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Combining Ability Analysis for Yield and Components Traits in Fine Grain Rice of Mid Hills of Uttarakhand

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Abstract

Nine fine grain rice genotypes *viz.*, VL 30925, VL 30926, VL 30928, VL 30929, VL 30938, VL 31486, VL 31632, VL 31634, VL 31638 were crossed with four basmati varieties Pusa Basmati 1, Pusa Sugandh 2, Pusa Sugandh 3 and Pusa Sugandh 5 in a line x tester mating design. The preponderance of dominant gene action was observed for plant height, days to 50% flowering, days to maturity, grains per panicle, fertile grains per panicle, 1000 grain weight, kernel length, kernel width, L/B ratio and grain yield per plant. Five genotypes *viz.*, VL 30928, VL 30929, VL 31632, VL 30925 and VL 31634 were found to be good general combiners and could be utilized to generate desirable segregants for future breeding programmes. High sca effects were observed in the crosses VL 30926 x P. Sug 5, VL 30929 x P. Sug 3, VL 30938 x P. Sug 5, VL 31486 x P. Sug 2, VL 31632 x P. Sug 5, VL 31634 x P. Bas 1 and VL 31638 x P. Bas 1 for grain yield and components traits.

Key words: Combining ability, gca, sca, grain yield, fine grain rice.

Introduction

Rice is the staple food for more than half of the world's population and the second most widely grown cereal crop of the world. It is the most extensively and the largest grown crop of India having an area of about 44 m ha and is grown in almost all parts of the country. In Uttarakhand, rice is the major cereal crop of *kharif* season accounting an area of about 280 thousand hectares with a production of 594 thousand tonnes and productivity of 2120 kg/ha during 2011-12. Irrigated rice in hills is grown in valleys where water is available in sufficient quantity to meet the growth stage conditions of rice crop. Success of any breeding programme depends primarily on the choice of appropriate parents in the hybridization and combining ability studies helps in selecting the parents for hybridization, provide information on additive and dominance variance (Thakare *et al.*, 2010) as well as breeding procedure to be followed to select desirable segregants (Salgotra *et al.*, 2009). Line x tester analysis provides information about general combining ability (gca) and specific combining ability (sca) effects of parents and is helpful in estimating various types of gene actions (Muhammad *et al.*, 2007). The present investigation was undertaken to get an idea of the combining ability for yield and other related traits in fine grain rice with a view to identify good combiners for effective breeding.

Materials and Methods

The experimental materials comprised of thirty six hybrids derived from crossing of nine lines with four basmati male parents in line x tester fashion. The parents used as lines were VL 30925, VL 30926, VL 30928, VL 30929, VL 30938, VL 31486, VL 31632, VL 31634 and VL 31638 while Pusa Basmati 1, Pusa Sugandh 2, Pusa Sugandh 3, Pusa Sugandh 5 were used as testers. All the parents and hybrids were grown in randomized block design (RBD) with two replications at experimental farm of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora. The standard agronomic practices were followed for raising good crop. The seedlings were planted at spacing of 20 x 15 cm with two meter length row. Observations were recording on five randomly selected competitive plants of the middle row of each plot for quantitative traits *viz.*, plant height, tillers per plant, flag leaf length, flag leaf width, panicles per plant, panicle length, grains per panicle, fertile grain per panicle, thousand grain weight, kernel length, kernel width, L/B ratio, grain yield per plant whereas days to 50 per cent flowering and days to maturity were recorded on plot basis. The mean value was used as the replicated data and was subjected to statistical analysis using INDOSTAT software package. The combining ability analysis was carried out following the method as suggested by Kempthorne (1957).

Results and Discussion

The analysis of variance revealed significant genotypic effect for all the characters under study except tillers/plant, flag leaf width, panicles/plant, panicle length. This provides evidence for the presence of sufficient genetic variability among lines, testers and test crosses indicating wide diversity among treatment themselves (Table 1). The mean sum of squares due to parents versus crosses also differed significantly for yield and major yield components *viz*., plant height, days to 50% flowering, days to maturity, grains per panicle, fertile grains per panicle, 1000 grain weight, kernel length, kernel width, L/B ratio and grain yield per plant. Significance of mean squares of lines and testers indicated prevalence of additive variance whereas, non additive variance by line x tester. Preponderance of non-additive variance in the expression of different traits in rice has also reported by Ram *et al.*, (1991) and Khirsagar, (2002). These results emphasized the importance of combining ability studies and indicated good prospects of selection of suitable parents and the crosses for the development of appropriate varieties and hybrids.

The general combining ability (GCA) identifies superior parental genotypes while specific combining ability (SCA) helps in identification of good hybrid combinations which may ultimately lead to the development of hybrids (Shiva Prasad *et al.*, 2013). Line x Tester analysis is one of the most powerful tools for estimating the GCA of parents and selection of desirable parents and crosses with high SCA for the exploitation of heterosis (Tiwari *et al.*, 2011). The estimates of general combining ability effects of line and tester (Table 2) revealed that the lines VL 30928, VL 30929 and tester Pusa Basmati 1 were good combiners for grain yield and component traits. However, good general combiners may not necessarily produce good specific combinations for different traits. Similar results were reported by Ramlingam *et al.*, (1997). The desirable gca effects of line VL 31634 and tester Pusa Sugandh 2 were the better general combiner for earliness. Promising parental lines identified for short plant stature were VL 30925, VL 30929, VL 31634 and Pusa Sugandh 3. It is worthwhile to mention here that the selection of parents for days to maturity and plant height depends on the target environment of the breeder. VL 30929 exhibited high gca effects for panicles per plant while good general combiners for panicle length was VL 30928. For grains per panicle, good general combiners were VL 30928, VL 30929, VL 31632, VL 31634 and Pusa Sugandh 3. The good general combiner for important traits like fertile grains per panicle were VL 30926 VL 30928, VL 30929, VL 30938,VL 31632, Pusa Sugandh 3 and Pusa Sugandh 5. The parental lines VL 30925, VL 30928, VL 30929, VL 30938, VL 31486, VL 31638, Pusa Basmati 1 and Pusa Sugandh 3 showed high gca effects for 1000 grain weight and kernel length while VL 30926, VL 30929, VL 30938, VL 31632, VL 31638, Pusa Sugandh 3 and Pusa Sugandh 5 were found to be good for kernel width. Parents with significant negative general combining ability (gca) estimates for days to 50% flowering, plant height and days to maturity and with significant positive gca effects for the remaining characters are considered as good general combiners. The parents with significant positive gca effects for days to 50% flowering, plant height and days to maturity are considered as poor general combiners. The parents with non significant gca estimates for all the characters were considered as average general combiners.

VL 30929 was identified as good general combiner for grain yield per plant, plant height, panicles per plant, grains per panicle, fertile grains per panicle, kernel length, kernel width and L/B ratio whereas, VL 30928 was found to be good general combiner for days to 50 % flowering, panicle length, grains per panicle, fertile grains per panicle, 1000 grain weight, kernel length, L/B ratio and grain yield per plant. It could be mentioned that the parents with significant and positive GCA values might be contributed positive alleles in their hybrid due to its additive nature of gene action for the respective traits. The crosses involving these parents might produce good progenies for the respective traits.

Specific combining ability (SCA) of a cross is the estimation and the understanding of the effect of non additive gene action for a trait which is an indicator for the selection of a hybrid combination (Akter *et al.*, 2010). Therefore, a highly significant SCA effect is desirable for a successful hybrid breeding program. Specific combining ability (sca) effects were estimated for all the 36 hybrids and sixteen characters (Table 3). The estimates of hybrid revealed that none of the hybrids was consistently superior for all the traits. In the present study, positive significant sca effects for grain yield per plant was exhibited by seven crosses *viz*., VL 30926 x P. Sug 5, VL 30929 x P. Sug 3, VL 30938 x P. Sug 5, VL 31486 x P. Sug 2, VL 31632 x P. Sug 5, VL 31634 x P. Bas 1 and VL 31638 x P. Bas 1. The high sca effects may be associated with high hybrid vigour (Saidaiah *et al.*, 2010). For plant height, negative estimates of sca are desirable and the promising specific combiners were VL 30926 x P. Sug 2, VL 31634 x P. Bas 1, VL 31634 x P. Sug 3, VL 31638 x P. Sug 2. The results confirm the findings of Muhammad *et al.*, (2007). Out of 36 crosses, as many as 20 cross combinations showed desirable sca effects for days to maturity. The cross combinations *viz*., VL 30925 x P. Bas 1, VL 30926 x P. Bas 1, and VL 31632 x P. Sug 2 showed higher sca effects for flag leaf length. Cross VL 31638 x P. Bas 1 was good specific combiner for tillers per plant whereas cross VL 31638 x P. Sug 2 for flag leaf width. The cross VL 31634 x P. Bas 1, the best specific combination for grain yield per plant was also good with high sca effects for plant height, 1000 grain weight, kernel length, kernel width and L/B ratio. The cross VL 31486 x P. Sug 2 combined positive and significant sca effects for quality traits like kernel length, kernel width, L/B ratio and 1000 grain weight. The cross VL 31632 x P. Sug 5 and VL 30929 x P. Sug 3 expressed desirable significant sca effects for yield component traits *viz.,* days to 50 % flowering, days to maturity, grains per panicle, fertile grains per panicle. The cross VL 31638 x P. Bas 1 showed significantly positive sca effects for grain yield per plant might be due to good specific combination for grains per panicle, fertile grain per panicle, panicle length, tiller per plant and days to maturity.

The proportional contribution of the total variance by lines, testers and interaction revealed that the lines and line x tester interaction have contributed more than testers in respect of all the characters (Table 4). From this study, it is concluded that no cross was good for all the characters but some crosses showed good sca effects for a number of characters. The best general combiners were VL 30928, VL 30929, VL 31632, VL 30925 and VL 31634 could be utilized in future breeding programmes. The crosses *viz.,* VL 30926 x P. Sug 5, VL 30929 x P. Sug 3, VL 30938 x P. Sug 5, VL 31486 x P. Sug 2, VL 31632 x P. Sug 5, VL 31634 x P. Bas 1 and VL 31638 x P. Bas 1 could be used for exploitation of heterosis for yield.

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Table 1. Analysis of variance for various yield contributing characters

Source of variance	d.f	Plant height	Days to 50% flowering	Days to maturity	Tillers per plant	Flag leaf length	Flag leaf width	Panicles per plant	Panicle length	Grains per panicle	Fertile grains per panicle	Spikelet Sterility %	1000grain weight	Kernel length	Kernel width	L/B ratio	Grain yield per plant
Replications	1	69.28	15.52	18.86	50.00	585.06	1.28	330.61	31.03	1396.93	961.72	11.79	12.42	0.00	0.00	0.00	0.01
Treatments	48	250.19**	78.51**	921.70**	8.46	7.64**	0.02	113.15	11.48	2993.96**	2434.47**	357.66**	40.17**	3.16**	0.21**	1.05**	41.50**
Parents	12	175.94**	38.23**	38.63**	7.29	5.48	0.02	10.08	7.44	2177.53**	816.13**	105.83**	16.19**	1.07**	0.08**	0.86**	18.09**
Lines	8	184.88**	44.51**	44.93**	6.93	4.71	0.02	11.93	10.36	2948.12**	1166.18**	108.12**	21.48**	1.23**	0.06**	0.69**	20.86**
Testers	3	23.59	26.12**	25.83**	10.33	4.63	0.03	8.45	2.08	771.45*	122.45	28.83	3.84	0.33**	0.12**	0.86**	11.86
Lines vs Testers	1	561.56**	24.36**	26.67**	1.09	14.22*	0.02	0.18	0.21	231.00	96.79	318.50**	10.92*	2.05**	0.13**	2.24**	14.65
Parents vs Crosses	1	1241.60**	815.57**	1993.95**	38.22	6.95	0.00	150.35	130.11	18191.68**	12227.23**	109.01	19.69**	1.02**	0.01*	0.76**	66.87**
Crosses	35	247.32**	71.26**	1193.84**	8.01	8.39**	0.02	147.43	9.48	2839.67**	2709.54**	451.11**	48.98**	3.94**	0.26**	1.12**	48.80**
Line Effect	8	490.43*	95.51	844.63	8.18	9.26	0.01	182.59	11.78	3691.07	4463.62*	866.07*	120.16**	9.16**	0.21	2.75**	79.60
Tester Effect	3	53.87	189.74*	1730.93	7.51	5.36	0.03	193.64	5.78	2113.16	7229.97*	760.25	25.49	1.45	0.23	0.46	54.95
Line vs Tester Effect	24	190.46**	48.36**	1243.10**	8.01	8.49**	0.03	129.93	9.17	2646.68**	1559.79**	274.15**	28.19**	2.51	0.27**	0.66**	37.77**
Error	48	18.09	0.27	0.59	5.58	3.47	0.02	109.82	2.93	199.00	115.07	32.58	2.58	0.04	0.00	0.02	4.88
Total	97	133.47	39.14	456.59	7.46	11.53	0.03	113.74	7.45	1594.42	1271.55	193.23	21.28	1.58	0.10	0.53	22.95

** Significant at 1% level of probability.

Table 2. Estimates of general combining ability (GCA) effects of Lines and Testers for sixteen characters in rice

Parents	Plant height	Days to 50% flowering	Days to maturity	Tillers per plant	Flag leaf length	Flag leaf width	Panicles per plant	Panicle length	Grains per panicle	Fertile grains per panicle	Spikelet Sterility %	1000 grain weight	Kernel length	Kernel width	L/B ratio	Grain yield per plant
Lines																
VL 30925	-7.59**	-1.51**	2.36**	1.02	0.34	-0.00	-0.43	-0.56	2.36	5.18	-0.98	1.33*	0.36**	-0.00	0.26**	0.25
VL 30926	6.55**	-3.6**	0.48	-0.97	0.38	0.06	-2.18	-0.09	-1.51	9.18*	-5.61**	-0.70	0.08	0.06**	0.01	0.05
VL 30928	0.65	-3.76**	0.23	-1.09	-1.95**	0.01	-2.43	1.62*	16.73**	24.80**	-6.23**	2.16**	0.17*	0.00	0.20**	2.45**
VL 30929	-4.13**	0.61**	4.48**	1.65	1.27	-0.01	12.56**	0.12	19.86**	15.68**	0.13	0.26	0.23**	0.04*	0.11*	4.99**
VL 30938	10.29*	-2.26**	2.11**	-0.84	-0.53	0.00	-2.18	1.10	-1.63	11.18**	-7.23**	1.05	0.24**	0.10**	0.02	1.43
VL 31486	2.20	-1.88**	1.86**	-0.47	1.03	-0.01	-1.93	0.95	-11.76*	-9.31*	1.13	2.87**	1.07**	-0.05**	0.75**	0.07
VL 31632	4.67**	2.36**	5.98**	1.02	0.63	0.00	-0.43	0.36	15.61**	19.18**	-3.36	-2.51**	-0.09	0.14**	-0.19**	-0.96
VL 31634	-15.25**	4.73**	-26.38**	-0.47	-1.32	0.01	-2.05	-2.21**	10.48*	-41.94**	26.63**	-8.85**	-2.70**	-0.40**	-1.40**	-6.50**
VL 31638	2.60	5.36**	8.86**	0.15	0.14	-0.06	-0.93	-1.28*	-50.13**	-33.94**	-4.48*	4.37**	0.62**	0.10**	0.22**	-1.80*
SEm(±)	1.50	0.18	0.27	0.83	0.65	0.05	3.70	0.60	4.98	3.79	2.01	0.56	0.07	0.02	0.05	0.78
CD(P=0.05)	3.05	0.37	0.55	1.69	1.33	0.10	7.52	1.22	10.12	7.69	4.09	1.15	0.14	0.04	0.10	1.58
Testers																
Pusa Basmati 1	0.37	-2.55**	1.48**	0.94	0.15	-0.02	4.91	0.72	-2.29	-2.51	1.11	0.20	0.18**	0.00	0.17**	1.69**
Pusa Sugandh 2	0.84	-3.05**	-14.29**	-0.44	-0.51	-0.04	-1.69	-0.48	-13.73**	-27.40**	8.55**	-1.72**	-0.41**	-0.16**	-0.21**	-2.31**
Pusa Sugandh 3	-2.53**	2.88**	6.54**	-0.11	-0.34	0.05	-1.47	-0.41	11.87**	15.31**	-3.16*	0.93*	0.17**	0.09**	0.02	0.92
Pusa Sugandh 5	1.31	2.72**	6.26**	-0.38	0.69	0.01	-1.75	0.17	4.15	14.59**	-6.50**	0.58	0.06	0.06**	0.01	-0.31
SEm(±)	1.00	0.12	0.18	0.55	0.43	0.03	2.47	0.40	3.32	2.52	1.34	0.37	0.04	0.01	0.03	0.52
CD(P=0.05)	2.03	0.24	0.36	1.13	0.89	0.06	5.01	0.81	6.75	5.13	2.73	0.76	0.09	0.02	0.06	1.05

Table 3. Estimates of specific combining ability (SCA) effects of hybrid for sixteen characters in rice

Cross combination	Plant height	Days to 50% flowering	Days to maturity	Tillers per plant	Flag leaf length	Flag leaf width	Panicles per plant	Panicle length	Grains per panicle	Fertile grains per panicle	Spikelet Sterility %	1000grain weight	Kernel length	Kernel width	L/B ratio	Grain yield per plant
VL 30925 x P. Bas 1	-2.68	-8.31**	-11.36**	0.80	4.06**	-0.08	-3.29	-2.24	-25.58*	-18.23*	-1.23	-1.59	-0.83**	0.00	-0.51**	-1.38
VL 30925 x P. Sug 2	-5.00	7.18**	18.91**	0.19	-1.29	-0.11	1.31	1.85	5.86	4.15	2.31	3.24**	0.77**	0.11**	0.48**	2.43
VL 30925 x P. Sug 3	3.06	-0.76*	-4.91**	-0.63	-2.07	0.08	0.59	1.67	3.75	6.93	-3.45	-0.27	-0.03	-0.08*	0.03	1.38
VL 30925 x P. Sug 5	4.62	1.90**	-2.63**	-0.36	-0.69	0.11	1.37	-1.28	15.97	7.15	2.37	-1.37	0.09	-0.03	0.00	-2.44
VL 30926 x P. Bas 1	-0.08	2.80**	-2.63*	-1.19	2.87*	0.08	-5.54	-1.56	-29.70**	-18.23*	-4.61	1.24	-0.33*	-0.04	-0.17	-4.57**
VL 30926 x P. Sug 2	-7.65*	-5.69**	6.79**	-0.80	-0.10	-0.14	0.56	2.30	-29.26**	-13.34	-2.05	0.57	0.80**	0.19**	0.35**	-1.67
VL 30926 x P. Sug 3	5.06	-0.63	-5.04**	1.86	0.27	0.06	3.34	-0.27	57.12**	35.93**	3.66	0.81	-0.03	-0.05	-0.02	2.27
VL 30926 x P. Sug 5	2.67	3.52**	-0.26	0.13	-3.03*	-0.00	1.62	-0.46	1.84	-4.34	3.00	-2.63*	-0.43**	-0.08*	-0.15	3.97*
VL 30928 x P. Bas 1	-0.88	3.43**	-0.73	-0.56	-0.67	0.03	-4.79	-0.08	-26.95*	-31.86**	6.51	-2.01	-0.12	-0.20**	0.22**	2.49
VL 30928 x P. Sug 2	2.59	-6.56**	6.54**	0.31	-2.61	-0.09	1.81	-2.02	-42.01**	-17.47*	-8.93*	3.16**	-0.29*	0.47**	-0.63**	1.42
VL 30928 x P. Sug 3	-1.08	3.48**	-1.29*	0.98	2.46	-0.04	2.09	1.64	56.37**	43.80**	0.29	-2.20	0.22	-0.16**	0.26*	-0.99
VL 30928 x P. Sug 5	-0.62	-0.34	-4.51**	-0.73	0.83	0.09	0.87	0.46	12.59	5.52	2.12	1.05	0.20	-0.10*	0.14	-2.93
VL 30929 x P. Bas 1	-2.65	-0.94*	-4.48**	-2.31	-0.72	0.07	31.20**	-1.78	-1.58	2.76	-2.86	0.68	-0.00	-0.05	0.00	-0.34
VL 30929 x P. Sug 2	6.38*	5.05**	15.79**	0.06	-1.29	0.04	-11.18	-0.32	13.36	12.15	0.19	2.01	1.00**	0.20**	0.42**	-0.95
VL 30929 x P. Sug 3	0.10	-1.38**	-5.04**	2.73	1.73	-0.00	-7.90	1.54	22.25*	14.43	0.91	-2.70*	-0.76**	-0.04	-0.39**	6.64**
VL 30929 x P. Sug 5	-3.83	-2.72**	-6.26**	-0.48	0.28	-0.11	-12.12	0.56	-34.02**	-29.34**	1.75	0.00	-0.24	-0.10*	-0.02	-5.34**
VL 30938 x P. Bas 1	-3.57	-7.56**	-10.11**	0.68	-2.25	0.05	-3.04	0.78	-3.58	4.26	-5.48	-0.15	-0.23	-0.05	-0.12	-1.86
VL 30938 x P. Sug 2	-3.39	1.93**	12.66**	0.06	-0.28	-0.12	1.56	-2.34	26.86*	37.65**	-8.43*	0.57	0.29*	0.15**	0.17	-0.94
VL 30938 x P. Sug 3	12.43**	2.48**	-1.66**	-0.26	2.19	0.12	0.84	1.57	-17.25	-28.56**	9.29*	0.76	0.02	-0.03	-0.03	-1.48
VL 30938 x P. Sug 5	-5.46	3.15**	-0.88	-0.48	0.35	-0.04	0.62	-0.01	-6.02	-13.34	4.62	-1.18	-0.07	-0.07	-0.00	4.29**

Sug 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.02	-0.01	-0.02	-13.54	4.62	-1.18	-0.07	-0.07	-0.00	4.29**

VL 31486 x P. Bas 1	4.11	1.05**	-2.86**	-2.69	-0.58	0.02	-7.29	-0.41	32.04**	19.76	1.63	-1.08	-0.24	-0.01	-0.20	-6.11**
VL 31486 x P. Sug 2	-4.15	0.55	11.91**	-1.30	1.73	-0.00	0.31	0.65	2.48	6.65	1.19	3.60**	0.54**	0.18**	0.22*	5.19**
VL 31486 x P. Sug 3	1.61	-5.38**	-8.41**	1.86	-0.53	-0.00	3.59	0.92	-17.62	-3.06	-9.08*	-0.36	-0.05	-0.10*	0.06	1.72
VL 31486 x P. Sug 5	-1.57	3.77**	-0.63	2.13	-0.62	-0.01	3.37	-1.16	-16.90	-23.34**	6.25	-2.15	-0.24	-0.07	-0.08	-0.80
VL 31632 x P. Bas 1	-0.61	3.80**	-0.48	0.30	-1.13	-0.15	-4.29	0.47	7.66	10.26	-3.86	0.70	-0.12	0.06	-0.26*	-2.70
VL 31632 x P. Sug 2	-3.42	-1.69**	10.29**	2.19	2.93*	0.17	3.31	-0.86	-25.88*	-2.84	-8.80*	-2.36*	0.71**	0.13**	0.39**	1.14
VL 31632 x P. Sug 3	-2.30	-0.63	-4.54**	-4.13*	-2.38	-0.17	-2.40	0.31	-35.50**	-45.06**	10.41*	1.27	-0.26	-0.18**	0.07	-3.55*
VL 31632 x P. Sug 5	6.34*	-1.47**	-5.26**	1.63	0.57	0.15	3.37	0.07	53.72**	37.65**	2.25	0.37	-0.32*	-0.01	-0.21*	5.10**
VL 31634 x P. Bas 1	-6.72*	3.43**	33.38**	0.80	-1.62	-0.06	-3.16	2.00	-12.20	12.88	-8.36*	4.24**	1.80**	0.42**	0.91**	9.38**
VL 31634 x P. Sug 2	30.05**	-5.56**	-98.33**	1.19	1.60	0.01	2.94	2.76*	59.73**	-42.72**	37.19**	-13.37**	-4.25**	-1.43**	-1.98**	-3.99*
VL 31634 x P. Sug 3	-19.41**	6.48**	37.83**	-0.13	-1.72	0.06	0.72	-6.01**	-43.87**	-10.94	-6.08	4.26**	1.36**	0.58**	0.49**	-3.00
VL 31634 x P. Sug 5	-3.91	-4.34**	27.11**	-1.86	1.73	-0.00	-0.50	1.24	-3.65	40.77**	-22.75**	4.86**	1.09**	0.42**	0.57**	-2.38
VL 31638 x P. Bas 1	13.11**	2.30**	-1.86**	4.18*	0.05	0.02	0.20	2.82*	59.91**	18.38*	18.26**	-2.03	0.10	-0.11**	0.15	5.10**
VL 31638 x P. Sug 2	-15.40**	4.80**	15.41**	-1.93	-0.67	0.24*	-0.68	-2.01	-11.13	15.77*	-12.68**	2.55*	0.40**	-0.03	0.57**	-2.62
VL 31638 x P. Sug 3	0.51	-3.63**	-6.91**	-2.26	0.05	-0.10	-0.90	-1.38	-25.25*	-13.44	-5.95	-1.56	-0.45**	0.08*	-0.47**	-3.01
VL 31638 x P. Sug 5	1.77	-3.47**	-6.63**	0.01	0.56	-0.16	1.37	0.57	-23.52*	-20.72**	0.37	1.04	-0.06	0.06	-0.24*	0.53
SEm(±)	3.00	0.36	0.54	1.67	1.31	0.10	7.41	1.21	9.97	7.58	4.03	1.13	0.14	0.04	0.10	1.56
CD (P=0.05)	6.10	0.74	1.10	3.39	2.67	0.20	15.04	2.45	20.25	15.39	8.19	2.30	0.29	0.08	0.20	3.17

Table 4. Contribution of lines, testers and their interaction

Contribution by	Plant height	Days to 50% flowering	Days to maturity	Tillers per plant	Flag leaf length	Flag leaf width	Panicles per plant	Panicle length	Grains per panicle	Fertile grains per panicle	Spikelet Sterility %	1000grain weight	Kernel length	Kernel width	L/B ratio	Grain yield per plant
Lines (%)	45.32	30.63	16.17	23.33	25.19	9.41	28.30	28.41	29.71	37.65	43.88	56.07	53.13	18.81	55.85	37.27
Testers (%)	1.86	22.82	12.42	8.04	5.47	11.61	11.25	5.22	6.37	22.87	14.44	4.46	3.16	7.66	3.57	9.65
Lines x Testers (%)	52.80	46.54	71.40	68.62	69.32	78.97	60.43	66.35	63.91	39.47	41.67	39.46	43.69	73.52	40.57	53.07