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GENETIC STUDIES ON THE PHOTOTHERMO SENSITIVE GENIC MALE STERILITY (PTGMS) AND ITS UTILIZATION IN RICE BREEDING.

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ABSTRACT

Studies of heterosis and combining ability of six photo /thermo-sensitive testers were estimated using line x tester analysis for some agronomic characters and yield and its components to get useful information for two-line system in hybrid rice breeding in Egypt .

The outstanding hybrid combinations for grain yield plant^{-1} were PTGMS-5/Dular (45.26%) with significant standard heterosis for ,panicle length (28.22%) productive tillers plant^{-1} (24.19%) ,panicle weight (26.93%) ,filled grains panicle^{-1} (25.89%),spikelets panicle^{-1}(14.19%) ,spikelet fertility % (10.20%) and 100-grain weight (35.62%) .In the mean time ,PTGMS-14/Norin PL9,PTGM-7/Dular ,PTGMS-14/Giza178 and PTGMS-5/Giza 178 were considered as promising hybrids.

Among the six PTGMS lines,PTGMS-5 and PTGMS-14 were the best general combiners for grain yield and all studies characters.The testers , Dular , Giza178,M202 and Pecos were the best general combiners among testers for grain yield and most studies characters.

INTRODUCTION

Rice (*Oryza sativa*, L.) is the main food for about half of the world population. Indica type rice varieties feed about 3 billion people, predominantly in developing contries. Rice provides 23% of global human per capita energy and 16% per capita protein. Rice protein ranks high in nutritional quality among cereals. Rice also provides minerals, vitamins, and fiber (Alam et al., 1998). The rapidly increasing demand for rice and the continuous decrease in rice growing areas have resulted in search to improve rice production. In addition to improved varieties and new plant type, the use of hybrid rice may provide the target requirement of 15t/ha.

Hybrid rice has proven to be an effective and economical way to increase rice production output. It is easy to obtain about 15-20% higher yield just growing hybrid rice instead of the common varieties .

Two-line system based on photo/thermo-sensitive genic male sterile (P/TGMS) lines could be used. Since the gene(s) expression of P/TGMS is controlled by environment, the P/TGMS also called environmental genic male sterile (EGMS). The EGMS lines are sterile in long day (LD) and / or high temperature (HT) and become fertile in short day (SD) and / or low temperature (LT). During the sterile phase they can be used to produce hybrid seeds by crossing them with normal fertile male line,while in fertile phase they propagate themselves. The EGMS lines possess the following advantages: (1) Higher selection and utilization; (2) Not sensitive to cytoplasmic type and sterile lines having different cytoplasmic types can be

bred easily; (3) Resources of restoring genes are wide ranging which can be used as its restoring lines provided they are not the heterozygotes of this recessive genic male sterile gene, thus up to date achievements in research of genetic breeding of rice can be collected and utilized for exploitation of heterosis.

MATERIALS AND METHODS

The experiment comprised progenies derived from 50 cross combinations generated through line x tester mating design. Six Photoperiod/Thermo-sensitive genic male sterile (PTGMS) Viz; PTGMS-1, 2, 4, 5, 7 and PTGMS-14 developed by Egyptian Hybrid Rice Breeding Program in Egypt were used as female lines. Seven diverse tester varieties Viz., Pecos (japonica WC), V20R(Indica isogenic restorer line), M202 (Japonica USA variety), Dular (Indica WC variety), GZ5310-20-3-3 (Japonica), Norin PL9 (Japonica WC) and Giza 178 (Indica / Japonica variety used as restorer for cytoplasmic male sterile lines) were used as pollen parents (testers) (Table 1). The F_1 hybrid combinations along with their respective parents were grown in a randomized complet block design with three replications at Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, in 2006and 2007 summer seasons. Thirty day –old seedlings were transplanted with one seedling hill^{-1} adopting a spacing of 20 cm between plants. Each test entry consisted of 3 rows of 5 m length.

Table(1): PTGMS male sterile and pollen parents lines used for the experiment.

Genotype	Sterility source	Origin
PTGMS-1	Photoperiod thermo sensetive genic male sterile.	China-Egypt
PTGMS-2	Photoperiod thermo sensetive genic male sterile.	China-Egypt
PTGMS-4	Photoperiod thermo sensetive genic male sterile.	China-Egypt
PTGMS-5	Photoperiod thermo sensetive genic male sterile.	China-Egypt
PTGMS-7	Photoperiod thermo sensetive genic male sterile.	China-Egypt
PTGMS-14	Photoperiod thermo sensetive genic male sterile.	China-Egypt
Pecos	Tester Japonica (WC)	Japan
V20R	Tester Indica	China
M202	Tester japonica	USA
Dular	Tester Indica (WC)	India
GZ5310-20-3-3	Tester Japonica	Egypt
Norin PL9	Tester Japonica (WC)	Japan
Giza 178	Indica / Japonica	China

Observation were recorded on five plants plot^{-1} taken at random from each entry replication for plant height, panicle length, panicles plant^{-1}, filled grains panicle^{-1}, spikelets panicle^{-1}, spikelet fertility and 100-grain weight. Ten plants from the middle row of three guarded rows were harvested from each entry in each replication to determine grain yield (g/plant^{-1}).

Standard heterosis (over the best inbred variety, Giza 178) was calculated for the studied characters while combining ability analysis was carried out as suggested by Kempthorne model (1957) for random lines

representing certain population. The present represent selected set of males and females.

RESULTS AND DISCUSSION

Mean performance of 13 parental lines (six PTGMS lines as females and seven pollen parents as testers) and their 42 hybrid genotype of line x tester for the nine studied characters are presented in Table (2).The mean performance of the studied characters varied from one combination to another. With respect to plant height, the most desirable mean values towards short stature (less than 110 cm) were found in 21 hybrid combinations. Complete to over dominance was observed in most hybrids towards the taller parents for plant height, longest panicle, higher productive tillers plant^{-1}, heavier panicle weight, highest spikelets panicle^{-1} and heavier 100-grain weight. However, some of the hybrids showed the same dominance effects towards the higher filled grains panicle^{-1}, higher rate of spikelet fertility % and higher grain yield plant^{-1}. on the other hand, some hybrid combinations exhibited dominance effect towards the lower parents, Viz., for plant height (no hybrids)for panicle length (one hybrid), for productive tillers (four hybrids), for spikelet fertility %(33 hybrids), for 100-grain weight (one hybrid) and for grain yield plant^{-1} (no hybrids). However, the rest of the hybrid combinations showed intermediate mean values between the parents involved for all studied characters.

The highest mean values of grain yield plant^{-1} (g) were obtained by the hybrid combinations PTGMS-5 / Dular, PTGMS-14 / Norin PL9, PTGMS-2 / Dular, PTGMS-7 / Dular, PTGMS-14 / Giza 178 and PTGMS-5 / Giza 178 with values of 67.69g, 66.56g, 65.21g, 65.08g, 64.36g and 63.49g, respectively. The lowest values were estimated for the hybrids PTGMS-1 / Norin PL9 (23.9g) and PTGMS-7 / V20R (20.54g). the parental lines Giza 178, M202, Gz5310-20-3-3 and Norin PL9, manifested highest mean performance of 46.6, 43.31, 40.29 and 40.20, respectively.

Standard heterosis:

The standard heterosis is especially important because the hybrid to be released is expected to outperform the existing superior local variety or hybrid. The data for standard heterosis in 42 hybrid combinations are presented in Table 3. Evaluation based on the standard heterosis revealed that three hybrids recorded significant negative standard heterosis for short stature plant^{-1}. 31 hybrid combinations recorded significant positive standard heterosis for panicle length, 3 hybrids for productive tillers plant^{-1}, 12 hybrids for panicle weight, 10 hybrids for filled grains panicle^{-1}, 15 hybrids for spikelets panicle^{-1}, 10 hybrids for spikelets fertility %, all 42 hybrids for 100-grain weight and 22 hybrids for grain yield plant^{-1}. The outstanding hybrid combinations for grain yield plant^{-1} were PTGMS-5 / Dular (45.26%) with significant standard heterosis for panicle length (28.22%), productive tillers plant^{-1}, panicle weight (26.93%), filled grains panicle^{-1} (25.89%), spikelets panicle^{-1} (14.19%), spikelet fertility (10.20%) and 100-grain (35.62%).

Table(2): Mean performance of parental lines (PTGMS and restorer lines) and hybrid combinations for nine tudied characters.

Genotype	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grain panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
PTGMS (female):									
PTGMS-1	54.50	18.05	25.3	1.12	22.58	96 5	90.45	2.26	19.24
PTGMS-2	56.00	18.20	28.5	1.17	24.05	89.3	92.30	2.39	22.05
PTGMS-4	55.50	18.35	25.5	1.28	26.60	91.9	95.03	2.29	22.01
PTGMS-5	55.25	19.28	27.8	0.96	28.45	99.7	92.83	2.35	18.45
PTGMS-7	59.75	19.45	29.5	1.05	29.23	118.6	90.03	2.30	19.41
PTGMS-14	60.00	19.00	22.3	0.98	28.20	108.2	91.28	2.23	14.83
Restorer lines(male):									
Pecos	97.25	18.48	17.3	3.13	127.83	136.7	93.45	2.47	36.57
V20R	60.25	17.18	21.8	1.96	64.15	67.60	94.95	3.13	26.39
M202	96.75	19.68	22.8	3.79	150.05	164.6	91.15	2.66	43.31
Dular	145.75	27.80	14.0	3.59	121.25	133.9	90.65	2.62	33.03
GZ5310	98.00	19.60	20.0	3.71	123.43	129.5	95.30	2.65	40.29
Norin PL9	92.00	21.42	19.0	3.60	112.65	123.7	91.10	2.31	40.20
Giza 178	89.00	22.15	24.8	4.01	141.70	163.4	86.75	2.19	46.60
Hybrid combinations:									
PGMS-1/Pecos	115.15	22.80	19.8	4.14	132.13	147.3	89.25	2.62	54.84
/V20R	86.50	22.30	23.4	2.67	85.88	104.2	82.45	2.74	38.75
/M202	91.50	20.90	18.4	3.55	97.90	130.5	75.10	2.88	36.69
/Dular	131.90	28.90	19.9	5.16	139.48	144.08	96.80	3.01	62.64
/GZ5310	108.25	25.50	21.1	3.32	74.15	151.95	48.75	2.58	25.60
/Norin PL9	113.23	23.80	19.4	2.92	78.48	138.68	56.58	2.79	23.90
/ Giza 178	106.83	25.70	25.6	2.76	95.65	149.5	64.00	2.85	32.70
PGMS-2/Pecos	82.00	23.40	19.1	4.16	130.40	144.15	90.45	2.60	53.76
/V20R	84.63	21.40	23.0	2.63	79.98	104.73	76.35	2.94	34.60
/M202	109.00	22.60	17.8	3.44	96.05	150.30	63.93	3.04	29.18
/Dular	136.35	27.60	23.1	4.89	147.03	155.63	94.50	3.01	65.21
/GZ5310	107.00	24.00	22.6	3.46	90.78	177.20	51.23	3.03	28.74
/Norin PL9	112.75	23.60	20.8	3.44	66.65	133.63	49.85	3.03	25.98
/ Giza 178	120.15	25.20	25.6	5.19	165.43	187.45	88.25	2.77	56.27

Table(2):Cont. mean performance of parental lines (PTGMS and restorer lines) and hybrid combinations for nine studied characters.

Genotype	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grain panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
PGMS-4/Pecos	114.23	24.40	18.7	4.24	136.50	147.83	92.35	2.86	55.00
/V20R	103.83	24.70	23.8	4.27	112.48	151.83	62.60	2.90	47.68
/M202	111.20	24.50	20.4	4.04	120.48	160.78	74.95	3.00	46.32
/Dular	119.10	23.90	27.3	2.45	88.23	127.15	69.38	2.53	34.70
/GZ5310	108.00	23.70	25.5	2.21	148.43	181.60	81.73	2.64	38.22
/Norin PL9	109.25	23.70	22.4	4.05	135.25	164.45	82.25	2.75	53.67
/ Giza 178	97.25	24.40	25.2	4.46	183.08	190.53	96.10	2.47	62.06
PGMS-5/Pecos	121.85	24.20	23.6	4.61	133.08	175.88	75.68	2.75	55.53
/V20R	85.45	21.40	23.2	3.67	128.90	155.45	82.93	2.85	53.01
/M202	103.58	23.70	24.7	3.59	125.50	179.15	70.05	3.04	50.94
/Dular	131.83	28.40	20.8	5.09	178.38	186.58	95.60	2.97	67.69
/GZ5310	111.05	26.80	24.4	2.96	90.50	189.50	47.75	3.03	25.79
/Norin PL9	119.48	26.60	23.7	4.50	135.58	176.73	76.70	3.02	59.79
/ Giza 178	103.08	26.10	26.2	4.25	151.85	188.88	80.40	2.47	63.49
PGMS-7/Pecos	122.00	25.15	23.4	5.10	117.10	167.75	69.85	2.81	62.40
/V20R	88.00	20.40	22.7	1.50	99.95	124.13	80.53	3.16	20.54
/M202	108.13	20.35	23.2	3.86	127.80	162.78	78.50	2.90	52.64
/Dular	134.6	28.90	23.4	5.55	162.80	171.88	94.70	3.01	65.08
/GZ5310	107.55	26.00	22.5	3.52	102.10	143.90	70.98	2.65	40.12
/Norin PL9	111.65	22.70	21.4	3.55	101.28	135.18	74.93	2.73	40.36
/ Giza 178	106.70	25.90	24.7	4.14	136.18	167.75	81.18	2.38	55.71
PGMS-14/Pecos	107.08	25.70	21.2	4.37	112.33	144.03	78.00	2.59	51.19
/V20R	110.15	24.20	19.6	4.88	143.98	162.28	88.73	2.79	55.11
/M202	115.15	24.50	24.4	4.88	110.15	185.60	59.35	2.75	41.31
/Dular	123.3	18.50	20.8	3.22	160.50	168.68	95.15	2.06	47.66
/GZ5310	106.58	20.60	21.1	2.85	132.95	176.10	75.50	3.02	33.96
/Norin PL9	131.00	29.90	23.9	5.92	170.68	185.78	91.88	2.66	66.56
/ Giza 178	110.38	25.20	25.2	4.18	158.13	180.53	87.60	2.45	64.36

Table 3. Standard heterosis for nine characters of 42 hybrid combinations.

Hybrid combinations	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grain panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
PGMS-1/Pecos	29.38**	2.93^{ns}	-20.16**	3.24^{ns}	-6.78**	-9.85**	2.88*	19.63**	17.68**
/V20R	-2.81^{ns}	0.68^{ns}	-5.65^{ns}	-33.42**	3.94**	-36.23**	-4.96**	25.11**	-16.85**
/M202	2.81^{ns}	-5.64*	-25.81**	-11.47**	-3.09**	-20 13**	-13.43**	31.51**	-21.27**
/Dular	48.20**	30.47**	-19.76**	28.68**	-1.57^{ns}	-11.82**	11.59**	37.44**	34.42**
/GZ5310	21.63**	15.12**	-14.92**	-17.21**	-47.67**	-7.01**	-43.80**	17.81**	-45.06**
/Norin PL9	27.22**	7.45**	-21.77**	-29.68**	-44.62**	-15.13**	-34.78**	27.40**	-48.71**
/ Giza 178	20.03**	16.03**	0.81^{ns}	-31.17**	-32.50**	-8.51**	-26.22**	30.01**	-29.83**
PGMS-2/Pecos	-7.87**	5.64*	-22.98**	-3.74^{ns}	-7.97**	-11.78**	4.27**	18.72**	15.36**
/V20R	-4.91**	-3.39^{ns}	7.26*	-34.41**	-43.56**	-36.35**	-11.99**	34.25**	-25.75**
/M202	22.47**	2.03^{ns}	-28.2**3	-14.21**	-32.22**	-8.02**	-26.31**	38.81**	-37.38**
/Dular	53.20**	24.60**	-6.85*	21.94**	3.76**	-4.76**	8.93**	37.44**	39.94**
/GZ5310	20.22**	8.35**	-8.87**	-13.72**	-35.94**	8.45**	-40.95**	38.36**	-38.33**
/Norin PL9	26.69**	6.55*	-16.13**	-14.21**	-52.96**	-18.22**	-42.54**	38.36**	-44.25**
/ Giza 178	35.00**	13.77**	0.31^{ns}	-45.39**	16.75**	14.44**	1.73^{ns}	26.48**	20.75**
PGMS-4/Pecos	28.35**	10.16**	-24.60**	5.74^{ns}	-3.67**	-9.53**	6.46**	30.59**	18.03**
/V20R	16.67**	11.51**	-4.03^{ns}	6.48^{ns}	-20.62**	-7.08**	-27.84**	32.42**	2.32^{ns}
/M202	24.94**	10.61**	-17.74**	0.75^{ns}	-14.98**	-1.60^{ns}	-13.60**	36.99**	-0.60^{ns}
/Dular	33.82**	7.90**	10.08**	-38.90**	-37.73**	-22.18**	-20.02**	15.53**	25.54**
/GZ5310	21.35**	7.00**	2.82^{ns}	-44.89**	4.75**	11.14**	-5.84**	20.55**	-17.98**
/Norin PL9	22.75**	7.00**	-9.68**	1.00^{ns}	-4.55**	0.64^{ns}	-5.19**	25.57**	15.17**
/ Giza 178	9.27**	10.16**	1.61^{ns}	11.22**	29.21**	16.60**	10.78**	12.79**	33.18**
PGMS-5/Pecos	36.91**	9.26**	-4.84^{ns}	14.96**	-6.08**	7.64**	-12.76**	25.57**	19.16**
/V20R	-3.99*	-3.39^{ns}	-6.45^{ns}	-8.48*	-9.03**	-4.87**	-4.40**	30.01**	13.76**
/M202	16.38**	7.00**	-0.40^{ns}	-10.47**	-11.43**	9.64**	-9.25**	38.81**	9.31*
/Dular	48.12**	28.22**	24.19**	26.93**	25.89**	14.19**	10.20**	35.62**	45.26**
/GZ5310	24.78**	20.99**	-1.61^{ns}	-26.18**	-36.13**	15.97**	-44.96**	38.36**	-44.66**
/Norin PL9	34.25**	20.09**	-4.44^{ns}	12.22**	-4.32**	8.16**	-11.59**	37.90**	28.30**
/ Giza 178	15.82**	17.83**	5.65^{ns}	5.99^{ns}	7.16**	15.59**	-7.32**	12.79**	36.24**
PGMS-7/Pecos	37.08**	13.54**	-5.65^{ns}	27.18**	-17.36**	2.66^{ns}	-19.40**	28.31**	33.91**
/V20R	-1.12^{ns}	-7.90**	-8.47*	-62.59**	-29.46**	-24.03**	-7.17**	44.29**	-55.92**
/M202	21.49**	-8.13**	-6.45^{ns}	-3.74^{ns}	-9.81**	-0.38^{ns}	-9.51**	32.42**	12.96**
/Dular	51.24**	30.47**	-5.65^{ns}	38.40**	14.89**	5.19**	9.16**	37.44**	39.66**
/GZ5310	20.84**	17.38**	-9.27**	-12.22**	-27.95**	-11.93**	-18.18**	21.00**	-13.91**
/Norin PL9	25.45**	2.48^{ns}	-13.71**	-11.47**	-28.53**	-17.27**	-13.63**	24.66**	-13.39**
/ Giza 178	19.89**	16.93**	-0.40^{ns}	3.24^{ns}	-3.90**	2.66^{ns}	-6.42**	8.68**	19.55**
PGMS-14/Pecos	20.31**	16.03**	-14.52**	8.98*	-20.73**	-11.85**	-10.09**	18.26**	9.85*
/V20R	23.76**	9.26**	-20.97**	21.70**	1.61^{ns}	-0.69^{ns}	2.28^{ns}	27.40**	18.26**
/M202	29.38**	10.61**	-1.61^{ns}	21.70**	-22.27**	13.59**	-31.59**	25.57**	-11.35**
/Dular	38.54**	-16.48**	-16.13**	-19.70**	13.27**	3.23*	9.68**	39.73**	2.27^{ns}
/GZ5310	19.75**	-7.00**	-14.92**	-28.93**	-6.18**	7.77**	-12.97**	37.90**	-27.12**
/Norin PL9	47.19**	34.99**	-3.63^{ns}	47.63**	20.45**	13.69**	5.91**	21.46**	42.83**
/ Giza 178	24.02**	13.77**	1.61^{ns}	4.24^{ns}	11.59**	10.48**	0.98^{ns}	11.87**	38.11**
LSD 5%	**2.91**	**1.17**	**3.93**	**0.32**	**4.57**	**4.57**	**2.18**	**0.062**	**4.57**
1%	**3.83**	**1.53**	**5.17**	**0.42**	**6.00**	**6.00**	**2.87**	**0.081**	**6.00**

In the mean time, PTGMS-14 /Norin PL9 gave significant desirable SH% grain yield plant^{-1} (42.83%) with significant heterosis for panicle length (34.99%), panicle weight (47.63%), filled grain panicle^{-1} (20.45%), spikelets panicle^{-1} (13.69%), spikelets fertility% (5.91%) and 100-grain weight (21.46%). PTGMS-2 / Dular (39.94%) with significant SH% for panicle length (24.60%), panicle weight (21.94%), filled grains panicle^{-1} (3.76%), spikelet fertility% (8.93%), 100-grain weight (37.44%). Also, PTGMS-7 / Dular (39.66%) with significant SH% for panicle length (30.47%), panicle weight (38.40%), filled grains panicle^{-1} (14.89%), spikelets panicle^{-1} (5.19%), spikelet fertility% (9.16%) and 100-grain weight (37.44%). PTGMS-14 / Giza 178 (38.11%) gave significant SH% for panicle length (13.77%), filled grains panicle $^{-1}$ (11.59%), spikelets panicle $^{-1}$ (10.48%) and 100-grain weight (11.87%). However, PTGMS-5 / Giza 178 (36.24%) gave significant standard heterosis for panicle length (17.83%), filled grain panicle (7.16%), spikelets panicle^{-1} (15.59%) and 100-grain weight (12.79%). Singh et al. (1980), Kim and Rutger (1988), Devaraj and Nadarajan (1996), Mishra and Pandey (1998), El-Mowafi (2001), Attia (2003), El-Refai (2002) and El-Mowafi (2005) also observed negative and positive standard heterosis for these traits.

Analysis of Variance :

Analysis of variance (table4) revealed highly significant difference among the 55 genotypes (42 hybrids ,6PTGMS lines and 7 testers) tested for all nine studied characters . The parental lines and hybrids showe highly significant differences for all characters .Parents vs crosses mean square indicated that average heterosis was highly significant in all crosses for all studies characters under investigation except productive tillers plant $^{-1}$

The analysis of variance for combining ability given in table 4 revealed significant differences among PTGMS lines for productive tillers plant^{-1} ,filled grains panicle and spikelets panicle $^{-1}$. On the other hand the testers exhibited significant differences for all the characters except panicle weight .The highly significant mean squares of lines x 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 .The estimate of variance due to GCA was higher than that due to SCA for plant height and spikelets panicle^{-1} suggesting greater importance of additive genetic variance which is in agreement with the results of Sardane and Borthakur (1987),Lokaprakash et al .(1991),Attia(2001),El Refaee(2002),El-Mowafu and Abou-Shousha (2003) and El-Mowafi et al(2005).

In case of the rest of the characters preponderance of non-additive gene action was recorded by virtu of low GCA/SCA variance ratios in agreement to reports of Ram et al . (1991),Singh and Singh (1991) and El-Mowafi (2001)

General combining abillty effects (GCA):

Significanmt differences of GCA effects were observed among the PTGMS lines for the studied characters (Table 4).The PTGMS-5 was best combiner for panicle length, productive tillers plant^{-1}, panicle weight, filled grains panicle^{-1}, spikelets panicle^{-1}, 100-grain weight and grain yield plant^{-1}.

PTGMS-14 was best combiner for panicle weight, filled grains panicle^{-1}, spikelets panicle^{-1}, spikelet fertility % and grain yield plant^{-1}. PTGMS-4 was best combiner for plant height, filled grains panicle^{-1}, spikelets panicle^{-1} and spikelet fertility %. However, PTGMS-7 was best combiner for spikelet fertility% while, PTGMS-2 was best combiner for 100-grain weight.

Among the testers or male parents lines (Table 5), Giza 178 was the best general combiner for plant height, panicle length, productive tillers plant^{-1}, panicle weight, filled grains panicle^{-1}, spikelets panicle^{-1}, spikelet fertility and grain yield. The indica wide compatibility variety (WCV), Dular was best combiner for panicle length, productive tillers plant^{-1}, panicle weight, filled grains panicle^{-1}, spikelet fertility%, 100-grain weight and grain yield plant^{-1} and grain yield plant^{-1}. The Japonica WC variety Pecos was best general combiner for panicle weight , filled grains panicle^{-1} , spikelet fertility% and grain yield plant^{-1}. According to the ranking numbers of the GCA, the data in Table (7) showed that the female lines (PTGMS), PTGMS-5 , PTGMS-14 and PTGMS- 4 and also the male lines, Giza 178 Dular, Giza 178, M202 and Pecos were the best general combiners for the nine characters studied.

Specific combining ability effects(SCA):

The data of the SCA given in Table (6) revealed that there are some superior combinations that could be useful in the local breeding program to get good recombinants. With respect to plant height 16 hybrids showed significant effects in the desired direction for this trait. For panicle length, 11 hybrids had superior SCA effects, ??? for productive tillers plant^{-1}, 15 for panicle weight, 17 for filled grains panicle^{-1}, 16 for spikelets panicle^{-1}, 20 for spikelet fertility %, 15 for 100-grain weight and 23 hybrid combinations for grain yield plant^{-1} were superior in SCA effects for panicle length, panicle weight, filled grains panicle, spikelets panicle^{-1}, spikelet fertility% and grain yield plant^{-1}. It was followed by PTGMS-1 / Dular for panicle length, panicle weight, filled grains panicl^{-1}, spikelets panicle^{-1}, spikelet fertility%, 100-grain weight and grain yield plant^{-1}, then PTGMS-2 / Dular for panicle length, panicle weight, filled grains panicle^{-1}, spikelets panicle^{-1}, spikelet fertility% and grain yield plant^{-1},PTGMS-14 / V20R for panicle length, panicle weight, filled grains panicle^{-1}, spikelets panicle $^{-1}$, spikelet fertility % and grain yield plant^{-1}.

Genetic parameters:

The estimates of genetic parameters for the nine studied characters (Table 9) revealed that the additive variance (σ^2 A) and relative importance of GCA% for plant height and spikelets panicle^{-1} were graeter than dominance variance (σ^2 D) and relative importance of SCA, respectively for these characters. The results indicate that the former character were largely governed by additive gene action. The importance of the additive gene action for the inheritance of these characters was in agreement with the finding of Lakaprakash *et al.* (1991), Sharma and Koranne (1995), El-Mowafi (2001), Attia (2001), El-Refae (2002), El-Mowafi and Abou shosha (2003) and El-Mowafi *et al.*(2005).

Table (4) : Mean square estimates of ordinary analysis for nine studied characters.

Source of variation	d. f.	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grain panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
Replication	3	4.380^{ns}	0.550^{ns}	1.920^{ns}	0.021^{ns}	17.345^{ns}	2.964^{ns}	4.526^{ns}	0.002^{ns}	2.160^{ns}
Genotypes	54	1921.03**	39.361**	39.622**	6.094**	6780.813**	3579.509**	1795.313**	0.277**	918.589**
Parents	12	3019.54**	29.276**	83.548**	6.695**	10983.728**	3379.509**	4630.077**	0.270**	480.837**
Hybrids	41	636.27**	24.144**	27.705**	3.703**	3649.816**	2039.611**	774.137**	0.160**	764.266**
Parents VS crosses	1	41413.77**	784.269**	1.127^{ns}	96.893**	84716.693**	69891.141**	9646.367**	5.177**	12498.830**
Females (F)	5	168.52^{ns}	4.195^{ns}	56.038**	2.420^{ns}	6891.963*	6247.557**	356.238^{ns}	0.134^{ns}	862.945^{ns}
Males (M)	6	2999.69**	41.123*	59.012**	6.957^{ns}	7615.014**	3950.984**	2155.242**	0.436**	2105.522**
Females × Males (F × M)	30	241.55**	24.073**	16.721**	3.266**	2316.419**	956.013**	567.566**	0.109**	479.569**
Error	162	4.414	0.710	1.457	0.054	7.849	10.862	2.282	0.002	8.051
CV %		2.04	3.62	5.29	6.57	2.49	2.21	2.05	1.44	6.61

*, ** Significant at 0.05 and 0.01 levels respectively.

Table (5). Estimates of GCA effects of PTGMS lines for the nine characters.

Tester	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grains panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
PTGMS-1	-3.1845**	0.0119	-1.6667**	-0.3944**	-23.3512**	-21.0714**	-3.8631**	-0.0295*	-7.8527**
PTGMS-2	0.1726	-0.3095	-1.0238**	-0.0094	-12.3869**	-8.7500**	-3.7917**	0.1034**	-5.1920**
PTGMS-4	-1.7560**	-0.1667	0.4405	-0.2205**	8.0060**	3.1429**	2.6012**	-0.0770**	1.0769
PTGMS-5	0.1726	0.7619**	2.3690**	0.1992**	11.6488**	19.7500**	-1.6131**	0.0620**	6.7023**
PTGMS-7	0.5298	-0.1310	0.3690	-0.0087	-2.0298**	-5.7857**	1.7083**	-0.0084	0.9698
PTGMS-14	4.0655**	-0.1667	-0.4881	0.4338**	18.1131**	12.7143**	4.9583**	-0.0505**	4.2958**
LSD 5%	1.10	0.44	0.63	0.12	1.47	1.73	0.79	0.023	1.49
1%	1.45	0.58	0.83	0.16	1.93	2.27	1.04	0.031	1.95

* , ** Significant at 0.05 and 0.01 levels, respectively.

Table 6. Estimates of GCA effects of tester lines for the nine studied characters.

Tester	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grains panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
Pecos	3.8274**	-0.0179	-1.7738**	0.5398**	3.7500**	-4.6905**	5.4167**	-0.1071**	8.4200**
V20R	-17.7560**	-2.0179	-0.1488	-0.6252**	-16.6667**	-22.3571**	1.6667**	0.0808**	-5.5413**
M202	-4.2560**	-1.4762**	-1.3155**	-0.0039	-10.1667**	1.5179	-7.0000**	0.1245**	-4.3071**
Dular	18.7857**	1.5238**	1.4345**	0.4957**	22.9167**	-0.1071	13.7917**	0.1195**	10.0104**
GZ5310	-2.7143**	0.1905	0.0595	-0.8431**	-16.6667**	10.8512**	-14.1250**	0.0129	-15.0804**
Norin PL9	5.4940**	0.7321**	-0.8988**	0.1677**	-8.3750**	-3.4821**	-5.3333**	0.0158	-2.1121**
Giza 178	-3.3810**	1.0655**	2.6429**	0.2690**	25.2083**	18.2679**	5.5833**	-0.2463**	8.6104**
LSD 5%	1.189	0.48	0.683	0.131	1.585	1.867	0.821	0.0253	1.605
1%	1.562	0.63	0.898	0.172	2.083	2.451	1.079	0.0333	2.110

* , ** Significant at 0.05 and 0.01 levels, respectively.

Table (7): Ranks of lines and testers for the nine studied characters.

Genotype	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grains panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility %	100-grin weight (g)	Grain yield Plant^{-1}	Total	Ranks
PTGMS (female)											
PTGMS-1	1	2	6	6	6	6	6	4	6	37	5
PTGMS-2	3	6	5	4	5	5	5	1	5	39	6
PTGMS-4	2	4	2	5	3	3	2	6	3	30	3
PTGMS-5	3	1	1	2	2	1	4	2	1	17	1
PTGMS-7	5	3	3	3	4	4	3	3	4	32	4
PTGMS-14	6	5	4	1	1	2	1	5	2	27	2
Restorer lines (male)											
Pecos	5	5	7	1	3	6	3	6	3	39	3
V20R	1	7	4	6	6	7	4	3	6	44	5
M202	2	6	6	5	5	3	6	1	5	39	3
Dular	7	1	2	2	2	4	1	2	1	20	1
GZ5310	4	4	3	7	6	2	7	5	7	45	6
Norin PL9	6	3	5	4	4	5	5	4	4	40	4
Giza 178	3	2	1	3	1	1	2	7	2	22	2

Tester	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grains panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
PGMS-1/Pecos	3.60119*	-1.30357*	0.41667	0.09732	28.39286**	13.90476**	11.15476**	-0.05429	7.11607**
/V20R	-3.31548*	-0.05357	2.29167**	-0.21018	-2.44048	-11.42857**	7.40476**	-0.11970**	4.98982*
/M202	-11.81548**	-1.84524**	-1.299167	0.05357	8.30952**	-9.05357**	8.82143**	-0.02345	1.69815
/Dular	5.39286**	3.15476**	-2.79167**	1.15899**	16.72619**	6.32143**	9.52976**	0.11155**	13.32565**
/GZ5310	3.39286*	0.98810	0.08333	0.66274**	-8.94048**	2.86310	-10.3036**	-0.21679**	1.37649
/Norin PL9	0.18452	-1.30357*	-0.70833	-0.75310**	-12.7321**	4.19643	-11.5952**	-0.01220	-13.2919**
/ Giza 178	2.55952	0.36310	2.00000**	-1.00935**	-29.3155**	-6.80357**	-15.0119**	0.31488**	-15.2144**
PGMS-2/Pecos	-7.75595**	-0.73214	-0.72619	-0.27018	15.67857**	-1.41667	11.58333**	-0.20964**	3.37536
/V20R	-8.67262**	-0.73214	1.39881	-0.63518**	-14.4048**	-23.00000**	1.08333	-0.05756	-1.82089
/M202	2.32738	0.22619	-2.68452**	-0.44643**	-4.65476*	-1.62500	-2.50000*	0.00369	-8.47256**
/Dular	6.53571**	2.22619**	0.06548	0.50649**	13.01190**	5.25000*	7.45833*	-0.02881	13.23744**
/GZ5310	-1.21429	0.05952	0.69048	0.42024*	-3.40476	15.79167**	-8.12500**	0.10036**	1.85827
/Norin PL9	-3.67262*	-1.23214*	-0.10119	-0.61310**	-35.4464**	-13.62500**	-18.4166**	0.09494**	-13.8726**
/ Giza 178	12.45238**	0.18452	1.35714	1.03815**	29.22024**	18.62500**	8.91667**	0.09702**	5.69494**
PGMS-4/Pecos	1.42262	0.12500	-2.69048**	0.02839	1.78571	-9.80952**	6.94048**	0.23071**	-1.66857
/V20R	12.50595**	2.62500**	0.68452	1.22339**	-8.79762**	28.85714**	-19.0595**	0.08530**	4.97018*
/M202	6.50595**	1.83333**	-1.64881	0.36964*	-0.29762	-8.26786**	2.10714	0.13655**	2.39351
/Dular	-8.53571**	-1.66667**	2.60119**	-1.72244**	-65.8809**	-34.89286**	-24.4345**	-0.32595**	-23.5365**
/GZ5310	1.71429	-0.83333	1.97619*	-0.62619**	33.95238**	8.39881**	15.98214**	-0.10929**	5.07435*
/Norin PL9	-5.24405**	-1.12500	-0.06548	0.20798	12.66071**	5.48214*	7.69048**	-0.0020	7.54851**
/ Giza 178	-8.36905**	-0.95833	-0.85714	0.51923**	26.57738**	10.23214**	10.77381**	-0.01512	5.21851**
PGMS-5/Pecos	7.24405**	-0.80357	0.13095	-0.02875	-5.35714**	1.58333	-5.09524**	-0.01821	-6.00143**
/V20R	-7.67262**	-2.05357**	-1.74405*	0.20375	10.80952**	-1.00000	5.65476**	-0.10863**	4.69982*
/M202	-3.17262*	0.15476	0.67262	-0.50250**	0.55952	-1.12500	1.32143	0.04262	1.38815
/Dular	2.03571	0.15476	4.17262**	0.49792**	20.72619**	7.75000**	6.27976**	-0.02488	3.82565
/GZ5310	2.78571	1.73810**	-0.95238	-0.29333	-27.6905**	-0.20833	-13.5536**	0.13929**	-12.9810**
/Norin PL9	3.07738*	0.94643	0.74405	0.23583	9.01786**	1.37500	6.15476**	0.12887**	8.04315**
/ Giza 178	-4.29762**	-0.13690	-1.53571	-0.11292	-8.06548**	-8.37500**	-0.76190	-0.15905**	1.02565
PGMS-7/Pecos	7.13690**	1.08929	2.38095**	0.66911**	-7.92857**	18.86905**	-14.6667**	0.11464**	5.86107**
/V20R	-5.77976**	-1.91071**	0.00595	-1.76089**	-4.51190*	-6.46429**	-0.16667	0.25173**	-22.0377**
/M202	1.22024	-2.20238**	1.42262	-0.02464	16.98810**	7.91071**	6.50000**	-0.02702	8.82815**
/Dular	4.67857**	3.29762**	-1.32738	1.16577**	18.90476**	18.53571**	2.20833*	0.08798**	6.94565**
/GZ5310	-1.07143	1.63095**	-0.45238	0.47202**	-2.26190	-20.17262**	8.37500**	-0.16286**	7.07899**
/Norin PL9	-5.02976**	-2.41071**	-0.99405	-0.50131**	-11.3036**	-14.83929**	1.08333	-0.08827**	-5.64935**
/ Giza 178	-1.15476	0.50595	-1.03571	-0.02006	-9.88690**	-3.83929	-3.33333**	-0.17619**	-1.02685
PGMS-14/Pecos	-11.64881**	1.62500**	0.48810	-0.49589**	-32.5714**	-23.13095**	-9.91667**	-0.06321*	-8.68250**
/V20R	12.93452**	2.12500**	-2.63690**	1.17911**	19.34524**	13.03571**	5.08333**	-0.05113	9.19875**
/M202	4.93452**	1.83333**	3.52976**	0.55036**	-20.9048**	12.16071**	-16.2500**	-0.13238**	-5.83542**
/Dular	-10.10714**	-7.16667**	-2.72024**	-1.60673**	-3.48810	-2.96429	-1.04167	0.18012**	-13.7979**
/GZ5310	-5.60714**	-3.58333**	-1.34524	-0.63548**	8.34524**	-6.67262**	7.62500**	0.24929**	-2.40.708
/Norin PL9	10.68452**	5.12500**	2.61310**	1.42369**	37.80357**	17.41071**	15.08333**	-0.12113**	17.22208**
/ Giza 178	-1.19048	0.04167	0.07143	-0.41506*	-8.52976**	-9.83929**	-0.58333	-0.06155	4.30208*
LSD 0.05	2.911	1.168	1.673	0.322	3.883	4.568	2.094	0.0620	3.932
0.01	3.803	1.535	2.199	0.423	5.103	6.003	2.752	0.0815	5.168

* , ** Significant at 0.05 and 0.01 levels, respectively.

Table 9. Genetic parameters for nine studied characters..

Parameter	Plant height (cm)	Panicle length (cm)	Productive tillers plant^{-1}	Panicle weight (g)	Filled grain panicle^{-1}	Spikelets panicle^{-1}	Spikelet fertility%	100-grin weight (g)	Grain yield Plant^{-1}
Additive variance (σ^2 A)	112.31	0.0005	3.17	0.184	384.20	313.40	57.48	0.02	81.44
Dominant variance (σ^2 D)	59.28	5.841	3.82	0.803	577.14	236.29	142.07	0.03	117.88
Environmental variance (σ^2 E)	4.41	0.710	1.46	0.054	7.85	10.86	2.48	0.002	8.05
Genotypic variance (σ^2 G)	176.01	5.841	6.98	0.987	961.34	549.69	199.59	0.04	199.32
Phenotypic variance (σ^2 P)	171.60	6.551	8.44	1.041	969.19	560.55	202.02	0.04	207.37
Broad sense heritability (h^2_b) %	97.49	89.162	82.74	94.812	99.19	98.06	98.77	95.38	96.12
Narrow sense heritability (h^2_n) %	63.81	00.745	37.52	17.676	39.64	55.91	28.45	33.55	39.27
Relative importance of gca %*	65.45	00.008	45.35	18.643	39.96	57.01	28.80	35.18	10.86
Relative importance of sca %**	34.55	99.992	54.65	81.136	60.04	42.99	71.20	64.82	89.14

* , ** Relative importance gca = σ^2 A / σ^2 G x 100 and Relative importance sca = σ^2 D / σ^2 G x 100, respectively.

On the other hand, high estimates of dominance genetic variance and its relative magnitude of SCA% were found to be more than those of the characters, such as panicle length, productive tillers plant^{-1}, panicle weight, filled grains panicle^{-1}, spikelet fertility%, 100-grain weight and grain yield plant^{-1}. These results indicate that dominance variance played a major role in the inheritance of these characters which are in general agreement with the results reported by Ramalingram *et al.*(1997) and El-Mowafi *et al.*(2005) .

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دراسات وراثية علي العقم الذكرى الوراثى البيئى (PTGMS) واستخدامه في برامج تربية الارز.

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أجري هذا البحث بغرض دراسة إمكانية استغلال قوة الهجين في الأرز باستخدام نظام السلالتين(العقم الوراثي البيئي) وذلك باستخدام تحليل السلالة X الكشاف لستة سلالات عقيمة ذكريا استخدمت كآباء مؤنثة وسبعة أصناف وسلالات مصرية معيدة للخصوبة (Restorers) وتمت دراسة قوة الهجين القياسيه مقارنة بالصنف الاعلي محصولا من الآباء المصرية والمستخدم كصنف تجاري (جيزه ١٧٨) كما تمت دراسة القدرة علي الائتلاف والارتباط بين قوة الهجين وكلا من القدرة العامه علي الائتلاف والقدرة الخاصه علي الائتلاف لكلا الأبوين الداخلين في الهجين وكذا دراسة فعل الجين لإمكانية متابعة التربية والانتخاب لهجن تستخدم في الأجيال الانعزالية المتقدمة لتحسين السلالات الأبوية في الصفات المرغوبة.

وقد أوضحت الدراسة أن التركيبة الهجينية PTGMS-5 / Dular (45.26%) كانت ممتازة في المحصول (٤٢,٢٦%) وقد أعطت معنوية عالية في صفات طول السنبلة(٢٨,٢٢%) ، عدد السنابل في النبات (٢٤,١٩%) ، وزن السنبلة (٢٦,٢٣%) ، عدد الحبوب في السنبلة (٢٥,٨٩%) ، عدد السنيبلات (١٤,١٩%) ، نسبة الخصوبة (١٠,٢٠%) و وزن المائة حبة (٣٥,٦٢%).

وقد أظهرت الدراسة انه هناك أربعة هجن مبشرة وهي

PTGMS-14 / Norin PL9, PTGMS-7 / Dular, PTGMS-14 / Giza 178 and PTGMS-5 / Giza 178.

كما أظهرت الدراسة انه من بين ستة سلالات PTGMS كانت السلالات PTGMS-5 و PTGMS-14 هي الأفضل في قدرتها العامه علي الائتلاف لمحصول الحبوب وكل الصفات الرئيسية في حين كانت الأصناف Dular, Giza 178, M202 و Pecos أحسن الأصناف المعيدة للخصوبة في قدرتها العامة علي الائتلاف في صفة المحصول ومعظم الصفات الرئيسية.