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Studies on heterosis for qualitative and quantitative traits in rice

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Key words: Genetic variability, Cluster analysis, Heterosis, *Oryza sativa.*

1 SUMMARY

The present investigation is carried out to estimate heterosis effects on the yield and its component traits in ten parent genotypes and their F1 hybrids as well as cluster analysis of the parent genotypes at the Experimental Farm of Rice Research and Training Center,(RRTC), Sakha, Kafr EL-Sheikh, Egypt during 2010 and 2011 summer seasons,. A line x tester cross was conducted among the ten parents in 2010 to produce 24 crosses. The analysis of variance revealed highly significant differences among the 34 genotypes (24 cross combinations, 4 lines and 6 testers) tested for all traits under investigation. Heterosis was found to be highly significant for all studied traits. For mid-parent heterosis, cross combination Giza 179xSKC 23819-192-2-1-2-3-1-1-1-2 scored the best values for number of tillers plant^{-1}, number of panicles plant^{-1}, number of filled grains panicle^{-1} and panicle density. The cross combination Sakha106xSKC 23819-192-2-2-1-1-2-1-2-2 gave the best values for number of days to heading (day) and 1000-grain weight (g).The cross Sakha103xSKC23819-192-2-1-2-4-5-3-2-1 gave the best values in flag leaf area (cm^2) and Spikelet's fertility%. The cross combination Sakha103x SKC23819-189-1-1-1-3-1-2-4-2 showed the lowest plant height among the genotypes studied, while the cross Sakha106x SKC23819-189-1-1-1-3-1-2-4-2 gave the highest value for grain yield plant^{-1} and for panicle weight. The cross Sakha106xSKC 23819-192-2-2-1-1-2-2-1-2 gave the highest value and for panicle length cross Giza 179x SKC23819-189-1-1-1-3-1-2-4-2 scored the highest value. For better-parent heterosis, cross combination Giza 179xSKC 23819-192-2-1-2-3-1-1-1-2 gave the highest values for number of tillers plant^{-1}, number of filled grains panicle^{-1}, panicle length and panicle density, cross Giza178x SKC 23819-192-2-1-2-2-4-2-1-2 recorded the best value for number of days to heading, for plant height the cross Sakha103x SKC23819-189-1-1-1-3-1-2-4-2 gave the best value and the cross Sakha103xSKC 23819-192-2-1-2-4-5-3-2-1 scored the highest value for flag leaf area, cross Sakha106x SKC23819-189-1-1-1-3-1-2-4-2 gave the highest value for grain yield plant^{-1}, and cross Giza 179x SKC23819-189-1-1-1-3-1-2-4-2 gave highest value for number of panicles plant^{-1}, and cross Sakha106xSKC 23819-192-2-2-1-1-2-1-2-2 scored the highest value for 1000-grain weight and Spikelet's fertility%, cross Sakha106xSKC 23819-192-2-2-1-1-2-2-1-2 gave the highest value for panicle weight. The cluster analysis showed that the parent genotypes formed two groups. The first group included only the variety Giza 178 because it was moderate in maturation. The second group included the rest of the parental genotypes according to the different traits.

2 INTRODUCTION

Rice (*Oryza sativa* L.), is the world leading cereal crop for human utilization, with growing area of almost 150 million hectars and a total production of almost 600 million ton annually (Khush, 2005). The world population is expected to reach 8 billion by 2030 and rice production must be increased by 50% in order to meet the growing demand for the world (Khush and Brar, 2002). Rice crop is one of the important strategic crops in Egyptian economy. It is also one of the important summer crops representing an area of about 27.8%, 10.7% of total planted area with summer crops and crop area, respectively. Besides, it is an important export crop, where its exports are about 32.2% of total value of agricultural exports on average during the period between the years of 2000 and 2011 (El-Eshmawiy *et al.*, 2013). Heterosis in rice was first found by Jones (1926) who reported a marked increasing in culm number and grain yield in some F1 hybrids with compare their parents. Vanaja and Babu (2004) pointed out that rice yield increasing could due to favorable heterosis in flag leaf area, number of spikelets per panicle and number of grains per panicle. Positive heterosis is desired for yield and negative heterosis for early maturity. Heterosis is expressed in three ways, depending on the criteria used to compare the performance of a hybrid (Alam et al., 2004). This investigation aimed to estimate the heterosis over mid and better parent in F_1 generation for yield and yield component traits to identification of the best crosses, which the breeder can select in hybrid program and concentrate on it.

3 MATERIALS AND METHODS

The research work of the present study was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr EL-Sheikh, Egypt, during 2010 and 2011 successive rice seasons. The study involved ten rice genotypes, i.e. three commercial varieties (Giza178, Sakha103 and Sakha106), one promising line (Gz 9057-6-1-3-2) as well as six bold grain lines (SKC 23819-189-1-1-1-3-1-2-4-2, SKC 23819-192-2-1-2-2-4-2-1-2, SKC 23819-192-2-1-2-3-1-1-1-2, SKC 23819-192-2-1-2-4-5-3-2-1, SKC 23819-192-2-2-1-1-2-1-2-2 and SKC 23819-192-2-2-1-1-2-2-1-2). The parental genotypes have a wide range of variations for all studied traits. Origin and pedigree of the ten parents were illustrated in Table 1.

Table 1: Origins and pedigrees of the parents utilized in this study

Number.	Entry	Origin	Pedigree
1	Giza 178	Egyptian	(Giza175/Milyang49)
2	Sakha 103	Egyptian	(Giza 177 / Suweon 349)
3	Sakha 106	Egyptian	(Giza 177 / Hexi 30)
4	GZ9057-6-1-3-2 (Giza 179)	Egyptian	(Gz 6296 / Gz 1368-S-5-4)
5	SKC 23819-189-1-1-1-3-1-2-4-2	America/ Egypt	(L 204 / Giza177)
6	SKC 23819-192-2-1-2-2-4-2-1-2	America/Egypt	(L 204 / Giza177)
7	SKC 23819-192-2-1-2-3-1-1-1-2	America/Egypt	(L 204 / Giza177)
8	SKC 23819-192-2-1-2-4-5-3-2-1	America /Egypt	(L 204 / Giza177)
9	SKC 23819-192-2-2-1-1-2-1-2-2	America /Egypt	(L 204 / Giza177)
10	SKC 23819-192-2-2-1-1-2-2-1-2	America /Egypt	(L 204 / Giza177)

The ten parental genotypes in this study were sown in the growing season of 2010 in three sowing dates with 15 days intervals to overcome the differences of heading date among the parental varieties. After 30 days from sowing, seedlings of the ten parents were transplanted to the experimental field in three rows. Each row was five meters long and 20 x 20 cm spacing between plants and rows. A line x tester cross was conducted among the ten parents (four lines and six testers) in 2010 to produce 24 crosses. The hybridization techniques of Jodon (1938) modified by Butany (1961) were used and the hot water method of emasculation was utilized. The seeds of the parental varieties and their resulting 24 crosses were sown in a randomized complete block design (RCBD) with three replications in 2011 growing season. Each replication contained 34 rows and each row included 25 individual plants for each genotype. The studied traits were number of days to heading (day), plant height (cm), number of tillers plant^{-1}, flag leaf area (cm^2), grain yield plant^{-1} (g), number of panicles plant^{-1}, 1000-grain weight (g), number of filled grains panicle^{-1}, panicle weight (g), spikelet fertility%, panicle length (cm) and panicle density. The data were subjected to analysis of variances for a randomized complete block design as suggested by Panse and Sukhatme (1957) and the analysis of variance for line x tester crossing followed the design of Kempthorne (1957). Heterosis was estimated also according to Mather (1949) and Mather and Jinks (1982). L. S. D. values were estimated according to the formula suggested by Wyanne *et al.* (1970).The analysis of cluster was conducted using the Numerical Taxonomy and Multivariate Analysis system, version 2.1 (NTSYSPS; Rohlf, 2000).

4 RESULTS AND DISCUSSION

4.1 Analysis of variance for some agro-morphological and phenological characteristics: Results of the variance analysis in Table 2 revealed that highly significant differences among the 34 genotypes including 24 cross combinations, 4 lines and 6 testers tested for all characters studied. Parents vs. crosses mean squares indicated that average heterosis was highly significant for all traits. On the other hand, the male testers and female lines exhibited highly significant differences for all studied characters. The highly significant mean squares of lines × testers for all characters indicated that they interacted and produced markedly different combining ability effects, and this might be due to the wide genetic diversity of lines and testers. This result is in agreement with the results of Singh *et al.* (2011) and Abdelkhalik *et al.* (2013).

Table 2: Analysis of variance, mean square from line x testers analysis for vegetative and stem borer characteristics.

S.O.V	D.F	Days to Heading (days)	Plant height (cm)	Tillers plant^{-1}	Flag leaf area (cm^2)
Reps.	2	0.992	0.381	0.055	2.206
Genotypes	33	74.09**	303.7**	100.2**	49.59**
Parents	9	121.6**	379.3**	32.11**	43.91**
P.Vs.C	1	706.6**	2839.2**	494.2**	242.2**
Crosses	23	644.0**	163.9**	109.8**	43.43**
Lines (gca,L)	3	320.1**	806.4**	721.8**	75.59**
Testers (gca,T)	5	90.52**	60.68**	7.917**	47.34**
Line x testers (sca)	15	233.4**	69.93**	21.37**	35.69**
Error	66	21.74	0.268	0.433	0.497

*and**, Significant at 5% and 1% levels of probability, respectively.

4.2. Analysis of variance for yield and its components characters: Highly significant differences were determined among genotypes, parents and hybrid rice combinations for yield and its component characters, i.e. grain yield plant^{-1}, number of panicles plant^{-1}, 1000-grain weight, number of filled grains panicle^{-1}, Panicle weight, Spikelet fertility%, Panicle length (cm) and Panicle density as presented in Table 3. These results indicated wide range of genetic variations among the parental lines used in this study. In the same time, the mean squares of parents vs. crosses were found to be highly significant for grain yield and its component characters. The results also illustrated that the general combining ability variances of lines (female parents) and testers were highly significant for all studied characters. The mean squares of lines x testers interaction (SCA) were statistically significant for all studied characters. These results were in general agreement with those reported by Singh *et al.* (2011) and Abdelkhalik *et al.* (2013). Parents vs. crosses mean squares as an indication to average of heterosis overall crosses were found to be highly significant for yield and its components characters. This result is in agreement with the results of Ram *et al.* (2010) and Koli *et al.* (2013).

4.3 Estimates of heterosis for vegetative characteristics: Heterosis values were calculated for days to heading, plant height, number of tillers plant^{-1}, flag leaf area. Data of heterosis estimates relative to mid and better-parents presented in Table (4). For days to heading (day), about 18 crosses exhibited undesirable positive and significant heterotic values over mid-parent towards lateness. The highest value of heterotic effect over mid-parent was 12.48% for cross No. 23 followed by 10.57% for the cross, No.15. However the lowest heterosis value was calculated as 4.6% for cross, No.8 followed by 5.24% for cross, No.23. The lowest value of heterotic effect over better parent was found as 5.81 % for the crosses, No. 1 followed by the crosses 2, 3 and 6 as7.88, 8.32 and 9.62, respectively. In general, the results are in agreement with those reported by El-Sherif (2011) and Anis (2013). For plant height, the results revealed that most of studied F_1 cross combinations exhibited undesirable positive and highly significant heterotic values for 20 crosses towards tallness for mid-parent heterosis, except the cross combinations, No. 13 and 7 (-8.16%) and (-1.55%) which exhibited negative and highly significant values towards shortness for mid-parent heterosis. Mid parent heterosis, values were not significant for the crosses 17 and 18 were Therefore, it could be concluded that these crosses could be of practical interest in rice breeding program for the short plant height. Heterotic effect over best parent P ranged from 1.97% for cross, No. 13 to 54.77% for cross No. 21. Similar results were obtained by Anis (2013) and Perera *et al.* (2013).As shown in Table (4) mid-parent heterosis was highly significant positive in 19 crosses for number of tillers plant^{-1}. The highest estimate was detected for cross No 21 as 62.83 % followed by the crosses No. 23 and 24 as 49.07% and 56.76%, respectively. Best parent heterosis was highly significant positive in 15 crosses, and the values ranged between 7.40% for cross combination, No. 5 and 44.08% for cross No. 21. Positive heterosis effects for tillers plant^{-1} have previously obtained by Palaniraja *et al.* (2010). For flag leaf area twenty-one cross, combinations showed highly significant positive and negative heterotic effects over mid-parent. Three of them, the crosses No. 20, 23 and 10 with values of 3.82%, 9.80% and 10.06%, respectively, gave the higher positive estimates. With respect to better-parent heterosis, two crosses showed highly significant positive values. The higher estimates were detected for the cross, No. 10 and cross No. 23. Similar results were reported by Anis (2013).

4.4 Heterosis for yield and its components characters: Results of heterosis estimates over better and mid-parent for yield and its components traits are presented in Tables 5 and 6. With respect to grain yield plant^{-1}, significant and highly significant positive heterotic effects over mid-parent up to 19 combinations were determined. The higher heterotic effects were determined for crosses, No. 22, 18 and 13-as 47.76%, 48.36% and 48.53%respectively. The estimates of better parent heterosis revealed significant and highly significant positive values for 14 cross combinations. The higher estimates were calculated for the crosses, No. 13, 18 and 22 as 37.96%, 40.81% and 46.49, respectively. The result is in agreement with those of Palaniraja *et al.* (2010), Satheeshkumar and Saravanan (2011), Patil *et al.* (2012) and Singh and Babu (2012). For number of panicles plant^{-1}, highly significant and positive heterosis was recorded for 17 crosses as deviation from the mid-parents value. The higher heterotic effects over mid-parents were observed for the crosses, No. 23, 24, 22 and 21 with values of (52.77%, 53.23%, 53.66% and 62.97%), respectively. Sixteen crosses showed positive significant and highly significant heterotic values over better parent towards highest panicles number plant^{-1}. The range of heterotic effect over better-parent varied from 49.85% for cross, No. 19 to 5.75% for cross, No. 18.These results similar to those of Patil *et al.* (2012) and Anil and Mani (2013). Results in Table 5 revealed highly significant positive heterosis over mid parent for 1000-grain weight in 11 rice crosses. These estimates ranged between 9.01% for cross, No. 17 to 0.68% for cross, No. 13. In addition, for better parent heterosis the values were negative. The results in agreement with those obtained Anil and Mani (2013). Regarding filled grains panicle^{-1}, mid-parent heterosis values in t seven crosses were highly significant positive which ranged from 7.50 to 74.71% for the crosses, No. 15 and 21, respectively. Better parent heterosis values 7 crosses combinations were highly significant positive ranging from 8.61 in the cross, No. 13 to 69.73 in the cross, No. 21, as show in Table (5). These results are similar with those of Patil *et al.* (2012) and Perera *et al.* (2013). For panicle weight, highly significant positive estimates of heterosis over mid-parents were recorded for four crosses, No. 7, 17, 11 and 18 with values of 8.90%, 11.12%, 23.56% and 27.67%, respectively (Table 6). In relation to better-parent heterosis, the higher estimates were recorded for the crosses 17, 11 and 18 with respective values of 9.57%, 16.86%, and 24.57%. With respect to spikelet fertility %, 15 crosses exhibited significant and highly significant positive heterosis over mid-parents (Table 6). For the cross, No. 17 (7.60%), cross, No. 9 (8.45%) and cross, No. 10 (9.17%) were higher values detected. With respect to better-parent hetorosis, highly significant positive effects were found in 12 crosses. The highest heterosis over better-parent was determined for the cross No 17 (6.44 %) by the cross No 15 (5.97 %) and the cross No 13 (5.38%. This result is in agreement with the results of Vaithiyalingan and Nadarajan (2010).

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Table 3: Analysis of variance for combining ability effects of yield and yield component characters in rice

S.O.V	D.F	Grain yield plant^{-1} (g)	No. of panicles plant^{-1}	1000-grain weight (g)	No. of filled grains panicle^{-1}	Panicle weight	Spikelet's fertility (%)	Panicle length (cm)	Panicle density
Reps.	**2**	1.569	0.191	0.003	26.90	0.024	0.281	0.123	0.128
Genotypes	**33**	272.0**	96.02**	43.41**	2600**	0.503**	610.1**	9.753**	3.852**
Parents	**9**	174.2**	24.01**	125.3**	515.3**	0.312**	25.25**	9.769**	1.433**
P.Vs.C	**1**	2478**	481.6**	37.83**	0.308**	0.425**	936.0**	0.470**	7.603**
Crosses	**23**	214.3**	107.4**	11.59**	3530**	0.581**	824.8**	10.15**	4.635**
Lines (gca,L)	**3**	376.0**	721.7**	49.97**	6216**	1.434**	3033**	64.22**	9.954**
Testers (gca,T)	**5**	234.3**	5.840**	13.62**	4459**	0.275**	815.6**	2.040**	6.811**
Line x testers (sca)	**15**	175.3**	18.45**	3.249**	2682**	0.513**	386.2**	2.041**	2.846**
Error	**66**	10.45	0.496	0.032	15.99	0.019	0.964	0.215	0.055

*** and ** significant at 5% and 1% levels of probability, respectively**

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Table 4: Estimates of heterosis relative to mid-parents and better parents for days to heading, plant height, number of tillers plant^{-1} and flag leaf area (cm^2).

No	Crosses	Days to heading (days)		Plant height (cm)		No. of tillers plant^{-1}		Flag leaf area (cm^2)	
		MP	BP	MP	MP	MP	BP	MP	BP
1	Giza178xSKC23819-	3.06	5.81*	15.41*	24.75*	-	-	-1.01	-
2	Giza178xSKC23819-	2.49	7.88**	3.44**	20.12*	-8.46**	-9.43**	-	-
3	Giza178xSKC23819-	3.42	8.32**	16.69*	39.64*	5.00**	-0.21	-	-
4	Giza178xSKC23819-	6.98**	12.79*	8.46**	25.95*	2.13	-8.01**	-	-
5	Giza178xSKC23819-	7.17**	12.07*	13.63*	30.10*	14.72*	7.40**	-	-
6	Giza178xSKC23819-	5.46*	9.62**	4.25**	23.70*	-5.21**	-	-	-
7	Sakha103xSKC2381	6.84**	11.96*	-1.55**	2.24**	-2.45	-	-8.65**	-
8	Sakha103xSKC2381	4.60*	12.43*	9.37**	21.71*	12.11*	1.96	-	-
9	Sakha103xSKC2381	3.94	11.16*	4.34**	19.53*	3.56*	-2.17	-	-
10	Sakha103xSKC2381	3.43	11.36*	5.89**	17.85*	28.41*	28.43*	10.06*	9.04**
11	Sakha103xSKC2381	5.68*	12.84*	7.25**	17.73*	32.91*	27.51*	-	-
12	Sakha103xSKC2381	6.62**	13.15*	14.58*	30.20*	29.39*	28.24*	-	-
13	Sakha106xSKC2381	9.12**	15.05*	-8.16**	1.97**	11.42*	-3.18*	-	-
14	Sakha106xSKC2381	6.34**	15.03*	5.35**	25.86*	28.93*	20.99*	-	-
15	Sakha106xSKC2381	10.57*	18.99*	2.96**	26.83*	34.76*	31.55*	-	-
16	Sakha106xSKC2381	3.73	12.38*	0.78**	20.40*	39.06*	34.44*	1.01	-5.79**
17	Sakha106xSKC2381	6.01**	13.90*	-0.14	17.59*	10.93*	10.03*	-2.81**	-4.42**
18	Sakha106xSKC2381	6.99**	14.26*	0.52	22.76*	11.27*	8.49**	-8.00**	-
19	Giza179x	8.17**	12.23*	31.60*	35.55*	42.63*	42.20*	-1.96	-8.01**
20	Giza 179x SKC	9.45**	16.46*	34.93*	39.91*	24.97*	14.75*	3.82**	-0.34
21	Giza 179xSKC	12.60*	19.20*	45.26*	54.77*	62.83*	44.08*	-	-
22	Giza 179xSKC	5.24*	12.15*	25.22*	29.84*	45.90*	22.91*	-	-
23	Giza 179xSKC	12.48*	18.89*	37.57*	40.81*	49.07*	30.10*	9.80**	9.26**
24	Giza 179xSKC	9.96**	15.52*	26.04*	33.27*	56.76*	33.01*	-	-
	L.S.D. 5%	4.40	5.38	0.49	0.60	0.62	0.76	0.66	0.81
	L.S.D. 1%	5.85	7.16	0.65	0.80	0.83	1.01	0.88	1.08

Table 5: Estimates of mid and better parent heterosis for grain yield plant-1, number of panicles plant-1, 1000-grain weight and number of filled grains panicle-1.

No	Crosses	Grain yield plant^{-1} (g)		No. of panicles plant^{-1}		1000-grain weight (g)		No .of filled grains panicle^{-1}	
		MP	BP	MP	BP	MP	BP	MP	BP
1	Giza178xSKC23819-	4.04	-	-	-	4.93**	-	-	-
2	Giza178xSKC23819-	-	-	-2.97	-3.61	1.67**	-	-	-
3	Giza178xSKC23819-	-3.23	-8.56**	-1.11	-3.41	-5.77**	-	-5.94**	-
4	Giza178xSKC23819-	20.77*	4.33	2.96	-4.63*	-2.35**	-	-	-
5	Giza178xSKC23819-	6.04*	-4.59	13.71*	8.42**	0.86**	-	-	-
6	Giza178xSKC23819-	-	-	-2.81	-9.59**	-1.66**	-	-	-
7	Sakha103xSKC2381	39.37*	25.00*	0.40	-	-1.97**	-	-2.42	-5.57**
8	Sakha103xSKC2381	30.71*	18.78*	12.40*	3.83*	-5.62**	-	-	-
9	Sakha103xSKC2381	8.08**	2.68	1.20	-3.74	-6.54**	-	0.74	-1.38
10	Sakha103xSKC2381	7.91**	2.99	19.46*	18.92*	0.80**	-	11.19*	10.97*
11	Sakha103xSKC2381	21.54*	21.44*	34.62*	31.17*	6.86**	-8.58**	2.91	2.35
12	Sakha103xSKC2381	10.01*	8.38*	31.47*	31.47*	3.06**	-	-5.30**	-7.44**
13	Sakha106xSKC2381	48.53*	37.96*	7.60**	-5.58**	0.68**	-	11.03*	8.61**
14	Sakha106xSKC2381	27.35*	19.90*	29.27*	22.39*	1.99**	-9.28**	16.63*	11.14*
15	Sakha106xSKC2381	28.43*	17.74*	31.97*	28.75*	-4.93**	-	7.50**	4.11*
16	Sakha106xSKC2381	33.88*	32.65*	38.41*	34.27*	-3.89**	-	2.63	1.30
17	Sakha106xSKC2381	32.78*	27.94*	10.88*	10.88*	9.01**	-3.03**	3.00	2.43
18	Sakha106xSKC2381	48.36*	40.81*	8.54**	5.75**	-0.40	-	43.35*	41.63*
19	Giza179xSKC23819-	26.14*	17.22*	49.83*	49.85*	0.13	-	61.04*	48.56*
20	Giza179xSKC23819-	20.20*	13.23*	30.56*	20.47*	1.19**	-	-	-
21	Giza179xSKC23819-	3.90	-4.82	62.97*	46.17*	-	-	74.71*	69.73*
22	Giza179xSKC23819-	47.76*	46.49*	53.66*	31.37*	-2.87**	-	-	-
23	Giza179xSKC23819-	9.66**	5.60	52.77*	34.06*	6.93**	-5.80**	-	-
24	Giza179xSKC23819-	40.83*	33.59*	53.23*	31.50*	0.06	-	-5.16**	-
	L.S.D. 5%	3.05	3.73	0.66	0.81	0.17	0.21	3.77	4.62
	L.S.D. 1%	4.05	4.96	0.88	1.08	0.22	0.27	5.01	6.14

For panicle length, nine crosses showed highly significant and positive heterosis over mid-parent. The higher values were recorded in the crosses, No. 1 and 19, 8.49% and 10.41% respectively. The better-parent heterosis was significant only in one cross, No. 21 with value (2.44%). With regard to panicle density, 15 crosses were significant and highly significant positive heterosis over mid-parents and the best cross was No. 21 with value 57.79%. Followed by cross No. 18 with value 42.55% and cross No 19 with value 39.64% and cross On the other hand, results recorded highly significant positive heterosis over better-parent for 16 hybrid combinations for this trait. The higher values were obtained for the cross No. 18 with 37.99 %, for, cross, No. 19 with 38.91% and (for cross, No. 21 with 57.40%. This result is in agreement with the results of Patil *et al.* (2012) and Perera *et al.* (2013).

4.5 Cluster analysis: Clustering of parent genotypes based on agro-morphological and yield characters produced two groups (Fig 1).The first group included Giza 178 alone.

This variety has the highest values of flag leaf area, grain yield plant^{-1}, number of filled grains panicle^{-1} and panicle density. The second group included rest of the parent genotypes such as Sakha 103, Sakha106, GZ9057-6-1-3-2, SKC23819-189-1-1-1-3-1-2-4-2, SKC 23819-192-2-1-2-2-4-2-1-2, SKC 23819-192-2-1-2-3-1-1-1-2, SKC 23819-192-2-1-2-4-5-3-2-1, SKC 23819-192-2-2-1-1-2-1-2-2 and SKC 23819-192-2-2-1-1-2-2-1-2. This group included genotypes with short number of days to heading like Sakha 103, Sakha106, GZ9057-6-1-3-2 and with lower values of plant height with the exception of Sakha106 as well as with higher values of number of tillers plant^{-1}, number of panicles plant^{-1}, 1000-grain weight, panicle weight and spikelet fertility%. This result is in agreement with that of Pani and Singh (2013). The second group was divided into two sub-groups. The first sub-group divided into two sub- sub- groups. The first one included Sakha 179 alone, which has the lowest value of plant height and highest values of number of tillers plant^{-1} , flag leaf area, number of panicles plant^{-1} and number of filled grains panicle^{-1}. Similar results were obtained by Bhadru *et al.* (2012) and Kiani (2013).

Table 6: Estimates of mid and better parent heterosis for panicle weight, spikelets fertility% panicle length and panicle density.

No	Crosses	Panicle weight (g)		Spikelet fertility (%)		Panicle length (cm)		Panicle density	
		MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
1	**Giza178x SKC23819-**	-0.92	-3.67*	-	-	8.49**	-2.46*	3.30*	-1.44
2	**Giza178x SKC 23819-**	-1.96	-2.51	3.36**	1.88**	-5.52**	-9.73**	-	-
3	**Giza178xSKC 23819-**	-	-	0.22	-1.07	-2.70**	-8.56**	-4.05**	-8.21**
4	**Giza178xSKC 23819-**	-5.09**	-	-	-	5.39**	-3.37**	-	-
5	**Giza178xSKC 23819-**	-1.20	-1.61	-	-	4.01**	-5.41**	-	-
6	**Giza178xSKC 23819-**	-	-	-	-	2.70**	-3.74**	13.98**	2.33
7	**Sakha103xSKC23819-**	8.90**	0.76	7.30**	4.24**	-	-	5.47**	1.04
8	**Sakha103xSKC**	-8.02**	-	5.65**	2.04**	-	-	-7.08**	-
9	**Sakha103xSKC**	-	-	8.45**	4.89**	-	-	4.62**	0.50
10	**Sakha103xSKC**	-1.84	-	9.17**	4.12**	-2.64*	-2.76*	3.99*	-1.25
11	**Sakha103xSKC**	23.56**	16.86**	4.54**	1.02**	2.16	1.37	-4.87**	-8.25**
12	**Sakha103xSKC**	-7.26**	-	5.00**	-0.67	-8.53**	-	-2.69	-
13	**Sakha106x**	-1.61	-2.53	5.95**	5.38**	-8.55**	-	12.90**	2.85
14	**Sakha106xSKC23819-**	0.71	-1.79	3.46**	2.29**	-9.47**	-	24.50**	24.20**
15	**Sakha106xSKC**	1.26	-4.92**	7.03**	5.97**	-	-	12.22**	1.94
16	**Sakha106xSKC**	-	-	3.37**	0.89	-7.28**	-	5.25**	-3.38
17	**Sakha106xSKC**	11.12**	9.57**	7.60**	6.44**	-4.62**	-	-0.91	-
18	**Sakha106xSKC**	27.67**	24.57**	1.03*	-2.21**	-1.02	-8.09**	42.55**	37.99**
19	**Giza 179x SKC23819-**	-7.23**	-9.71**	3.85**	2.55**	10.41**	1.45	39.64**	38.91**
20	**Giza 179x SKC**	-2.50	-3.18	-0.56	-2.39**	0.43	-1.77	-	-
21	**Giza 179xSKC 23819-**	-8.64**	-	3.19**	1.44**	6.53**	2.44*	57.79**	57.40**
22	**Giza 179xSKC 23819-**	-	-	-	-	5.18**	-1.39	31.35**	29.48**
23	**Giza 179xSKC 23819-**	-7.16**	-7.45**	-	-	3.79**	-3.50**	14.43**	14.31**
24	**Giza 179xSKC 23819-**	-9.87**	-	-	-	5.86**	1.51	10.67**	3.31
L.S.D. 5%		0.13	0.16	0.93	1.13	0.44	0.54	0.22	0.27
L.S.D. 1%		0.17	0.21	1.23	1.51	0.58	0.71	0.29	0.36

However, the second sub- sub- group included Sakha 103 and Sakha106, which were similar in short number of days to heading, highest values of number of panicle^{-1} .The obtained results are in harmony with those reported by Reddy *et al.* (2010). The second sub- sub groups were divided into two sub- sub – sub groups. The first one included two genotypes such as SKC23819-189-1-1-1-3-1-2-4-2, SKC23819-192-2-1-2-2-4-2-1-2, which have highest values of number of tillers plant^{-1} and number of panicles plant^{-1}. The result is in agreement with Kiani (2013). The second sub- sub- sub division separated to two division (sub- sub- sub- sub) one of them was the genotype SKC 23819-192-2-1-2-3-1-1-1-2, which has the lowest values of plant height, flag leaf area and spikelet fertility% and has the highest values of number of tillers plant^{-1}, grain yield plant^{-1}, number of panicles plant^{-1}, number of filled grains panicle^{-1}, panicle weight and panicle length. Similar results were obtained by Sedeek *et al.* (2009). The second one included three genotypes spread over two groups (sub- sub- sub sub sub)., The first containing one genotype SKC 23819-192-2-1-2-4-5-3-2-1, which recorded the highest value for number of days to heading, number of filled grains panicle^{-1}, and panicle weight and lowest value at number of tillers plant^{-1}, flag leaf area, grain yield plant^{-1} and number of panicles plant^{-1}. The result is in agreement with Bhadru *et al.* (2012). The second division containing SKC 23819-192-2-2-1-1-2-1-2-2 and SKC 23819-192-2-2-1-1-2-2-1-2, which were similar at flag leaf area and panicle weight. The obtained results are in harmony with those reported by Bhadru *et al.* (2012).

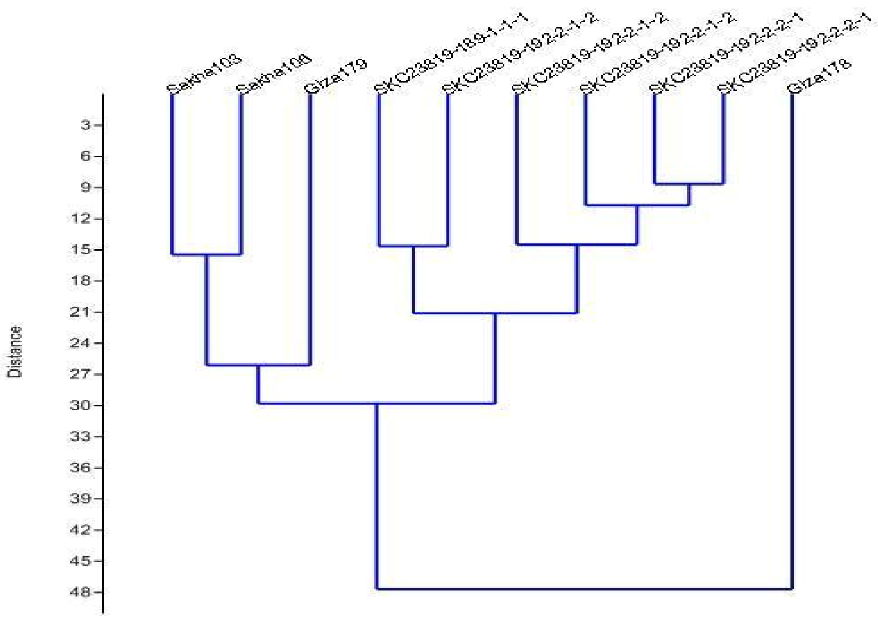

Fig. 1: Similarity matrix for ten varieties based on sixteen morphological characteristics.

5 CONCLUSION

On the basis of the results ,For mid and better parent cross Sakha106x SKC23819-189-1-1-1-3-1-2-4-2 gave the highest value for grain yield plant^{-1}, and cross Giza 179xSKC 23819-192-2-1-2-3-1-1-1-2 scored the best values for number of tillers plant^{-1}, number of filled grains panicle^{-1} and panicle density, and for cross combination Sakha106xSKC 23819-192-2-2-1-1-2-1-2-2 which gave the best values for number of days to heading (day) and 1000-grain weight (g), and spikelets fertility%, these three cross combinations gave highly significant positive estimates of SCA effects for important traits. Hence, the Egyptian rice breeders might concentrate on it in breeding programme.

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