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Estimation of Gene Action and Variance Components of Some Reproductive Traits of Rice (*Oryza sativa L*) Through Line x Tester Analysis

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Abstract

Twenty one parents (five cm S lines and sixteen Restorer lines) were considered for through line x tester analysis to study gene action and combining ability effects of developedcmS and restorer lines. Experiment was carried out at the experimental farm, Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh in Boro 2011-12 following RCBD design in three replications. Significant genotypic variances for yield related traits indicated that there were significant variations among the genotypes. Significant gca variances along with additive variance component for reproductive traits indicated the accessibility of additive gene action. Degree of dominance were found negative for most of traits which reveals that regression lines passing below the origin i.e., this character are responsible for over dominance. The linear non-significant relationship between female vs male indicates the reliability of the crosses to go through heterosis breeding. The contributions of lines were found significant indicating preponderance of dominant genes among the lines with tester. The significant interaction of line x tester indicated higher estimates for sca variances. Four restorer lines showed significant negative effects for days to 1st flowering, 80% flowering and days to maturity. Three pollen parents and onecmS line, showed significant positive gca effects for pollen fertility while six pollen parents showed significant positive effects for spikelet's fertility but two pollen parents showed significant positive gca effects for both panicle and stigma exertion rate. The estimated of gca effects of parents indicated that five pollen parents contributed highly significant negative effects for plant height which were responsible for dwarfing character. Fifteen crosses showed significant negative sca estimates for days to first flowering, sixteen crosses for days to 80% flowering and twenty crosses for days to maturity. Among 80 crosses fifty two crosses showed significant positive sca effects along with above average perse performances for grain yield.

Keywords: General combining ability; Specific combining ability; gca effects; sca effects; *Perse* performances

Introduction

Combining ability analysis is one of the powerful available evaluation tools to estimate the combining ability variance and effects for selecting the desirable parents and crosses for exploitation of heterosis. Combining ability variance is usually used for estimate of genetic control of a specific trait .The estimates of additive and non-additive gene action through this technique may be useful in determining the possibility of commercial exploitation of heterosis and isolation of pure line. Hybrid rice offers an opportunity to boost the yield potential of rice. It has a yield advantage of 15-20% over conventional high-yielding varieties. Hybrid rice research now concentrates on the conversion and identification of stable local cytoplasmic male sterile (CMS) lines and effective restorers from local elite lines through repeated backcrossing. To exploit maximum heterosis using male sterility system in hybrid breeding program, we must know the combining ability of different male sterile and restorer lines. The development and use of hybrid rice varieties on commercial scale utilizing cm S fertility restoration system has proved to be one of the mile stones in the history of rice improvement. General combiining ability effect is used to select the desirable parents to be used in crosses. Selection of heterotic hybrid depends on expected level of heterosis as well as the specific combining ability effect. Combining ability is a powerful tool in identifying the best combiners that may be used in crosses either to exploit heterosis or to accumulate fixable genes and obtain desirable segregates that helps to understand the genetic architecture of various characters that enable the breeder to design effective breeding plan for future up-gradation of the existing materials. Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability. In breeding high yielding varieties of crop plant, the breeders often face with the problem of selecting parents and crosses. Line x tester analysis provides information about general combining ability (gca) effects of parents and is helpful in estimating various types of gene actions. [1-3] Therefore, the present investigation was carried out to estimate combining ability effects for yield components involving cm S and restorer lines. Considering the above idea the present investigation was undertaken

1. To determine the extent of general combining ability variances in some morpho-reproductive strains for selection of suitable parents.
2. To determine the extent of specific combining ability effects and *perse* performances in some morpho-reproductive trains for selection of suitable parents.

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Material and methods

To study combining ability effects of developedcmS and restorer lines an experiment was carried out at the experimental farm, Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during Aman and Boro following RCBD design in three replications. Five knowncmS lines and sixteen developed R-lines were considered for through line x tester analysis. Analysis of variance for general and specific combining ability (gca and sca) were estimated according to line x tester method [4] Five female parents i.e., IR 58025A, BRRI 1A, GAN46A, IR 68888A and IR 62820A and sixteen male parents i.e., RG-BU08-001R, RG-BU08-002R, RG-BU08-005R, RG-BU08-006R, RG-BU08-007R, RG-BU08-013R, RG-BU08-016R, RG-BU08-018R, RG-BU08-025R, RG-BU08-034R, RG-BU08-038R, RG-BU08-046R, RG-BU08-057R, RG-BU08-063R, RG-BU08-097R and RG-BU08-105R were used in the experiment. Data were collected from 10 hills of each genotype on 10 randomly selected individual plant basis were plant height, days to 1st flowering, days to 80% flowering, days to maturity and grain yield (ton/ha). Data obtained for each character was subjected to the analysis of variance following three replicated randomized complete block design by using GENSTAT program.

Results and Discussions

Results from combined ANOVA

Plant height is considered as an important character to select a hybrid. Highly significant variances were found for male (2694.95**), female (1381.70**) and parents (529.05*) indicating the contribution of male, female and parents. The linear non-significant relationship between female vs male (56532.15 ns) indicates the reliability of the crosses to go through heterosis breeding. Significant contribution of female in hybrid (3191.60**) was estimated followed by male in hybrid (3139.24**). While parent vs hybrid (646.91**) was found highly significant. Observed significant differences between parents and hybrids. Significant gca variances along with additive variance component (12.82*) indicates the accessibility of additive gene action .Degree of dominance (0.40937) was found negative which reveals that regression lines passing below the origin i.e. this character is responsible for over dominance (Table 1). The progenies also found the

Sl no	Parents/F_1s	Status	Sl no	Parents/F_1s	Status
1	RG-BU 08-001 (RG-BU 08-001 R)	Male Parent (Tester)	17	IR 58025A	Female Parent (Line)
2	RG-BU 08-002 (RG-BU 08-002 R)	Male Parent (Tester)	18	GAN 46 A	Female Parent (Line)
3	RG-BU 08-005 (RG-BU 08-003 R)	Male Parent (Tester)	19	IR 62829A	Female Parent (Line)
4	RG-BU 08-006 (RG-BU 08-004 R)	Male Parent (Tester)	20	IR 68888A	Female Parent (Line)
5	RG-BU 08-007 (RG-BU 08-005 R)	Male Parent (Tester)	21	BRRI 1 A	Female Parent (Line)
6	RG-BU 08-013 (RG-BU 08-006 R)	Male Parent (Tester)			
7	RG-BU 08-016 (RG-BU 08-007 R)	Male Parent (Tester)			
8	RG-BU 08-018 (RG-BU 08-008 R)	Male Parent (Tester)			
9	RG-BU 08-025 (RG-BU 08-009 R)	Male Parent (Tester)			
10	RG-BU 08-034 (RG-BU 08-010 R)	Male Parent (Tester)			
11	RG-BU 08-038 (RG-BU 08-011 R)	Male Parent (Tester)			
12	RG-BU 08-046 (RG-BU 08-012 R)	Male Parent (Tester)			
13	RG-BU 08-057 (RG-BU 08-013 R)	Male Parent (Tester)			
14	RG-BU 08-063 (RG-BU 08-014 R)	Male Parent (Tester)			
15	RG-BU 08-097 (RG-BU 08-015 R)	Male Parent (Tester)			
16	RG-BU 08-105 (RG-BU 08-016 R)	Male Parent (Tester)			

And eighty crosses from these parents in winter 2011-12, and winter 2012-13.

Sl	Crosses (F_1s)	Sl	Crosses (F_1s)	Sl	Crosses (F_1s)	Sl	Crosses (F_1s)
1	IR 58025A × RG-BU08-001R	21	GAN 46A × RG-BU08-007R	41	BRRI 1A× RG-BU08-025R	61	IR 68888A× RG-BU08-057R
2	IR 58025A × RG-BU08-002R	22	GAN 46A × RG-BU08-013R	42	BRRI 1A× RG-BU08-034R	62	IR 68888A× RG-BU08-063R
3	IR 58025A × RG-BU08-005R	23	GAN 46A × RG-BU08-016R	43	BRRI 1A× RG-BU08-038R	63	IR 68888A× RG-BU08-097R
4	IR 58025A × RG-BU08-006R	24	GAN 46A × RG-BU08-018R	44	BRRI 1A× RG-BU08-046R	64	IR 68888A× RG-BU08-105R
5	IR 58025A × RG-BU08-007R	25	GAN 46A × RG-BU08-025R	45	BRRI 1A× RG-BU08-057R	65	IR 62829A× RG-BU08-001R
6	IR 58025A × RG-BU08-013R	26	GAN 46A × RG-BU08-034R	46	BRRI 1A× RG-BU08-063R	66	IR 62829A× RG-BU08-002R
7	IR 58025A × RG-BU08-016R	27	GAN 46A × RG-BU08-038R	47	BRRI 1A× RG-BU08-097R	67	IR 62829A× RG-BU08-005R
8	IR 58025A × RG-BU08-018R	28	GAN 46A × RG-BU08-046R	48	BRRI 1A× RG-BU08-105R	68	IR 62829A× RG-BU08-006R
9	IR 58025A × RG-BU08-025R	29	GAN 46A × RG-BU08-057R	49	IR 68888A× RG-BU08-001R	69	IR 62829A× RG-BU08-007R
10	IR 58025A × RG-BU08-034R	30	GAN 46A × RG-BU08-063R	50	IR 68888A× RG-BU08-002R	70	IR 62829A× RG-BU08-013R
11	IR 58025A × RG-BU08-038R	31	GAN 46A × RG-BU08-097R	51	IR 68888A× RG-BU08-005R	71	IR 62829A× RG-BU08-016R
12	IR 58025A × RG-BU08-046R	32	GAN 46A × RG-BU08-105R	52	IR 68888A × RG-BU08-006R	72	IR 62829A× RG-BU08-018R
13	IR 58025A × RG-BU08-057R	33	BRRI 1ª × RG-BU08-001R	53	IR 68888A × RG-BU08-007R	73	IR 62829A × RG-BU08-025R
14	IR 58025A × RG-BU08-063R	34	BRRI 1ª × RG-BU08-002R	54	IR 68888A × RG-BU08-013R	74	IR 62829A × RG-BU08-034R
15	IR 58025A × RG-BU08-097R	35	BRRI 1ª × RG-BU08-005R	55	IR 68888A × RG-BU08-016R	75	IR 62829A × RG-BU08-038R
16	IR 58025A × RG-BU08-105R	36	BRRI 1ª × RG-BU08-006R	56	IR 68888A × RG-BU08-018R	76	IR 62829A × RG-BU08-046R
17	GAN 46A × RG-BU08-001R	37	BRRI 1ª × RG-BU08-007R	57	IR 68888A × RG-BU08-025R	77	IR 62829A × RG-BU08-057R
18	GAN 46A × RG-BU08-002R	38	BRRI 1ª × RG-BU08-013R	58	IR 68888A × RG-BU08-034R	78	IR 62829A × RG-BU08-063R
19	GAN 46A × RG-BU08-005R	39	BRRI 1ª × RG-BU08-016R	59	IR 68888A × RG-BU08-038R	79	IR 62829A × RG-BU08-097R
20	GAN 46A × RG-BU08-006R	40	BRRI 1ª × RG-BU08-018R	60	IR 68888A × RG-BU08-046R	80	IR 62829A × RG-BU08-105R

Table 1: List of parental lines (five CMS and sixteen restorer lines).

similar contribution of lines was found significant (13.77**) indicating preponderance of fertile genes among the lines followed by (3.73*) with tester for plant height. The interaction of line x tester was found significant (82.50**) that indicated higher estimates for variances among the preponderance of non-additive gene action. Significant genotypic variances for days to first (310.49**) flowering, days to 80% flowering (3937.62**) and days to maturity (4501.57**) indicates that there is signicant variations among the genotypes. But significant negative variances parents of these traits; days to first (-47.52**) flowering, days to 80% flowering (-602.70**) and days to maturity (-602.70**) indicates that short duration materials are present among these parents. Like parents, significant negative variances were also recorded for female parents for these traits but significant positive variances were recorded for male parents which indicate that restorer lines are mostly long duration materials. The linear non-significant relationship between female vs male (-9704.37, -69886.36 and -82993.74) indicates the reliability of these traits to go through heterosis breeding. While parent vs hybrid (11605.32**, 93994.24** and 110554.38**) were found highly significant. [5, 6] has observed significant differences between parents and hybrids. Significant negative gca variances (-6.455*, -40.556** and -38.864**) along with negative additive variance component (-1.614*, -10.139* and -9.716*) indicates the accessibility of additive gene action towards short duration parents. Like gca variance (∂^2 gca) significant negative sca (∂^2) variances were also recorded -61.427**, -137.922**and -164.943**) along with significant negative dominant variance component (-24.857**, -36.481**and-41.736**) indicates the accessibility of dominant gene action towards short duration hybrids among these 80 cross combinations. Degree of dominance (-0.2779, -0.2964 and -0.40937) were found negative which reveals that regression lines passing below the origin i.e., these characters are responsible for over dominance. Yield is considered as the most important character to select any hybrid. The analysis of variances due to genotypes showed a highly significance (6.85**) indicating a wide range of variability for grain yield highly significant variances for male (8.21**), female (2.79**) and parents (11.01**) indicating equal contribution of male, female and parents which might lead to a wide range of variability among the offspring's. The linear non-significant relationship between female vs male (132.07 ^{ns}) indicates the reliability of the parents to go through heterosis breeding. Non-significant contribution of female in hybrid (1.78 ^{ns}) indicates there is no significant differences between the female lines for grain yield. Significant contribution of male in hybrid (8.66**) was estimated followed by parents vs hybrid (7.29**) implies that there is a significant difference between parents and hybrids. These results were supported [7,8] (Table 2).

Non-significant general combining ability variances (0.069 ^{ns}) reveals that grain yield was not controlled by the additive gene but highly significant specific combining ability variances (1.390**) were observed which reveals that this character is completely controlled by the dominant gene action. The result was completely supported by non-significant additive variance (0.017 ^{ns}) and significant dominant genetic variance (0.848*). While selection of suitable cross combination might be done on the basis of significant specific combining ability variances along with dominance variance. Observed that gca and sca variances were highly significant for yield and the yield attributing characters which indicated the importance of both additive and non-additive gene action. Degree of dominance (0.020) was found near zero which reveals that this character is responsible for complete dominance. conducted experiments on combining ability using eight lines and four testers in rice and observed non-additive gene action governing the characters. While non-significant (1.24^{ns}) error sum squares of tester indicates no significant deviations among the testers. Reported highly significant variance for combining ability in different characters among lines, testers and line x tester interactions. In fact, five recognized cm S (Cytoplasmic male sterile) lines were used as testers and among the cm S-lines there was no significant difference for pollen fertility and spikelet fertility. The interaction of line x tester was found significant (76.26**) that indicated higher estimates for variances due to dominant gene action [9-12].

Estimation of general combining ability (GCA) effects

The general combining ability effects of the parents in the present

Source of Variation		df	Plant height (cm)	Days first flowering	Days 80 % flowering	Days to maturity	Yield (t/ha)
Replication	r-1	2	529054.36	47523.73	602697.02	689015.99	1007.38
Genotypes	g-1	100	3456.49**	310.49**	3937.62**	4501.57**	6.58**
Parents	p-1	20	529.05**	-47.52**	-602.70**	-689.02**	11.01**
females (f)	f-1	4	1381.70**	449.59**	2580.82**	3216.64**	-2.79**
males (m)	m-1	15	2694.95**	-463.70**	-3167.27**	-4521.46**	8.21**
f vs m	1	1	56532.15	-9704.37	-69886.36	-82993.74	-132.07
Hybrids (c)	c-1	79	3525.77**	-258.15**	-3947.11**	-4473.208**	6.40**
female in hybrids (fh)	f-1	4	3191.60**	546.79**	4472.00**	5324.35**	1.78 ^{ns}
male in hybrid (mh)	m-1	15	3139.24**	475.99**	3702.70**	4370.63**	8.66**
fh x mh (Line×Testers)	(f-1)(m-1)	60	4703.29**	317.74**	5304.04**	6013.42**	76.29**
Parents vs hybrids	1	1	77694.32**	11605.32**	93994.24**	110554.38**	172.36**
Error	(e-1)(r-1)	200	724.45	65.08	825.29	943.49	1.38
Total	cr-1	239	1058108.72	95047.47	1205394.05	1378031.99	2014.76
Variance components							
∂^2 gca			-51.26*	-6.455*	-40.556**	-38.864**	0.068
∂^2 sca			125.22**	-61.427**	-137.922**	-164.943**	1.390**
∂^2A			12.82*	-1.614*	-10.139*	-9.716*	-0.017 ^{ns}
∂^2 D			31.31**	-24.857**	-36.481**	-41.736**	0.848**
∂^2 gca / ∂^2sca			-0.40937	0.1051	-0.2941	-0.2356	-0.0497
∂^2A/∂^2D (Degree of dominance)			-0.2328	-0.2779	-0.2964	-0.40937	-0.0204

*p=0.05, **p=0.01 and ^{ns}=non-significant.

Table 2: Estimates of mean sum of squares for lines, testers, line x tester as well as variance components (additive, dominance and degree of dominance) in 80 F_1 hybrids and their parents.

study have brought to light the parents with high gca effects for five different traits. A total of 16 crosses were found having significant negative heterosis for plant height. Where three crosses of IR 58025A, three crosses of BRRI 1A, four crosses of GAN46A, two crosses of IR 68888A and four crosses of IR 62820A are significant negative heterosis for plant height. This result indicates that the following croosses are semi dwarf in nature. The crosses of IR58025A showed significant positive specific combining ability effects with RG-BU08-006R&RG-BU08-034R. As these crosses showed highly significant positive sca effects and above average *perse* performances, might not be selected as suitable hybrid. The crosses of GAN46A also found significant positive sca effects and above average *perse* performances with RG-BU08-007R, RG-BU08-018R & RG-BU08-105R. The crosses of IR68888A showed significant positive sca effects and above average *perse* performances with RG-BU08-002R, RG-BU08-006R, RG-BU 08-018R and RG-BU08-016R which can be considered as good specific combination for tallness. As the above crosses showed positive sca effects which could be used as above average combinations for tall stature. These results are in line with the findings of Good specific combinations for tallness were evolved from high × high, general combiner parents. Low × above average general combiner parents produced above average specific combination for tall plant height in rest of the crosses also found similar findings. Semi-dwarf plant height is needed to protect the crop from lodging. The estimated gca effects of parents indicated that the parent, RG-BU 08-001R, RG-BU 08-002R, RG-BU 08-0046R, RG-BU 08-0057R, RG-BU 08-0097R, BRRI 1A and IR62829A contributed highly significant negative effects .These facts indicated that the former parents possessed more negative alleles for the dwarf stature of the parents. *Perse* performance also supported that RG-BU 08-001R (89.03 cm), RG-BU 08-006R (96.72 cm), RG-BU 08-057R (90.39 cm), RG-BU 08-097R (81.39 cm) and BRRI 1A (90.59 cm) except RG-BU 08-002R (103.69 cm) and IR62829A (108.57cm)were dwarf in stature. Although general gca effects found significant negative but *perse* performances did not correlate with RG-BU 08-002R (103.69 cm) and IR62829A (108.57 cm) which might be due to pseudo recessive gene effect or wide environmental fluctuation. Therefore, RG-BU 08-001R, RG-BU 08-046R, RG-BU 08-057R, RG-BU 08-097R and BRRI 1A are potential parents and have highly significant gca effect in the desirable direction (negative direction) for plant height. These findings are in accordance with [13-16]. Out of sixteen restorer lines eight restorer lines showed significant negative effects for days to 1st flowering, seven showed significant negative effects for days to 80% flowering and five showed significant negative effects for days to maturity. But among these 16 restorer lines, only four showed significant negative gca effects for all these three traits. The restorer lines showing significant nigative gca effects for all three traits are RG-BU 08-005R (-7.43**, -6.847**, -7.590**), RG-BU 08-006R (-6.073**, -6.177**, -7.412**), RG-BU 08-007R (-3.743*, -5.057**, -7.564**), RG-BU 08-097R (-8.743**, -6.177**, -5.532**). Such lines could be used as male parent for development of early maturing hybrids in rice. performed line x tester analysis using five lines and four testers to study the combining ability and heterosis for yield and its contributing characters in rice and observed that IR58025A and IR62829A were good general combiners for earliness, grain yield per plant and per day productivity [17] (Table 3).

While estimating the life cycle of these fivecmS lines, it was observed that IR 62829A (-2.996**) showed significant negative effects for days to 1st flowering and IR 62829A (-3.224*) for days to 80% flowering while GAN 46A (-2.236**, -2.994**, -5.740**) showed significant negative effects for all three traits. Such estimates indicated that these female parents possessing more negative alleles for first flowering. *Perse*

Source of Variation	Plant height (cm)		Days first flowering		Days 80% flowering		Days to maturity		Yield (ton/ha)	
Lines	gi/gj	Mean	gi/gj	mean	gi/gj	Mean	gi/gj	Mean	gi/gj	Mean
IR 58025A	-0.466	89.02 ± 12.07	0.824	106.66 ± 1.12	-1.074	115.32 ± 3.06	-2.020	139.66 ± 2.45	0.074**	2.30 ± 0.04
IR 62829A	-2.797	90.59 ± 12.07	-2.996*	102.84 ± 1.12	-3.224*	113.17 ± 3.06	-0.170	141.51 ± 2.45	-0.154**	2.16 ± 0.04
GAN 46 A	6.905	93.81 ± 12.07	-2.236*	103.60 ± 1.12	-2.994*	113.40 ± 3.06	-5.740**	135.94 ± 2.45	0.016	2.32 ± 0.04
IR 68888A	0.194	107.73 ± 12.07	-0.706	105.13 ± 1.12	1.066	117.46 ± 3.06	2.660*	144.34 ± 2.45	0.346**	2.66 ± 0.04
BRRI 1 A	-3.836	108.57 ± 12.07	5.114**	110.95 ± 1.12	6.226**	112.62 ± 3.06	5.270**	146.95 ± 2.45	-0.184**	2.13 ± 0.04
SE (gi)		**12.074**		**1.129**		**2.085**		**2.455**		**0.023**
SE (gi - gj)		**30.185**		**2.222**		**3.711**		**3.387**		**0.057**
Testers										
RG-BU 08-001 R	-5.123**	89.03 ± 2.27	-2.403	103.01 ± 3.48	3.153*	117.67 ± 5.67	5.436**	146.34 ± 5.04	0.389	5.49 ± 0.784
RG-BU 08-002 R	-5.823**	103.69 ± 2.27	-4.743*	100.67 ± 3.48	-1.177	113.34 ± 5.67	1.106	142.01 ± 5.04	0.879**	5.98 ± 0.784
RG-BU 08-005 R	-1.788	99.40 ± 2.27	-7.743**	97.67 ± 3.48	-6.847**	107.67 ± 5.67	-7.590**	133.34 ± 5.04	0.439*	5.54 ± 0.784
RG-BU 08-006 R	12.536**	96.72 ± 2.27	-6.073**	99.34 ± 3.48	-6.177**	108.34 ± 5.67	-7.412**	133.37 ± 5.04	1.609*	6.71 ± 0.784
RG-BU 08-007 R	-1.394	136.52 ± 2.27	-3.743*	101.67 ± 3.48	-5.507*	109.01 ± 5.67	-7.564**	133.02 ± 5.04	0.449*	5.55 ± 0.784
RG-BU 08-013 R	-1.063	98.54 ± 2.27	4.098*	109.51 ± 3.48	1.653	116.17 ± 5.67	-1.064	139.84 ± 5.04	0.449*	5.55 ± 0.784
RG-BU 08-016 R	-0.188	99.23 ± 2.27	11.928**	117.34 ± 3.48	8.823**	123.34 ± 5.67	5.436**	146.34 ± 5.04	0.449*	5.55 ± 0.784
RG-BU 08-018 R	0.320	91.23 ± 2.27	4.598*	110.01 ± 3.48	4.153*	118.67 ± 5.67	0.106	141.01 ± 5.04	0.109	5.21 ± 0.784
RG-BU 08-025 R	0.511	86.79 ± 2.27	-3.743*	101.67 ± 3.48	-4.847*	109.67 ± 5.67	-2.564	138.34 ± 5.04	-2.141**	2.96 ± 0.784
RG-BU 08-034 R	10.682**	92.94 ± 2.27	11.258**	116.67 ± 3.48	6.493**	121.01 ± 5.67	-2.694	138.21 ± 5.04	0.909**	6.01 ± 0.784
RG-BU 08-038 R	0.199	96.11 ± 2.27	9.598**	115.01 ± 3.48	5.823**	120.34 ± 5.67	5.436**	146.34 ± 5.04	-0.431*	4.67 ± 0.784
RG-BU 08-046 R	-3.282*	96.13 ± 2.27	-9.073**	96.34 ± 3.48	-6.507**	108.01 ± 5.67	7.436**	148.34 ± 5.04	-0.341	4.76 ± 0.784
RG-BU 08-057 R	-7.027**	100.39 ± 2.27	-1.403	104.01 ± 3.48	-4.177*	110.34 ± 5.67	-7.564**	133.34 ± 5.04	-1.231**	3.87 ± 0.784
RG-BU 08-063 R	2.580*	87.41 ± 2.27	-6.073**	99.34 ± 3.48	-0.177	114.34 ± 5.67	-2.564	138.34 ± 5.04	-0.101	5.00 ± 0.784
RG-BU 08-097 R	-4.083*	81.39 ± 2.27	-8.743**	96.67 ± 3.48	-6.177**	108.34 ± 5.67	-5.532**	135.31 ± 5.04	-1.311**	3.79 ± 0.784
RG-BU 08-105 R	2.942*	97.95 ± 2.27	12.258**	117.67 ± 3.48	11.493**	126.01 ± 5.67	10.106**	151.01 ± 5.04	-0.121	4.98 ± 0.784
SE (gi)		**2.278**		**3.483**		**3.067**		**3.581**		**0.426**
SE (gi - gj)		**4.594**		**5.730**		**5.677**		**5.039**		**0.784**

*p= 0.05, **p= 0.01 and ns = Insignificant.

Table 3: GCA effects of parents for different yield and yield contributing character of rice.

Citation: Ariful Islam MD, Khaleque Mian MA, Golam Rasul, Khaliq QA, Mannan Akanda MA (2015) Estimation of Gene Action and Variance Components of Some Reproductive Traits of Rice (*Oryza sativa L*) Through Line x Tester Analysis. J Rice Res 3: 144. doi:10.4172/2375-4338.1000144

performances also recorded similar results supported parents RG-BU 08-005R (97.67, 107.07, 133.44 days), RG-BU 08-006R (99.34, 108.34, 133.47 days), RG-BU 08-007R (101.67, 109.01, 133.02 days), RG-BU08-097R (96.67, 108.34, 135.31 days) and GAN 46A (103.60, 113.40, 135.94 days). These facts indicated that the above parents possessed more negative alleles for the decreasing the life cycle. Compared to BRRI than29 of? these parents matured 27 ± 2 days earlier. So, RG-BU 08-005R, RG-BU 08-006R, RG-BU 08-007R and RG-BU 08-057R might be used in the heterosis breeding. As general combining ability (gca) effects found significant negative and their *perse* performances were comparatively lower; therefore, these parents might be used as suitable parents to develop short duration hybrid variety. These findings are in accordance with Won & Yoshida 2000 Significant positive gca effects was found in pollen parents RG-BU 08-002R (0.879**), RG-BU 08-005R (0.439*), RG-BU 08-006R (1.069**), RG-BU 08-007R (0.449*), RG-BU 08-013R (0.449*), RG-BU 08-016R (0.449*), RG-BU 08-034R (0.909**) and positive general combining ability effects ofcmS parents IR 58025A (0.074**) and IR 68888A (0.346**). *Perse* performances revealed that among 21 parents (16 pollen parents and 5cmS parents) seven pollen parents RG-BU 08-002R (5.98 t/ha), RG-BU 08-005R (5.54 t/ha), RG-BU 08-006R (6.71 t/ha), RG-BU 08-007R (5.55 t/ha), RG-BU 08-013R (5.55 t/ha), RG-BU 08-016R (5.55 t/ha), RG-BU 08-034R (6.01 t/ha) and 2 cmS lines IR 58025A (2.40 t/ha) and IR 68888A (2.66 t/ha) were superior to others. These facts indicated that among 21 parents these nine parents possessed more positive alleles for the increase of grain yield. Observed good general combinercmS lines for grain yield along with other yield contributing characters in rice. So, among the male parents, RG-BU 08-002R, RG-BU 08-005R, RG-BU 08-006R, RG-BU 08-007R, RG-BU 08-013R, RG-BU 08-016R and RG-BU 08-034R were the best general combiner due to highly significant positive gca effects. On the other hand RG-BU 08-025R (-2.141**, 2.96 t/ha), RG-BU 08-038R (-0.431*, 4.67 t/ha), RG-BU 08-046R (-0.341*, 4.76 t/ha), RG-BU 08-057R (-1.231*, 3.87 t/ha), and RG-BU 08-097R (-1.311*, 3.79 t/ha) as well ascmS parents IR 62829A (-0.154**, 2.16 t/ha) and BRRI 1A (-0.184**, 2.13 t/ha) showed highly significant negative general combining ability effects found similar results while studying gca effects in rice [18-20].

Estimation of specific combining ability (SCA) effects

The specific combining ability effects of the trait plant height is considered as an important character to select a hybrid. The crosses of IR58025A showed significant positive specific combining ability effects with RG-BU08-006R & RG-BU08-034R. As these crosses showed highly significant positive sca effects and above average *perse* performances, might not be selected as suitable hybrid. The crosses of GAN46A also found significant positive sca effects and above average *perse* performances with RG-BU08-007R, RG-BU08-018R & RG-BU08-105R. The crosses of IR68888A showed significant positive sca effects and above average *perse* performances with RG-BU08-002R, RG-BU08-006R, RG-BU 08-018R and RG-BU08-016R which can be considered as good specific combination for tallness. As the above crosses showed positive sca effects which could be used as above average combinations for tall stature. These results are in line with the findings of. Good specific combinations for tallness were evolved from high x high, general combiner parents. Low × above average general combiner parents produced above average specific combination for tall plant height in the rest of the crosses also found similar findings [13-15]. Out of 80 test crosses fifteen crosses showed significant negative sca estimates for days to first flowering and sixteen crosses showed significant negative sca estimates for days to 80% flowering. Out of 80 crosses twenty crosses showed significant negative sca estimates for days to maturity, where seven with IR 58025A, two with GAN46A, six with IR 62829A, two with IR 68888A and three with BRRI 1A. In all the cases it was observed that maximum number of crosses were found showing significant negative sca estimates with IR 58025A. The F_1s crosses of IR 58025A with seven restorer lines showed significant negative sca estimates for days to first flowering, 6 F_1s for days to 80% flowering and seven for days to maturity (Tables 4,5).

Line / Testers	Plant height									
	IR 58025A		**GAN 46A**		**IR 62829A**		**IR 68888A**		**BRRI 1A**	
	Sij effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	Mean
RG-BU 08-001 R	-4.98	98.79 ± 7.26	-4.28	99.49 ± 7.78	-9.95**	93.82 ± 7.85	-5.93*	92.84 ± 7.39	-3.45	107.32 ± 7.25
RG-BU 08-002 R	-5.50*	98.27 ± 7.26	-3.91	99.86 ± 7.78	-8.86**	94.91 ± 7.85	4.44	108.22 ± 7.39	-15.27**	88.50 ± 7.25
RG-BU 08-005 R	-2.74	101.03 ± 7.26	-7.50*	96.27 ± 7.78	6.60*	110.38 ± 7.85	-1.01	102.76 ± 7.39	-4.28	99.49 ± 7.25
RG-BU 08-006 R	10.71**	114.49 ± 7.26	1.59	105.37 ± 7.78	46.40**	150.18 ± 7.85	7.88**	111.66 ± 7.39	-3.91	99.86 ± 7.25
RG-BU 08-007 R	-0.34	103.43 ± 7.26	4.87	108.65 ± 7.78	-2.31	101.46 ± 7.85	-1.67	102.10 ± 7.39	-7.50*	96.27 ± 7.25
RG-BU 08-013 R	-3.49	100.28 ± 7.26	-15.64**	88.13 ± 7.78	12.34**	116.12 ± 7.85	-0.11	103.66 ± 7.39	1.59	105.37 ± 7.25
RG-BU 08-016 R	-0.74	103.03 ± 7.26	-3.54	100.23 ± 7.78	-3.47	100.30 ± 7.85	1.95	105.73 ± 7.39	4.87	108.65 ± 7.25
RG-BU 08-018 R	1.06	104.84 ± 7.26	4.76	108.54 ± 7.78	8.05**	111.83 ± 7.85	3.36	107.14 ± 7.39	-15.64**	88.13 ± 7.25
RG-BU 08-025 R	0.10	103.88 ± 7.26	-1.91	101.86 ± 7.78	5.37*	109.15 ± 7.85	2.53	106.31 ± 7.39	-3.54	100.23 ± 7.25
RG-BU 08-034 R	8.60**	112.38 ± 7.26	-1.75	102.02 ± 7.78	45.17**	148.95 ± 7.85	-3.38	100.39 ± 7.39	4.76	108.54 ± 7.25
RG-BU 08-038 R	-0.20	103.57 ± 7.26	-2.21	101.56 ± 7.78	9.04*	112.82 ± 7.85	-3.71	100.06 ± 7.39	-1.91	101.86 ± 7.25
RG-BU 08-046 R	-3.93	99.84 ± 7.26	-7.22	96.55 ± 7.78	-5.74*	98.03 ± 7.85	2.25	106.03 ± 7.39	-1.75	102.02 ± 7.25
RG-BU 08-057 R	-6.56*	97.21 ± 7.26	-4.25	99.52 ± 7.78	-17.54**	86.23 ± 7.85	-4.55	99.22 ± 7.39	-2.21	101.56 ± 7.25
RG-BU 08-063 R	1.71	105.49 ± 7.26	-2.62	101.15 ± 7.78	17.52**	121.30 ± 7.85	3.51	107.29 ± 7.39	-7.22*	96.55 ± 7.25
RG-BU 08-097 R	-5.38*	99.39 ± 7.26	-5.88*	97.89 ± 7.78	-5.66**	98.44 ± 7.85	-6.55*	97.22 ± 7.39	-4.25	99.52 ± 7.25
RG-BU 08-105 R	3.24	107.02 ± 7.26	4.78	108.56 ± 7.78	7.19*	110.97 ± 7.85	2.10	105.88 ± 7.39	-2.62	101.15 ± 7.25
Mean		103.31		100.98		110.68		103.97		99.94
***SE** (sij)*	3.113									
***SEd** (Sij-Sik)*	5.153									
***SEd** (Sij-Skj)*	7.561									
t = *Sij/SEI (Sij) at error df=239*										

*p=0.05, **p=0.01 and ^{ns}=non-significant.

Table 4: SCA effects (*Sij*) vis-à-vis *per-se* mean performance of hybrids for plant height (cm) in 80 F_1 hybrids.

Line / Testers	Days to first flowering									
	IR 58025A		**GAN 46A**		**IR 62829A**		**IR 68888A**		**BRRI 1A**	
	Sij effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	Mean
RG-BU 08-001 R	-4.214*	105.90 ± 2.63	4.450*	114.56 ± 3.63	0.12	114.56 ± 3.63	-5.54*	110.23 ± 3.63	4.450*	104.56 ± 3.63
RG-BU 08-002 R	-1.550	108.56 ± 2.63	0.340	110.45 ± 3.63	-0.88	110.45 ± 3.63	7.12*	109.23 ± 3.63	0.340	117.23 ± 3.63
RG-BU 08-005 R	-6.547*	103.56 ± 2.63	-0.880	109.23 ± 3.63	-1.88	109.23 ± 3.63	9.12*	108.23 ± 3.63	-0.880	119.23 ± 3.63
RG-BU 08-006 R	-8.650*	101.46 ± 3.63	0.570	110.68 ± 3.63	-4.88*	102.23 ± 3.63	-13.21**	107.23 ± 3.63	-17.880**	96.90 ± 3.63
RG-BU 08-007 R	2.340	112.45 ± 3.63	-5.880*	104.23 ± 3.63	-1.88	111.23 ± 3.63	3.12	108.23 ± 3.63	1.120	113.23 ± 3.63
RG-BU 08-013 R	-7.547*	102.56 ± 2.63	-3.214	106.90 ± 3.63	3.12	107.90 ± 3.63	3.12	113.23 ± 3.63	-2.214	113.23 ± 3.63
RG-BU 08-016 R	-9.547*	100.56 ± 2.63	-9.547*	100.56 ± 3.63	2.12	110.23 ± 3.63	6.13*	112.23 ± 3.63	0.120	116.23 ± 3.63
RG-BU 08-018 R	-7.880*	102.23 ± 2.63	-7.880*	102.23 ± 3.63	-1.88	113.56 ± 3.63	8.78*	108.23 ± 3.63	3.453	118.23 ± 3.63
RG-BU 08-025 R	-5.547*	104.56 ± 2.63	-5.547*	104.56 ± 3.63	0.12	120.23 ± 3.63	2.78	110.23 ± 3.63	10.120**	112.90 ± 3.63
RG-BU 08-034 R	-3.214	106.90 ± 2.63	-3.214	106.90 ± 3.63	1.12	113.23 ± 3.63	-1.21	111.23 ± 3.63	3.120	108.90 ± 3.63
RG-BU 08-038 R	-0.660	109.45 ± 2.63	-0.660	109.45 ± 3.63	2.12	113.23 ± 3.63	-2.54	112.23 ± 3.63	3.120	107.56 ± 3.63
RG-BU 08-046 R	-0.214	109.90 ± 2.63	-0.214	109.90 ± 3.63	0.12	116.23 ± 3.63	0.12	110.23 ± 3.63	6.120*	110.23 ± 3.63
RG-BU 08-057 R	3.120	113.23 ± 2.63	3.120	113.23 ± 3.63	-0.88	118.23 ± 3.63	-0.88	109.23 ± 3.63	8.120*	109.23 ± 3.63
RG-BU 08-063 R	2.453	112.56 ± 2.63	2.453	112.56 ± 3.63	5.12*	112.90 ± 3.63	-0.88	115.23 ± 3.63	2.786	109.23 ± 3.63
RG-BU 08-097 R	5.120*	115.23 ± 2.63	5.120*	115.23 ± 3.63	3.12	108.90 ± 3.63	5.19*	113.23 ± 3.63	-1.214	115.23 ± 3.63
RG-BU 08-105 R	1.453	111.56 ± 2.63	1.453	111.56 ± 3.63	2.12	107.56 ± 3.63	3.12	112.23 ± 3.63	-2.547	113.23 ± 3.63
Mean		107.54		108.89		111.87		110.67		111.58
***SE** (sij)*		4.126								
***SEd** (Sij-Sik)*		11.692								
***SEd** (Sij-Skj)*		13.205								
t = *Sij/SEI (Sij) at error df = 239*										

*p=0.05, **p=0.01 and ^{ns}=non-significant.

Table 5: SCA effects (*Sij*) vis-à-vis *per-se* mean performance of hybrids for days to first flowering in 80 F_1 hybrids.

Crosses of IR 58025A showed significant negative relationship for days to 1st flowering and 80% flowering with RG-BU08-005R (-6.547*, -6.827*, -6.407* and 103.56, 110.42, 137.15 days), RG-BU08-006R (-8.65*, -8.950**, -9.23** and 101.46, 108.30, 134.33 days), RG-BU08-013R (-7.54*, -7.71*, -7.99* and 102.56, 109.43, 134.56 days), RG-BU08-016R (-9.54*, -9.17*, -9.35* and 100.56, 108.07, 134.20 days), RG-BU08-018R (-7.88*, -7.56*, -7.54* and 102.23, 109.69, 135.92 days) and RG-BU08-025R (-5.54*, -5.23*,-5.01 and 104.56, 112.01, 138.54 days). As these combinations showed significant negative sca effects that could be used as above average specific combinations for earlier flowering [10] in rice found significant negative sca values in days to 1st flowering, 80% flowering and maturity. From this table earliness considering both sca effects and *perse* performances for the characters days to 1st flowering and 80% flowering crosses of IR 58025A with RG-BU08-005R, RG-BU08-006R, RG-BU08-016R, RG-BU08-018R and RG-BU08-025R might be recommended. So, among these 80 cross combinations the following crosses might be selected for earliness. These results are in line with the findings [21].

Ten crosses of IR 58025A, seven crosses of GAN46A, fourteen crosses of IR 62829A, nine crosses of IR 68888A and ten crosses of BRRI 1A showed significant positive sca effects along with mean values. Ten crosses of IR 58025A with the restorers showed significant positive specific combining ability effects along with above average *perse* performances of the crosses were found in RG-BU 08-001R (0.881*, 4.97 t/ha), RG-BU 08-002R (2.67*, 6.71 t/ha), RG-BU 08-006R (2.024**, 6.11 t/ha), RG-BU 08-013R (2.852**, 6.94 t/ha), RG-BU 08-018R (1.269**, 5.36 t/ha), RG-BU 08-046R (1.425**, 5.52 t/ha), RG-BU 08-063R (1.513**, 5.60 t/ha), RG-BU 08-063R (2.95**, 6.73 t/ha) and RG-BU 08-105R (1.774**, 5.86 t/ha). Seven Crosses of GAN46A with the restorers also showed highly significant positive sca effects and above average *perse* performances for grain yield were found in RG-BU 08-001R (0.578*, 4.67 t/ha), RG-BU 08-002R (3.50*, 7.59 t/ha), RG-BU 08-007R (3.426**, 7.33 t/ha), RG-BU 08-018R (0.722*, 4.86 t/ha), RG-BU 08-063R (1.544**, 5.63 t/ha), RG-BU 08-097R (2.452**, 6.54 t/ha).

Fourteen crosses of IR62829A resulted highly significant positive specific combining ability effects. These were found in the crosses with RG-BU08-001R (1.16**, 5.26 t/ha), RG-BU 08-002R (2.06*, 6.02 t/ha), RG-BU08-005R (2.350**, 6.44 t/ha), RG-BU08-013R (1.138**, 5.23 t/ha), RG-BU08-016R (0.960*, 5.05 t/ha), RG-BU08-025R (2.239**, 6.33 t/ha), RG-BU08-034R (1.056**, 5.15 t/ha), RG-BU08-057R (2.885**, 6.97 t/ha), RG-BU08-063R (1.459**, 5.63 t/ha) and RG-BU08-097R (1.83**, 6.26 t/ha) (Tables 6,7). Nine crosses of IR68888A showed significant positive sca effects and above average *perse* performance were found in the crosses with RG-BU 08-001R (0.98**, 5.10 t/ha), RG-BU 08-006R (2.66*, 5.93 t/ha), RG-BU 08-007R (1.62**, 5.71 t/ha), RG-BU 08-018R (3.09**, 7.18 t/ha), RG-BU 08-057R (0.84**, 4.93 t/ha), RG-BU 08-063R (0.81**, 4.88 t/ha) and RG-BU 08-097R (1.16**, 5.26 t/ha). Ten crosses of BRRI1A showed significant positive sca effects and above average *perse* performance were found in the crosses with RG-BU 08-001R (1.972**, 6.06 t/ha), RG-BU 08-002R (1.97*, 6.06 t/ha), RG-BU 08-005R (1.570**, 5.66 t/ha), RG-BU 08-006R (1.47**, 5.62 t/ha), RG-BU 08-007R (2.21**, 6.10 t/ha), RG-BU 08-016R (3.491**, 7.48 t/ha), RG-BU 08-025R (3.278**, 6.37 t/ha), RG-BU 08-063R (1.572**, 5.66 t/ha) and RG-BU 08-097R (2.21**, 6.18 t/ha) [10,11] observed non-additive gene action governing the characters. Banumathy and Thiyagarajan 2005 also found similar results while studying sca variances of rice. The crosses of five R-lines, RG-BU08-001R, RG-BU08-002R, RG-BU08-006R, RG-BU08-007R and RG-BU08-097R were found resulting significant positive sca effects and above average *perse* performances with all five cm S lines for grain yield. RG-BU08-002R and RG-BU08-097R were found resulting significant positive sca effects with all yield contributing characters like pollen fertility, spikelets fertility, panicle exertion rate, stigma exertion rate, effective tillers per plant, primary branches per panicle and secondary primary branches

Line / Testers	Days to 80% flowering									
	IR 58025A		**GAN 46A**		**IR 62829A**		**IR 68888A**		**BRRI 1A**	
	Sij effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	Mean
RG-BU 08-001 R	-3.844	113.41 ± 3.20	4.090	121.34 ± 3.20	4.770*	122.02 ± 3.20	-0.150	117.10 ± 3.20	-5.8278	111.42 ± 3.20
RG-BU 08-002 R	-1.070	116.18 ± 3.20	0.070	117.32 ± 3.20	0.650	117.90 ± 3.20	-0.510	116.74 ± 3.20	6.820*	124.07 ± 3.20
RG-BU 08-005 R	-6.827*	110.42 ± 3.20	-0.510	116.74 ± 3.20	-1.150	116.10 ± 3.20	-1.510	115.74 ± 3.20	8.760**	126.01 ± 3.20
RG-BU 08-006 R	-8.95**	108.30 ± 3.20	0.890	118.14 ± 3.20	-8.15**	109.10 ± 3.20	-4.400*	114.85 ± 3.20	-13.48**	103.77 ± 3.20
RG-BU 08-007 R	1.980	119.23 ± 3.20	-5.570*	111.68 ± 3.20	0.850	118.10 ± 3.20	-2.160	115.09 ± 3.20	3.490	120.74 ± 3.20
RG-BU 08-013 R	-7.817*	109.43 ± 3.20	-3.484	113.77 ± 3.20	-1.844	115.41 ± 3.20	2.820	120.07 ± 3.20	3.440	120.69 ± 3.20
RG-BU 08-016 R	-9.17**	108.07 ± 3.20	-9.817**	107.43 ± 3.20	0.600	117.85 ± 3.20	1.760	119.01 ± 3.20	6.430*	123.68 ± 3.20
RG-BU 08-018 R	-7.56**	109.69 ± 3.20	-8.150**	109.10 ± 3.20	3.173	120.42 ± 3.20	-2.150	115.10 ± 3.20	7.850**	125.10 ± 3.20
RG-BU 08-025 R	-5.237*	112.01 ± 3.20	-5.177*	112.07 ± 3.20	9.820**	127.07 ± 3.20	0.490	117.74 ± 3.20	2.516	119.77 ± 3.20
RG-BU 08-034 R	-3.484	113.77 ± 3.20	-2.844	114.41 ± 3.20	2.760	120.01 ± 3.20	1.440	118.69 ± 3.20	-1.484	115.77 ± 3.20
RG-BU 08-038 R	-0.930	116.32 ± 3.20	-0.180	117.07 ± 3.20	2.850	120.10 ± 3.20	2.430	119.68 ± 3.20	-2.177	115.07 ± 3.20
RG-BU 08-046 R	-0.484	116.77 ± 3.20	-0.494	116.76 ± 3.20	6.490*	123.74 ± 3.20	-0.150	117.10 ± 3.20	0.490	117.74 ± 3.20
RG-BU 08-057 R	3.490	120.74 ± 3.20	2.820	120.07 ± 3.20	8.440**	125.69 ± 3.20	-1.150	116.10 ± 3.20	-0.400	116.85 ± .20
RG-BU 08-063 R	2.933	120.18 ± 3.20	2.093	119.34 ± 3.20	3.096	120.35 ± 3.20	4.850*	122.10 ± 3.20	-1.160	116.09 ± 3.20
RG-BU 08-097 R	4.840*	122.09 ± 3.20	4.850*	122.10 ± 3.20	-1.484	115.77 ± 3.20	3.490	120.74 ± 3.20	4.820*	122.07 ± 3.20
RG-BU 08-105 R	1.153	118.40 ± 3.20	1.823	119.07 ± 3.20	-2.817	114.43 ± 3.20	2.600	119.85 ± 3.20	2.760	120.01 ± 3.20
Mean		114.69		116.03		119.00		117.86		118.67
SE *(sij)*		4.317								
SEd *(Sij-Sik)*		7.366								
SEd *(Sij-Skj)*		3.205								
t = *Sij/SEI (Sij) at error df=239*										

*p=0.05, **p=0.01 and ^{ns}=non-significant.

Table 6: SCA effects (*Sij*) vis-à-vis *per-se* mean performance of hybrids for days to 80% flowering in 80 F_1 hybrids.

ine / Testers	Days to maturity									
	IR 58025A		**GAN 46A**		**IR 62829A**		**IR 68888A**		**BRRI 1A**	
	Sij effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	Mean
RG-BU 08-001 R	-3.92	139.64 ± 6.87	-5.29*	137.47 ± 6.87	-4.91*	140.85 ± 6.87	-4.43*	139.15 ± 6.87	-6.07*	137.55 ± 6.87
RG-BU 08-002 R	-1.25	142.31 ± 6.87	1.17	143.45 ± 6.87	-0.11	144.73 ± 6.87	-0.59	142.97 ± 6.87	6.64*	150.20 ± 6.87
RG-BU 08-005 R	-6.40*	137.15 ± 6.87	-1.13	142.97 ± 6.87	-0.59	142.43 ± 6.87	-1.59	141.97 ± 6.87	8.68**	152.24 ± 6.87
RG-BU 08-006 R	-9.23**	134.33 ± 6.87	-8.23**	144.97 ± 6.87	1.41	135.33 ± 6.87	-1.88	141.68 ± 6.87	-13.26**	130.30 ± 6.87
RG-BU 08-007 R	1.70	145.26 ± 6.87	0.67	137.91 ± 6.87	-5.65*	144.23 ± 6.87	-1.64	141.92 ± 6.87	3.21	146.77 ± 6.87
RG-BU 08-013 R	-7.99**	135.56 ± 6.87	-2.02	139.90 ± 6.87	-3.66	141.54 ± 6.87	2.84	146.40 ± 6.87	3.36	146.92 ± 6.87
RG-BU 08-016 R	-9.35**	134.20 ± 6.87	0.52	134.16 ± 6.87	-9.39**	144.08 ± 6.87	1.68	145.24 ± 6.87	6.35*	149.91 ± 6.87
RG-BU 08-018 R	-7.64**	135.92 ± 6.87	3.69	135.13 ± 6.87	-8.43**	147.25 ± 6.87	-2.33	141.23 ± 6.87	8.37**	151.93 ± 6.87
RG-BU 08-025 R	-5.01*	138.54 ± 6.87	9.64**	138.10 ± 6.87	-5.45*	153.20 ± 6.87	0.31	143.87 ± 6.87	3.03	146.60 ± 6.87
RG-BU 08-034 R	-3.76	139.80 ± 6.87	3.18	140.54 ± 6.87	-3.02	146.74 ± 6.87	1.36	144.92 ± 6.87	-1.46	142.10 ± 6.87
RG-BU 08-038 R	-1.01	142.55 ± 6.87	2.57	143.20 ± 6.87	-0.36	146.13 ± 6.87	2.95	146.51 ± 6.87	-2.25	141.30 ± 6.87
RG-BU 08-046 R	-0.56	143.00 ± 6.87	6.21*	142.99 ± 6.87	-0.57	149.77 ± 6.87	-0.23	143.33 ± 6.87	0.31	143.87 ± 6.87
RG-BU 08-057 R	4.01	147.57 ± 6.87	8.26**	146.60 ± 6.87	3.04	151.82 ± 6.87	-1.33	142.23 ± 6.87	-0.58	142.98 ± 6.87
RG-BU 08-063 R	3.45	147.01 ± 6.87	2.91	145.37 ± 6.87	1.81	146.48 ± 6.87	5.27*	148.83 ± 6.87	-1.24	142.32 ± 6.87
RG-BU 08-097 R	-4.86*	138.42 ± 6.87	-7.56	132.33 ± 6.87	-4.77*	140.07 ± 6.87	-7.21**	136.77 ± 6.87	-5.34*	140.90 ± 6.87
RG-BU 08-105 R	1.07	144.63 ± 6.87	-2.59	145.30 ± 6.87	1.74	140.96 ± 6.87	2.32	145.88 ± 6.87	2.68	146.24 ± 6.87
Mean		140.99		142.27		145.35		144.18		145.01
SE *(sij)*		4.013								
SEd *(Sij-Sik)*		6.870								
SEd *(Sij-Skj)*		7.442								
t=*Sij/SEI (Sij) at error df=239*										

*p=0.05, **p=0.01 and ^{ns}=non-significant.

Table 7: SCA effects (*Sij*) vis-à-vis *per-se* mean performance of hybrids for days to maturity in 80 F_1 hybrids.

per panicle with all five cm S lines. Increased sca effect in yield might be due to significant positive sca values in pollen fertility, spikelet's fertility, panicle exertion rate, stigma exertion rate, effective tillers per plant, primary branches per panicle, secondary primary branches per panicle and significant negative sca values in days to 1st flowering, 80% flowering and maturity. In rice found similar results in sca effects of several cross combinations [3] found high specific combinations of crosses of rice from high × high general combiner parents (Table 8).

Conclusion

Significant genotypic variances for yield related traits indicated that there were significant variations among the genotypes. Significant

Line / Testers	Grain yield									
	IR 58025A		GAN 46 A		IR 62829A		IR 68888A		BRRI 1 A	
	Sij effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean	*Sij* effect	mean
RG-BU 08-001 R	0.88*	4.97 ± 0.35	0.57*	4.67 ± 0.21	1.16**	5.26 ± 0.22	0.98**	5.10 ± .35	1.97**	6.06 ± 0.35
RG-BU 08-002 R	2.67*	6.71 ± 0.35	3.50**	7.59 ± 0.35	2.06**	6.02 ± 0.35	1.24*	5.73 ± 0.35	1.23**	5.86 ± 0.35
RG-BU 08-005 R	-1.22**	2.87 ± 0.35	-1.36**	2.73 ± 0.21	2.35**	6.44 ± 0.35	-2.91**	1.18 ± 0.21	1.57**	5.66 ± 0.35
RG-BU 08-006 R	2.02**	6.11 ± 0.35	1.17**	5.91 ± 0.21	0.38*	4.48 ± 0.21	2.66**	5.93 ± 0.35	1.47**	5.62 ± 0.35
RG-BU 08-007 R	1.55**	5.53 ± 0.35	3.23**	7.33 ± 0.35	1.54*	5.64 ± 0.22	1.62**	5.71 ± 0.35	2.21**	6.10 ± 0.35
RG-BU 08-013 R	2.85**	6.94 ± 0.35	-0.93*	3.16 ± 0.21	1.13**	5.23 ± 0.21	-1.02**	3.06 ± 0.21	-0.55*	3.53 ± 0.21
RG-BU 08-016 R	-1.69**	2.39 ± 0.35	-0.35	3.74 ± 0.21	0.96*	5.05 ± 0.21	-0.70*	3.39 ± 0.22	3.39**	7.48 ± 0.35
RG-BU 08-018 R	1.26**	5.36 ± 0.35	0.77*	4.86 ± 0.21	0.44*	4.53 ± 0.21	3.09**	7.18 ± 0.35	-0.63*	3.46 ± 0.21
RG-BU 08-025 R	-0.54*	3.54 ± 0.35	0.22	4.31 ± 0.21	2.23**	6.33 ± 0.35	-2.18**	1.91 ± 0.21	3.27**	7.37 ± 0.35
RG-BU 08-034 R	0.30	4.39 ± 0.35	0.31	4.40 ± 0.21	1.05**	5.15 ± 0.21	0.33	4.43 ± 0.22	-0.91*	3.17 ± 0.21
RG-BU 08-038 R	-0.71*	3.37 ± 0.35	-0.08	4.01 ± 0.21	2.64**	6.74 ± 0.35	-1.54**	2.54 ± 0.25	-2.75**	1.33 ± 0.21
RG-BU 08-046 R	1.42**	5.52 ± 0.35	-0.77*	3.32 ± 0.21	-0.47*	3.61 ± 0.21	-0.70*	3.38 ± 0.21	-0.22	3.86 ± 0.21
RG-BU 08-057 R	-2.81**	1.27 ± 0.35	-2.26**	1.83 ± 0.21	2.88**	6.97 ± 0.35	0.84*	4.93 ± 0.21	0.89*	4.98 ± 0.21
RG-BU 08-063 R	1.51**	5.60 ± 0.35	1.54**	5.63 ± 0.21	1.45**	2.63 ± 0.21	0.81*	4.88 ± 0.21	1.57**	5.66 ± 0.21
RG-BU 08-097 R	2.95**	6.73 ± 0.35	2.45**	6.34 ± 0.35	1.83**	6.26 ± 0.35	1.16**	5.26 ± 0.35	2.21**	6.18 ± 0.35
RG-BU 08-105 R	1.77**	5.86 ± 0.35	0.13	4.23 ± 0.21	-0.68*	3.41 ± 0.22	-0.05	4.04 ± 0.35	0.01	4.10 ± 0.21
Mean	4.08		3.89		4.67		3.60		4.20	
***SE** (sij)*	0.354									
***SEd** (Sij-Sik)*	0.977									
***SEd** (Sij-Skj)*	1.104									
t = *Sij/SEI (Sij) at error df = 239*										

*p= 0.05, **p=0.01 and ^{ns} =Insignificant.

Table 8: SCA effects (Sij) vis-à-vis per-se mean performances of hybrids for grain yield (ton/ha) in 80 F1 hybrids.

gca variances along with additive variance component for reproductive traits indicated the accessibility of additive gene action. Degree of dominance were found negative for most of traits which reveals that regression lines passing below the origin i.e., this character are responsible for over dominance. The linear non-significant relationship between female vs male indicates the reliability of the crosses to go through heterosis breeding. The contributions of lines were found significant, indicating preponderance of dominant genes among the lines with tester. The significant interaction of line x tester indicated higher estimates for sca variances. Four restorer lines showed significant negative effects for days to 1st flowering, 80% flowering and days to maturity. Three pollen parents and one cm S line, showed significant positive gca effects for pollen fertility while six pollen parents showed significant positive effects for spikelets fertility but two pollen parents showed significant positive gca effects for both panicle and stigma exertion rate. The estimated gca effects of parents indicated that five pollen parents contributed highly significant negative effects for plant height which were responsible for dwarfing character. Fifteen crosses showed significant negative sca estimates for days to first flowering, sixteen crosses for days to 80%flowering and twenty crosses for days to maturity. Among 80 crosses fifty two crosses showed significant positive sca effects along with above average *perse* performances for grain yield.

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