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Research Article

Combining ability analysis for yield in hybrid rice *(Oryza sativa* L.)

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Abstract

Eighty four hybrids developed from crossing three CMS lines with 28 restores were studied alongwith parents for 13 yield and yield attributing characters. Among the male parental lines, PD-19, NAUR-1 and IET-18654 appeared to be best general combiner for grain yield and most of the component characters. The female line IR-58025B was found to be good general combiner for all the traits and average general combiner for plant height and harvest index whereas poor general combiner for 1000-grain weight. The most promising specific combinations were IR-58025A x NAUR-1, IR-68888A x NAUR-1 and IR-58025A x IET-18654 for grain yield plant^{-1}.

Key words :
Rice, combining ability, yield, yield components.

Introduction:

Demand for rice is expected to grow faster than production in most countries so much that by the year 2025, 800 million tones of it will be needed annually (Anon.,1994). Population increase will be more in developing countries where rice is the staple food. It is crucial step for a breeder to select right type of parents in hybridization programme. Combining ability analysis is a powerful tool to discriminate good as well as poor combiner and selecting out appropriate parental material and type of gene action involved in the inheritance of various traits. Knowledge of type of gca effects and their magnitude is of fundamental importance to the plant breeder. The present investigation in rice (*Oryza sativa* L.) was therefore undertaken with an objective to estimate the general and specific combining ability of the parental lines and their hybrids using L x T analysis.

Material and methods

The experimental material for the present investigation consisted of 31 parents (3 females and 28 males) and their 84 crosses. The genotypes GNR-3 and PA-6201 were used as check. The crossing programme was carried out using 3 CMS lines and 28 pollen parents (restorers) adopting isolation free system (advocated by Virmani and Casal, 1993) during *Rabi* 2011 and *Summer* 2012 at the RRRS Farm, NAU, Vyara. Thus seeds of 84 experimental crosses were obtained. Complete sets of 117 entries comprising of 84 F_1s, 3 females, 28 males and 2 checks were evaluated during *kharif* 2012 at three locations *viz*., Navsari, Vyara and Danti. The trials were conducted in a Randomized Block design (RBD), replicated thrice. Recommended agronomical practices were followed while raising the crop. Observations were recorded on the five randomly selected hills from each treatment in each replication for days to 50 per cent flowering, productive tillers plant^{-1}, plant height (cm), panicle length (cm), grains panicle^{-1}, grain yield plant^{-1} (g), straw yield plant^{-1}(g), harvest index (%), spikelet fertility(%), kernel L:B ratio, 1000-grain weight (g), protein content (%) and amylose content (%). Combining ability analysis was calculated following the method suggested by Kempthorne (1957). The pooled mean value over three locations for each parent and hybrid was taken for computation of combining ability and standard heterosis over GNR-3 (SC-I) and hybrid check PA-6201 (SC-II).

Results and Discussion

Analysis of variance for combining ability for the data pooled across the environments revealed that both additive and non-additive variances were important in the inheritance of various traits as evident from significance of females, males and females x males interaction for all the characters except plant height, grain yield plant^{-1}, harvest index and amylose content for females, amylose content for males, while spikelet fertility for females x males interaction. The magnitude of specific combining ability (sca) variances were higher than the general combining ability (gca) variances for all the characters except days to 50 per cent flowering and panicle length which indicates preponderance of non-additive gene action in the inheritance of these traits, while preponderance of additive type of gene action in days to 50 per cent flowering and panicle length. This was further supported by low magnitude of σ^2 gca : σ^2 sca ratios. Preponderance of non-additive variance in the expression of different traits in rice has also been reported by Ram *et al*. (1991), Khirsagar (2002) and Waghmode *et. al.*(2011). Preponderance of additive variance in the expression of days to 50 per cent flowering and panicle length was also reported by Rao *et al*. (1980), Singh *et al*. (1996) and Lavanya (2000).

Mean square due to males x locations were found to be non-significant for productive tillers plant^{-1}, kernel L:B ratio and protein content as well as mean squares due to females x locations were non-significant for all the characters except panicle length and harvest index which indicate that gca variances of females and males were not influenced by environments in above said traits. The sca variances were not influenced by environmental fluctuations as evident by the non-significance mean square due to females x males x locations interaction for all characters except productive tillers plant^{-1} and plant height,

Based on estimates of general combining ability effects on pooled basis for various characters, the parents were classified as good, average and poor combiners (Table 1). It was observed that among three females, IR-58025B, was found to be good general combiner for all the traits and average general combiner for plant height and harvest index, whereas poor general combiner for 1000-grain weight. Similar results were also reported by Yadav *et al.* (1999), Lavanya (2000) and Narasimman *et al.* (2007); while IR-68897B was found good general combiner for 1000-grain weight only.

Among males PD-19 found to be good general combiner for most of the characters and average and poor performance in plant height and protein content respectively. It was followed by NAUR-1, which showed poor combiner plant height and straw yield plant^{-1}. Among males gca effects for grain yield plant^{-1} in PD-19, NAUR-1, IET-18654, PD-10, PD-12 and IR-65483-14-1-4-1-3 was associated with productive tillers plant^{-1}, panicle length and harvest index. NAUR-1 possessed negative (desirable) gca effects for days to 50 per cent flowering. These findings are in agreement with those reported by Yadav *et al.* (1999), Shunmugavalli *et al.* (1999) and Bhadru *et.al.* (2013). In general, it was observed (Table 2) that among female IR-58025B and among males NAUR-1, IET-18654, PD-10, PD-12 and PD-19 were good general combiner for yield and most of the yield contributing characters. Therefore, these parents may be extensively used in future hybrid rice breeding programme.

The estimates of sca effects revealed that none of the hybrids were consistently superior for all the traits. The hybrid IR-58025A x NAUR-1 was superior or ranking first in productive tiller plant^{-1}, panicle length, grain yield plant^{-1}, harvest index and spikelet fertility. Out of 84 hybrids studied, as many as 19 cross combinations exhibited significant positive sca effects for grain yield plant^{-1} on pooled basis. These 19 crosses also manifested significant and desired sca effects for some of yield attributing traits *viz*., grains panicle^{-1} (9), harvest index (9), productive tiller plant^{-1} (5), panicle length (4), spikelet fertility (3) and 1000-grain weight (3). Hence hybrids with high sca effects for grain yield plant^{-1} were also associated with high and desired sca effects for yield contributing characters. The best three hybrids on the basis of significant positive sca effects for grain yield plant^{-1} were IR-58025A x NAUR-1, IR-68888A x NAUR-1 and IR-58025A x IET-18654. Of these, IR-58025A x NAUR-1 depicted significant positive/desired sca effects for all the character except days to 50 per cent flowering and straw yield plant^{-1}, whereas IR-68888A x NAUR-1 exhibited significant positive sca effects for grains panicle^{-1}, grain yield plant^{-1} (g), straw yield plant^{-1}(g), 1000-grain weight, protein content (%) and amylose content (%), while IR-58025A x IET-18654 exhibited significant positive sca effects for productive tiller plant^{-1}, grains panicle^{-1}, grain yield plant^{-1} (g), straw yield plant^{-1}(g), harvest index and 1000-grain weight.

A perusal of Table 2 showed a good agreement between best general combining parents and best performing parents for most of the traits. This suggested that while selecting the parents for hybridization programme, *per se* performance of parents should be given due weightage. It is also evident (Table 2) that the three best performing hybrids for various characters also had high heterotic response over better parent and standard checks and desired sca effects except one hybrid for the characters *viz*., grains panicle^{-1}and amylose content. Therefore, it can be concluded that *per se* performance of parents and hybrids agrees well with gca effects of parents and heterotic response of hybrids, respectively. Thus, the potentiality of a genotype to be used as a parent in hybridization, or a cross to be used as a commercial hybrid may be judged by comparing *per se* performance of parents and hybrids, along with combining ability effects of parents and heterotic response of hybrids. The crosses exhibited higher *per se* performance, high heterosis and significant desirable sca effects (Table 2) for various traits involved either good x good, good x average, good x poor, average x good and poor x good combing parents. Thus, crosses exhibiting high sca effects did not always involve parents with high gca effects. It may be suggested that interallelic interactions were also important for these characters.

The best three hybrids for grain yield plant^{-1} *viz.*, IR-58025A x NAUR-1 (good x good), IR-68888A x NAUR-1 (good x good) and IR-58025A x IET-18654 (good x good) had significant desired sca effects and significant desired heterotic response over better parent as well as both standard checks.

High yielding hybrids had high sca effects, high heterosis as well as high *per se* performance for most of the yield contributing characters. This appeared appropriate as yield being a complex character depends on a number of its component traits. Considering the *per se* performance, heterotic response and sca effects in desired direction, hybrids IR-58025A x NAUR-1 showed superiority for productive tiller plant^{-1}, panicle length, harvest index and spikelet fertility, whereas IR-68888A x NAUR-1 indicated superiority for harvest index and spikelet fertility (Table 2).

The results revealed that parents with good *per se* performance are also good general combiners for most of the traits. Further, good general combiners may not necessarily produce good specific combination for different traits. Similar results were reported by Ramlingam *et al.* (1997). In many cases, it was observed that at least one good general combining parent was involved in heterotic hybrid having desirable sca effects. This was true for most of the traits studied. Parents with highest gca effect will not necessarily generate top specific cross combinations as also reported by Rao *et al*. (1980) and Peng and Varmani (1990). This suggests that information of gca effects of parents should be considered along with sca effects and *per se* performance of hybrid for predicting the value of any hybrid. It is desirable to search out parental lines with high gca and low sensitivity to environmental variation in a crop improvement programme.

Among top three hybrids IR-58025A x Tulsai, IR-58025A x IR-28, IR-58025A x Vandana (Days to 50 per cent flowering), IR-68897A x Zinia-31(grains panicle^{-1}), IR-58025A x IR-65912-90-1-6-3-2 (straw yield plant^{-1}), IR-68888A x PD-12 (kernel L:B ratio), IR-68888A x PR-120 (1000-grain weight), IR-68897A x PR-106 and IR-68888A x IR-64 (amylose content) resulted from one good and one poor general combiners. This might be due to dominant x recessive type of interaction with non-additive, non-fixable genetic component for various characters. Random mating and selective among the segregates could lead to transgressive desirable early sergeants in latter generations.

With respect to combining ability effects, following broad inferences could be drawn from the present study: i) in general, the crosses showing desirable sca effects for grain yield also had high sca effects for yield contributing characters *viz*., productive tillers plant^{-1}, panicle length (cm), harvest index (%), spikelet fertility (%), kernel L:B ratio and protein content (%). ii) the crosses having best heterotic effects of various traits always involved one good general combining parents for that character. iii) best performing parents were mostly good general combiners for majority of the traits. iv) the crosses exhibiting high heterosis with desirable sca effects did not always involve parents with high gca effects, thereby suggesting the importance of interallelic interaction. However, it was also observed that at least one good general combiner was involved in best performing cross combinations.

From the results it is clear that hybrids IR-58025A x NAUR-1, IR-68888A x NAUR-1 and IR-58025A x IET-18654 having high mean, high heterosis over better parents and standard checks, desirable sca effects for grain yield plant^{-1} and its related traits can be exploited in practical breeding. It is also clear that the high degree of non-additive gene action for grain yield and its component traits observed in the present study favours hybrid breeding programme. The two characters *viz*., days to 50 per cent flowering and panicle length can be improved through selection (pure line/progeny) due to their additive gene action. The evaluation of hybrids have suggested that a substantial degree of heterosis over better parent and standard check GNR-3 and PA-6201 were available in several crosses.

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Table 1. General combining ability effects of the parents for different characters based on pooled data at three location

Characters Parents	Days to 50 % flowering	Productive tillers plant^{-1}	Plant height (cm)	Panicle length (cm)	Grains panicle^{-1}	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Harvest index (%)	Spikelet fertility (%)	Kernel L:B ratio	1000-grain weight (g)	Protein content (%)	Amylose content (%)
Females													
1) IR-58025 B	P (92.7)	G (8.7)	A (88.5)	G (24.7)	G (157.1)	G (28.5)	G (41.6)	A (40.6)	G (77.6)	G (3.68)	P (21.2)	G (7.17)	G (22.82)
2) IR-68897 B	A (86.2)	P (6.8)	A (83.9)	A (24.9)	P (134.4)	P (22.3)	P (36.3)	A (37.8)	P (76.2)	A (3.49)	G (23.3)	P (6.66)	P (20.01)
3) IR-68888 B	G (84.0)	A (7.6)	A (82.8)	P (21.8)	P (113.2)	P (24.9)	P (45.4)	A (35.4)	A (79.8)	P (3.12)	P (20.1)	P (7.00)	P (21.78)
Males													
1) NAUR-1	P (93.1)	G (5.6)	P (107.1)	G (24.7)	G (161.0)	G (29.1)	P (38.4)	G (43.0)	G (80.9)	G (3.19)	G (25.3)	G (6.50)	G (21.26)
2) IET-15429	A (90.5)	P (8.0)	P (105.0)	A (20.7)	P (139.6)	P (26.0)	A (42.9)	A (37.5)	G (73.9)	A (3.05)	G (26.8)	G (7.91)	P (22.14)
3) IET-22016	P (95.5)	A (6.1)	G (113.8)	A (23.2)	P (100.4)	A (20.1)	G (41.0)	P (32.4)	P (75.3)	P (2.96)	P (24.7)	G (7.33)	P (23.06)
4) IET-22017	P (95.8)	A (7.1)	G (115.3)	G (25.1)	A (117.8)	P (23.1)	P (42.8)	G (34.9)	P (74.4)	A (3.02)	G (25.1)	P (6.90)	A (22.24)
5) IR-64	A (99.4)	P (8.1)	P (112.8)	P (23.6)	P (133.6)	P (29.7)	A (61.5)	P (32.5)	A (80.2)	G (3.45)	G (29.7)	A (7.21)	G (24.29)
6) IR-28	G (86.6)	G (9.6)	P (99.0)	P (20.5)	P (109.2)	G (28.0)	G (49.2)	A (36.1)	P (71.7)	A (3.00)	G (24.7)	G (7.81)	G (23.25)
7) IR-65912-90-1-6-3-2	P (96.9)	G (7.7)	G (111.0)	A (22.6)	G (137.8)	A (25.1)	P (55.8)	G (30.9)	G (78.6)	A (2.87)	P (19.2)	P (6.87)	P (22.77)
8) IR-65483-14-1-4-1-3	P (97.6)	G (7.6)	P (104.6)	G (24.3)	P (130.0)	G (28.0)	G (44.8)	G (38.2)	A (75.9)	G (3.16)	G (22.8)	G (7.51)	A (22.19)
9) PAU-201	P (99.6)	A (6.9)	P (92.4)	A (21.7)	P (97.0)	P (22.7)	P (42.7)	A (34.6)	P (74.6)	G (3.13)	G (27.4)	G (7.59)	A (22.94)
10) P D-10	G (77.7)	G (8.9)	A (98.4)	G (24.5)	P (112.6)	G (28.0)	G (38.8)	G (41.8)	G (77.2)	A (3.16)	G (26.2)	G (7.83)	G (25.21)
11) P D-11	G (76.6)	A (5.6)	P (90.6)	P (19.3)	P (110.3)	A (21.5)	G (37.6)	A (36.0)	A (75.5)	A (2.79)	G (27.1)	G (7.63)	G (18.96)
12) P D-12	G (75.9)	G (6.7)	A (97.2)	G (22.8)	P (103.4)	G (25.2)	G (39.7)	G (38.3)	G (78.2)	G (3.19)	G (26.3)	P (6.20)	A (23.09)
13) P D-16	G (87.6)	P (6.7)	A (102.3)	A (23.5)	P (159.0)	P (21.9)	P (34.3)	P (38.2)	P (71.7)	P (2.32)	A (24.0)	A (7.21)	G (20.11)
14) P D-19	G (78.7)	G (7.9)	A (99.6)	G (21.1)	G (154.0)	G (25.8)	G (37.8)	G (40.5)	G (80.2)	G (2.69)	G (27.5)	P (5.69)	G (24.30)
15) Vandana	G (79.8)	P (6.6)	A (108.7)	G (24.0)	A (126.6)	P (24.8)	P (42.2)	A (36.5)	P (72.9)	P (2.86)	P (23.7)	P (6.21)	A (20.96)
16) Ashoka-200-F	G (79.5)	P (6.6)	G (112.8)	G (22.6)	G (122.9)	P (24.9)	P (38.3)	P (38.8)	A (74.1)	G (3.01)	P (26.3)	P (6.42)	A (18.77)
17) Tulsai	G (85.2)	P (8.7)	P (93.8)	P (21.5)	P (109.8)	P (25.1)	P (37.5)	P (40.0)	A (75.5)	P (2.75)	A (23.3)	G (7.22)	A (17.43)
18) IET- 18654	G (83.1)	G (6.6)	G (126.1)	G (23.1)	G (176.8)	G (27.6)	G (38.5)	G (41.6)	G (79.2)	P (2.41)	P (20.4)	G (7.50)	A (22.37)
19) IET- 19253	G (86.6)	P (6.0)	G (119.8)	G (22.4)	P (99.0)	P (19.7)	P (32.7)	P (37.1)	P (71.1)	G (3.22)	A (25.8)	G (7.72)	A (18.84)
20) IET- 18651	G (79.9)	G (8.0)	G (119.6)	A (26.3)	P (113.0)	G (29.3)	G (41.1)	G (41.4)	P (75.5)	P (2.93)	P (23.7)	P (6.41)	P (21.77)
21) CO-47	A (97.8)	A (7.9)	P (90.6)	A (21.5)	G (161.8)	A (25.7)	G (45.2)	P (35.9)	P (77.6)	P (2.79)	P (18.1)	P (7.39)	P (21.84)
22) PR-106	P (101.2)	A (6.6)	A (98.8)	A (21.3)	P (122.0)	A (24.9)	G (40.8)	P (37.4)	A (78.5)	G(3.35)	A (25.7)	P (6.22)	G (23.07)
23) PR-108	P (99.7)	P (7.9)	G (102.4)	P (25.9)	G (111.0)	A (29.2)	G (41.6)	P (40.9)	P (76.3)	A (3.27)	G (23.3)	A (7.59)	P (24.08)
24) PR-111	P (94.4)	P (7.9)	A (89.8)	A (23.6)	G (135.0)	A (29.4)	P (40.6)	G (41.6)	A (76.4)	P (3.33)	G (23.9)	P (6.85)	A (24.58)
25) PR-113	A (93.1)	G (7.1)	A (96.0)	P (20.7)	G (109.2)	G (26.5)	G (38.1)	G (40.7)	G (80.6)	P (2.81)	G 30.8)	A (7.61)	A (21.80)
26) PR-120	P (94.6)	P (6.2)	G (104.0)	G (22.9)	G (201.6)	P (23.5)	P (39.6)	P (36.8)	P (74.6)	G (3.43)	G (22.9)	P (5.76)	A (21.64)
27) Zinia-31	A (91.9)	G (9.1)	G (139.0)	P (24.0)	G (261.0)	G (29.6)	P (40.8)	G (41.9)	A (78.6)	P (3.19)	P (13.3)	P (6.12)	A (23.27)
28) RPBio-226	P (107.7)	P (5.6)	P (87.6)	P (22.4)	A (179.0)	P (21.4)	G (35.9)	P (37.1)	A (80.7)	G (3.20)	P (14.3)	A (7.09)	A (23.19)

G = Good parent having significant gca effect in desired direction; **A** = Average parent having either positive or negative but non-significant gca effects and
P = Poor parent having significant gca effects in undesired direction, Value in parentheses indicate *per se* performance

Table 2. Summary of three best performing parents and hybrids along with their GCA effects and SCA effects and per cent heterosis for various traits

Character	Best performing parents		Best general combiner		Best performing hybrids	GCA effect	SCA effect	Heterobeltiosis (%)	Standard heterosis over	
	Female	Male	Female	Male					SC-I	SC-II
Days to 50 % flowering	IR-68888B	PD-12	IR-68888B	IR-28	IR-58025A x Tulsai	P x G	-3.76*	-16.82**	-15.36**	-21.50**
	IR-68897B	PD-11	-	Vandana	IR-58025A x IR-28	P x G	-2.12	-16.67**	-15.20**	-21.36**
	IR-58025B	PD-10	-	IET-19253	IR-58025A x Vandana	P x G	-2.13	-16.57**	-15.11**	-21.27**
Productive tillers plant^{-1}	IR-58025B	IR-28	IR-58025B	NAUR-1	IR-58025A x NAUR-1	G x G	1.59**	47.54**	60.54**	32.53**
	IR-68888B	Zinia-31	-	IET-18654	IR-58025A x IET-18654	G x G	1.48**	34.12**	45.95**	20.48**
	IR-68897B	PD-10	-	PD-10	IR-58025A x IR-65912-90-1-6-3-2	G x G	2.59**	32.40**	44.07**	18.94**
Plant height (cm)	IR-68888B	RPBio-226	-	Tulsai	IR-68888A x IR-64	A x G	-8.12**	-20.27**	-18.61**	-12.15**
	IR-68897B	PR-111	-	RPBio-226	IR-68888A x RPBio-226	A x G	-2.71	2.69	-18.60**	-12.14**
	IR-58025B	CO-47/PD-11	-	NAUR-1	IR-58025A x Tulsai	A x G	-1.23	-2.19	-16.97**	-10.38**
Panicle length (cm)	IR-68897B	IET-18651	IR-58025B	IET-18654	IR-58025A x NAUR-1	G x G	0.82	10.11**	10.60**	16.23**
	IR-58025B	PR-108	-	NAUR-1	IR-58025A x IR-65912-90-1-6-3-2	G x A	2.60**	9.24**	9.73**	15.31**
	IR-68888B	IET-22017	-	PD-10	IR-58025A x IET-18654	G x G	-0.37	8.48**	8.96**	14.50**
Grains panicle^{-1}	IR-58025B	Zinia-31	IR-58025B	Zinia-31	IR-58025A x Zinia-31	G x G	4.69	-12.94**	37.19**	24.02**
	IR-68897B	PR-120	-	PR-120	IR-58025A x PR-111	G x G	27.41**	29.65**	22.93**	11.13**
	IR-68888B	RPBio-226	-	CO-47	IR-68897A x Zinia-31	P x G	-4.11	7.13**	4.16	-5.84**
Grain yield plant^{-1} (g)	IR-58025B	IR-64	IR-58025B	NAUR-1	IR-58025A x NAUR-1	G x G	3.93**	53.38**	42.25**	27.45**
	IR-68888B	Zinia-31	-	IET-18654	IR-68888A x NAUR-1	P x G	1.81**	40.59**	30.39**	16.82**
	IR-68897B	PR-111	-	PD-19	IR-58025A x IET-18654	G x G	2.88**	40.93**	28.14**	14.81**
Straw yield plant^{-1} (g)	IR-68888B	IR-64	IR-58025B	PR-108	IR-58025A x IET-22016	G x G	2.74**	33.84**	37.02**	30.58**
	IR-58025B	IR-65912-90-1-6-3-2	-	IET-22016	IR-58025A x PR-108	G x G	1.72**	32.46**	35.60**	29.23**
	IR-68897B	IR-28	-	PD-19	IR-58025A x IR-65912-90-1-6-3-2	G x P	8.82**	-3.37**	32.74**	26.51**
Harvest Index (%)	IR-58025B	NAUR-1	-	NAUR-1	IR-58025A x NAUR-1	A x G	3.09**	15.49**	14.30**	10.39**
	IR-68897B	Zinia-31	-	IET-18654	IR-68888A x NAUR-1	A x G	0.74	9.82**	8.69**	4.97
	IR-68888B	PD-10	-	PD-10	IR-68888A x IET-18654	A x G	1.83*	9.04**	4.40	0.83
Spikelet fertility (%)	IR-68888B	NAUR-1	IR-58025B	NAUR-1	IR-58025A x NAUR-1	G x G	1.98	9.92**	14.21**	12.93**
	IR-58025B	RPBio-226	-	IET-18654	IR-68888A x NAUR-1	A x G	0.84	7.76**	11.97**	10.70**
	IR-68897B	PR-113	-	IET-15429	IR-68888A x IET-18654	G x G	0.13	7.91**	9.84**	8.60**
Kernel L:B ratio	IR-58025B	IR-64	IR-58025B	IR-64	IR-68897A x IR-64	A x G	0.13**	9.31**	17.39**	23.04**
	IR-68897B	PR-120	-	NAUR-1	IR-68888A x PD-12	P x G	0.26**	18.90**	16.71**	22.32**
	IR-68888B	PR-106	-	PD-12	IR-58025A x NAUR-1	G x G	0.12*	2.72	16.33**	21.92**
1000-grain weight (g)	IR-68897B	PR-113	IR-68897B	PD-12	IR-68888A x PR-120	P x G	2.50**	30.56**	13.52**	39.74**
	IR-58025B	IR-64	-	PD-19	IR-68897A x PD-12	G x G	0.43	11.42**	11.23**	36.92**
	IR-68888B	PD-19	-	PR-120	IR-68897A x PD-19	G x G	-0.54	2.91	7.46**	32.28**
Protein Content (%)	IR-58025B	IET-15429	IR-58025B	IET-15429	IR-58025A x IR-65912-90-1-6-3-2	G x G	0.53**	8.54**	25.06**	12.39**
	IR-68888B	PD-10	-	PAU-201	IR-58025A x PAU-201	G x G	0.25**	7.13**	24.83**	12.19**
	IR-68897B	IR-28	-	PD-10	IR-58025A x NAUR-1	G x G	0.29**	10.13**	21.25**	8.97**
Amylose Content (%)	IR-58025B	PD-10	IR-58025B	PR-106	IR-68897A x PR-106	P x G	1.61**	3.49*	14.55**	6.91**
	IR-68888B	PR-111	-	PD-10	IR-58025A x PD-10	G x G	1.23**	-5.59**	14.21**	6.59*
	IR-68897B	PD-19	-	PD-11	IR-68888A x IR-64	P x G	1.85**	-2.13	14.08**	6.47**

*,** significant at 5% and 1% level of probability