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EVALUATION OF SOME RICE VARIETIES FOR WIDE COMPATIBILITY AND RESTORING ABILITY TRAITS

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ABSTRACT

Expression of variable degree of spikelet sterility in Indica / Japonica inter-subspecific crosses is one of the barriers in the exploitation of higher degree of heterosis manifested in such crosses. Two cytoplasmic male sterile (CMS) and their maintainer lines (B) one of them was Japonica (Giza177 A and Giza177 B) and the other was Indica (IR 69625 A and IR 69625 B) were crossed as female parents in lines x tester mating design with twenty seven diverse tester lines to study their behavior and combining ability for wide compatibility traits pollen fertility, spikelet fertility and filled grains panicle). The results indicated that the mean squares of genotypes and including parental lines were highly significant for all studied WC traits at the two years and their combined data, indicating the presence of large variations among them. The interactions of genotypes, parents, crosses and parents VS crosses with years were highly significant for all studied traits. Combining ability analysis revealed that both additive and non-additive gene action contributed in the genetic expression of the studied traits. The results also indicated that the tester lines, Giza175, Giza178, Giza181, Giza182, IR25571-31, GZ5121, GZ1368, GZ6296-12-1-4, GZ6296-12-1-2, IR56381-139 and BR1141-28-37 showed high fertilities with Indica CMS line (IR69625 A) and their maintainer line IR69625 B in the two years and their combined data and were identified as restorer lines. On the other hand, the tester lines IR65598-112, Palawan, 02428-p7-1, Pecos and Dular showed high fertility with both Indica and Japonica maintainer lines and confirmed as wide compatibility (WC) rice varieties. In addition, the tester lines Mars, 02428-p7-1, Pecos, Dular and Lambyque showed complete sterile with both of the Indica and Japonica CMS lines and defined as a maintainer lines to increas the probability of getting new CMS and maintainers lines with the WC gene.

INTRODUCTION

Rice (Oryza sativa L.) is the second largest crop grown in the world in terms of both area and production. It is a major source of calories for more than three billion peoples in south East Asia, Africa, and Latin American (Ahmed and Siddiq, 1998). Therefore, to meet the demond of continous increasing population, development of high yielding hybrid varieties for commercial exploitation of heterosis is a major rice breeding objective in several countries (El-Mowafi and Abou shousha 2003). However, exploitation of higher degree of heterosis manifested in Indica x Japonica inter-subspecific crosses is one of the current trends in hybrid rice breeding. However, low seed setting with poor filling of spikelet and obvious transgression of plant height and growth duration are the major barriers in the commercial exploitation of heterosis from such crosses (Kumar and Chakrabarti, 2000).

The success of the hybrid breeding program however, would depend upon accessible source material and identification of desirable parental lines and their combinations. these can be achieved by making large number of testcrosses and estimation of combining ability of parental lines. However, higher heterotic expressions could be due to greater diversity between Indica and Japonica germplasm that had largely remained distinct and there has been very little gene flow between them. Therefore, it could provide heterotic combinations if one of the parents had wide compatible gene (Ikehashi and Araki, 1984). Also the Japonica and Indica rice cultivars which used in this study were high yielding and widely adapted. Such high yielding and adapted parents might produce large proportion of heterotic hybrids for grain yield.

Thus, the choice of parents, especially for heterosis breeding should be based on the combining ability test and their mean performance (Yaddav and Murty, 1966). The present investigation was aimed to study the mean performance and combining ability of some Indica and Japonica rice genotypes with presence of wide compatibility (WC) and restoring ability traits.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during the three successivel growing seasons from 2003 to 2005. The genetic materials used in this investigation included two cytoplasmic male sterile (CMS) lines and their maintainers (B) lines. The CMS line Giza177A their maintainer and Giza177B were used as Japonica lines while, IR69625A and IR69625B, used as Indica lines. The aforementioned four female lines were crossed as parents with twenty seven male lines selected as testers to produce 108 F_1 hybrids seeds according to 4 x27 Line x Tester mating design during 2003 growing season. All the genotypes were evaluated in a randomized complete blocks design (RCBD) experiment with three replications during the second week of May of 2004 and 2005 seasons. The observations were recorded on ten plants which were taken at random from each test entry in each replication for three WC and restoring ability traits i.e. Pollen fertility (%), spikelet fertility (%) and filled grains panicle^{-1}. The analysis of variance were made for the single year and their combined data according to the analysis of line x tester mating design as outlined by Kempthorne, (1957).

RESULTS AND DISCUSSION

Analysis of variances:

The analysis of variance given in Table 1, revealed that highly significant differences among 139 genotypes (108 hybrids, 4 lines and 27 testers) tested for the studied traits i.e. pollen fertility %, spikelet fertility % and filled grains panicle^{-1}. Similarly, the results cleared that the parental lines and hybrid combinations showed highly significant differences for all the studied traits at the two years and their combined data. These finding indicating the presence of large variations

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among the genotypes. Parents vs. crosses mean square indicated that the average heterosis was significant in all the three studied traits. The mean squares of years as well as the interactions of genotypes, parents, crosses and parents vs. crosses with years were highly significant for all the studied traits. Therefore, it could be also concluded that the evaluation of potentiality of parents for the expression of heterosis should necessarily be conducted over a number of environmental conditions and that genetic diversity alone would not guarantee the expression of heterosis but the suitability of the environmental conditions is required. Similar results were obtained by, Ahmed (2004), Awad-Alla (2006) and El Mowafi (2006). The analysis of variances for combining ability of each year and combined data for all studied traits are presented also in Table 1. General combining ability of lines and tester were found to be highly significant for all the studied traits at the two years and their combined data. In the same time, the mean squares of lines x tester's interaction (SCA) were highly significant for all studied traits at the two years and their combined data these findings indicating to the importance of additive and non-additive gene action in the genetic expression of these traits. The interaction of years with both type of combining ability, general combining ability (GCA) of lines and testers and specific combining ability(SCA) line x tester were found to be highly significant for all studied traits indicating to these parameters are unstable with different environmental conditions. These results agree with the results obtained by Rangaswamy and Ganesan (1998), El Namaky (2003),El Mowafi and Abou Shousha (2003), El Mowafi *et al* (2005), Hammoud (2004), Awd-allah (2006). and El Mowafi (2006).

Mean performance:

Mean performances of the four female parental lines (two CMS and their two maintainers) and 27 tester lines as well as their hybrid combinations of line x tester for the three WC and restoring ability traits i.e. pollen fertility %, spikelet fertility %and filled grains panicle^{-1} are presented in Tables from 2 to 6. Concerning the mean performances for pollen and spikelets fertility %, the CMS lines showed complete sterile at the two years and their combined data, while their maintainer gave high fertility % of pollen and spikelet and ranged from 90.6 to 92.73 % and 93 to 93.53 %, respectively (Table 2). However, the mean performances of pollen and spikelet fertility of all testers were high and more than 87.03% and 86.13% for both of WC and *R f* traits, respectively at the two years and their combined data (Table 3). In the same time, the mean performances of filled grains panicle^{-1}, illustrated that Giza178, GZ5121 and IR65598-112 gave highest mean values over all the testers, while the maintainer line IR69625B gave highest mean value for lines.

Mean performances of the 108F$_1$ hybrids (Tables 4, 5 and 6) showed large differences for the pollen and spikelet fertility% in the two years and their combined data. However, the tester lines, Giza175, Giza178, Giza181, Giza182, IR25571, GZ5121, GZ1368, GZ6296-12-1-4, GZ6296-12-1-2, IR56381-139 and BR1141-28-37 showed high fertilities with both of theIndica CMS line IR69625A and their maintainer line IR69625B in the two years and their combined data. These results indicated that those testers have restoring ability for the Indica CMS lines. Also the results indicated that the genotypes which were identified could be used as restorer lines to produce Indica hybrids. The variety Giza178

Table 2: Mean performances of the lines and testers for the studied traits at the two years Y_1, Y_2 and their ombined data

	% pollen fertility			%spikelet fertility			Filled grains panicle^{-1}		
Testers	**Y1**	**Y2**	**Com**	**Y1**	**Y2**	**Com**	**Y1**	**Y2**	**Com**
Giza175	87.03	95.93	91.48	92.07	89.60	90.83	160.1	156.9	158.5
Giza178	93.13	94.27	93.70	94.67	94.53	94.60	174.6	170.6	172.6
Giza181	92.47	93.00	92.73	91.50	91.97	91.73	155.8	148.9	152.3
IR25571-31	92.17	92.30	92.23	91.47	91.20	91.33	157.8	163.2	160.5
GZ1368-5-5-4	93.53	95.00	94.27	90.30	89.37	89.83	161.5	158.2	159.8
GZ5121	93.80	92.30	93.05	93.67	91.60	92.63	165.3	161.9	163.6
GZ6296-12-1-4	92.27	94.47	93.37	91.77	92.40	92.08	157.2	154.6	155.9
GZ6296-12-1-2	90.30	92.10	91.20	92.03	91.17	91.60	158.2	159.2	158.7
IR65598-12	94.47	90.87	92.67	90.47	86.13	88.30	161.8	164.3	163.1
Drew	91.93	92.03	91.98	92.73	90.97	91.85	163.1	138.4	150.7
G52	89.77	95.23	92.50	91.40	88.73	90.07	165.9	156.6	161.3
Katy	93.57	94.30	93.93	89.50	91.20	90.35	153.0	162.9	158.0
Mars	89.23	90.57	89.90	89.93	93.33	91.63	158.0	155.0	156.5
Suweon392	92.63	91.17	91.90	91.97	90.67	91.32	152.9	145.0	149.0
Giza182	94.20	94.73	94.47	93.03	88.57	90.80	160.6	144.3	152.4
IR56381-139	93.57	90.87	92.22	91.47	90.47	90.97	157.6	156.5	157.1
Palawan	91.70	93.57	92.63	92.60	92.60	92.60	148.7	153.8	151.2
O2428-P7-1	91.07	90.13	90.60	90.20	90.70	90.45	159.5	149.7	154.6
Pecos	93.03	93.93	93.48	92.57	91.90	92.23	152.7	144.0	148.3
Indian 1	92.53	89.77	91.15	90.40	92.80	91.60	158.4	150.5	154.5
BR1141-28-37	91.10	93.67	92.38	90.13	94.37	92.25	161.5	161.6	161.5
Dular	94.67	91.80	93.23	92.40	91.77	92.08	155.6	154.7	155.2
Indian 2	91.87	90.57	91.22	90.57	93.30	91.93	154.1	149.8	151.9
IR72080B	93.57	93.70	93.63	92.63	90.13	91.38	150.9	158.6	154.8
Lambyque	90.07	93.30	91.68	92.33	91.83	92.08	148.4	147.8	148.1
KBNT	92.80	92.93	92.87	93.57	93.03	93.30	152.3	149.5	150.9
IET1444	92.77	94.77	93.77	92.30	92.37	92.33	160.0	162.3	161.2
Lines									
Giza177A	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
Giza177B	91.23	92.8	92.0	93.53	93.0	93.27	159.8	159.0	159.4
IR69625A	0.00	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
IR69625B	92.73	90.6	91.67	93.30	93.4	93.37	163.9	164.5	164.2
LSD 5%	**5.19**	٥,٢٩	٥,٤٣	٤,٥٨	٦,٤٨	٥,٦٩	**12.57**	**12.29**	١٤,١١
1%	**6.82**	٦,٩٥	٧,١٤	٦,٠٢	٨,٥٢	٧,٤٧	**16.52**	**16.15**	١٨,٥٥

was used as restorer line to produce first Egyptian commercial hybrid rice (Bastawisi *et al* 2002). These results were in general agreement with those reported by El Mwafi (2003) and Ahmed (2004). On the other hand, the tester lines IR65598-112, Palawan, 02428-P7-1, Pecos and Dular gave highest fertility% with the Indica and japonica maintainer lines. In the same time, these testers showed lowest fertility% with Indica and Japonica CMS lines with respect to the results of the two years and their combined data. These results indicated that these rice genotypes may have wide-compatibility genes and could be used to overcome the sterility between Indica/ Japonica hybrids Kumar and Virmani (1992) and El-Namaky (2003). Furthermore, the tester lines Mars, 02428-P7-1, Pecos, Dular and Lambyque showed complete sterile with indica and japonica CMS lines. These lines could be used as the maintainer lines and we can transfer the cytoplasmic male sterility (CMS) factor and WC gene to the best genotype between theme through recurrent backcrossing, also it could be used to produce the indica / japonica female parents to overcome sterility problem of Indica or Japonica restorer lines. However, the fertility with CMS lines detect for restoring ability while the fertility with two maintainer lines (Indica and Japonica) indicated to wide compatibility. Also, the fertility with CMS lines and maintainer lines from sub-species Indica and Japonica indicated that widely compatible restorer line (Tables 4 and 5). Concerning the filled grains panicle^{-1} (Table 6), the results showed that the testers gave lower filled grains panicle^{-1} and ranged from zero to 95.5 with the japonica CMS lines Giza177A at the two years and their combined data. Also the results indicted that its is difficult to find restorers to japonica cytoplasm male sterile. On the other hand, eleven testers gave high number of filled grains with indica CMS line (IR69625A). Furthermore, the highest testers were Giza178, IR25571-31 and GZ5121 gave mean values of 186.4, 164.7 and 176.3, respectively with IR69625A at combined data. Therefore, these testers can be used as a good restorers for the most of CMS lines. Also, the results showed that the testers Lambyque, Palawan, Pecos, O2428-P7-1 and Dular gave highest mean values with both of the maintainers' lines Giza177B and IR69625B. Thus, these genotypes may have wide compatibility gene and could be used to overcome sterility in indica / japonica hybrids. .

General Combining Ability Effects.

Significant differences of GCA effects were observed among the CMS and their maintainer lines for all the studied traits at the two years and their combined data (Table 7 and 8). The Indica CMS line IR69625A and their maintainer IR69625B were the best general combiner among the studied lines for fertility percentage as pollen and spikelet fertility, while the maintainer line IR69625B was the best general combiner for filled grains panicle^{-1} (Table 7). The results shown in Table 8 revealed that Giza181, Giza178, Giza175, GZ1368-5-5-4 and GZ5121 were the best general combiner for pollen and spikelet fertility percentage at the two years and their combined data. Regarding the filled grains panicle^{-1}, the results illustrated that 14 testers showed negative significant and highly significant estimates. On the other hand, 12 testers' revealed positive and highly significant estimates for the filled grains panicle^{-1}. The testers GZ1368-5-5-4, Giza178 and GZ5121gave highest positive values in both of the two years and the combined data (Table 8).

Specific Combining ability effects.

Concerning pollen fertility % the data in Table 9, revealed that the combinations Giza177A x Giza182, Giza177A x IR56381-139, IR69625A x Giza178, IR69625A x Giza181 and IR69625A x Giza175 were the best combinations between testers with Japonica and Indica CMS lines which were exhibited highly significant and positive estimates. While, the cross combinations Giza177B x Dular, Giza177B x Pecos, IR69625B x IR72080B and IR69625B x Mars were the best between the testers and Japonica and Indica maintainer lines which were exhibited highly significant and positive estimate at the two years and their combined data.

Regarding spikelet fertility% the data in Table 10, revealed that the crosses Giza177A x G52, Giza177A x IET1444, Giza177A x Suweon392, IR69625A x GZ6296-12-1-2, IR6962A x GZ6296-12-1-4 and IR69625A x Giza178 were the best combinations using Japonica and Indica CMS lines, which were exhibited highly significant and positive estimates. In the same time, the crosses Giza177B x Dular, Giza177B x Pecos, Giza177B x Lambyque, IR69625B x Mars, IR69625B x IR72080B, IR69625B x Pecos, IR69625B x O2428P7-1 and IR69625B x Dular were the best combinations when their testers crossed with Japonica and Indica maintainer lines which were exhibited highly significant and positive estimates at the two years and their combined data.

With respect to the filled grains panicle^{-1} , the data in Table 11, reveled that the crosses Giza177A x KBNT, Giza177A x G52, IR69625A x GZ5121 and IR69625A x IR6296-12-1-2 were the best combinations between testers with japonica and indica CMS lines which were exhibited highly significant and positive estimate at the two years and their combined data. However, the crosses Giza177B x O2428-P7-1, Giza177B x Lambyque, IR69625B x Mars and IR69625B x Drew were the best combinations between testers with japonica and indica maintainer lines which were exhibited highly significant and positive estimates at the two years and their combined data.

Genetic parameter:

The estimates of genetic parameters i.e., additive genetic variance (σ^2A), non-additive genetic variance including dominance (σ^2D), environmental variance (σ^2E), genotypic variance (σ^2G), phenotypic variance (σ^2P), broad sense heritability (h^2_b%), narrow sense heritability (h^2_n%), dominance degree(D.d), importance of GCA% and SCA% for all studied traits were determined for each year and their combined data are presented in Table12. The results indicated that the estimates of the additive genetic variance (σ^2A) and the relative importance of GCA% for all studied characters were higher than those of non-additive genetic variance (σ^2D) and relative importance of SCA% at the two years and their combined data. These findings indicated that the aforementioned characters were largely governed by additive gene action. Furthermore, the results also showed that both of the variances due to additive (σ^2A x Y) and non-additive (σ^2D x Y) by years interaction were positive in all studied traits. These finding indicated that these parameter are unstable with different environmental conditions. Many authors obtained similar results among them Hammoud (1996); Rangaswamy and Ganesan (1998); El-Mowafi and Abou Shousha (2003) and El-Mowafi *et al.* (2005). On the other hand, the importance of the non-additive or dominance gene action for the inheritance of the former characters were reported by Rogbell and Subbaramanian (1997); Rangswamy and Ganesan (1998), Babu and Reddy (2002**)**.

Regarding the estimates of heritability in broad (h^2_b) and narrow (h^2_n) sense, the results indicated that the values of h^2_b and h^2_n were high for all the studied characters at the two years and their combined data. These results indicated that a major part of the total genotypic variances was additive variance for the traits %pollen fertility, and spikelet fertility, as well as filled grain panicle^{-1} . These results were in agreement with those reported by El-Mowafi (1994); El-Mowafi and Abou-Shousha(2003), El-Namaky (2003), Ahmed (2004) and Awd-allah (2006).

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تقييم بعض أصناف الأرز لصفتي التوافق العام وإعادة الخصوبه

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أجرى هذا البحث بالمزرعة البحثية بمركز البحوث والتدريب فى الأرز بسخا- كفرالشيخ- مصر خلال ثلاثة أعوام من ٢٠٠٣ إلى ٢٠٠٥ وكان الهدف من هذا البحث هو تقييم بعض التراكيب الوراثية لصفتي التوافق العام و إعادة الخصوبة.

استخدم فى هذا البحث اثنان من سلالات العقم الذكرى السيتوبلازمى والسلالات المحافظة عليها وهى سلاله العقم الذكري السيتوبلازمي الوراثي اليابانية Giza 177A وسلالتها المحافظة علي خصوبتها ، Giza 177B، وسلالة العقم الذكري السيتوبلازمي الوراثي الهندية IR69625A، وسلالتها المحافظة علي خصوبتها IR69625B تم تهجينهم بنظام السلالة × الكشاف مع ٢٧ تركيب وراثى من مجاميع مختلفة وتم زراعة الهجن والأباء فى ثلاث مكررات عشوائية فى موسمين متتاليين (٢٠٠٤، ٢٠٠٥)- وتمت دراسة الصفات الآتية : النسبة المئوية لخصوبة حبوب اللقاح، النسبة المئوية لخصوبة السنيبلات، عدد الحبوب الممتلئة في السنبلة وكانت أهم النتائج كالآتى :

- أظهر تحليل التباين وجود اختلافات معنوية عالية لكل من التراكيب الوراثية، الهجن والأباء، متوسط الهجن فى العامين.
- كان تفاعل التراكيب الوراثية، الأباء، الهجن مع السنين عالى المعنوية لجميع الصفات.
- أعطت الكشافات جيزة١٧٥، جيزة١٧٨، جيزة ١٨١، جيزة ١٨٢، IR25571-31، IR56381-139، GZ1368-5-5-4، GZ6296-12-1-4، GZ6296-12-1-2، BR1141-28-37 خصوبة عالية مع السلالات الهندية العقيمة والسلالات المحافظة عليها (IR69625A، IR69625B) فى العامين الأول والثانى والتحليل المشترك بينهم هذه الأصناف عرفت على أنها أصناف معيدة للخصوبة.
- أعطت الكشافات IR65598-112، Palawan، O2428-P7-1، Pecos، Dular خصوبة عالية مع السلالات الهندية واليابانية المحافظة على الخصوبة هذه الأصناف عرفت بأنها أصناف توافق عام.
- أعطت الكشافات Mars، O2428-P7-1، Dular، Lambyque عقم تام مع السلالات العقيمة هذه الأصناف عرفت بأنها أصناف محافظة على الخصوبة.
- أظهرت نتائج تحليل تباين القدرة العامة والخاصة على التآلف وجود اختلافات معنوية من خلال السلالة والكشاف لجميع صفات الدراسة فى العامين الأول والثانى والتحليل المشترك بينهم.
- كانت التراكيب جيزة ١٧٨، جيزة ١٨١، GZ1368-5-5-4، GZ5121، جيزة ١٨٢ وIR56381-139 أفضل الكشافات من حيث القدرة العامة على التآلف لصفة إعادة الخصوبة. بينما كان Pecos، Dular، O2428-P7-1، IR65598-112، Palawan، Lambyque أفضل الكشافات من حيث القدرة العامة على التآلف لصفة التوافق العام.
- أوضحت النتائج أهمية الفعل الجينى المضيف لجميع صفات الدراسة ماعدا صفة عدد السنيبلات بالسنبلة كان الفعل الجينى الغير مضيف أو السائد له دور مهم فى توريث هذه الصفة.

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Table 1: Mean square estimates from line x tester analysis of variance for the studied traits in each years and the combined data over both years

S .O.V	Df		% pollen fertility			%spikelet fertility			Filled grains-1		
	sing	com	Y1	Y2	Com	Y1	Y2	Com	Y1	Y2	
Years (Y)		1	-	-	١١١,٠**	-	-	278.9**	-	-	١٠٤٤٧,٤**
Reps / Y		4	-	-	٧,٩0**	-	-	١٧,٦**	-	-	٣٥٦,٤**
Genotypes(G)	١٣٨	138	١٦٩٠,٧**	١٧٦٨,٦**	٣٤٤٤,٥**	١٨٨٧,٦**	١٨٥٢,٥**	٣٧٢٦,٢**	١١٦٩٣,٩**	١٠٨٨٤,٤**	٢٢٤٣٠,٩**
Parent (p)		30	١٠١٨,٨**	١٠٣٣,٣**	٢٠٤٠,٦**	١٠٠٥,٨**	٩٩٦,٥**	١٩٩٥,٧**	٤٧٦٦,٨**	٤٦٦٠,٤**	٩٣٥٨,٢**
P.Vs.C		1	50227.5**	٤٨٩١٢,٩**	٩٩١٣٦,١**	٤٥٤٩١,٨**	٤٩٠٠٩,٤**	٩٤٤٦٨,٥**	٢١٠٦٣٣,٥**	٢٥٥٧٨٠,١**	٤٦٥٣١٨,٦**
Crosses (C)		107	١٤٢٥,٤**	١٥٣٤,٢**	٢٩٤٣,٨**	١٧٢٧,٣**	١٦٥١,٨**	٣٣٦٣,٣**	١١٧٧٦,٩**	١٠٣٤٠,٨**	٢١٩٥٧,١**
Lines (GCA)		٣	٢٦٦٥١,٦**	٢٨٦٩٠**	55265.4**	٣٤٢٢٢,٩**	٣١٦٩٢,٦**	٦٥٨٨٥,٣**	٢٤٨١٩٧,٣**	٢٠٦٦٥٨,٩**	٤٥٣٤٩٠,٤**
Testers(GCA)		٢٦	١٠٨٠,٧**	1094.6**	2166.0**	٨٤٢,٣**	٨٤٨,٩**	١٦٧٦,٩**	٥٠٩٠,٠**	٥١٩٢,٧**	١٠١٦٨,١**
L x T (SCA)		٧٨	٥٧٠,١**	٦٣٦,٢**	1190.7**	٧٧٢,٥**	٧٦٣,٩**	١٥٢٠,٨**	٤٩١٢,٨**	٤٥٠٦,١**	٩٢٨٩,٣**
G x Y		138	-	-	14.8**	-	-	١٣,٩**	-	-	١٤٧,٤**
P x Y		٣٠	-	-	11.5**	-	-	٦,٦٦**	-	-	٦٩,٠**
P.Vs.C xY		1	-	-	4.3**	-		32.75	-	-	1095.1**
C x Y		107	-	-	15.8**	-	-	15.14**	--	-	160.5**
L x Y		٢٦	-	-	9.3**	-	-	١٤,٣٤**	-	-	١١٤,٥**
T x Y		٣	-	-	76.2**	-	-	٣٠,٢٣**	-	-	١٣٦٥,٨**
L x T xY		٧٨	-	-	15.6**	-	-	١٥,٦٦**	-	-	١٢٩,٥**
Error	٢٧٦	٥٥٢	١٠,٥١	١٠,٩٢	11.53	٨,١٨	١٦,٤١	١٢,٦٢	٦١,٧	٥٩,٠	٧٧,٧٧
C.V%			٦,٦٤	٦,٦٧	6.91	٥,٧٩	٨,٣٩	٧,٢٧	٧,٤	٧,٧٦	٨,٦

** Significant at 1% probability levels

Table 3: Mean performances of % pollen fertility-1 for 108 F1 hybrids at the two years Y1 , Y 2 and their combined data

Testers	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625B		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	29.17	25.6	27.40	77.87	90.0	83.95	53.93	49.8	51.8	87.6	91.6	89.6
Giza178	31.90	28.7	30.32	81.47	89.8	85.63	47.70	47.9	47.8	87.3	90.8	89.0
Giza181	31.40	29.1	30.25	88.10	84.3	86.22	54.33	51.1	52.7	85.2	91.1	88.2
IR25571-31	23.00	25.3	24.15	80.23	81.7	80.95	55.20	54.0	54.6	82.4	90.5	86.4
GZ1368-5-5-4	31.13	25.8	28.45	69.97	83.9	76.92	69.80	64.9	67.3	78.9	89.5	84.2
GZ5121	32.50	26.7	29.60	78.60	84.6	81.62	56.13	59.8	57.97	82.0	86.9	84.5
GZ6296-12-1-4	36.87	28.8	32.83	80.37	80.8	80.57	45.67	43.3	44.48	78.3	84.5	81.4
GZ6296-12-1-2	27.40	29.5	28.47	74.23	82.8	78.52	52.13	48.7	50.40	78.7	81.2	79.9
IR65598-12	30.20	21.6	25.90	37.20	34.1	35.67	74.67	77.1	75.90	76.3	79.0	77.6
Drew	7.40	11.3	9.33	23.63	20.6	22.13	42.90	39.6	41.23	82.4	87.4	84.9
G52	9.03	10.9	9.97	13.90	18.4	16.17	41.50	41.7	41.60	84.2	88.9	86.6
Katy	3.70	10.7	7.20	12.57	12.3	12.45	39.50	36.7	38.10	78.7	82.9	80.8
Mars	0.03	0.2	0.02	0.04	0.0	0.02	47.20	51.1	49.15	75.6	86.4	80.9
Suweon392	6.43	9.0	7.70	10.27	12.1	11.17	54.47	50.8	52.65	73.6	80.7	77.2
Giza182	53.43	50.2	51.83	81.23	78.2	79.72	52.47	49.3	50.88	84.5	87.3	85.9
IR56381-139	44.73	35.4	40.07	72.33	76.6	74.48	61.53	58.2	59.85	82.5	82.3	82.4
Palawan	10.23	11.0	10.60	13.73	15.5	14.63	80.30	78.3	79.28	72.9	76.7	74.8
O2428-P7-1	0.05	0.01	0.03	0.01	0.0	0.01	79.27	81.2	80.23	73.1	74.1	73.6
Pecos	0.04	0.01	0.03	0.03	0.0	0.02	86.10	84.8	85.47	85.8	81.5	83.6
Indian 1	13.67	17.2	15.43	38.83	42.6	40.70	43.93	42.1	43.03	85.9	88.3	87.1
BR1141-28-37	35.73	34.5	35.13	71.77	80.5	76.13	51.97	49.9	50.92	78.8	85.2	82.0
Dular	0.06	0.0	0.03	0.04	0.01	0.03	80.53	86.8	83.68	73.6	79.8	76.7
Indian 2	18.97	25.5	22.23	47.57	49.2	48.38	43.03	41.7	42.38	81.5	78.7	80.1
IR72080B	0.05	0.0	0.03	0.05	0.0	0.03	56.77	55.3	56.05	85.6	87.4	86.5
Lambyque	0.04	0.0	0.02	0.03	0.01	0.02	74.20	79.7	76.97	74.6	74.4	74.5
KBNT	10.43	12.7	11.55	11.50	14.2	12.83	62.07	58.2	60.12	83.8	83.9	83.9
IET1444	11.53	12.6	12.08	14.33	14.5	14.43	47.10	50.5	48.82	80.0	83.6	82.1
LSD 5%	5.19	5.29	5.43	5.19	5.29	5.43	5.19	5.29	5.43	5.19	5.29	5.43
1%	6.82	6.95	7.14	6.82	6.95	7.14	6.82	6.95	7.14	6.82	6.95	7.14

Table 4: Mean performances of % spikelet fertility for 108 F1 hybrids at the two Years Y1, Y 2 and their combined data.

testers	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625B		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	21.50	21.27	21.38	82.70	79.43	81.07	39.83	46.30	43.07	85.80	83.83	84.82
Giza178	20.43	23.80	22.12	90.90	88.43	89.67	48.00	43.70	45.85	92.20	88.97	90.58
Giza181	16.73	14.57	15.65	88.03	89.39	88.71	44.23	45.20	44.72	87.17	87.70	87.43
IR25571-31	23.67	24.63	24.15	88.73	70.37	79.55	43.00	41.50	42.25	90.80	90.20	90.50
GZ1368-5-5-4	35.30	41.63	38.47	72.87	65.43	69.15	67.00	66.37	66.68	89.30	89.20	89.25
GZ5121	29.77	35.30	32.53	91.57	91.60	91.58	41.00	39.43	40.22	88.30	90.30	89.30
GZ6296-12-1-4	21.23	21.23	21.23	87.37	88.30	87.83	37.07	31.33	34.20	88.13	87.20	87.67
GZ6296-12-1-2	17.40	15.80	16.60	87.77	89.70	88.73	36.57	26.77	31.67	89.60	85.60	87.60
IR65598-12	18.43	19.00	18.72	21.57	20.00	20.78	87.17	82.62	84.89	85.07	85.00	85.03
Drew	16.33	10.03	13.18	24.47	24.13	24.30	33.53	29.63	31.58	88.00	86.40	87.20
G52	24.90	24.40	24.65	21.77	28.10	24.93	39.23	34.37	36.80	89.73	88.60	89.17
Katy	13.83	13.07	13.45	24.97	26.47	25.72	37.43	33.63	35.53	89.37	89.97	89.67
Mars	0.04	0.03	0.03	0.03	0.03	0.03	33.77	22.30	28.03	86.73	84.40	85.57
Suweon392	19.67	21.73	20.70	19.20	19.40	19.30	44.73	28.90	36.82	90.17	88.73	89.45
Giza182	19.57	19.20	19.38	87.13	80.03	83.58	40.53	41.93	41.23	86.30	81.73	84.02
IR56381-139	19.23	15.33	17.28	84.07	81.57	82.82	34.77	23.63	29.20	89.97	83.83	86.90
Palawan	15.60	18.57	17.08	21.37	23.57	22.47	88.00	84.73	86.37	87.83	87.20	87.52
O2428-P7-1	0.03	0.04	0.04	0.02	0.03	0.03	85.53	86.77	86.15	86.57	84.07	85.32
Pecos	0.02	0.07	0.04	0.02	0.05	0.03	91.03	91.13	91.08	89.10	85.33	87.22
Indian 1	16.00	9.80	12.90	26.47	26.40	26.43	34.90	29.67	32.28	87.07	88.07	87.57
BR1141-28-37	17.03	14.33	15.68	76.67	77.03	76.85	37.90	49.07	43.48	91.23	88.23	89.73
Dular	0.03	0.06	0.05	0.02	0.05	0.03	88.87	85.40	87.13	88.30	85.57	86.93
Indian 2	17.97	16.40	17.18	30.83	32.23	31.53	38.63	32.67	35.65	89.97	87.37	88.67
IR72080B	0.02	0.02	0.02	0.03	0.03	0.03	36.07	29.57	32.82	88.07	84.90	86.48
Lambyque	0.04	0.04	0.04	0.04	0.05	0.05	85.80	81.97	83.88	83.50	78.83	81.17
KBNT	18.23	16.30	17.27	13.40	10.27	11.83	43.27	35.73	39.50	88.23	87.87	88.05
IET1444	23.67	18.73	21.20	21.47	22.97	22.22	41.33	35.63	38.48	89.90	81.33	85.62
LSD 5%	4.58	6.48	5.69	4.58	6.48	5.69	4.58	6.48	5.69	4.58	6.48	5.69
1%	6.02	8.52	7.47	6.02	8.52	7.47	6.02	8.52	7.47	6.02	8.52	7.47

Table 5: Mean performances of number of filled grains panicle-1 for 108 F1 hybrids at the two years Y1 , Y 2 and their combined data

testers	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625B		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	73.0	36.5	54.8	158.5	134.7	146.6	80.7	88.8	84.8	163.9	165.9	164.9
Giza178	37.7	40.7	39.2	181.0	191.8	186.4	107.8	103.3	105.6	177.1	163.9	170.5
Giza181	30.2	41.4	35.8	159.3	138.4	148.8	103.8	88.0	95.9	166.0	152.1	159.1
IR25571-31	46.9	39.8	43.4	165.8	163.6	164.7	85.3	77.1	81.2	171.8	161.9	166.9
GZ1368-5-5-4	77.3	95.5	86.4	141.8	127.7	134.8	137.4	127.4	132.4	170.5	156.1	163.3
GZ5121	51.9	62.3	57.1	179.8	172.7	176.3	84.3	77.0	80.7	170.5	152.7	161.6
GZ6296-12-1-4	38.1	34.7	36.4	155.8	143.1	149.5	75.4	57.2	66.3	161.2	141.3	151.3
GZ6296-12-1-2	31.1	29.2	30.1	163.6	151.9	157.7	73.3	48.6	61.0	160.8	144.6	152.7
IR65598-12	37.0	34.9	36.0	41.1	38.7	39.9	160.4	145.1	152.8	160.9	146.9	153.9
Drew	31.7	21.6	26.7	46.0	44.4	45.2	68.1	65.3	66.7	172.2	186.8	179.5
G52	47.6	47.3	47.4	42.2	50.2	46.2	74.5	65.6	70.0	176.9	184.0	180.4
Katy	28.6	21.5	25.1	46.8	44.6	45.7	76.1	62.8	69.5	168.9	155.5	162.2
Mars	0.03	0.02	0.02	0.01	0.04	0.03	64.3	37.4	50.9	165.6	150.3	157.9
Suweon392	39.7	43.2	41.5	36.1	32.3	34.2	70.8	50.7	60.8	164.7	152.5	158.6
Giza182	35.0	30.1	32.5	164.3	145.5	154.9	79.5	64.6	72.1	169.1	138.0	153.5
IR56381-139	36.1	27.3	31.7	161.5	145.0	153.3	67.6	44.6	56.1	172.0	170.1	171.1
Palawan	28.7	34.9	31.8	40.6	43.3	42.0	156.6	141.4	149.0	159.7	134.4	147.1
O2428-P7-1	0.01	0.01	0.01	0.01	0.02	0.01	158.4	138.3	148.4	161.9	134.0	148.0
Pecos	0.01	0.01	0.01	0.01	0.05	0.03	154.5	137.0	145.8	156.2	143.6	149.9
Indian 1	29.8	16.2	23.0	47.0	41.2	44.1	67.2	57.4	62.3	160.0	146.9	153.5
BR1141-28-37	32.2	33.2	32.7	142.2	131.9	137.1	74.3	70.5	72.4	169.1	150.7	159.9
Dular	0.0	0.04	0.02	0.03	0.0	0.02	158.1	137.5	147.8	161.5	144.6	153.1
Indian 2	30.9	41.7	36.3	58.8	57.5	58.2	76.9	64.1	70.5	163.1	155.8	159.4
IR72080B	0.01	0.06	0.04	0.07	0.03	0.05	77.9	59.0	68.5	155.7	142.2	148.9
Lambyque	0.04	0.02	0.03	0.11	0.12	0.12	155.8	155.6	155.7	154.2	132.4	143.3
KBNT	34.8	35.6	35.2	24.8	18.6	21.7	83.8	66.5	75.2	163.5	152.8	158.2
IET1444	45.0	30.5	37.8	38.2	37.1	37.7	83.8	68.0	75.9	164.3	147.5	155.9
LSD 5%	12.57	12.3	14.11	12.57	12.3	14.11	12.57	12.3	14.11	12.57	12.3	14.11
1%	16.52	16.2	18.55	16.52	16.2	18.55	16.52	16.2	18.55	16.52	16.2	18.55

Table 6: Estimation of GCA effects (gi) both lines and tester at each year and their combined data for the studied traits

Testers		% pollen fertility			%spikelet fertility			Filled grains panicle^{-1}		
		Y1	Y2	Com	Y1	Y2	Com	Y1	Y2	Com
Giza175		9.94**	11.26**	10.60**	7.03**	7.38**	7.21**	24.98**	7.38**	22.87**
Giza178		10.01**	11.28**	10.64**	10.32**	7.80**	9.06**	31.87**	7.80**	35.53**
Giza181		11.85**	10.76**	11.31**	7.30**	8.74**	8.02**	20.77**	8.74**	20.00**
IR25571-31		8.49**	9.85**	9.17**	9.35**	7.75**	8.55**	23.40**	7.75**	24.13**
GZ1368-5-5-4		10.01**	11.73**	10.87**	11.47**	12.43**	11.95**	37.71**	12.43**	39.32**
GZ5121		9.77**	10.37**	10.07**	10.17**	12.65**	11.41**	27.61**	12.65**	29.02**
GZ6296-12-1-4		8.58**	7.46**	8.02**	7.15**	7.74**	7.44**	13.57**	7.74**	10.97**
GZ6296-12-1-2		7.33**	8.05**	7.69**	6.84**	5.96**	6.40**	13.13**	5.96**	10.48**
IR65598-12		4.97**	3.21**	4.09**	3.53**	3.97**	3.75**	5.80	3.97	5.74**
Drew		-5.15**	-5.05**	-5.10**	-4.27**	-5.28**	-4.78**	-14.56**	-5.28*	-10.38**
G52		-6.42**	-8.31**	-7.36**	-1.89**	-0.54	-1.22	-8.76**	-0.54	-3.87*
Katy		-8.38**	-8.07**	-8.22**	-3.69**	-2.63*	-3.16**	-13.96**	-2.63	-14.29**
Mars		-16.67**	-14.91**	-15.79**	-17.48**	-18.19**	-17.83**	-36.53**	-18.19**	-37.65**
Suweon392		-8.04**	-6.95**	-7.50**	-2.41**	-3.38**	-2.89**	-16.24**	-3.38	-16.14**
Giza182		13.32**	11.59**	12.45**	6.93**	6.67**	6.80**	17.90**	6.67**	13.35**
IR56381-139		11.43**	9.37**	10.40**	7.25**	3.36**	5.30**	15.27**	3.36	13.14**
Palawan		-2.25*	-2.26*	-2.25**	3.69**	5.28**	4.48**	2.34**	5.28*	2.56
O2428-P7-1		-10.80**	-12.50*	-11.65**	-11.71**	-8.36**	-10.03**	-13.91**	-8.36**	-15.77**
Pecos		-8.92**	-10.49**	-9.70**	-7.72**	-7.16**	-7.44**	-16.31**	-7.16**	-15.92**
Indian 1		-0.32	0.21	-0.06	-3.88**	-4.50**	-4.19**	-18.03**	-4.50*	-19.17**
BR1141-28-37		7.90**	9.30**	8.60**	5.26**	6.95**	6.11**	10.38**	6.95**	10.61**
Dular		-11.86**	-10.46**	-11.16**	-8.42**	-8.22**	-8.32**	-14.13**	-8.22**	-14.65**
Indian 2		0.76	0.68	0.72	-1.68*	-2.02	-1.85*	-11.64**	-2.02	-8.81**
IR72080B		-13.42**	-14.12**	-13.77**	-16.88**	-17.10**	-16.99**	-35.61**	-17.10**	-35.51**
Lambyque		-12.77**	-12.96**	-12.87**	-10.07**	-10.19**	-10.13**	-16.51**	-10.19**	-15.11**
KBNT		-3.76**	-3.98**	-3.87**	-4.42**	-5.44**	-4.93**	-17.33**	-5.44*	-17.33**
IET1444		-5.60**	-5.07**	-5.33**	-1.80*	-3.65**	-2.72**	-11.23**	-3.65	-13.09**
LSD	5%	١,٨٦	١,٩٠	١,٣٨	١,٦٤	٢,٣٣	١,٤٤	٤,٥١	٤,٤١	٣,٥٨
	1%	٢,٤٧	٢,٥٢	١,٨٣	٢,١٨	٣,٠٨	١,٩١	٥,٩٨	٥,٨٥	٤,٧٥
lines										
Giza177A		-20.75**	-21.88**	-21.32**	-23.03**	-22.12**	-22.58**	-62.80**	-56.16**	-59.48**
Giza177B		-7.35**	-6.27**	-6.81**	-5.54**	-4.98**	-5.26**	-12.73**	-9.63**	-11.18**
IR69625A		6.71**	5.48**	6.09**	2.07**	1.46**	1.76**	4.35**	-0.59	1.88**
IR69625B		21.39**	22.68**	22.04**	26.50**	25.64**	26.07**	71.18**	66.39**	68.79**
LSD	5%	0.72	٠,٧٣	٠,٥٣	٠,٦٣	٠,٩٠	٠,٥٦	١,٧٤	١,٧٠	١,٣٨
	1%	0.95	٠,٩٧	٠,٧٠	٠,٨٤	١,١٩	٠,٧٤	٢,٣٠	٢,٢٥	١,٨٣

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

Table 7: Estimation of SCA effects for 108 F1 hybrids at each year and their combined data for %pollen fertility .

Male parents	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625A		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	0.55	-2.74	-1.10	16.47**	23.12**	19.80**	-12.31**	23.12**	-13.96**	-4.71*	-4.78	-4.74**
Giza178	2.09	-0.75	0.67	18.62**	22.76**	20.69**	-15.94**	22.76**	-16.30**	-4.77	-5.34	-5.06**
Giza181	-0.06	-0.08	-0.07	22.51**	18.65**	20.58**	-13.98**	18.65**	-14.15**	-8.46**	-4.26	-6.36**
IR25571-31	-2.06	-1.59	-1.83	19.68**	17.57**	18.63**	-10.05**	17.57**	-10.90**	-7.57**	-4.23	-5.90**
GZ1368-5-5-4	1.63	-3.15	-0.76	11.27**	17.38**	14.33**	-2.94	17.38**	-5.10**	-9.97**	-6.96*	-8.46**
GZ5121	2.75	-2.45	0.15	17.13**	19.30**	18.22**	-10.86**	19.30**	-9.89**	-9.02**	-7.94**	-8.48**
GZ6296-12-1-4	6.56**	3.13	4.84**	19.71**	19.25**	19.48**	-15.64**	19.25**	-15.58**	-10.62**	-6.86*	-8.74**
GZ6296-12-1-2	3.06	2.90	2.98	16.63**	20.21**	18.42**	-10.65**	20.21**	-11.84**	-9.04**	-10.09**	-9.56**
IR65598-112-98	6.16**	2.47	4.32**	-2.98	-4.94	-3.96**	5.23**	-4.94	7.26**	-8.41**	-6.83*	-7.62**
Drew	-1.10	2.80	0.85	-1.40	-5.46*	-3.43*	-3.59	-5.46*	-4.36**	6.08**	7.79**	6.94**
G52	1.57	5.69*	3.63*	-7.32**	-3.79	-5.56**	-3.11	-3.79	-1.90	8.85**	-1.21	3.82**
Katy	2.20	5.26	3.73**	-6.51**	-8.67**	-7.59**	-2.34	-8.67**	-3.11*	6.66**	7.28**	6.97**
Mars	-4.93*	-6.36*	-5.65**	-18.33**	-21.97**	-20.15**	10.42**	-21.97**	10.88**	12.83**	17.00**	14.92**
Suweon392	0.28	2.48	1.38	-8.96**	-10.26**	-9.61**	5.82**	-10.26**	4.53**	2.86	4.54	3.70**
Giza182	11.50**	11.71**	11.60**	15.53**	13.23**	14.38**	-16.54**	13.23**	-16.36**	-10.49**	-8.74**	-9.62**
IR56381-139	8.36**	5.01	6.69**	11.31**	14.44**	12.88**	-9.37**	14.44**	-9.11**	-10.29**	-10.61**	-10.45**
Palawan	-1.30	-0.33	-0.81	-11.63**	-12.06**	-11.84**	16.29**	-12.06**	15.80**	-3.36	-2.92	-3.14*
O2428-P7-1	-10.80**	-8.78**	-9.79**	-24.20**	-24.39**	-24.29**	24.15**	-24.39**	25.89**	10.85**	5.53*	8.19**
Pecos	-12.69**	-10.78**	-11.73**	-26.08**	-26.39**	-26.24**	27.59**	-26.39**	28.05**	11.18**	8.66**	9.92**
Indian 1	0.30	2.44	1.37	3.36	3.01	3.19*	-7.91**	3.01	-8.43**	4.25*	3.50	3.88**
BR1141-28-37	6.38**	4.74	5.56**	14.54**	17.15**	15.85**	-11.40**	17.15**	-12.49**	-9.52**	-8.31**	-8.92**
Dular	-9.74**	7.75**	-10.28**	-23.14**	-26.43**	-24.78**	26.10**	-26.43**	28.07**	6.79**	7.21**	7.00**
Indian 2	2.80	-10.82**	5.27**	7.27**	6.41*	6.84**	-9.75**	6.41*	-9.70**	-0.32	-4.52	-2.42
IR72080B	-8.18**	-7.16**	-7.67**	-21.58**	-22.77**	-22.17**	12.69**	-22.77**	12.83**	17.07**	16.95**	17.01**
Lambyque	-8.83**	-8.31**	-8.57**	-22.23**	-23.92**	-23.07**	22.68**	-23.92**	24.32**	8.38**	6.27*	7.32**
KBNT	0.33	2.95	1.64	-12.09**	-11.42**	-11.75**	6.12**	-11.42**	5.30**	5.64**	3.98	4.81**
IET1444	3.18	3.96	3.57*	-7.60**	-10.03**	-8.81**	-0.70	-10.03**	0.23	5.12**	4.89	5.01**
LSD 5%	3.72	5.37	2.76	3.72	5.37	2.76	3.72	5.37	2.76	3.72	5.37	2.76
1%	4.94	7.12	3.66	4.94	7.12	3.66	4.94	7.12	3.66	4.94	7.12	3.66

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

Table 8: Estimation SCA effects for 108 F1 hybrids at each year and their combined data for % spikelet fertility

Male parents	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625B		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	-0.24	-0.32	-0.28	23.52**	18.20**	20.86**	-13.80**	-8.43**	-11.12**	-9.48**	-9.45**	-9.46**
Giza178	-4.64*	1.00	-1.82	23.84**	24.91**	24.38**	-12.36**	-10.38**	-11.37**	-6.83**	-15.52**	-11.18**
Giza181	-3.97*	-6.81**	-5.39**	24.19**	24.55**	24.37**	-11.63**	-10.42**	-11.02**	-8.60**	-7.32**	-7.96**
IR25571-31	-1.16	1.61	0.22	22.77**	14.01**	18.39**	-14.31**	-11.60**	-12.96**	-7.30**	-4.01	-5.65**
GZ1368-5-5-4	4.04*	7.17	5.60**	8.84**	4.25	6.55**	-2.11	-1.74	-1.93	-10.77**	-9.68**	-10.23**
GZ5121	2.07	3.45	2.76	24.68**	23.06**	23.87**	-16.26**	-17.68**	-16.97**	-10.50**	-8.83**	-9.66**
GZ6296-12-1-4	-0.61	-0.92	-0.77	23.75**	25.39**	24.57**	-15.57**	-17.70**	-16.63**	-7.57**	-6.77**	-7.17**
GZ6296-12-1-2	-2.88	-2.88	-2.88*	24.44**	27.88**	26.16**	-15.58**	-18.75**	-17.17**	-5.97**	-6.24**	-6.11**
IR65598-112-98	1.09	1.50	1.30	-14.17**	-15.00**	-14.59**	19.67**	18.13**	18.90**	-6.59**	-4.63	-5.61**
Drew	7.19**	3.05	5.12**	-4.63**	-2.92	-3.77*	-6.26**	-5.67*	-5.96**	3.69*	5.54*	4.62**
G52	10.91**	9.79**	10.35**	-8.64	-4.97*	-6.81**	-5.24**	-7.52**	-6.38**	2.98	2.71	2.84*
Katy	4.79**	3.44	4.12**	-4.63**	-3.92	-4.28**	-4.49**	-5.85*	-5.17**	4.34*	6.33**	5.33**
Mars	-2.76	-1.58	-2.17	-20.25**	-18.73**	-19.49**	7.10**	2.43	4.76**	15.90**	17.88**	16.89**
Suweon392	7.83**	10.55**	9.19**	-9.94**	-8.02**	-8.98**	-1.75	-8.07**	-4.91**	3.85*	5.54*	4.69**
Giza182	-1.53	0.85	-0.34	23.79**	19.46**	21.62**	-13.29**	-10.25**	-11.77**	-8.97**	-10.05**	-9.51**
IR56381-139	-2.10	-0.73	-1.41	20.94**	23.83**	22.38**	-17.02**	-18.23**	-17.62**	-1.82	-4.88*	-3.35*
Palawan	-1.33	-0.14	-0.73	-14.51**	-13.83**	-14.17**	20.26**	18.40**	19.33**	-4.42**	-4.43	-4.43**
O2428-P7-1	-8.53**	-11.41**	-9.97**	-26.02**	-28.56**	-27.29**	24.64**	33.15**	28.89**	9.91**	6.82**	8.36**
Pecos	-12.51**	-12.61**	-12.56**	-30.00	-29.75**	-29.88**	34.40**	36.02**	35.21**	8.12**	6.34**	7.23**
Indian 1	6.65**	2.34	4.50**	-3.47*	-2.19	-2.83	-5.81**	-6.42**	-6.12**	2.63	6.27**	4.45**
BR1141-28-37	-1.62	-5.59*	-3.60*	17.58**	16.95**	17.27**	-13.17**	-6.29**	-9.73**	-2.80	-5.07*	-3.94**
Dular	-11.82**	4.82*	-11.68**	-29.31**	-28.55**	-28.93**	33.03**	31.91**	32.47**	8.09**	8.19**	8.14**
Indian 2	5.75**	-11.55**	5.29**	-2.89	-0.90	-1.89	-5.79**	-7.11**	-6.45**	2.93	3.19	3.06*
IR72080B	-3.35**	-2.67	-3.01*	-20.84**	-19.67**	-20.26**	7.78**	6.10*	6.94**	16.41**	16.24**	16.32**
Lambyque	-10.17**	-9.58**	-9.87**	-27.66**	-26.72**	-27.19**	32.03**	31.48**	31.76**	5.79**	4.82*	5.31**
KBNT	8.81**	8.32**	8.56**	-12.49**	-13.46**	-12.97**	-0.35	-1.85	-1.10	4.03*	6.99**	5.51**
IET1444	10.07**	8.90**	9.49**	-8.90**	-5.29*	-7.10**	-4.10*	-3.64	-3.87**	2.93	0.03	1.48
LSD 5%	٣,٢٩	4.65	2.88	٣,٢٩	4.65	2.88	٣,٢٩	4.65	2.88	٣,٢٩	4.65	2.88
1%	٤,٣٦	6.17	3.83	٤,٣٦	6.17	3.83	٤,٣٦	6.17	3.83	٤,٣٦	6.17	3.83

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

Male parents	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625A		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	-62.8**	-13.8**	-38.3**	71.2**	37.8**	45.0**	-23.6**	-17.1**	-29.9**	-22.**	-6.98	-16.6**
Giza178	-25.4**	-28.0**	-26.7**	67.8**	76.5**	72.2**	-22.4**	-21.1**	-21.7**	-20.0**	-27.4**	-23.7**
Giza181	-21.9**	-7.42	-14.6**	57.2**	43.1**	50.1**	-15.4**	-16.4**	-15.8**	-19.9**	-19.3**	-19.6**
IR25571-31	-7.75	-14.6**	-11.2**	61.1**	62.6**	61.9**	-36.5**	-32.9**	-34.7**	-16.8**	-15.1**	-15.9**
GZ1368-5-5-4	8.38	25.0**	16.7**	22.8**	10.7**	16.7**	1.29	1.33	1.31	-32.4**	-36.9**	-34.7**
GZ5121	-6.92	2.29	-2.31	70.9**	66.1**	68.5**	-41.7**	-38.6**	-40.1**	-22.3**	-29.8**	-26.1**
GZ6296-12-1-4	-6.72	-3.21	-4.96	60.7**	58.7**	59.8**	-36.6**	-36.3**	-36.4**	-17.6**	-19.1**	-18.4**
GZ6296-12-1-2	-13.3**	-8.24	-10.8**	69.1**	67.9**	68.5**	-38.2**	-44.4**	-41.3**	-17.6**	-15.3**	-16.5**
IR65598-112-98	-0.05	-0.36	-0.20	-46.0**	-43.1**	-44.6**	56.2**	54.3**	55.2**	-10.1*	-10.9*	-10.5**
Drew	15.0**	-1.75	6.6*	-20.8**	-25.5**	-23.1**	-15.7**	-13.7**	-14.7**	21.5**	40.9**	31.2**
GZ52	25.1**	16.7**	20.9**	-30.3**	-26.9**	-28.6**	-15.2**	-20.6**	-17.9**	20.4**	30.8**	25.6**
Katy	11.3*	6.54	8.9*	-20.6**	-16.8**	-18.7**	-8.31	-7.69	-8.0*	17.6**	18.0**	17.8**
Mars	5.39	9.3*	7.3*	-44.7**	-37.3**	-41.0**	2.44	-8.96*	-3.26	36.9**	36.9**	36.9**
Suweon392	24.7**	29.7	27.2**	-29.0**	-27.7**	-28.4**	-11.4**	-18.4**	-14.9**	15.7**	16.5**	16.1**
Giza182	-14.2**	-8.28	-11.2**	65.0**	60.6**	62.8**	-36.8**	-29.4**	-33.1**	-14.1**	-22.9**	-18.5**
IR56381-139	-10.4*	-13.3**	-11.9*	64.9**	57.9**	61.4**	-46.1**	-51.5**	-48.8**	-8.47	6.98	-0.74
Palawan	-4.92	2.57	-1.18	-43.0**	-35.6**	-39.3**	55.8**	53.5**	54.7**	-7.91	-20.1**	-14.2**
O2428-P7-1	-17.2**	-11.9*	-14.6**	-67.3**	-58.4**	-62.8**	73.9**	70.8**	72.4**	10.6*	-0.54	5.04
Peco	-14.8**	-13.9**	-14.4**	-64.9**	-60.5**	-62.7**	72.4**	67.4**	69.9**	7.31	7.04	7.2*
Indian 1	16.6**	6.96	11.6**	-16.3**	-14.6**	-15.4**	-13.1**	-7.44	-10.3**	12.8**	15.1**	13.9**
BR1141-28-37	-9.46*	-7.22	-8.3*	50.5**	45.0**	47.7**	-34.5**	-25.5**	-30.0**	-6.52	-12.3**	-9.4*

Dullar	0.01	18.1**	-15.7**	-67.1**	-60.8**	-64.0**	73.8**	67.6**	70.7**	10.4*	7.64	9.0*
Indian 2	11.26*	-14.4**	14.7**	-10.9**	-12.6**	-11.7**	-9.9**	-15.1**	-12.5**	9.5*	9.6*	9.5**
IR72080B	4.46	5.88	5.17	-45.6**	-40.6**	-43.1**	15.1**	9.3*	12.2**	26.0**	25.4**	25.7**
Lambyque	-14.6**	-15.8**	-15.2**	-64.7**	-62.3**	-63.5**	73.9**	84.2**	79.0**	5.47	-6.06	-0.29
KBNT	20.8**	23.4**	22.1**	-39.2**	-40.1**	-39.7**	2.73	-1.31	0.71	15.6**	18.1**	16.8**
IET1444	25.0**	15.9**	20.5**	-31.9**	-24.1**	-28.0**	-3.41	-2.16	-2.78	10.3*	10.3*	10.3**
LSD 5%	9.02	8.82	5.97	9.02	8.82	5.97	9.02	8.82	5.97	9.02	8.82	5.97
1%	11.96	11.70	9.50	11.96	11.70	9.50	11.96	11.70	9.50	11.96	11.70	9.50

panicle-1

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

Table 9: Estimation of SCA effects for 108 F1 hybrids at each year and their combined data for number of field grains panicle- ١

Male parents	CMS Line						Maintainer Line					
	Giza177A			IR69625A			Giza177B			IR69625A		
	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com	Y1	Y2	com
Giza175	-62.8**	-13.8**	-38.3**	71.2**	37.8**	45.0**	-23.6**	-17.1**	-29.9**	-22.**	-6.98	-16.6**
Giza178	-25.4**	-28.0**	-26.7**	67.8**	76.5**	72.2**	-22.4**	-21.1**	-21.7**	-20.0**	-27.4**	-23.7**
Giza181	-21.9**	-7.42	-14.6**	57.2**	43.1**	50.1**	-15.4**	-16.4**	-15.8**	-19.9**	-19.3**	-19.6**
IR25571-31	-7.75	-14.6**	-11.2**	61.1**	62.6**	61.9**	-36.5**	-32.9**	-34.7**	-16.8**	-15.1**	-15.9**
GZ1368-5-5-4	8.38	25.0**	16.7**	22.8**	10.7**	16.7**	1.29	1.33	1.31	-32.4**	-36.9**	-34.7**
GZ5121	-6.92	2.29	-2.31	70.9**	66.1**	68.5**	-41.7**	-38.6**	-40.1**	-22.3**	-29.8**	-26.1**
GZ6296-12-1-4	-6.72	-3.21	-4.96	60.7**	58.7**	59.8**	-36.6**	-36.3**	-36.4**	-17.6**	-19.1**	-18.4**
GZ6296-12-1-2	-13.3**	-8.24	-10.8**	69.1**	67.9**	68.5**	-38.2**	-44.4**	-41.3**	-17.6**	-15.3**	-16.5**
IR65598-112-98	-0.05	-0.36	-0.20	-46.0**	-43.1**	-44.6**	56.2**	54.3**	55.2**	-10.1*	-10.9*	-10.5**
Drew	15.0**	-1.75	6.6*	-20.8**	-25.5**	-23.1**	-15.7**	-13.7**	-14.7**	21.5**	40.9**	31.2**
GZ52	25.1**	16.7**	20.9**	-30.3**	-26.9**	-28.6**	-15.2**	-20.6**	-17.9**	20.4**	30.8**	25.6**
Katy	11.3*	6.54	8.9*	-20.6**	-16.8**	-18.7**	-8.31	-7.69	-8.0*	17.6**	18.0**	17.8**
Mars	5.39	9.3*	7.3*	-44.7**	-37.3**	-41.0**	2.44	-8.96*	-3.26	36.9**	36.9**	36.9**
Suweon392	24.7**	29.7	27.2**	-29.0**	-27.7**	-28.4**	-11.4**	-18.4**	-14.9**	15.7**	16.5**	16.1**
Giza182	-14.2**	-8.28	-11.2**	65.0**	60.6**	62.8**	-36.8**	-29.4**	-33.1**	-14.1**	-22.9**	-18.5**
IR56381-139	-10.4*	-13.3**	-11.9*	64.9**	57.9**	61.4**	-46.1**	-51.5**	-48.8**	-8.47	6.98	-0.74
Palawan	-4.92	2.57	-1.18	-43.0**	-35.6**	-39.3**	55.8**	53.5**	54.7**	-7.91	-20.1**	-14.2**
O2428-P7-1	-17.2**	-11.9*	-14.6**	-67.3**	-58.4**	-62.8**	73.9**	70.8**	72.4**	10.6*	-0.54	5.04
Peco	-14.8**	-13.9**	-14.4**	-64.9**	-60.5**	-62.7**	72.4**	67.4**	69.9**	7.31	7.04	7.2*
Indian 1	16.6**	6.96	11.6**	-16.3**	-14.6**	-15.4**	-13.1**	-7.44	-10.3**	12.8**	15.1**	13.9**
BR1141-28-37	-9.46*	-7.22	-8.3*	50.5**	45.0**	47.7**	-34.5**	-25.5**	-30.0**	-6.52	-12.3**	-9.4*
Dullar	0.01	18.1**	-15.7**	-67.1**	-60.8**	-64.0**	73.8**	67.6**	70.7**	10.4*	7.64	9.0*

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

Table 10: Estimates of genetic parameters and heritability in broad and narrow senses for studied tr
two years and their combined data

Genetic parameters and heritability	%pollen fertility			%spikelet fertility			Filled grai	
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y
Additive variance (σ^2A)	364.48	384.54	374.43	418.79	389.2	403.81	3018.3	255
dominant variance (σ^2D)	186.53	208.43	196.53	254.77	249.16	251.36	1617.0	148
σ^2A x L	-	-	187.29	-	-	202.09	-	-
σ^2D x L	-	-	99.25	-	-	126.28	-	-
Environmental variance (σ^2E)	10.51	10.92	11.53	8.18	16.41	12.62	61.7	59
Genotypic variance (σ^2G)	551.01	592.97	570.96	673.56	638.08	655.17	4635.3	403
Phenotypic variance (σ^2P)	561.52	603.89	582.49	681.74	654.49	667.79	4696.9	409
Dominance degree (σ^2D/ σ^2A)	0.51	0.54	052	0.61	0.65	0.62	0.54	0.
Broad sense heritability (h^2_b%)	98.13	98.2	98.02	98.8	97.5	98.11	98.69	98
Narrow sense heritability (h^2_n%)	64.94	63.68	64.28	61.43	59.42	60.47	64.26	62
Relative importance of gca%*	66.15	64.85	65.58	62.18	60.95	61.63	65.11	63
Relative importance of sca%**	33.85	35.15	34.42	37.82	39.05	38.37	34.89	36

* Relative importance of gca% = σ^2A/σ^2G
* * Relative importance of sca% = σ^2D/σ^2G.

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