**
Sakha 104× Sakha 106	16.03**	16.77**	-11.8**	-8.78**	-13.52**	-9.55**
Sakha 104×Gz 7576-10-3-2-1	13.47**	31.64**	-7.80**	-0.50	-15.52**	-11.50**
Sakha 104× BL 1	17.97**	30.93**	-10.9**	-1.38	-24.27**	-21.69**
Sakha 104× Shien 2	29.22**	43.68**	-9.11**	1.36	-16.40**	-15.10**
Sakha 105× Sakha 106	5.44**	11.33**	-26.5**	-25.21**	-28.96**	-28.61**
Sakha 105×Gz 7576-10-3-2-1	26.64**	40.77**	-16.7**	-14.58**	-25.63**	-25.15**
Sakha 105× BL 1	41.70**	50.32**	13.5**	19.74**	-11.20**	-10.57**
Sakha 105× Shien 2	15.17**	22.41**	-0.42	5.85**	-16.41**	-14.27**
Sakha 106× Gz 7576-10-3-2-1	15.38**	34.58**	-22.7**	-19.33**	-26.76**	-26.64**
Sakha 106 × BL 1	40.93**	57.32**	10.9**	19.00**	-7.16**	-6.05**
Sakha 106 × Shien 2	21.37**	35.72**	-11.5**	-4.38**	-24.62**	-22.33**
Gz 7576-10-3-2-1× BL 1	41.30**	48.51**	0.23	3.05**	-15.52**	-14.38**
Gz 7576-10-3-2-1× Shien 2	46.57**	53.76**	-7.01**	-3.62**	-21.91**	-19.41**
BL 1× Shien 2	37.07**	37.35**	-9.64**	-8.89**	-27.64**	-26.30**
L.S.D. 5%	3.46	2.59	2.95	2.21	0.36	0.28
1%	4.55	3.41	3.88	2.91	0.47	0.38

Table 4. Estimates of phenotypic correlation coefficients among each pair of studied characters

Characters	Plant height	Flag Leaf area	No. of days to heading (day)	No. of panicles plant^{-1}	No of filled grains panicle^{-1}	1000- grain weight	Grain yield plant^{-1}	Panicle density
Plant height	1.00							
Flag Leaf area	0.693**	1.00						
Days to heading	0.129	0.389**	1.00					
No. of panicles plant^{-1}	0.59**	0.634**	0.207	1.00				
No of filled grains panicles^{-1}	0.006	0.125	0.155	-0.275	1.00			
1000-grain weight	0.042	0.108	-0.202	0.251	-0.029	1.00		
Grain yield plant^{-1}	0.689**	0.700**	0.289	0.744**	0.055	-0.067	1.00	
Panicle density	-0.52**	-0.426**	-0.1	-0.686**	0.75**	-0.115	-0.478**	1.00

Table 5. Estimates of genetic parameters of parental varieties and their F_1 crosses for all studied characters

Genetic Parameter	plant height (cm)	days to heading (days)	No-of Panicles plant^{-1}	grain yield plant^{-1} (g)	1000-grain weight (g)	Flag leaf area (cm^2)	No .of filled grains panicle^{-1}	Panicle density
Additive variance (σ^2 A)	-3.675	16.91	-0.593	-33.29	0.09	-3.13	18.65	-0.07
Dominant variance (σ^2 D)	79.02	49.13	6.765	260.7	0.50	29.12	219.86	0.62
Broad sense heritability (h^2_b) %	98.2	99.4	96.3	99.5	83.46	94.33	99.5	96.9
Narrow sense heritability (h^2_n) %	- 4.70	25.4	-9.20	-14.5	31.61	-11.3	7.78	-12.4

For plant height all hybrid combinations for the better-parent and mid-parent were found to be highly significant positive heterotic effects which in detected that there is not any negative heterotic for this trait so, the dominance teller play an important role in the heritance of this trait. For No. of days to heading (days), three hybrid combination exhibited highly significant negative heterotic effect which varied from - 90.14 to -3.16 % over the respectively better-parent, the early crosses in included Sakha101 x Sakha104, Sakha101 x Sakha105 and BL1 x Shien2. While, five hybrid combinations gave significant and highly significant negative heterotic effect which varied from -10.24 to -1.59% over the respectively mid-parent. Twenty eight hybrid combinations showed significant desirable positive heterosis for No. of panicles plant^{-1}, relative to the respective better parent and mid-parent. Significant heterosis was also detected by El-Refaee (2002), Sedeek (2006), Saleem *et al* (2008) and Anis (2013). As for grain yield plant^{-1}, all the twenty eight hybrid combinations had significantly positive heterotic which ranged from 23.12 to 114.56% over the respective batter parents but for mid-parent heterotic ranged from 126.82 to 26.94% under this trait.

As for 1000-grain weight eight hybrid combinations from the twenty eight crosses were found to be highly significant positive heterotic over the respective batter parents. While fourteen hybrid combinations were found to be highly significant positive heterotic over the respective mid- parents. With regard to flag leaf area (cm^2), twenty seven out of the twenty eight hybrid combinations were significantly and highly significant and had bigger leaf area than there respectively better-parent. The heterosis varied from 3.62 to 57.39 % over to respective parent. While, twenty seven hybrid combinations were highly significant than there respectively mid-parent. Results indicated that, Tow hybrid combinations (Sakha105 x BL1 and Sakha106 x BL1) were found to be highly significant heterotic effects for No. of filled grain panicle^{-1} with the values of 10.9 and 13.5%, respectively over the respective better parent but four crosses had highly significant heterotic effects relative to both mid-parent. Heterosis for No. of filled grains panicle^{-1} was previously found by El-Mowafi (2001), Pushpam *et al*. (2005) and Essa *et al*. (2011).

Correlation coefficient

The correlation coefficients between nine studied traits are presented in Table 4. The correlation coefficient was statistically estimated are reported by Gomez and Gomez (1984). Significant and highly significant positive correlation were observed between No. of days to heading with, No. of primary branches panicle^{-1}. For plant height significant and highly significant positive correlation coefficients were observed with flag leaf area, No. of panicles plant-1 and grain yield plant^{-1}. This conclusion was also drawn by El-Rawainy *et al*. (2011), Keshava *et al*. (2011), Essa (2012) and Hammoud *et al*. (2012). As for flag leaf area significant and highly significant positive correlation coefficients between flag leaf area and, No. of days to heeding, No. of tillers plant^{-1}, panicle length, No. of panicles plant^{-1} and grain yield plant^{-1}. On the other side, significant and highly significant negative correlation coefficients between flag leaf area with spikelets fertility% and panicle density. With regard to No. of panicle plant^{-1} highly significant positive correlation coefficient showed with grain yield plant^{-1}. On the contrarily, highly significant negative correlation coefficient were found with panicle density. As for No. of filled grains panicle^{-1}, significant and highly significant positive correlation coefficient were detected with panicle density.

Genetic components of variance for agronomic characters studied

Genetic parameters, additive and dominance genetic variance as well as heritability values were estimated for the nine agronomic traits i.e. plant height, days to heading, No. of panicles plant^{-1}, grain yield plant^{-1}, 1000-grain weight, flag leaf area, No. of filled grain panicle^{-1}and panicle density and the results are presented in (Table 5). The results indicate that the non-additive genetic variance (σ^2 D) and the relative importance of SCA% of all studies traits, playing a major role in the inheritance of their traits, so we can make selection in the late generation to improving their trite in rice breeding program Similar results were obtained by Hammoud (1996), El-Mowafi (2001), El-Refaee (2002) and Ahmed (2004). Heritability estimates in both broad and narrow sense for all studied traits are presented in (Table 5).

The results showed that heritability estimates in broad sense (h^2_b%) were high for all studied traits. while, heritability estimates in narrow sense (h^2_n%) were relatively low for plant height, days to heading, No. of panicles plant^{-1}, grain yield plant^{-1}, 1000-grain weight, flag leaf area, No. of filled grain panicle^{-1} and panicle density ^{1} with values 4.7, 25.4, 9.2, 14.5, 13.61, 11.3, 7.78, 32.1 and 12.4, respectively. This further suggested that a major part of the total phenotypic variance for these traits was due to dominance genetic variance and environmental effects. Thus these results led to conclusions the selection for these traits must be done in the late generations. These results were in full agreement with the previous results obtained by Hammoud (2004) and Sedeek (2006).

Conclusion

In the light of above discussion, it could be accomplished that that the rice crosses Sakha 101/Sakha 104, Sakha 104/Sakha 106, Sakha 105/BL1 and Sakha 106/BL1 exhibited positively and significantly heterosis and heterobelitosis for grain yield and some other traits studied. Consequently, these crosses would be useful for finding transgressive segregations in late segregating generations to develop superior genotypes in future breeding programs

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