GENETIC ANALYSIS FOR QUANTITATIVE TRAITS USING LINE X TESTER MATING DESIGN IN RICE (*Oryza sativa* L.)

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ABSTRACT

Asia is considered as 'rice bowl' of the world and it produced and consumed more than 90 per cent of world rice. In India, a newly born state Chhattisgarh is known as 'rice bowl' of India. A set of three lines as females and ten testers as males of aerobic rice were crossed in line x tester fashion to estimate combining ability and gene action for yield and its components. The gca variances for females was found significant for plant height, panicle length and days to maturity, while it was found non-significant for other traits, whereas gca variance for males were found highly significant for days to 50 % flowering, plant height, panicle length, grains per panicle, seed test weight, days to maturity and leaf area, while it was found non-significant for other traits. The study of sca variance and gca variance for all characters indicated the predominance of non additive gene action for all the studied traits except days to 50 % flowering, panicle length and days to maturity. For grain yield per plant and some of economic traits, male parents, KMP 128 and RCPR 7 were found good general combiners. The best specific combinations for grain yield per plant and other attributing traits were GNR-3 × RCPR 6, AICRIP-1335 × RCPR 8 and NAUR-1 × NDR 1132-5. These crosses could be exploited fully in future rice breeding programme by adopting appropriate breeding technique in order to evolve high yielding hybrids or varieties.

KEY WORDS: Aerobic rice, combining ability, gene action, line × tester

INTRODUCTION

Rice is hydrophilic, self pollinated, short day and C_3 plant. It is highly adaptable to different climatic conditions. Rice belongs to family *Poaceae* and sub-family *Oryzoidae*. It is believed to be originated in South East Asia. Rice is grown in most of soils, however heavy neutral soils (clay, clay loam and loamy) are more suited for its cultivation. Rice is a staple food of 50 % world's population. Out of 258 countries of the world, it is cultivated in 144 countries. Global production of rice is 724 million tones from162.9 million ha area with a productivity of 4.57 tones/ha (Anonymous, 2014). India is the largest rice growing country, while China is the largest producer of rice. In India, rice is cultivated on 42.75 million hectares during 2013 with production of 105.24 million tonnes and productivity of 2462 kg per hectare. In Gujarat, rice is cultivated on 7.01 lakh hectares with production of 15.41 lakh tonnes and productivity of 2198 kg per hectare (Anonymous, 2014).

Various biometrical techniques have been developed to obtain valid information with regards to genetic architecture and inheritance of different yield components, among which line × tester analysis has been extensively used in almost all the major field crops in evaluation of breeding materials for heterosis. To study the extent of heterosis for yield and yield contributing characters, the knowledge of nature and the magnitude of gene action controlling yield and yield components are very useful for development of the breeding procedures to be followed for crop improvement. Aerobic rice refers to growing of rice varieties in non-puddled and non-flooded condition.

MATERIALS AND METHODS

The three lines *viz.*, NAUR-1, AICRIP-1335 and GNR-3 and ten testers *viz.*, KMP 128, CRR 682-B-141-4-1, RCPR 6 (IR 84899-B-179-16-1-1-1), RCPR 7 (IR 83920-B-B-277-2-1-1-1), RCPR 8 (IR 77298-14-1-2-130-2), OR 2493-1, CR 2883-22-4-1, CR 3728-2 (IR 73930-313-2-2 CR 3728-2-2), NDR 1132-5 and R 1458-231-1-275-1 were crossed in line × tester fashion during summer 2014 to obtained 30 F_1s. These hybrids along with their parents were tested in a randomized block design with three replications at Main Rice Research Center, Navsari Agricultural University, Navsari. Each entry was planted in a single row consist of 10 plant in each row with a spacing 20 × 15 cm. The standard agronomical practices were followed to raise the experimental crop. Biometrical observations were recorded for 17 yield and yield attributing traits *viz.*, Days to 50 % flowering, plant height (cm), panicle length (cm), productive tillers per plant, grains per panicle, seed test weight (g), grain yield per plant (g), straw yield per plant (g), harvest index (%), day to maturity, L/B ration (%), protein content (%), amylose content (%), leaf area (cm^2), chlorophyll content, photosynthetic rate (μmol/m^2/s) and stomata conductance (mmol/m^2/s). Observations were made on five randomly selected competitive plants. The estimates of combining ability and variance were worked out according to the method outlined by Kempthorne (1957).

RESULT AND DISCUSSION

The analysis of variance for combining ability revealed that *gca* variances for lines (σ^2l) were highly significant for plant height, panicle length and days to maturity, while it was found non-significant for other traits, whereas *gca* variance for males (σ^2t) were found highly significant for days to 50 % flowering, plant height, panicle length, grains per panicle, seed test weight, days to maturity and leaf area, while it was found non-significant for other traits (Table 1). On the other hand, specific combining ability (*sca*) variances were found highly significant for all characters. The magnitude of *sca* variance was higher than *gca* variance for all characters except days to 50 % flowering, panicle length and days to maturity, which indicated the predominance of non-additive gene action for the above characters. This was further supported by low magnitude of $\sigma^2 gca/ \sigma^2 sca$ ratios.

Nature and magnitudes of combining ability effects provide guideline in identifying the better parents and their utilization. The summary of general combining ability effects of the parents is depicted in Table 2. The results revealed that none of the parent was found to be good general combiner for all the characters. An overall appraisal of *gca* effects revealed that among the testers, KMP 128 and RCPR 7 were recognized as good general combiners for grain yield per plant and some of other yield related traits and could be exploited for yield improvement in aerobic rice.

Among females, NAUR-1 was found to be the good general combiner for panicle length and productive tillers per plant, whereas AICRIP-1335 was found good general combiner for plant height, panicle length, seed test weight and stomatal conductance, and GNR-3 was found good general combiner for days to 50 % flowering, seed test weight, straw yield per plant, days to maturity, L/B ratio, protein, leaf area, chlorophyll content at panicle initiation stage and photosynthetic rate at panicle initiation stage. Among male parents, RCPR 8 was found good general combiner for days to 50 % flowering, plant height, panicle length, seed test weight, L/B ratio, amylose content, chlorophyll content at panicle initiation stage, photosynthetic rate at panicle initiation stage, photosynthetic rate at flowering stage and stomatal conductance; KMP 128 was good general combiner for panicle length, productive tillers per plant, grains per panicle, grain yield per plant, straw yield per plant, amylose content, leaf area and photosynthetic rate at panicle initiation stage; CR 3728-2 for plant height, panicle length, grains per panicle, L/B ratio, amylose content, chlorophyll content at flowering stage, photosynthetic rate at panicle initiation stage and stomatal conductance; RCPR 7 was good general combiner for traits like days to 50 % flowering, seed test weight, grain yield per plant, harvest index, days to maturity, photosynthetic rate at panicle initiation stage and stomatal conductance; R 1458-231-1-275-1 was good general combiner for grains per panicle, harvest index, protein, leaf area, chlorophyll content at panicle initiation stage, chlorophyll content at flowering stage and stomatal conductance; CR 2883-22-4-1 was good general combiner for traits like days to 50 % flowering, plant height, productive tillers per plant, grains per panicle, days to maturity and chlorophyll content at panicle initiation stage; NDR 1132-5 was good general combiner for days to 50 % flowering, seed test weight, days to maturity, L/B ratio, amylose content and chlorophyll content at flowering stage; CRR 682-B-141-4-1 was found good general combiner for plant height, grains per panicle and amylose content. Male RCPR 6 was found good general combiner for L/B ratio and amylose content; and OR 2493-1 was found good general combiner for L/B ratio and leaf area. This could be considered as the best combining parents of the parent study in yield attributes and hence could be initiated in the future breeding programme. These results are in agreement with the findings of Dalvi and Patel (2006), Jagadeesan and Ganesan (2006), Pradhan *et al.* (2006), Singh *et al.* (2007), Jayasudha and Sharma (2008), Pradhan and Singh (2008), Sharma and Mani (2008), Tyagi *et al.* (2008), Salgotra *et al.* (2009), Saidaiah *et al.* (2010), Salim *et al.* (2010), Malarvizhi *et al.* (2011), Patil *et al.* (2012) and Utharasu and Anandakumar (2013).

In case of specific combining ability effects, none of the hybrid exhibited favourable *sca* effects for all the characters. Significant *sca* effects in favourable direction as observed in many crosses for days to 50 % flowering (6 crosses), plant height (7), panicle length (3), productive tillers per plant (9), grains per panicle (4), seed test weight (5), grain yield per plant (3), straw yield per plant (2), harvest index (3), days to maturity (1), L/B ratio (10), protein (8), amylose content (12), leaf area (6), chlorophyll content at panicle initiation stage (7), chlorophyll content at flowering stage (4), photosynthetic rate at panicle initiation stage (10), photosynthetic rate at flowering stage (7) and stomatal conductance (9) are presented in Table 3. These results are getting support from the findings of Dalvi and Patel (2006), Jagadeesan and Ganesan (2006), Singh *et al.* (2007), Jayasudha and Sharma (2008), Pradhan and Singh (2008), Sharma and Mani (2008), Saidaiah *et al.* (2010), Salim *et al.* (2010), Malarvizhi *et al.* (2011), Mirarab *et al.* (2011), Patil *et al.* (2012), Pratap *et al.* (2013) and Thakare *et al.* (2013).

Grain yield is the complex character dependent upon the contribution of various component characters affecting directly or indirectly. The existance of total genetic variability and magnitude as well as nature of gene effects in the population under improvement to a large extent would dictate the choice of breeding methodology. The magnitude of *sca* effects is vital importance in selecting the cross combinations with higher probability of obtaining desirable transgressive segregation. The range of *sca* effects for grain yield per plant varied from -4.290 (AICRIP-1335 × NDR 1132-5) to 3.557 (GNR-3 × RCPR 6). Seven hybrids showed significant *sca* effects of which three hybrids [GNR-3 × RCPR 6 (3.557 g), AICRIP-1335 × RCPR 8 (3.199 g) and NAUR-1 × NDR 1132-5 (3.144 g)] attributed towards positive direction were the best specific crosses for grain yield per plant. The crosses having best specific combination for grain yield per plant were obtained through average x average, average x average and average x average parental combination. The best specific combinations for grain yield per plant *viz.*, GNR-3 × RCPR 6 recorded the desirable significant *sca* effect for the traits like plant height, grains per panicle, grains yield per plant, harvest index, L/B ratio, amylase content and photosynthetic rate at flowering stage; AICRIP-1335 × RCPR 8 protein content, amylose content, leaf area, photosynthetic rate at panicle initiation stage and stomatal conductance; and NAUR-1 × NDR 1132-5 for straw yield per plant, L/B ratio and amylose content. These crosses also had higher *per se* performance. This indicated possibly to obtained desirable hybrid vigour from such crosses by adopting heterosis breeding programme.

CONCLUSION

On the basis of combining ability, selection of desirable traits for developing high yielding varieties should be made by crossing GNR-3 and CR 2883-22-4-1 for earliness, KMP-128 and RCPR 7 for yield and yield contributing characters. Taking in to the consideration for an efficient breeding programme, parents with desirable agronomical traits and good general combining ability for grain yield per plant and its component characters which in cross combination may result in high specific combining ability and high *per se* performance. The study extended to the estimation of *sca* effects revealed that cross combination GNR-3 × RCPR 6, AICRIP-1335 × RCPR 8 and NAUR-1 × NDR 1132-5 were highly promising for yield and most of the yield attributing characters. These crosses were in combinations of either average x average, average x average and average x average combining parents *gca* effects and could be exploited for getting desirable recombinants from the segregating population.

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Table 1: Analysis of variance for combining ability for different characters in aerobic rice

Source of Variation	DF	Days to 50 % Flowering	Plant Height (cm)	Panicle Length (cm)	Productive Tillers Per Plant	Grains per Panicle	Seed Test Weight (g)	Grain Yield Per Plant (g)	Straw Yield Per Plant (g)	Harvest Index (%)	Days to Maturity
Replication	2	6.38683	6.14183	0.67513	0.53577	24.89491	0.23025	16.99031	12.3069	0.95086	14.07255
Line	2	73.55623	312.05486	163.94891	2.62371	151.50828	23.30636	0.3823	27.61239	25.64606	88.45608
Tester	9	425.5353	266.20516	22.91027	6.4356	4344.2782	51.81752	19.47748	16.75733	18.97013	436.35753
Line x Tester	18	20.7557	62.53398	5.37894	3.18322	1380.5875	7.69144	20.21422	17.84474	19.94933	22.81045
Error	58	3.64136	6.75632	1.00504	0.10488	149.253	0.94233	3.49958	3.72888	4.30993	11.49833
σ^2l		2.3419	10.1721 *	5.4293 **	0.084	-0.4343	0.7501	-0.1529	0.7566	0.734	2.6060 *
σ^2t		46.9152 **	28.8124 **	2.4267 **	0.7036	464.4158 *	5.6682 **	1.6121	1.316	1.7049	47.3425 **
σ^2gca		12.6281 **	14.4737 **	4.7364 **	0.2270 *	106.8388 *	1.8850 **	0.2544	0.8857	0.9581	12.9298 **
σ^2sca		5.8192 ***	18.5469 **	1.4364 **	1.0265 **	405.3504 **	2.2959 **	5.0820 **	4.3105 **	5.4411 **	4.1785 *
σ^2gca/σ^2sca		2.1701	0.7804	3.2973	0.2211	0.2636	0.8211	0.0501	0.2055	0.1761	3.0944

Table 1: Contd...

Source of Variation	DF	L/B Ratio	Protein Content (%)	Amylose Content (%)	Leaf Area (cm^2)	Chlorophyll Content (Panicle Initiation Stage)	Chlorophyll Content (Flowering Stage)	Photosynthetic Rate (Panicle Initiation Stage) ($\mu mol/m^2/s$)	Photosynthetic Rate (Flowering Stage) ($\mu mol/m^2/s$)	Stomatal Conductance ($mmol/m^2/s$)
Replication	2	0.00411	0.00278	0.12881	0.19859	1.43476	01.78366	0.86151	0.51824	0.12439
Line	2	0.19128	0.73017	40.22386	31.84769	6.02131	2.33852	2.91649	0.35606	146.44929
Tester	9	0.46163	3.60854	28.32717	35.42557	20.31368	15.99637	2.12173	1.02111	60.4648
Line x Tester	18	0.31521	2.01828	19.41126	14.40601	15.4305	9.69478	2.46898	2.59385	56.87153
Error	58	0.00636	0.08951	0.38607	1.79544	1.55603	0.92793	0.184	0.31602	0.17863
σ^2l		0.0061	0.022	1.3315	1.017	0.15	0.0416	0.0923	0.0042	4.8752
σ^2t		0.0504	0.3932	3.1166	3.7874 *	2.088	1.656	0.2195	0.0878	6.697
σ^2gca		0.0163	0.1076	1.7435 *	1.6563 **	0.5972	0.4141	0.1217	0.0235	5.2957 *
σ^2sca		0.1023 **	0.6494 **	6.3779 **	4.3557 **	4.6363 **	2.8676 **	0.7742 **	0.7878 **	18.8932 **
σ^2gca/σ^2sca		0.1595	0.1658	0.2734	0.3803	0.1288	0.1444	0.1572	. 0298	0.2803

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

Table 2: Estimates of general combining ability effects of parents for different characters in aerobic rice

Sr. No	Parents	Days to 50 % Flowering	Plant Height (cm)	Panicle Length (cm)	Productive Tillers Per Plant	Grains per Panicle	Seed Test Weight (g)	Grain Yield Per Plant (g)
				Females				
1	**NAUR -1**	-0.065	0.951	0.497 *	0.307 **	2.553	-1.008 **	0.058
2	**AICRIP-1335**	1.597 **	-3.594 **	2.050 **	-0.024 **	-0.872	0.380 *	0.072
3	**GNR-3**	-1.532**	2.643 **	-2.546 **	-0.283 **	-1.681	0.628 **	-0.13
	SE (gi)	0.3316	0.4793	0.1888	0.0588	2.3419	0.1631	0.4069
	SE (gi-gj)	0.4689	0.6779	0.267	0.0831	3.312	0.2315	0.5755
				Males				
1	**KMP 128**	4.474 **	1.764 *	1.863 **	2.080 **	25.487 **	-3.718 **	1.555 *
2	**CRR 682-B-141-4-1**	4.984 **	-5.601 **	0.121	0.001	17.735 **	-0.013	-1.43
3	**RCPR 6**	1.338 *	3.621 **	-1.164 **	-0.164	-19.513 **	0.499	-1.047
4	**RCPR 7**	-5.793 **	1.399	-1.753 **	-0.714 **	-11.181 *	3.682 **	3.001 **
5	**RCPR 8**	-1.743 **	-3.267 **	1.651 **	0.063	-16.403 **	2.990 **	-1.065
6	**OR 2493-1**	8.131 **	2.521 **	-1.565 **	0.093	-35.846 **	-2.678 **	-1.405
7	**CR 2883-22-4-1**	-13.392 **	-8.923 **	-0.589	0.430 **	20.152 **	-0.414	-0.295
8	**CR 3728-2**	5.361 **	-2.801 **	2.566 **	-0.154	25.042 **	-0.243	-0.66
9	**NDR 1132-5**	-7.268 **	0.721	-1.626 **	-0.905 ***	-14.404 **	1.928 **	0.241
10	**R 1458-231-1-275-1**	3.908 **	10.566 **	0.496	-0.731 **	8.931 *	-2.032 **	1.106
	SE (gj)	0.6054	0.8752	0.0.3447	0.1073	4.2757	0.2989	0.743
	SE ((gi-gj)	0.8561	1.2377	0.4875	0.1517	6.0468	0.4227	1.0507

Table 2: Contd….

Sr. No.	Parents	Straw Yield Per Plant (g)	Harvest Index (%)	Days to Maturity	L/B Ratio	Protein Content (%)	Amylose Content (%)
				Females			
1	**NAUR -1**	-0.947	0.858 *	0.909	0.002	0.044	-0.230 *
2	**AICRIP-1335**	-0.023	0.121	1.071	-0.0081 **	-0.173 **	-1.026
3	**GNR-3**	0.971 *	-0.979 **	-1.981 **	0.079 **	0.129 **	1.577
	SE (gi)	0.4047	0.3477	0.5852	0.0168	0.0484	0.0962
	SE (gi-gj)	0.5723	0.4917	0.8277	0.0237	0.0684	0.136
				Males			
1	**KMP 128**	1.943 *	0.035	4.950 **	-0.324 **	-0.601 **	2.241 **
2	**CRR 682-B-141-4-1**	1.391	-2.199 **	5.457 **	-0.059	-0.361 **	0.988 **
3	**RCPR 6**	-2.495 **	0.964	1.814	0.312 **	-0.044	0.805 **
4	**RCPR 7**	0.196	2.556 **	-5.318 **	-0.112 **	-0.123	-0.461 *
5	**RCPR 8**	-0.54	-0.58	-1.27	0.293 **	-0.132	1.345 **
6	**OR 2493-1**	-1.29	-0.088	7.605 **	0.115 **	0.136	-0.936 **
7	**CR 2883-22-4-1**	0.121	-0.292	-13.917 **	-0.345 **	-0.242 **	-3.778 **
8	**CR 3728-2**	1.175	-1.415 *	4.834 **	0.087 **	0.089	0.632 **
9	**NDR 1132-5**	0.558	-0.854	-7.794 **	0.107 **	-0.404 **	0.954 **
10	**R 1458-231-1-275-1**	-1.059	1.873 **	3.639 **	-0.073 *	1.683 **	-1.790 **
	SE (gj)	0.7399	0.6347	1.0685	0.0306	0.0883	0.1756
	SE ((gi-gj)	1.0449	0.8977	1.5111	0.0433	0.1249	0.2484

Table 2: Contd….

Sr. No.	Parents	Leaf Area (cm^2)	Chlorophyll Content (Panicle Initiation Stage)	Chlorophyll Content (Flowering Stage)	Photosynthetic Rate (Panicle Initiation Stage) (µmol/m^2/s)	Photosynthetic Rate (Flowering Stage) (µmol/m^2/s)	Stomatal Conductance (mmol/m^2/s)
Females							
1	**NAUR -1**	-0.128 **	-0.035	0.236	0.016	0.101	-6.173
2	**AICRIP-1335**	-960 **	-0.43	0.072	-0.319 **	-0.116	2.261**
3	**GNR-3**	1.088 **	0.464 *	-0.308	0.304 **	0.015	-2.154 **
	SE (gi)	0.2113	0.2252	0.1908	0.0698	0.0877	0.08
	SE (gi-gj)	0.2988	0.3185	0.2698	0.0988	0.124	0.1131
Males							
1	**KMP 128**	2.828 **	-0.411	-0.699 *	0.517 **	-0.142	-0.449 **
2	**CRR 682-B-141-4-1**	-1.341 **	0.667	-1.254 **	-0.016	-0.367 *	-3.286 **
3	**RCPR 6**	-0.727	-2.678 **	-0.156	-0.467 **	-0.269	-0.743 **
4	**RCPR 7**	-1.505 **	-0.078	-0.411	0.567 **	-0.08	2.769 **
5	**RCPR 8**	-1.615 **	1.045 *	-0.998 **	0.514 **	0.855 **	1.567 **
6	**OR 2493-1**	3.827 **	-0.222	-1.165 **	-0.602 **	0.074	-0.234
7	**CR 2883-22-4-1**	-0.339	1.066 *	-0.930 **	-0.619 **	-0.167	-2.109 **
8	**CR 3728-2**	-0.507	-1.311 **	1.945 **	0.467 **	-0.043	4.227 **
9	**NDR 1132-5**	-1.894 **	-0.867 *	1.923 **	-0.08	-0.005	-3.601 **
10	**R 1458-231-1-275-1**	1.273 **	2.789 **	1.744 **	-0.282 *	0.143	1.860 **
	SE (gj)	0.3857	0.7122	0.3483	0.1275	0.1601	0.146
	SE ((gi-gj)	0.5455	0.5815	0.4926	0.1803	0.2264	0.2065

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

Table 3: Estimates of specific combining ability effects for different characters in aerobic rice

Sr	Crosses	Days to 50 % Flowering	Pl. Height (cm)	Panicle Length (cm)	Productive Tillers/Plant	Grains / Panicle	Seed Test Weight (g)	Grain Yield/ Plant (g)	StrawYield/ Plant (g)	Harvest Index(%)	Days to Maturity
1	NAUR -1 × KMP 128	2.373 *	0.128	0.103	-0.295	-1.219	0.772	1.463	-1.368	2.154	3.398
2	NAUR -1 × CRR 682-B-141-4-1	-0.054	-4.506 **	-0.365	-1.179 **	5.863	2.004 **	-1.145	2.321	-2.832 *	0.974
3	NAUR -1 × RCPR 6	0.298	4.938 **	1.817 **	-0.105	-18.219 *	-2.475 **	-3.065 *	-1.197	-1.958	1.324
4	NAUR -1 × RCPR 7	-0.591	-2.84	0.606	1.522 **	43.449 **	-1.595 **	-0.219	-0.655	0.206	0.433
5	NAUR -1 × RCPR 8	-3.301 **	-6.837 **	-0.245	-0.401 *	1.001	0.018	0.233	-1.428	1.359	-2.279
6	NAUR -1 × OR 2493-1	3.255 **	1.372	0.155	-1.371 **	-1.219	-0.401	0.276	-1.075	0.951	2.28
7	NAUR -1 × CR 2883-22-4-1	-0.738	-1.851	0.051	0.545 **	2.45	0.329	-0.057	-0.133	-0.096	-1.711
8	NAUR -1 × CR 3728-2	0.662	0.427	0.433	0.929 **	-26.444 **	0.404	1.998	1.733	0.411	-0.312
9	NAUR -1 × NDR 1132-5	0.044	4.508 **	-0.694	-0.274	0.669	-0.08	3.144 *	3.861 **	0.583	-0.928
10	NAUR -1 × R 1458-231-1-275-1	-1.948	4.660 **	-1.860 **	0.630 **	-6.329	1.023	-2.628 *	-2.059	-0.777	-3.178
11	AICRIP-1335 × KMP 128	-2.773 *	-0.894	1.104	-0.134	9.538	-2.639 **	-2.181	0.908	-2.652 *	-3.245
12	AICRIP-1335 × CRR 682-B-141-4-1	-3.863 **	3.705 *	-0.202	0.965 **	-8.959	0.557	-0.812	-2.153	0.716	-4.338 *
13	AICRIP-1335 × RCPR 6	-0.921	-0.184	-0.963	1.270 **	1.872	1.888 **	-0.492	1.436	-1.544	-1.395
14	AICRIP-1335 × RCPR 7	1.557	-0.295	0.716	-0.504 **	-14.794	1.041 *	0.314	-0.479	0.594	1.084
15	AICRIP-1335 × RCPR 8	1.307	-0.296	0.448	0.066	-6.572	0.477	3.199 *	1.948	1.467	0.832
16	AICRIP-1335 × OR 2493-1	-1.584	-3.051 *	-1.352 *	0.066	-11.128	-0.679	-0.417	4.745 **	-3.982 **	-1.059
17	AICRIP-1335 × CR 2883-22-4-1	2.969 **	0.727	0.575	-0.470 *	-2.463	-0.832	2.536	-1.573	3.408 **	3.493
18	AICRIP-1335 × CR 3728-2	1.469	5.905 **	0.487	0.213	-2.349	0.917	0.511	-1.718	1.768	1.995
19	AICRIP-1335 × NDR 1132-5	2.378 *	-0.654	0.489	-0.043	-3.57	0.709	-4.290 **	-2.717 *	-1.373	2.906
20	AICRIP-1335 × R 1458-231-1-275-1	-0.541	-4.962 **	-1.303 *	-1.429 **	38.425 **	-1.438 **	1.631	-0.397	1.597	-0.274
21	GNR-3 × KMP 128	0.4	0.766	-1.207 *	0.429 *	-8.319	1.867 **	0.718	0.46	0.498	-0.153
22	GNR-3 × CRR 682-B-141-4-1	3.917 **	0.801	0.567	0.214	3.096	-2.561 **	1.957	-0.168	2.116	3.364
23	GNR-3 × RCPR 6	0.622	-4.754 **	-0.854	-1.165 **	16.347 *	0.587	3.557 **	-0.239	3.502 **	0.071
24	GNR-3 × RCPR 7	-0.967	3.135 *	-1.322 *	-1.018 **	-28.655 **	0.553	-0.094	1.134	-0.8	-1.517
25	GNR-3 × RCPR 8	1.993	7.134 **	-0.203	0.335	5.571	-0.494	-3.432 **	-0.52	-2.827 *	1.447
26	GNR-3 × OR 2493-1	-1.671	1.679	1.197 *	1.305 **	12.347	1.080 *	0.141	-3.670 **	3.031 **	-1.221
27	GNR-3 × CR 2883-22-4-1	-2.231 *	1.124	-0.626	-0.075	0.013	0.503	-2.479	1.706	-3.312 **	-1.782
28	GNR-3 × CR 3728-2	-2.131 *	-6.332 **	-0.921	-1.141 **	28.793 **	-1.321 *	-2.51	-0.015	-2.179	-1.683
29	GNR-3 × NDR 1132-5	-2.422 *	-3.854 *	0.205	0.316	2.902	-0.629	1.146	-1.144	0.79	-1.978
30	GNR-3 × R 1458-231-1-275-1	2.489 *	0.301	3.163 **	0.800 **	-32.096 **	0.415	0.997	2.456	-0.82	3.452
	SE (Sij)	1.4828	2.1437	0.8444	0.2628	10.4733	0.7321	1.8199	1.8098	1.5548	2.6173
	SE (Sij- Skl)	0.9378	1.3558	0.5341	0.1662	6.6239	0.463	1.151	1.1446	0.9833	1.6553

Table 3: Contd...

Sr. No.	Crosses	L/B Ratio	Protein Content (%)	Amylose Content (%)	Leaf Area (cm^2)	Chlorophyll Content (Panicle Stage)	Chlorophyll Content (Flowering Stage)	Photosynthetic Rate (Panicle Initiation Stage) ($\mu mol/m^2/s$)	Photosynthetic Rate (Flowering Stage) ($\mu mol/m^2/s$)	Stomatal Conductance ($mmol/m^2/s$)
1	**NAUR -1 × KMP 128**	0.230 **	0.067	-2.147 **	1.236	-1.109	1.144	0.041	0.139	1.536 **
2	**NAUR -1 × CRR 682-B-141-4-1**	-0.145 **	0.541 **	0.087	0.072	1.514 *	0.032	0.898 **	-1.183 **	1.643 **
3	**NAUR -1 × RCPR 6**	-0.036	-0.106	-0.337	-0.872	-2.342 **	2.364 **	0.269	-0.897 **	-1.466 **
4	**NAUR -1 × RCPR 7**	-0.132 *	0.303	0.319	0.239	1.255	0.753	1.361 **	0.187	-0.979 **
5	**NAUR -1 × RCPR 8**	-0.371 **	-0.942 **	-3.237 **	-1.651 *	1.102	0.476	-0.089	2.415 **	-0.780 **
6	**NAUR -1 × OR 2493-1**	0.131 *	-0.379 *	3.804 **	1.24	-0.664	0.876	0.443 *	-0.334	-1.912 **
7	**NAUR -1 × CR 2883-22-4-1**	-0.002	-0.145	-2.014 **	1.407 *	0.681	-2.758 **	-0.722 **	0.574 *	-0.274
8	**NAUR -1 × CR 3728-2**	0.229 **	0.714 **	2.276 **	-0.428	1.091	-1.601 *	0.478 *	-0.43	7.964 **
9	**NAUR -1 × NDR 1132-5**	0.269 **	0.071	1.188 **	0.962	-0.02	-0.082	-1.311 **	-0.518	0.441
10	**NAUR -1 × R 1458-231-1-275-1**	-0.174 **	-0.124	0.061	-2.205 **	-1.509 *	-1.203	-1.367 **	0.047	-6.173 **
11	**AICRIP-1335 × KMP 128**	-0.304 **	0.351 *	2.629 **	-4.259 **	1.453 *	-1.362 *	-0.994 **	-0.511	-1.065 **
12	**AICRIP-1335 × CRR 682-B-141-4-1**	0.217 **	-0.039	1.646 **	0.404	0.605	-0.237	-0.571 *	0.890 **	-2.392 **
13	**AICRIP-1335 × RCPR 6**	-0.200 **	0.844 **	-1.568 **	0.294	2.750 **	-0.972	-0.596 **	0.342	-2.768 **
14	**AICRIP-1335 × RCPR 7**	0.051	-0.623 **	0.865 **	0.071	2.253 **	0.117	-0.631 **	0.157	4.917 **
15	**AICRIP-1335 × RCPR 8**	0.032	1.155 **	1.959 **	2.185 **	-2.703 **	1.107	0.723 **	-1.192 **	2.756 **
16	**AICRIP-1335 × OR 2493-1**	0.437 **	0.051	-3.493 **	-1.261	0.397	-0.296	-0.148	0.699 *	-1.227 **
17	**AICRIP-1335 × CR 2883-22-4-1**	0.324 **	0.085	1.648 **	0.572	0.64	-0.961	0.273	-0.610 *	-2.735 **
18	**AICRIP-1335 × CR 3728-2**	-0.441 **	-0.206	-2.795 **	3.074 **	-1.317	3.027 **	0.196	-0.18	-1.404 **
19	**AICRIP-1335 × NDR 1132-5**	-0.325 **	0.051	-3.250 **	0.294	-3.595 **	-0.151	0.977 **	0.595 *	-3.210 **
20	**AICRIP-1335 × R 1458-231-1-275-1**	0.209 **	-1.670 **	2.360 **	-1.373 *	-0.484	-0.272	0.772 **	-0.19	7.129 **
21	**GNR-3 × KMP 128**	0.073	-0.418 **	-0.482	3.023 **	-0.344	0.218	0.953 **	0.372	-1.065 **
22	**GNR-3 × CRR 682-B-141-4-1**	-0.072	-0.502 **	-1.732 **	-0.475	-2.119 **	0.206	-0.327	0.293	-2.392 **
23	**GNR-3 × RCPR 6**	0.237 **	-0.738 **	1.904 **	0.578	-0.408	-1.392 *	0.327	0.555 *	-2.768 **
24	**GNR-3 × RCPR 7**	0.081	0.321 *	-1.183 **	-0.311	-3.508 **	-0.87	-0.730 **	-0.344	4.917 **
25	**GNR-3 × RCPR 8**	0.339 **	-0.214	1.278 **	-0.534	1.600 *	-1.583 *	-0.634 **	-1.223 **	2.756 **
26	**GNR-3 × OR 2493-1**	-0.569 **	0.328 *	-0.311	0.02	0.267	-0.58	-0.295	-0.365	-1.227 **
27	**GNR-3 × CR 2883-22-4-1**	-0.322 **	0.059	0.367	-1.980 **	-1.321	3.719 **	0.450 *	0.036	-2.735 **
28	**GNR-3 × CR 3728-2**	0.212 **	-0.508 **	0.52	-2.645 **	0.226	-1.426 *	-0.674 **	0.609 *	-1.404 **
29	**GNR-3 × NDR 1132-5**	0.056	-0.122	2.062 **	-1.255	3.615 **	0.233	0.334	-0.076	-3.210 **
30	**GNR-3 × R 1458-231-1-275-1**	-0.034	1.794 **	-2.421 **	3.578 **	1.992 **	1.475 *	0.595 **	0.143	7.129 **
	SE (Sij)	0.0751	0.2163	0.4302	0.9448	1.0072	0.8532	0.3123	0.3921	0.3576
	SE (Sij- Skl)	0.0475	0.1368	0.2721	0.5976	0.637	0.5396	0.1975	0.248	0.2262

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

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