Egypt. J. Plant Breed. 25(2):203– 222(2021)

COMBINING ABILITY AND GENE ACTION FOR AGRONOMIC AND YIELD TRAITS OF NOVEL EGYPTIAN PHOTO THERMO-SENSITIVE GENIC MALE STERILE (PTGMS) IN HYBRID RICE

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ABSTRACT

Studies of combining ability and gene action of newly developed Photo Thermo sensitive genic male sterile lines (PTGMS) and six exotic and novel Egyptian testers of new plant types were estimated using Line x tester analysis for some agronomic and yield traits to get useful information for two line system hybrid rice in Egypt. Significant differences of GCA among PTGMS lines testers for all agronomic and yield studied traits. Highly significant differences of line x tester (SCA) for all the studied traits, indicated that they interacted and produced markedly different combining ability effects. The estimates of variances due to GCA were higher than that due to SCA for all traits indicating the predominance of additive gene action in the inheritance of all these traits. Heritability estimates in narrow sense (h^2n) were high for all traits studied.Among the five PTGMS lines, PTGMS 78and PTGMS 39 were the best general combining for grain yield and most studied traits. The testers, EJGSR 182, EJGSR 180, and Sakha Super 300 were the best general combiners among testers for grain yield and most studied traits. Eight hybrid rice combinations gave significantly positive estimates of SCA effects. The best estimates were obtained of the combinations, PTGMS 19/Sakha 104, PTGMS 78/Sakka Super 300 and PTGMS 43/Sakha Super 300.

Key word: ***Novel PTGMS, Photo –Thermo sensitive, Two Line system, EGMS line, GCA, SCA.***

INTRODUCTION

Rice is one of the most important food crops. Hybrid rice technologies are mainly based on the three lines and two- line systems. The development of hybrid rice is a major approach for increasing yield productivity and Production of rice, since hybrid nice varieties have about 20.25% yield advantage over improved inbred varieties. Hybrid rice technologies are mainly based three line and two-line systems. Three line systems used Cytoplasmic male sterility line (A line), maintainer line (B line) and restorer line (R line). The two line hybrid rice system is based on use environmentally sensitive genic male sterile (EGMS) lines, which serve as both the A and B lines under different environmental conditions. Thus the two line hybrid system is an important innovation for the exploitation of heterosis. Hybrid rice based on the two line system using PGMS, TGMS and PTGMS lines has been successfully developed and applied widely in agriculture.

Two line hybrid rice breeding in Egypt uses photo period/thermo sensitive genetic male sterility (PTGMS) to produce superior hybrid rice combinations with high yield depending on day length or temperature. EGMS lines are playing an important role in developing two- line system hybrid rice. Unlike in three-line systems, the relations of the restorer or maintainer are not restrictive factor when making combinations with the two line system. Thus, there is a greater chance of finding superior hybrid combinations. There are no genetic barriers on fertility problems in inter varietal hybrids, therefore, it is easier to obtain better inter varietal hybrids by test crossing once an EGMS (PGMS, TGMS and PTGMS) line is available.

China has successfully developed a number of superior inter varietal and inter sub specific hybrid. The Indica/Japonica hybrids possess the higher yield potential both in sink. Theoretically, Indica/Japonica hybrids may have a 25-30Percent yield advantage over the best existing inter varietal hybrids. However, exploit in of the strong heterosis in Indica Japonica hybrids has been the major goal in the two line system hybrid rice breeding programme. The aim of the present study isto estimate combining ability and gene actionfor some agronomic and yield traits F_1 hybrids developed using Photo-thermo Sensitive genic male sterilitySystem (two line system) and new planttype Egyptian testers.

MATERIAL AND METHODS

The present study was carried out at the Experimental farm of Sakha Agricultural Reasearch Station, Kafr El-Sheikh , Egypt during 2019 and 2020 growing seasons.The genetic materials used in this investigation involved five selected Photo-Thermo-Sensitve Genic Male Sterile (PTGMS)Lines which developed by H.F. EL-Mowafi and his team (Abd Allah 2008, Abd Allah 2012 and EL-Mowafi *et al* 2012 and 2021). PTGMS lines identified as two line system for hybrid rice seed production. The PTGMS lines were used as female lines to produce rice hybrids .However, six exotic and Egyption pollenators involved one indica with wide Compatibility gene namely Minghui 63, four of new Egyption Japonica Green Super Rice (EJGSR) viz., Sakha Super 300, EJGSR180, EJGSR182 and EJGSR177 developed by the National project for Development Productivity and markting the hybrid and one traditional japonica rice variety, Sakha 104 were used as male parents (testers).

The weather conditions for agriculture research station during 2019 and 2020 seasons were shown in table 1.

Table 1. Period of fertility alteration phases of the five Egyptian Japonica PTGMS lines under natural day length at 15.25 days before heading in Sokha during 2019 and 2020 rice growing seasons.

Line	Phase	DS (m/d)	Year	DH (m/d)	FTP(m/d)	DDLh/d	DT(C°)			Fertility%	
							D Max T (C°)	D Min T (C°)	D Mean	PF%	SPF%
Egyptian Japonica PTGMS Lines	Fertility Transformation Period	April 1 - 29	2019	August 3 -12	7/9 – 7/28	13.94	34.16	28.85	31.50	0.00	0.00
		April 1 - 29	2020	August 4 -12	7/10 – 7/26	13.95	34.30	26.20	30.25	0.00	0.00
	Sterility Period	May 6 to13	2019	August 14 - 16	7/20 – 8/1	13.78	34.65	28.51	31.08	0.23	0.25
		May 6 to13	2020	August 1- 8	7/21 – 8/3	13.75	34.48	25.40	31.83	0.25	0.27
	Partial sterility/ Fertility period	May 20 to 27	2019	August 18 to 20	7/24 – 8/5	13.69	33.80	28.45	31.12	32.65	34.80
		May20to27	2020	August 18 to 20	7/26 – 8/7	13.65	34.10	25.30	29.7	45.60	46.18
	Fertility Period	June 3-25	2019	August 22 – 27	7/28 – 8/12	13.56	30.96	25.89	28.42	81.30	82.27
		June 3-25	2020	August 23 - 29	7/29 – 8/14	13.52	31.12	24.60	27.86	80.45	84.15

Note :Ds: date of sowing ; DH : date of heading; DDL: daily day length during sensitive period (Average).
:D Max T: daily maximum temprature during sensitive period; D Min T daily minimum temprature during sensitive period; PF%: Pollen fertilite%; SPF%; Spikelet fertility%.

The experiment comprised hybrid rice progenies drived from 30 F_1 hybrid rice combinations generated through Line×Tester mating design. Five Egyptian Japonica PTGMS lines namely PTGMS 19, PTGMS 28, PTGMS 39, PTGMS 43 and PTGMS 78 were used as lines. Six diverse Pollenators viz., Minghui 63, Sakha Super 300, EJGSR 180, EJGSR 182, EJGSR 177 and Sakha 104 were used as testers (Table 2). These materials were grown during 2019 growing season in different sowing dates either in 5 days intervals to get good synchronization in hybrid rice seed production plots isolation field conditions. the 30 F_1 hybrid rice combinations along with their respetive parents were grown in a Randomized Block Design with three replication at Sakha Research Station Farm in 2020 summer growing season .Twenty five days-old seedling were transplanted with one seedling hill^{-1} adopting a spacing of 20x20 cm between rows and between plants. Each genoty consisted of seven rows of five meters.

Table 2. PTGMS and Pollenators lines used in this study.

Genotype	Type	PTGMS and R Source	Origin
PTGMS Lines (female)			
PTGMS 19	Japonica	Nong Ken 58s/Sakha 101	Egypt
PTGMS 28	Japonica	Nong Ken 58s/Sakha 101	Egypt
PTGMS 39	Japonica	Nong Ken 58s/Sakha 101	Egypt
PTGMS 43	Japonica	Nong Ken 58s/Sakha 101	Egypt
PTGMS 78	Japonica	Nong Ken 58s/Sakha 101	Egypt
Pollenator (Testers)			
Minghui 63	Indica	Restorer for CMS Lines	China
Sakha Super 300	Japonica	New Pollenator	Egypt
EJGSR 180	Japonica	New Pollenator	Egypt
EJGSR 182	Japonica	New Pollenator	Egypt
EJGSR 177	Japonica	New Pollenator	Egypt
Sakha 104	Japonica	New Pollenator	Egypt

Studied traits

The data were recorded on ten plants plot^{-1} taken at random from each genotype in each replication according to Standard Evaluation System (SES) of IRRI 2014, for ten agronomic and yeild and its component traits . These characters were days to maturity (day), plant height (cm), panicle length (cm), spikelets panicle^{-1}, spikelets fertility%, panicles plant^{-1}, Panicle weight (g), filled grains panicle^{-1}, 1000-grain weight and grain yield plant^{-1}

Ten guraded plants were harvested from each genotype in each replication to determine grain yield plant^{-1} trait.

Statistical analysis

The data were analyzed by using the ordinary analysis of variance to test the Significance of differences among the 41 genotypes (five females of PTGMS lines and Six male parents used as tester and their 30 F_1 hybrid combination. The data were subjected to analysis of variances for a RCBD. Combining ability analysis was done using line x tester method (Kempthorne, 1957)

RESULTS AND DISCUSSION

Analysis of variance and combining ability

Analysis of variances for all agronomic and yield traits are presented in Table 3.The results revealed highly significant difference among the 41 genotypes (Five PTGMS lines, Six testers and their 30 hybrid rice Combinations) for the agronomic and yield traits, days to maturity (day), Plant heigh (cm), panicle length (cm), spikelets panicle^{-1} and yield traits panicles plant^{-1}, panicle weight (gm), filled grains panicle^{-1}, spikelet fertility%, 1000- grain weight(gm) and grain yield plant (gm). The Parental lines and the hybrid rice combinations showed highly significant differences for all studied traits. Parents vs hybrids mean squares indicated that average heterosis was significant or highly significant in all hybrids for all studied traits in this investigation.

analysis of variance for combining ability given in Table 3 revealed highly significant differences among the PTGMS (lines) and Pollenators parents (Testers) for all agronomic and yield studied characters.

Highly significant mean squares of all studied traits for L×T (SCA), indicated that they interacted and produced markedly different combining ability effects and this might be due to the wide genetic divesity of PTGMS lines and the super rice and new plant type pollenators (testers). The estimated values of variance due to GCA were higher than that due to SCA for all agronomic and yield traits (Table 3) Suggesting greater importance of additive variance. These results also were reported by El Mowafi *et al* (2005), Panwar (2005), Sharma (2006), Abdallah (2008),EL Diasty *et al* (2008), EL-Mowafi *et al* (2012), Abdallah (2013) and Hadifa (2021).

Table 3. Mean square estimates of line x tester analysis for agronomic and yield traits.

SOV	df	Days to maturity (day)	Plant height (cm)	Panicle length (cm)	Spikelets/ panicle	Panicles plant^{-1}
Replication	2	0.25	0.153	0.027	0.343	0.049
Genotypes	40	49.433**	414.539**	35.724**	6950.682**	15.823**
Parents	10	77.759**	326.109**	61.419**	6104.758**	28.676**
Hybrids	29	41.367**	320.235**	24.421**	5267.311**	11.916**
Parents vs. crosses	1	0.072*	4033.688**	106.557**	64227.67**	0.601**
Females (lines)	4	46.381**	271.109**	4.926**	2894.521**	7.985**
Males (testers)	5	192.882**	1601.335**	117.38**	26987.68**	56.568**
Females × Males (F × M)	20	2.486**	9.785**	5.08**	311.776**	1.539**
Error	80	0.212	0.433	0.071	1.775	0.102
SOV	**df**	**panicle weight (g)**	**filled grains panicle^{-1}**	**1000 grain weight**	**spikelets fertility%**	**grain yield plant**
Replication	2	0.001	74.214	0.001	0.055	3.292
Genotypes	40	3.02**	2904.301**	3.261**	207.52**	401.659**
Parents	10	6.055**	5417.351**	7.016**	8.329**	263.558**
Hybrids	29	0.641**	1297.776**	1.664**	269.087**	140.104**
Parents vs. crosses	1	41.68**	24363.03**	12.037**	413.966**	9367.744**
Females (lines)	4	0.659**	2546.534**	4.435**	0.753**	309.153**
Males (testers)	5	2.656**	4469.738**	4.374**	1557.122**	494.885**
Females × Males (F × M)	20	0.133**	255.034**	0.432**	0.746	17.599**
Error	80	0.001	82.124	0.001	0.036	2.593

***, ** significant at 0.05 and 0.01 level of probability, respectively.**

Estimates of genetic Parameters and heritability

The estimates of genetic parameters for four agronomic studied traits i.e days to maturity, Plant height , panicle length and spikelets ponicle^{-1} and six yield studied traits i.e panicles plant^{-1}, panicle weight, filled grains panicle^{-1}, spikelet fertility%, 1000-grain weight and grain yield plant^{-1} are presented in Table 4.

Table 4. Estimates of genetic parameters for agronomic and yield traits.

SOV	Days to maturity (day)	Plant height (cm)	Panicle length (cm)	Spikelets/ panicle	Panicles $plant^{-1}$
Parameter					
Additive variance (σ^2 A)	16.35	127.88	7.47	1993.62	4.21
Dominant variance (σ2 D)	0.76	3.12	1.67	103.33	0.48
Environmental variance (σ2 E)	0.21	0.43	0.07	1.78	0.10
Genotypic variance (σ2 G)	17.11	131.00	9.14	2096.96	4.68
Phenotypic variance (σ2 P)	17.32	131.43	9.21	2098.73	4.79
Broad sense heritability (h2b) %	98.78	99.67	99.23	99.92	97.87
Narrow sense heritability (h2n) %	94.40	97.30	81.11	94.99	87.86
Relative importance of gca %*	95.57	97.62	81.74	95.07	89.78
Relative importance of sca %**	4.43	2.38	18.26	4.93	10.22
SOV	**Panicle weight (g)**	**Filled grains $panicle^{-1}$**	**1000 grain weight**	**Spikelets fertility%**	**Grain yield plant**
Parameter					
Additive variance (σ^2 A)	0.21	471.94	0.60	103.76	56.12
Dominant variance (σ2 D)	0.04	57.64	0.14	0.24	5.00
Environmental variance (σ2 E)	0.00	82.12	0.00	0.04	2.59
Genotypic variance (σ2 G)	0.26	529.58	0.74	104.00	61.12
Phenotypic variance (σ2 P)	0.26	611.70	0.74	104.03	63.71
Broad sense heritability (h^2b) %	99.61	86.57	99.87	99.97	95.93
Narrow sense heritability (h^2n) %	82.49	77.15	80.48	99.74	88.08
Relative importance of GCA %*	82.81	89.12	80.59	99.77	91.82
Relative importance of SCA %**	17.19	10.88	19.41	0.23	8.18

L x T mating designwas developed and used to partition genetic ariance into its components. The total genetic variance was divided to lines,testers and L×T interaction Components. The first portion of variance, i.e. Line and tester estimate additive genetic variance, on the other side the second portion, L×T interaction estimate non-additive dominance genetic variance. The results indicated that the additive genetic variance (σ^2A) and relative the important of GCA for all agronomic and yield traits studied were greater than dominance variance (σ^2D)and relative importance of SCA%. The importance of the additive gene action for the inheritance of these traits was in agreement with the finding reported by EL-Mowafi and Abou shousha (2003), EL Mowafi *et al* (2005), Abdallah (2008), El Mowafi *et al* (2012), Abdallah (2013) and EL Mowafi *et al* (2021).

Concerning heritability estimates in broad sense ($h^2b\%$),the results in Table 4 indicated that the heritability values were high for all agronomic and yield characters and ranged between 86.57% for Filled grains panicle^{-1} to 99.97 for spikelet fertility%. However, hertability estimates in narrow sense ($h^2n\%$) were high for all traits, days to maturity (94.40%), Plant height (97.30%), panicle length (81.11%),spikelets panicle^{-1} (94.99%), panicles plant^{-1}(87.86%), for panicle weight (82.49%), filled grains panicle^{-1} (77.15%), spikeletfertility% (99.97%),1000-grain weight (80.48%) and grain yield plant (88.03%). These results were in general agreement with those reported by EL Mowafi and Abou shousha (2003), EL Mowafi *et al* (2005), EL Mowafi *et al* (2015) and EL Mowafi *et al* (2018)

General combining ability effects (GCA)

Significant differences of GCA effects were observed among the female Photo-Thermo Sensitive Genic Male Sterile (PTGMS) lines and tester or pollenator lines for all the agronomic and yield traits as shown in Table 5.

Agronomic traits

For days to maturity, the PTGMS lines, PTGMS 43 and PTGMS 28 showed significant and negative estimates of GCA effects with values of (-2.224 ± 0.181) and (-1.174 ± 0.181), respectively. These PTGMS lines appeared to be a good maternal combiners in hybrid rice combinations for early maturation. On the other hand, the rest of PTGMS lines gave highly significant and positive estimates of GCA effects. Among the tester or pollenator lines, EJGSR 177 (-4.358 ±198), EJGSR 182 (-3.071± 0.198) and EJGSR 180 (-1.878 ± 0.198) showed highly significant and negative (desirable) estimates of GCA effects for days to maturity trait. EL Mowafi *et al* (2018) and EL Mowafi *et al* 2021 reported rice CMS, restorers, PTGMS and pollenators showing negative GCA effects.

For the plant height, the results indicated that the PTGMS lines, PTGMS 43 and PTGMS 28 were the best combiners by virtue of their highly significant and negative estimates(desirable) of GCA effects with the values of (-5.134 ± 0.258)and (-2.223 ± 0.258), respectively. Four tester lines, EJGSR 180, Sakha 104 , EJGSR 182 and EJGSR 177 gave highly significant negative estimates of GCA effects for the same trait with values of (-10.560 ± 0.283), (-9.587 ± 0.283),(-3.827 ± 0.283) and (-1.027 ± 0.283)), respectively. However, the negative GCA effects values that mean decreased plant height could be useful to breed short stature rice hybrids. Abdallah 2008 and 2012 adjudged several parents with desirable GCA effects for plant height in rice hybrids.

The PTGMS lines PTGMS 19 and PTGMS 39 and the tester lines Minghui 63 and Sakha 104 exhibited desirable and highly significant positive estimates of GCA effects for panicle length with values of (o.543 ± 0.105), (0.228 ± 0.105), (4.956 ± 0.114) and (1.278 ± 0.114),respectively, these PTGMS and Pollenator lines appeared to be good females and males combiners in rice hybrids for panicle length .On the other hand, the PTGMS 28 and the three Pollenators, EJGSR180, EJGSR 182 and EJGSR 177 gave highly significant and negative estimates of GCA effects (-0.862 ± 0.105), (-2.344 ± 0.114), (-2.222 ± 0.114) and (-1.577 ± 0.114) in respective order. This result means that rice genotypes were poor general combiners in hybrid rice Combinations. Akram *et al* (2007), Abdallah 2013 and Hadifa 2021 observed Promising female and male lines with high GCA effects for panicle length character.

Furthermore, the estimates of GCA effects of spikelets panicle^{-1} were highly Significant and positive for the female lines PTGMS 39 (15.436 ± 0.523) and PTGMS 78 (11.930 ± 0. 523) and the pollen parents, Minghui 63 (74.353 ± 0.572) and EJGSR 182 (3.067 ± 0.572). It means that these rice genotypes could be Considered as good combiners for high number of spikelets panicle^{-1}.On the contrary, highly significant and negative estimates were obtained for three PTGMS lines, PTGMS 19, PTGMS 28 and PTGMS 43 and three tester lines, Sakha super 300, EJGSR 177 and Sakha 104 which gave significant and negative estimates (undesirable) of GCA effects with values of (-10.587 ± 0.523), (-10.603 ± 0.523), (-6.176 ± 0.523), (-5.680 ± 0.572), (-15.573 ± 0.572) and (-56.420 ± 0.572), respectively for spikelets panicle^{-1}.

Yield and its component traits

The estimates of GCA effects of panicles plant^{-1} for the pollinator Parents (Testers) were either significant and highly significant positive or negative for all male parents. Sakha 104, Sakha Super 300 and Minghui 63 showed Significantly positive and desirable estimates, The values respectively being (3.343 ± 0.137), (0.826 ± 0.137) and (0.177 ±0.137) . On the other hand, Significantly negative GCA effects (undesirable) were recorded in the case of other three male parents namely EJGSR 182(-1.111 ± 0.137) and EJGSR 177 (-2.119 ± 0.137) which were in agreement with the results of El Mowafi *et al* (2012), Abdallah (2013),El Mowafi *et al* (2018)

Estimates of GCA effects for PTGMS lines in (Table 5) on panicles plant^{-1} were either significant positive or negative for all the Five Female parents. PTGMS 78 and PTGMS 39 showed desirable significantly Positive estimates. The values respectively were (0.765 ± 0.125) and (0.625 ± 0.125) On the other hand, undesirable highly significant negative GCA effects were recorded in the case of the other three PTGMS lines namely PIGMS 43 (-0.151 ± 0.125), PTGMS 19 (-0.564 ± 0.125) and PTGMS 28 (-0.676 ± 0.125)

For panicle weight (g) all PTGMS lines manifested highly significant positive and negative GCA effects estimates (Table 8). Highly significant and Positive values (desirable) of GCA effects were estimated for two PTGMS lines namely PTGMS 39 (0.208 ± 0.012)and PTGMS 78 (0.210 ± 0.012). on the other hand, three Pollenator Parents namely EJGSR 182, EJGSR 180 and Sakha super300with values of (0.629 + 0.014), (0.126 +0.014), (0.123 ± 0.014),respectively were highly significant and positive values of GCA effects.

The data revealed that filled grains panicle^{-1} trait, highly significant and positive values (desirable) of GCA effects was estimated for two PTGMS lines namely PTGMS 39 and PTGMS 78 having values of (13.529 ± 3.554) and (11.284 ± 3.554), respectively. On the other hand, the PTGMS lines PTGMS 19, PTGMS 28 and PTGMS 43 gave significant and negative estimates (undesirable) of GCA effects with values of (-13.652 ± 3.554), (-7.435 ± 3.554) and (-3.727 ± 3.554), respectively for filled grains panicle^{-1} (Table 5). However, the results showed that the tester lines, Sakha super

300, EJGSR 182 and EJGSR 180 proved to be best Combiners for filled grains panicle^{-1}, Since their estimates of GCA effects were highly significant and positive (desirable) with values of (13.422 ± 3.894), (15.827 ± 3.894) and (5.966 ± 3.894) for these pollenator lines, respectively, whears, the estimates of GCA effects were significantly highly and negative in the cases of male rice genotypes, Minghui 63 (-5.941 ± 3.894) and Sakha 104 (-31.369 ± 3.894) for the same trait. Abdallah (2008) and, 2012 and EL Mowafi *et al* 2012 and EL Mowafi *et al* (2021) reported the PTGMS and Pollenator parents high GCA for filled grains panicle^{-1}, Similarly, Abdallah 2013 and Hadifa 2021, identified a good general combiner genotype for filled grain panicle^{-1} to improve rice yield.

In case of spikelet forSpikelete fertility%, the PTGMS lines namely PTGMS 28 and PTGMS 43 had preferred significant positive estimates of GCA effects of (0.321 ± 0.074) and (0.085 ± 0.074), respectively. Sakha 104, Sakha Super 300, EJGSR 177, EJGSR 182 and EJGSR 180 among male parents were found as the best general combiners based on estimates of GCA effects with values of (5.948 ± 0.082), (4.908 ± 0.082), (4.083 ± 0.082), (2.957 ± 0.082) and (2.757 ± 0.082), respectively. Swamy *et al* (2003, El Diasty *et al* 2008, EL Mowafi *et al* (2012) and EL Mowafi et al. (2021) identified parents with desirable GCA effects for spikelet fertility%.

The PTGMS lines, PTGMS 78, PTGMS 39 and PTGMS 43 and the pollinator Parents EJGSR 182, EJGSR 180 and Sakha Super 300 exhibited desirable and highly significant positive estimates of GCA effects for 1000-grain weight with values of (0.560 ± 0.012), (0.306 ± 0.012)and (0.098 ± 0.012) and (0.621 ± 0.014), (0.583 ± 0.014) and (0.197 ± 0.014), respectively. These PTGMS lines and pollenator parents appeared to be good parental combiners in rice hybrid for this trait. On the other hand, two of PTGMS lines namely PTGMS 19 and PTGMS 28 and another three of pollenator parents (testers) namely Sakha 104, Minghui 63 and EJGSR 177 gave highly significant and negative estimates of GCA effects this result means that these parental lines were poor general combiners in hybrid rice combinations. Abdallah (2013), EL Mowafi *et al* (2018) and Hadifa (2021) registered promising lines and testers with high GCA effects for 1000-grain weight.

Regarding grain yield plant^{-1}, two PTGMS lines (Female parents) namely PTGMS 78 and PTGMS 39 expressed desirable highly Significant and positive GCA effects of (5.754 ± 0.632) and (1.559 ± 0.632), respectively. The new pollenator parents (testers), EJGSR 182, EJGSR 180 and Sakha Super 300 exhibited highly significant positive GCA effect with values of (5.276 ± 0.692), (4.740 ± 0.692)and (3.481 ± 0,692), respectively. These rice genotypes considerd to be excellent general combiners for grain yield plant^{-1} trait in hybrid rice programme in Egypt El Mowafi *et al* (2012), Abdallah (2013), EL Mowafi *et al* (2021) and Hadifa (2021) identified PTGMS and Pollenators on the basis of GCA effects for yield plant^{-1}

Table 5. Estimates of GCA effects (gi) of each PTGMS and tester line for agronomic and yield traits.

Genotypes PTGMS Lines	Days to maturity (day)	Plant height (cm)	Panicle length (cm)	Spikelets/ panicle	panicles plant^{-1}
PTGMS 19	**0.892****	**-0.190***	**0.543****	**-10.587****	**-0.564****
PTGMS 28	**-1.174****	**-2.223****	**-0.862****	**-10.603****	**-0.676****
PTGMS 39	**1.109****	**3.316****	**0.228****	**15.436****	**0.625****
PTGMS 43	**-2.224****	**-5.134****	**0.059**	**-6.176****	**-0.151***
PTGMS 78	**1.398****	**4.232****	**0.032**	**11.930****	**0.765****
LSD 5%	**0.181**	**0.258**	**0.105**	**0.523**	**0.125 0.179**
1%	**0.258**	**0.368**	**0.149**	**0.745**	**-0.564****
Pollenator (tester lines)					
Minghui 63	**4.609****	**13.540****	**4.956****	**74.353****	**0.177***
Sakha super 300	**2.162****	**11.460****	**-0.092**	**-5.680****	**0.826****
EJGSR 180	**-1.878****	**-10.560****	**-2.344****	**0.253**	**-1.115****
EJGSR 182	**-3.071****	**-3.827****	**-2.222****	**3.067****	**-1.111****
EJGSR 177	**-4.358****	**-1.027****	**-1.577****	**-15.573****	**-2.119****
Sakha 104	**2.536****	**-9.587****	**1.278****	**-56.420****	**3.343****
LSD 5%	**0.198**	**0.283**	**0.114**	**0.572**	**0.137**
0.010	**0.282**	**0.403**	**0.163**	**0.817**	**0.196**

Table 5. Cont.

Genotypes PTGMS Lines	Panicle weight	Filled grains panicle	Spikelets fertility%	1000 grain weight	Grain yield plant
PTGMS 19	**-0.157****	**-13.652****	**-0.155****	**-0.711****	**-5.275****
PTGMS 28	**-0.118****	**-7.435****	**0.321****	**-0.253****	**-2.296****
PTGMS 39	**0.208****	**13.529****	**-0.101***	**0.306****	**1.559****
PTGMS 43	**-0.143****	**-3.727***	**0.085***	**0.098****	**0.258**
PTGMS 78	**0.210****	**11.284****	**-0.150****	**0.560****	**5.754****
LSD 5%	**0.012**	**3.554**	**0.074**	**0.012**	**0.632**
1%	**0.018**	**5.071**	**0.106**	**0.018**	**0.901**
Pollenator (tester lines)					
Minghui 63	**-0.011**	**-5.941****	**-20.653****	**-0.449****	**-8.220****
Sakha super 300	**0.123****	**13.422****	**4.908****	**0.197****	**3.481****
EJGSR 180	**0.126****	**5.966****	**2.757****	**0.583****	**4.740****
EJGSR 182	**0.629****	**15.827****	**2.957****	**0.621****	**5.276****
EJGSR 177	**-0.230****	**2.096****	**4.083****	**-0.337****	**0.606**
Sakha 104	**-0.637****	**-31.369****	**5.948****	**-0.615****	**-5.883****
LSD 5%	**0.014**	**3.894**	**0.082**	**0.014**	**0.692**
0.010	**0.019**	**5.555**	**0.116**	**0.019**	**0.987**

***, ** significant at 0.05 and 0.01 level of probability, respectively.**

Estimates of specific combining ability (SCA)

Estimates of SCA effects for each F_1 hybrid rice combinations for the studied traits are given in Table 6.

4.5.1 Agronomic traits

For days to maturity (day), Seven hybrids viz. PTGMS 78 / Minghui 63, PTGMS 39/ Sakha104, PTGMS 43/Super 300, PTGMS 28/Super 300, PTGMS 39/EJGSR 182, PTGMS 43/EJGSR180 and PTGMS19/ Super 300 gave significant and highly Significant negative SCA estimates of (-1.864 ± 0.442), (-1.236 ± 0.442), (-0.962 ± 0.442), (-0.846 ± 0.442), (-0.729 ± 0.442), (-0.722 ± 0.442) and (-0.579 ± 0.442), respectively. Seven hybrids combinations also expressed Significant and highly significant positive SCA effects which mean that these hybrids were not suitable for developing Short duration hybrids. Sixteen hybrids exhibited non-significant SCA effects. Rosamma and Vija Kumar (2005), Gnanesakaran *et al* 2006, El Mowafi *et al* (2012) and El Mowafi *et al* 2021 identified promising hybrids with higher desirable SCA effects for days to maturity.

Table 6. Estimates of SCA effects of each hybrid rice combinations for agronomic and yield traits.

Genotypes	Days to maturity (day)	Plant height (cm)	Panicle length (cm)	Spikelets/ panicle	Panicles $plant^{-1}$
PTGMS 19/Minghui 63	0.174	1.943**	0.455**	-20.087**	-0.371*
PTGMS 19/ Sakha Super 300	-0.579*	-1.610**	-1.026**	1.613*	-0.107
PTGMS 19/EJGSR 180	0.261	-0.857*	0.236	3.647**	-0.160
PTGMS19/EJGSR 182	0.154	0.443	1.467**	5.267**	0.254
PTGMS19/EJGSR 177	0.308	0.443	-1.215**	3.740**	0.175
PTGMS19/Sakha 104	-0.319	-0.363	0.083	5.820**	0.210
PTGMS 28/Minghui 63	0.641**	1.677**	-0.433*	-5.170**	0.582**
PTGMS 28/Sakha super300	-0.846**	-0.877*	-0.361*	-0.037	-0.571**
PTGMS 28/ EJGSR 180	-0.072	-0.657*	-0.142	-2.070**	-0.250
PTGMS 28/EJGSR 182	0.054	-0.023	-0.408**	2.617**	0.636**
PTGMS 28/EJGSR 177	-0.292	0.010	1.070**	-2.177**	0.814**
PTGMS 28/ Sakha 104	0.514*	-0.130	0.275	6.837**	-1.211**
PTGMS 39/Minghui 63	0.324	1.871**	0.930**	24.891**	1.313**
PTGMS 39/Sakha super 300	2.038**	1.418**	-1.045**	-1.176	0.617**
PTGMS 39/EJGSR 180	-0.089	-0.229	0.467**	-4.009**	-0.169
PTGMS 39/EJGSR 182	-0.729**	-1.429**	-1.222**	-7.489**	-0.862**
PTGMS 39/EJGSR 177	-0.309	-0.429	0.800**	-1.282*	-0.674**
PTGMS 39/Sakha 104	-1.236**	-1.202**	0.071	-10.936**	-0.226
PTGMS 43/Minghui 63	0.724**	-5.279**	-1.248**	-15.598**	-0.791**
PTGMS 43/Sakha super 300	-0.962**	-0.532	3.731**	0.169	0.267
PTGMS 43/EJGSR 180	-0.722**	1.488**	-0.964**	1.936**	-0.296
PTGMS 43/EJGSR 182	-0.229	2.421**	-1.177**	1.456*	-0.133
PTGMS 43/EJGSR 177	0.024	0.054	0.275*	6.096**	0.245
PTGMS 43/Sakha 104	1.164**	1.848**	-0.617**	5.942**	0.707**
PTGMS 78/Minghui 63	-1.864**	-0.212	0.296*	15.963**	-0.733**
PTGMS 78/Sakha super 300	0.349	1.601**	-1.298**	-0.570	-0.206
PTGMS 78/EJGSR 180	0.622**	0.254	0.404**	0.497	0.875**
PTGMS 78/EJGSR 182	0.749**	-1.412**	1.341**	-1.850**	0.105
PTGMS 78/EJGSR 177	0.269	-0.079	-0.930**	-6.377**	-0.561**
PTGMS 78/Sakha 104	-0.124	-0.152	0.188	-7.663**	0.521**
LSD 0.05 %	0.442	0.632	0.256	1.280	0.307
0.01%	0.631	0.902	0.365	1.826	0.438

***, ** significant at 0.05 and 0.01 level of probability, respectively.**

Table 6. Cont.

Genotypes	panicle weight (g)	filled grains panicle	spikelets fertility%	1000 grain weight	grain yield plant^{-1}
PTGMS 19/Minghui 63	-0.289**	-5.840	0.636**	-0.752**	3.763**
PTGMS 19/ Sakha Super 300	0.027	4.120	-0.232*	0.739**	-3.248**
PTGMS 19/EJGSR 180	-0.006	-22.121**	-0.784**	0.159**	-2.476**
PTGMS19/EJGSR 182	0.215**	7.005	-0.438**	-0.072**	-0.366
PTGMS19/EJGSR 177	-0.067**	7.466	0.340**	-0.127**	-0.620
PTGMS19/Sakha 104	0.121**	9.370*	0.478**	0.054**	2.946**
PTGMS 28/Minghui 63	-0.244**	-4.854	-0.713**	0.063**	1.417
PTGMS 28/Sakha super300	0.042*	-2.537	-0.308**	-0.266**	-3.700**
PTGMS 28/ EJGSR 180	-0.064**	4.625	0.447**	-0.206**	1.058
PTGMS 28/EJGSR 182	0.213**	2.218	0.413**	-0.204**	1.761*
PTGMS 28/EJGSR 177	-0.052**	-3.705	0.094	0.261**	-2.656**
PTGMS 28/ Sakha 104	0.106**	4.253	0.069	0.352**	2.120*
PTGMS 39/Minghui 63	0.369**	15.969**	0.553**	0.028	-1.265
PTGMS 39/Sakha super 300	-0.034**	-2.064	-0.552**	-0.101**	1.705*
PTGMS 39/EJGSR 180	0.056**	4.019	0.213*	0.276**	1.379
PTGMS 39/EJGSR 182	-0.310**	-6.182	0.102	0.328**	-1.101
PTGMS 39/EJGSR 177	0.082**	-1.281	-0.127	-0.267**	0.913
PTGMS 39/Sakha 104	-0.161**	-10.460*	-0.189*	-0.263**	-1.631*
PTGMS 43/Minghui 63	-0.193**	-13.789**	-0.800**	-0.172**	-1.503
PTGMS 43/Sakha super 300	0.007	0.535	0.775**	-0.014	2.343**
PTGMS 43/EJGSR 180	-0.026	7.284	0.183*	0.083**	-0.146
PTGMS 43/EJGSR 182	0.205**	-0.420	-0.017	0.138**	-1.239
PTGMS 43/EJGSR 177	-0.053**	3.214	-0.133	0.060**	2.031*
PTGMS 43/Sakha 104	0.061**	3.175	-0.008	-0.096**	-1.486
PTGMS 78/Minghui 63	0.358**	8.514	0.325**	0.834**	-2.412**
PTGMS 78/Sakha super 300	-0.042*	-0.053	0.317**	-0.358**	2.900**
PTGMS 78/EJGSR 180	0.041*	6.193	-0.058	-0.312**	0.185
PTGMS 78/EJGSR 182	-0.322**	-2.621	-0.059	-0.190**	0.945
PTGMS 78/EJGSR 177	0.090**	-5.694	-0.174	0.072**	0.332
PTGMS 78/Sakha 104	-0.126**	-6.339	-0.350**	-0.047**	-1.949*
LSD 0.05 %	0.030	8.706	0.182	0.030	1.547
0.01%	0.043	12.421	0.260	0.043	2.207

***, ** significant at 0.05 and 0.01 level of probability, respectively.**

For plant height (cm), hybrids like PTGMS 43/Minghui 63, PTGMS 19/Sakha super 300, PTGMS 39/EJGSR 182, PTGMS 78/EJGSR 182, PTGMS 39/Sakha 104, PTGMS 28/Sakha Super 300, PTGMS 19/EJGSR 180 and PTGMS 28/EJGSR 180 indicated Significant and highly significant preferable negative SCA effects of (-5.279 ± 0.632), (-1.610 ± 0.632), (-1.429 ± 0.632), (-1.412 ± 0.632), (-1.202 ± 0.632), (-0.877 ± 0.632), (-0.857

± 0.632) and (-0.657 ± 0.632), respectively for short stature plant. Improvement in plant height in term of intermediate or short stature plant can be brought by exploit on of hybrid vigor in these hybrid combinations. Eight hybrids observed positive and highly significant SCA effects for plant height ranging from (1.418 ± 0.632) for PTGMS 39/Sakha Super 300 to (2.421 ± 0.632) for PTGMS 43/EJGSR 182. On the other hand, 14 hybrids showed non-significant SCA effects. These results were in agreement with those of Sharma *et al* (2006), El Mowafi *et al* (2018) and El Mowafi *et al* (2021) on the identification of best specific combinations for short stature plant.

For panicle length, 12 hybrids recorded significant and positive estimates of SCA effects. The extent of significantly positive SCA values was variable among the hybrid rice combinations for panicle length. Hybrids namely PTGMS 43/Super 300, PTGMS 19/EJGSR 182, PTGMS 78/EJGSR 182, PTGMS 28/EJGSR 177 and PTGMS 39/Minghui 63 observed highly Significant preferable positive SCA estimates of (3.731 ± 0.256), (1.467 ± 0.256), (1.341 ± 0.256), (1.070 ± 0.256) and (0.930 ± 0.256), respectively for panicle length. Heterosis breeding is proposed to develop superior genotypes with increased panicle length. 13 hybrids expressed significant and negative (undesirable) SCA effects. Five rice hybrids manifested non-Significant SCA effects. Bagheri and Jelodar (2010), and EL Mowafi *et al* (2021) reported a specific combiner and showed desirable SCA effects for panicle length.

Estimates of SCA effects from the 30 F_1 hybrid rice combinations are shown in Table 6. It is obvious that 13 hybrids gave significant and highly significant positive estimates desirable of SCA effects for spikelets panicle^{-1}, such estimates were maximized in hybrids PTGMS 39/Minghui 63 (24.891 ± 1.280) PTGMS 43/Minghui 63 (-15.598 ± 1.280), PTGMS 28/Sakha 104 (6.837 ± 1.280), PTGMS 43/EJASR 177 (6.096 ± 1.280) and PTGMS 43/Sakha 104 (5.942 ± 1.280) but minimized in the hybrids PTGMS 43/EJGSR 182 (1.456 ± 1.280) and PTGMS 19/Sakha Super 300 (1.613 ± 1.280). These results revealed that non additive genetic effect were predominant in these Particular combinations of rice hybrids for Spikelets panicle^{-1}. On the other hand, 12 hybrid combinations gave significant negative estimates values of SCA effects and varied from (-1.850 ± 1.280) for the hybrid PTGMS 78/ EJGSR 182 to (-20.087 ± 1.280) for PTGMS 19/ Minghui 63. The results are in the same side with those reported byAbd Allah (2008), Abd Allah (2013), EL Mowafi *et al* (2012), EL Mowafi *et al* (2018) and EL Mowafi *et al* (2021).

4.5.2. Yield and its component traits

Estimates of SCA effects from F_1 Hybrid combinations for Yield and its component traits in Table 6

With regard to panicles plant^{-1}, eight hybrid rice combinations recorded Significant and positive estimates of SCA effects that ranged from (0.521 ± 0.307) for the hybrid PTGMS 78/ Sakha 104 to (1.313 ± 0.302) for PTGMS 39/Minghui 63. Eight hybrids gave significant and negative (undesirable) estimates, ranging from (- 0.371 ± 0.307) for the hybrid PTGMS 19/Minghui 63 to (-1.211 ± 0.307) for the hybrid PTGMS 28/ Sakha 104. The best hybrid rice combinations for Panicles plant^{-1} were PTGMS 39/ Minghui 63, PTGMS 78/ EJGSR 180, PTGMS 28/ EJGSR 177, PTGMS 43/Sakha 104 and PTGMS 28/ EJGSR 182.

Thirteen hybrid rice combinations recorded positive and significant estimates of SCA effects for Panicle weight trait ranging from (0.042 ± 0.030) for PTGMS 28/Sakha super 300 to (0.369 ± 0.030) for PTGMS 39/Minghui 63. In the contrary, negative significant estimates (undesirable) were recordedin 12hybrids. The hybrid rice combinations, PTGMS 39/Minghui 63, PTGMS 78/Minghui 63, PTGMS 19 / EJGSR 182, PTGMS 28/EJGSR 182 and PTGMS 43 /EJGSR 182 recorded the highest positive and highly significant values for panicle weight trait.

For filled grains panicle^{-1}, significant and positive estimates of SCA effects were recorded for only two hybrid rice combinations namely, PTGMS 39/Minghui 63 (15.967 ± 8.706) and PTGMS 19/Sakha 104 (9.370 ± 8.706). Three hybrid Combinations observed significantly negative (undesirable) SCA effects. The most of hybrid combinations (25 hybrids) had non- significant SCA effects. El Mowafi *et al* (2018), and El Mowafi *et al* 2021 identified a better hybrid disclosing high SCA effect for filled grains Panicle^{-1} in hybrid rice.

Regarding spikelet fertility %, eleven hybrid rice combinations recorded highly Significant and significant positive (desirable) SCA effects. Hybrid PTGMS 43/Sakha Super 300 indicated maximum SCA value of (0.775 ± 0.180) followed by the hybrid combinations, PTGMS 19/ Minghui 63, PTGMS 39/Minghui 63, PTGMS 19/Sakh104 and PTGMS 28/ EJGSR180 having SCA effects values of (0.636 ± 0.182), (0.553 ± 0.182), (0.478 ± 0.182) and (0.447 ± 0.182), respectively. Also, nine hybrids observed non-significant SCA effects for spikelet fertility %. These results are similar with El Mowafi *et al* 2012, Abd Allah (2013), Nassar (2013) and EL Mowafi *et al* (2021).

For 1000-grain weight trait, 13 hybrid rice combinations showed Significantly positive (desirable) estimates of SCA effects. Five hybrid rice combinations namely, PTGMS 78/ Minghui 63 (0.834 ± 0.030), PTGMS 19 /Sakha Super 300 (0.739 ± 0.030), PTGMS 28/Sakha 104 (0.352 ± 0.030), PTGMS39/ EJGSR 182 (0.328 ± 0.030) PTGMS 39/EJGSR 180 (0.276 ± 0.030) recorded the highest SCA effect values for 1000-grain weigh trait and could be utilized for increasing 1000- grain weight following breeding approach for gene accumulation for this trait (Table 6). On the other hand, 15 hybrids showed significantly negative (undesirable) estimates of SCA effects for 1000-grain weight trait.

Estimates of SCA effects for grain yield plant^{-1} trait in the 30 rice hybrids of different parental hybrid rice combinations are presented in Table 6. Eight hybrids gave significantly positive (desirable) estimates of SCA effects. The highest estimates were obtained of the combinations, PTGMS 19 / Minghui 63, PTGMS 19/ Sakha 104, PTGMS 78/ Sakhasuper 300 and PTGMS 43/Sakha Super 300 with values of (3.763 ± 1.547), (2.946 ± 1.547), (2.900 ± 1.547) and (2.343 ± 1.547) respectively.

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العنوان: القدره على التألف وفعل الجين للصفات الحقليه والمحصوليه فى مبتكرات الأرز الهجين من السلالات المصريه العقيمه ذكريا لطول النهار ودرجة الحراره

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أجرى هذا البحث بغرض دراسة القدرة العامة والخاصة على الائتلاف وفعل الجين بإستخدام نظام العقم الوراثى لطول النهار ودرجة الحرارة باستخدام نظام السلاله × الكشاف لخمسة سلالات مصريه مبتكره عقيمه الذكريبيا لطول النهار ودرجة الحرارة استخدمت وستة تراكيب وراثيه متنوعه عالميه ومحليه ومبتكرات مصريه من الطرز النباتيه الحديثه استخدمت كشافات لدراسة القدره العامه والقدره الخاصه على التالف وكذا فعل الجين للاستفاده منها فى برنامج تربية الأرز الهجين نظام السلالتين فى مصر. أظهرت النتائج ان الفعل الجينى المضيف والأهميه النسبيه للقدره العامه على التالف كان أهم من الفعل الجينى غير المضيف والأهميه النسبيه للقدره الخاصه على التالف كما أشارت النتائج الى ارتفاع قيم معامل التوريث بالمعنى الضيق لكل الصفات تحت الدراسه. أظهرت الدراسه أن سلالات العقم الوراثى لطول النهار ودرجة الحراره PTGMS 78 و السلاله PTGMS 43 هى الأفضل فى قدرتها العامه على التألف لمحصول الحبوب ومعظم الصفات الرئيسيه فى حين كان الكشاف EJGSR 182 و EJGSR 180 و سخا سوبر ٣٠٠ أفضل الكشافات فى قدرتها العامه على الائتلاف فى صفة المحصول ومعظم الصفات الرئيسيه. على الجانب الأخر كانت أفضل الهجن فى القدره الخاصه على التألف فى صفة المحصول ومعظم الصفات الرئيسيه هى PTGMS 19/Sakha104 و PTGMS 43/Sakha super 300 و PTGMS78/Sakha super 300.

المجلة المصرية لتربية النبات ٢٥(٢): ٢٠٣– ٢٢٢ (٢٠٢١)