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Genetic parameters and association studies for important quantitative traits in advanced lines of Sambamahsuri derivatives

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ABSTRACT

Thirty three lines of F_5 progenies obtained from Sabita/Sambamahsuri derivatives were evaluated along with parents and three check varieties for 19 characters. Significant differences were observed for all the characters studied. Three lines possessed significantly higher grain yield than superior check variety. High estimates of PCV and GCV were recorded for grain yield per plant, panicle weight, number of panicles per plant, number of secondary branches per panicle, number of grains per panicle, 1000 grain weight and florets number per panicle. High heritability was observed for most of the characters viz. plant height, grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth, days to 50 % flowering, fertility %, days to maturity, 1000 grain weight and kernel L/B ratio. High genetic advance was observed for florets number per panicle, plant height and number of grains per panicle. Genetic advance as percentage of mean was highest for grain yield per plant where as lowest was for days to maturity. High heritability coupled with high GA was recorded for plant height, days to 50% flowering, fertility %, days to maturity and 1000 grain weight. High heritability with low genetic advance was observed for grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth and kernel L/B ratio. Grain yield per plant was significantly correlated with number of panicle per plant, panicle weight, number of secondary branches per panicle. Kernel length imparted the highest positive direct effect on grain yield followed by grain L/B ratio, grain breadth and fertility %.

Keywords: Correlation coefficient, genetic advance, heritability, path coefficient, Sambamahsuri derivative

To evolve a variety having high yield in combination with good yield contributing traits requires information on the nature and magnitude of variation in the available materials. This information is most important, meaningful and has practical utility in a segregating population, where the selection is actually practiced. The present study was, therefore, planned to study the genetic variability, heritable component of variation, correlation between yield and its contributing characters and the extent of magnitude and direction of association between yield and yield attributes in F_5 generation.

MATERIALS AND METHODS

The experiment was conducted under rainfed shallow low land condition during Kharif 2011 at Regional Research Station, New Alluvial Zone, Sub-Centre Chakadah, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The experiment was laid out in Randomized Block Design with two replications. The materials consisted 33 lines of F_5 progenies, obtained from Sabita / Sambamahsuri derivatives and two parents as well as three check varieties *viz.* Swarna Sub-1 as regional check, Dhanarasi as national check and MTU 7029 as local check which are recommended for rainfed lowland AICRIP trial. Single seedling per hill was transplanted with a spacing of 20 × 15 cm in 4 × 3 m^2 plot. The recommended packages of practices were followed to obtain a good harvest. The observation on 19 characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), panicle weight (g), number of panicle per plant, panicle length (cm), number of primary branches per panicle, number of secondary branches per panicle, number of grains per panicle, florets number per panicle, fertility %, 1000 grain weight (g), grain length (mm), grain breadth (mm), grain L/B ratio, kernel length (mm), kernel breadth (mm), kernel L/B ratio and grain yield per plant (g) were recorded on five randomly selected plants from each replication. The mean data were used for statistical analysis following appropriate computer based statistical programme (Genres).

RESULTS AND DISCUSSION

The mean performances of Sambamahsuri derivatives along with parents as well as check varieties for 19 characters are presented in table-1. The mean table showed that days to 50% flowering ranged from 95 days in S_{26} to 135 days in Dhanarasi with a mean of 119 days. Days to maturity varied from 139 to 158 days. Swarna Sub-1 had the longest duration and S_{14} and S_{20} were the earliest in this regard followed by S_{16} and S_{24}. The range for plant height varied from 72.5 to 161 cm. The maximum plant height was observed in S_4 followed by the line S_{10} while the minimum plant height was observed in Sambamahsuri followed by Swarna Sub-1. Number of panicles per plant ranged from 4.5 to 11.5. It was observed that S_{14} and S_{30} registered the highest number of panicles per plant followed by S_{17} and Dhanarasi, respectively. The lowest number of panicles per plant was observed in line S_{32}. The range for panicle weight varied from 1.16 to 3.94 g. The

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maximum panicle weight was observed in Sabita followed by S_{29} while the minimum value for panicle weight was observed in S_{14}. S_{19} registered the maximum panicle length (29.16 cm) followed by the S_{21}. The minimum panicle length was recorded in Sambamahsuri (19 cm) followed by Swarna Sub-1. The number of primary branches ranged from 7.5 to 14. Line S_{29} possessed the maximum value (14) followed by line S_1 while the S_{14} possessed the minimum value (7.5) followed by S_{16} in this regard. The number of secondary branches varied from 18.4 to 51.8. The maximum number of secondary branches were observed in line S_{30} followed by S_{28} while the minimum value was observed in line S_{14} followed by S_{16} in this regard. Florets number per panicle ranged from 111 to 306. The highest florets number per panicle was observed in line S_{13} followed by S_3 while the lowest florets number per panicle was observed in line S_{16} followed by Sambamahsuri. The number of grains per panicle varied from 92 – 235. S_7 was found to possess the highest number of grains per panicle followed by the S_8 while the line S_{16} had the lowest number of grains per panicle followed by the S_{15}.

Highest (90.58) fertility percentage was recorded in S_9 followed by S_7 while the lowest (47.3) fertility percentage was observed in S_{13} followed by S_{15}. The range for 1000 grain weight varied from 11.5 to 27.06g. Sabita possessed the maximum 1000 grain weight followed by S_4. The minimum 1000 grain weight was recorded in S_{15} followed by S_{33}. Grain length varied from (7.25 mm) in S_{15} to (10.8 mm) in S_{16} with a mean of (8.74 mm). Grain breadth ranged from 2 to 3.15 mm, where Dhanarasi recorded the maximum grain breadth and S_{14} showed the minimum. The mean for this trait was 2.45 mm.

The grain length/ breadth (L/B) ratio varied from 2.66 to 5.27 with a mean of 3.58. S_{14} registered maximum grain L/B ratio (5.27) while the minimum grain L/B ratio (2.66) was found in MTU 7029. The range for kernel length was found to be 5.55 to 7.55 mm. The maximum kernel length was observed in S_{14} followed by Sabita while the minimum kernel length was observed in Sambamahsuri and Swarna Sub-1followed by S_{15}. Dhanarasi showed maximum kernel breadth (2.55 mm) followed by MTU 7029 and the minimum kernel breadth was observed in Sambamahsuri (1.75 mm) followed by S_{29}, S_{30} and S_{33}, respectively. A large variation was observed for kernel L/B ratio (2.46 – 4.19 mm). S_{14} possessed highest kernel L/B ratio followed by S_{16}. Swarna Sub-1 recorded the lowest kernel L/B ratio followed by MTU 7029. Grain yield per plant showed highest amount of variability with a mean of 15.43 g. S_{30} registered the maximum grain yield per plant (26.68g) followed by S_{29} (25.20g) and S_{17} (22.08g) respectively while line S_{16} recorded the minimum (8.41g) grain yield per plant.

Estimates of different genetic parameters for 19 different characters were presented in table 2. The analysis of variance revealed highly significant differences for all the characters, indicating the presence of high genetic variability in the tested materials.

Estimates of phenotypic and genotypic variance revealed the highest phenotypic and genotypic variances in florets number per panicle followed by number of grains per panicle and plant height. The PCV was higher than the corresponding GCV for all the characters indicating the influence of environment in the expression of the characters. The high estimates of GCV and PCV were obtained for grain yield per plant, panicle weight, number of panicles per plant, number of secondary branches, number of grains per panicle, 1000 grain weight and florets number per panicle. In this regards, Sawant *et al*. (1994) reported high GCV and PCV for grains per panicle, plant height, 1000 grain weight and grain yield per plant; Singh and Choudhary (1996) for number of panicles per plant, number of grains per panicle, grain yield per plant and 1000 grain weight; Nayak *et al*. (2002) for number of panicles per plant, number of spikelets per panicle, number of grains per panicle and grain yield per plant; Sarkar *et al*. (2005) for number of panicles per plant, number of tillers per plant and grain yield per plant; Panwar *et al*. (2007) for straw yield per plant, grain yield per plant, total biological yield per plant, number of fertile florets per plant and number of branches per panicle; Raut *et al*. (2009) for seed yield per plant, 1000 grain weight, grains per panicle and effective tiller per plant; Karthikeyan *et al*. (2009) for straw yield per plant, grain yield per plant, total biological yield per plant, number of fertile florets per panicle and number of branches per panicle and Anjaneyulu *et al*. (2010) for number of grain per panicle, fertility % and grain yield per plant.

High heritability was observed for most of the characters studied viz. plant height, grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth, kernel L/B ratio, days to 50 % flowering, fertility %, days to maturity and 1000 grain weight. These findings were earlier corroborated by Yadav *et al.* (1992) for plant height, yield per plant, sterility %, harvest index, days to 50 % flowering and days to maturity; Bihari *et al.* (2004) for days to 50% flowering and test weight; Panwar *et al*. (2007) for days to 50% flowering, days to maturity and 1000 grain weight and Karthikeyan *et al*. (2009) for days to 50% flowering, days to maturity and 1000 grain weight. Other characters like panicle weight, florets number per panicle, grain yield per plant, number of grains per panicle, number of primary branches per panicle, panicle length and number of secondary branches were observed to possess low heritability.

The number of panicles per plant had the lowest heritability.

Florets number per panicle recorded the highest GA followed by plant height and number of grains per panicle. These findings were in agreement with that of Kumar and Ramesh (2008) for plant height and Vishwakarma *et al*. (1989) for grains per panicle. Lowest GA was observed in kernel breadth followed by grain breadth, kernel L/B ratio, kernel length and grain L/B ratio.

Genetic advance as percentage of mean was highest for grain yield per plant followed by panicle weight, 1000 grain weight, plant height, number of secondary branches per panicle, number of panicle per plant, florets number per panicle and number of grains per panicle, respectively. These findings were earlier corroborated by different workers for one or more characters e.g. Karthikeyan *et al*. (2009) for number of branches per panicle, straw yield per plant, total biological yield per plant and grain yield per plant; Sarma *et al*. (1996) for effective tillers per m row length followed by panicle weight; Chaubey and Singh (1994) for grain yield per plant followed by panicle weight and total number of spikelets. The lowest GA as percentage of mean was observed in days to maturity followed by panicle length, kernel length, days to 50 % flowering and grain length.

High heritability coupled with high genetic advance was obtained for plant height, days to 50% flowering, fertility%, days to maturity and 1000 grain weight. These findings were corroborated by Singh *et al*. (2005) for plant height; Sanker *et al*. (2006) for days to 50 % flowering, plant height, productive tiller per plant, panicle length, grain per panicle, 1000 seed weight and single plant yield; Singh *et al*. (2007) for days to 50% flowering, grain per panicle and plant height; Kishore *et al*. (2008) for days to 50% flowering, plant height, water uptake and gel consistency; Anjaneyulu *et al*. (2010) for number of grains per panicle, plant height and fertility %. It indicated the predominance of additive gene action for controlling these characters. Therefore, these characters can be improved simply through selection. High heritability associated with low genetic advance was observed for grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth and kernel L/B ratio. It suggested non-additive gene action for the expressions of these characters. The high heritability was being exhibited due to favourable influence of environment rather than genotype therefore, direct selection for such traits might not be rewarding. Low heritability coupled with high genetic advance was registered for number of secondary branches per panicle. It revealed that the character is governed by additive gene effects. The low heritability was being exhibited due to high environmental effects. Therefore, selection for this character might be effective. Low heritability coupled with low genetic advance was observed for panicle weight, florets number per panicle, grain yield per plant, number of grains per panicle, number of primary branches per panicle, panicle length and number of panicles per plant. It indicated that these characters were highly influenced by environmental effects and controlled by non-additive gene action thus direct selection would be ineffective for these characters.

Correlation studies (Table 3.) revealed that grain yield per plant was significantly correlated in positive direction with plant height, number of panicle per plant, panicle weight and number of secondary branches per panicle. This finding was in agreement with that of Choudhary and Das (1997) for days to 50 % flowering, days to maturity, plant height, grains per panicle and panicle length. Similar finding was also obtained by Senapati *et al.* (2009). Therefore, above mentioned characters were the principal yield determining trait in rice.

Genotypic pathway associations of yield attributing characters are presented in table 4. Correlation is partitioned into direct and indirect effects through genotypic path coefficient analysis. Residual effect of path coefficient analysis was low (0.24723). It indicated that the number of characters, chosen for the study were very much appropriate for yield determination in rice.

Path coefficient analysis revealed that eleven characters *viz.* days to 50% flowering, number of panicle per plant, panicle weight, panicle length, number of primary branches per panicle, number of secondary branches per panicle, florets number per panicle, fertility %, grain breadth, grain L/B ratio and kernel length had positive direct effect on grain yield while the remaining seven characters namely days to maturity, plant height, number of grains per panicle, 1000 grain weight, grain length, kernel breadth and kernel L/B ratio incurred negative direct effect on grain yield. The kernel length imparted the highest positive direct effect on grain yield per plant followed by grain L/B ratio, grain breadth and fertility % respectively. The value of correlation coefficient between number of secondary branches and grain yield per plant was almost equal to its direct effect. Therefore, correlation explained the true relationship and direct selection through number of secondary branches would be effective. The plant height was significantly correlated with grain yield per plant in positive direction but its direct effect was negative, it indicated that indirect effects would be the cause of correlation. In this situation, the indirect causal factors were to be considered simultaneously during selection for yield improvement in rice. Therefore, it would be better to consider the other characters that showed high indirect effect on grain yield per plant.

Table 1: Mean performance of 33 lines of Sabita or Sambamahsuri derivative along with parents and check varieties for different characters

Entry or Genotype	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of panicle plant^{-1}	Panicle weight (g)	Panicle length (cm)	No. of primary branches	No. of secondary branches	Florets No. panicle^{-1}	No. of grains panicle^{-1}	Fertility %	1000 grain weight (g)	Grain length (mm)	Grain breadth (mm)	Grain L/B ratio	Kernel length (mm)	Kernel breadth (mm)	kernel L/B ratio	Grain yield Plant^{-1} (g)
1. S_1	124.5	151.0	153.0	6.50	2.26	23.48	13.9	38.8	193.2	161.7	83.75	15.23	8.45	2.60	3.24	6.25	2.00	3.12	12.51
2. S_2	125.0	153.0	146.5	6.25	2.14	24.22	11.7	39.5	212.9	166.1	77.86	16.67	8.45	2.60	3.24	6.45	2.20	2.92	11.59
3. S_3	122.5	155.0	152.0	9.00	2.01	22.95	13.6	46.5	298.7	175.1	58.61	14.85	8.40	2.55	3.29	6.30	2.25	2.79	15.24
4. S_4	121.0	154.5	161.0	6.00	2.51	24.42	11.9	45.7	217.5	155.0	71.25	25.94	8.25	2.60	3.17	6.20	2.25	2.75	12.82
5. S_5	120.0	155.0	142.0	9.00	1.97	22.80	8.7	32.2	159.3	135.4	84.92	14.90	9.05	2.40	3.77	6.45	1.90	3.39	15.08
6. S_6	115.0	145.0	144.0	6.50	3.01	23.65	11.0	43.3	215.6	188.0	87.16	15.67	8.45	2.45	3.45	6.25	1.90	3.28	16.33
7. S_7	111.5	144.0	145.5	8.50	2.78	24.98	11.5	46.5	277.5	235.0	87.26	14.32	8.05	2.20	3.65	5.85	1.90	3.07	20.17
8. S_8	114.0	146.0	137.5	4.75	3.12	24.50	12.2	36.5	251.5	208.1	83.00	15.82	8.45	2.40	3.52	6.25	1.90	3.28	12.73
9. S_9	113.5	145.0	138.0	6.75	2.51	22.62	10.5	33.6	200.3	181.4	90.58	16.99	8.15	2.50	3.26	6.15	2.00	3.07	14.12
10. S_{10}	114.5	144.0	156.5	6.00	3.00	24.02	11.5	36.5	203.1	171.2	84.30	20.25	9.25	2.60	3.55	6.85	2.30	2.97	15.27
11. S_{11}	115.5	146.0	147.0	9.00	2.81	21.93	11.3	29.7	188.2	159.0	84.45	17.29	8.85	2.45	3.61	6.15	2.05	3.00	21.44
12. S_{12}	122.5	153.5	144.0	6.50	2.40	22.27	11.7	30.9	182.0	151.2	83.05	17.26	8.85	2.65	3.33	6.15	2.15	2.86	13.28
13. S_{13}	120.5	156.5	146.5	8.75	1.76	22.53	13.7	41.9	306.0	144.8	47.30	13.40	7.85	2.25	3.48	5.95	1.95	3.05	13.17
14. S_{14}	111.5	139.0	107.0	11.50	1.16	23.78	7.5	18.4	224.9	148.9	66.19	13.81	10.55	2.00	5.27	**7.55**	1.80	4.19	11.39
15. S_{15}	119.0	154.5	146.5	7.25	1.80	20.73	12.0	28.4	187.5	98.0	52.18	11.50	7.25	2.25	3.22	5.75	1.95	2.95	11.06
16. S_{16}	110.0	139.5	116.5	6.50	1.50	23.70	8.0	19.5	111.0	92.0	82.05	17.85	10.80	2.45	4.41	7.20	1.85	3.89	8.41
17. S_{17}	124.0	152.0	132.5	10.00	2.57	23.39	8.3	34.8	172.3	125.2	72.45	20.16	8.95	2.50	3.58	6.75	2.20	3.06	22.08
18. S_{18}	125.5	153.0	145.5	7.00	3.16	23.62	12.6	34.1	226.8	190.6	84.02	19.80	9.25	2.55	3.62	6.65	2.05	3.24	18.85
19. S_{19}	101.0	141.0	126.0	8.25	2.92	29.16	9.9	39.7	220.1	180.6	82.12	17.00	8.85	2.45	3.61	6.25	1.95	3.20	19.93
20. S_{20}	98.0	139.0	138.0	6.50	2.36	26.71	10.1	34.7	193.0	129.4	67.03	18.62	9.15	2.45	3.73	6.85	2.05	3.34	13.08
21. S_{21}	129.5	153.5	123.5	8.25	2.79	27.03	9.2	35.0	223.5	176.5	78.95	15.54	8.45	2.35	3.59	6.45	1.95	3.30	19.60
22. S_{22}	125.0	154.5	124.5	5.00	2.36	26.44	10.2	39.5	202.3	162.9	80.28	15.50	8.85	2.35	3.76	6.45	1.95	3.30	9.82
23. S_{23}	115.0	142.0	126.5	7.25	2.39	22.55	10.5	34.5	204.0	166.7	82.91	16.84	8.85	2.35	3.76	6.25	1.95	3.20	14.70
24. S_{24}	96.0	140.0	111.5	7.50	2.09	22.75	9.2	35.8	178.3	122.2	68.31	15.70	8.85	2.35	3.76	6.35	1.95	3.25	13.34
25. S_{25}	125.5	154.0	131.0	6.75	2.74	23.36	9.7	36.5	206.5	151.2	73.19	16.45	8.75	2.30	3.80	6.55	1.90	3.44	15.89
26. S_{26}	95.0	156.0	138.5	7.00	2.00	23.92	10.1	36.6	195.4	142.7	72.80	16.38	9.35	2.30	4.06	6.95	2.00	3.47	12.14
27. S_{27}	123.0	154.5	143.5	9.25	2.64	20.87	10.6	42.1	188.0	137.7	73.19	18.11	9.05	2.45	3.69	6.35	2.05	3.09	20.79
28. S_{28}	129.5	155.5	151.0	6.80	3.31	22.27	12.1	49.7	233.1	178.7	76.37	17.69	8.95	2.45	3.65	6.65	2.05	3.24	18.89
29. S_{29}	124.5	156.0	146.5	9.00	3.30	21.69	14.0	47.6	200.6	150.7	75.29	16.72	9.05	2.35	3.85	6.35	1.85	3.43	25.20
30. S_{30}	118.5	155.0	132.5	11.50	2.77	24.79	11.5	51.8	206.3	151.1	73.15	19.19	8.25	2.20	3.74	6.15	1.85	3.32	26.68
31. S_{31}	124.5	155.5	146.0	5.50	2.66	25.00	10.9	45.5	225.0	161.8	72.12	17.93	9.05	2.65	3.41	6.65	2.05	3.24	12.43
32. S_{32}	121.0	157.0	122.0	4.50	2.26	21.85	9.3	30.6	180.1	133.2	74.25	18.36	9.25	2.55	3.62	6.55	2.05	3.19	8.65
33. S_{33}	119.5	150.0	107.0	7.50	3.05	25.81	10.9	44.8	246.8	193.3	78.26	13.22	9.05	2.05	4.42	6.45	1.85	3.48	19.46
34. Sabita	120.0	157.5	146.5	6.25	3.94	23.94	10.7	32.8	162.9	138.0	84.76	27.06	9.75	2.85	3.42	7.25	2.25	3.22	20.94
35.Sambamahsuri	122.5	154.0	72.5	9.25	1.17	19.00	9.9	28.6	155.0	127.0	81.95	12.76	7.75	2.20	3.52	5.55	1.75	3.17	9.23
36.Swarna sub-1	133.0	158.0	76.5	8.50	1.77	20.06	11.8	24.4	169.2	120.0	70.73	17.35	7.35	2.55	2.88	5.55	2.25	2.46	12.84
37. Dhanarasi	135.0	156.0	111.0	10.00	1.85	24.00	9.3	32.0	183.6	131.6	71.82	19.83	8.55	3.15	2.71	6.45	2.55	2.53	15.53
38. MTU 7029	124.0	155.0	82.0	7.50	1.79	22.09	10.7	31.7	178.9	136.7	76.30	17.56	7.75	2.90	2.66	6.05	2.45	2.47	11.67
Mean	**118.65**	**150.80**	**132.05**	**7.57**	**2.44**	**23.49**	**10.85**	**36.59**	**204.76**	**154.69**	**76.16**	**17.09**	**8.74**	**2.45**	**3.58**	**6.40**	**2.03**	**3.16**	**15.43**
SEm (±)	**2.23**	**1.82**	**0.79**	**1.29**	**0.32**	**1.42**	**0.83**	**5.48**	**23.51**	**19.31**	**2.49**	**0.87**	**0.07**	**0.05**	**0.06**	**0.07**	**0.06**	**0.07**	**2.93**
LSD (0.05)	**4.52**	**3.69**	**1.60**	**2.62**	**0.65**	**2.88**	**1.68**	**11.10**	**47.65**	**39.13**	**5.06**	**1.76**	**0.14**	**0.11**	**0.13**	**0.14**	**0.11**	**0.14**	**5.97**

Table 2: Variability and genetic parameters for different quantitative characters in F_5 progenies of Sabita or Sambamahsuri derivatives

Characters	Mean	Range	Variance			C V (%)	G C V (%)	P C V (%)	h^2 (BS)	G.A.	G.A. as% of mean
			Phenotypic	Genotypic	Environmental						
Days to 50 % flowering	118.65	95.00-135.00	89.590	84.602	4.988	1.882	7.751	7.976	0.944	18.413	15.517
Days to maturity	150.80	139-158	38.612	35.293	3.319	1.208	3.939	4.120	0.914	11.700	7.758
Plant height (cm)	132.05	72.50- 161	457.418	456.791	0.627	0.599	16.185	16.196	0.998	43.997	33.318
No. of panicle plant^{-1}	7.57	4.5- 11.50	3.694	2.024	1.670	17.060	18.785	25.376	0.548	2.169	28.647
Panicle weight (g)	2.44	1.16-3.94	0.423	0.321	0.102	13.076	23.220	26.650	0.759	1.017	41.677
Panicle length (cm)	23.49	19-29.16	4.857	2.841	2.016	6.042	7.173	9.378	0.585	2.656	11.3017
No. of primary branches	10.84	7.50-14	2.869	2.178	0.691	7.661	13.606	15.614	0.759	2.649	24.423
No. of secondary branches	36.59	18.40-51.80	74.815	44.790	30.025	14.972	18.286	23.633	0.598	10.667	29.147
Floret No. panicle^{-1}	204.76	111.00-306.00	1707.500	1154.594	552.906	11.483	16.594	20.179	0.676	57.559	28.109
No. of grains panicle^{-1}	154.69	92.00-235.00	1027.756	654.828	372.927	12.483	16.542	20.723	0.637	42.077	27.200
Fertility %	76.16	47.3-90.58	90.663	84.423	6.240	3.279	12.063	12.501	0.931	18.264	23.980
1000 grains weight (g)	17.09	11.50-27.06	9.715	8.963	0.751	5.070	17.514	18.233	0.923	5.923	34.655
Grain length (mm)	8.74	7.25-10.80	0.523	0.519	0.005	0.775	8.240	8.276	0.991	1.477	16.900
Grain breadth (mm)	2.45	2.00-3.15	0.050	0.047	0.003	2.156	8.849	9.110	0.944	0.434	17.707
Grain L/B ratio	3.58	2.66-5.27	0.212	0.208	0.004	1.805	12.699	12.825	0.980	0.930	25.901
Kernel length (mm)	6.40	5.55-7.55	0.183	0.178	0.005	1.082	6.592	6.680	0.974	0.857	13.399
Kernel breadth (mm)	2.03	1.75- 2.55	0.033	0.030	0.003	2.781	8.560	8.995	0.905	0.341	16.781
kernel L/B ratio	3.16	2.46-4.19	0.114	0.109	0.005	2.210	10.425	10.655	0.957	0.665	21.014
Grain yield plant^{-1} (g)	15.43	8.41-26.68	24.966	16.271	8.695	19.106	26.137	32.376	0.652	6.708	43.467

Note: C V: Coefficient of variation, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, GA: Genetic Advance

Table 3: Correlation coefficients for grain yield and quality traits in F_5 progenies of Sabita or Sambamansuri derivative

Characters		Days to maturity	Plant height (cm)	No. of panicle plant^{-1}	Panicle weight (g)	Panicle length (cm)	No. of primary branches	No. of secondary branches	Floret No. panicle^{-1}	No. of grains panicle^{-1}	Fertility %	1000 grains weight (g)	Grain length (mm)	Grain breadth (mm)	Grain L/B ratio	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Grain yield plant^{-1} (g)
Days to 50 % flowering	G	0.703**	-0.075	0.092	0.066	-0.360*	0.305	0.115	0.048	0.013	-0.029	0.108	-0.318	0.357*	-0.437**	-0.259	0.355*	-0.422**	0.117
	P	0.677**	-0.074	0.081	0.061	-0.279	0.235	0.070	0.021	-0.004	-0.020	0.091	-0.307	0.344*	-0.424**	-0.249	0.337*	-0.411**	0.108
Days to maturity	G		0.029	0.032	0.059	-0.392*	0.364*	0.303	0.030	-0.204	-0.271	0.166	-0.380*	0.298	-0.467**	-0.269	0.332*	-0.439**	0.110
	P		0.027	-0.001	0.048	-0.310	0.319	0.216	0.021	-0.159	-0.249	0.144	-0.356*	0.287	-0.444**	-0.238	0.322*	-0.415**	0.067
Plant height (cm)	G			-0.320*	0.560**	0.246	0.491**	0.578**	0.404*	0.382*	0.011	0.262	0.135	0.072	-0.029	0.204	0.031	0.040	0.323*
	P			-0.229	0.488**	0.194	0.428**	0.447**	0.335*	0.308	0.010	0.252	0.134	0.069	-0.028	0.201	0.028	0.040	0.268
No. of panicle plant^{-1}	G				-0.309	-0.348*	-0.234	-0.115	-0.021	-0.326*	-0.357*	-0.227	-0.078	-0.308	0.235	-0.117	-0.109	0.061	0.396*
	P				-0.281	-0.062	-0.106	0.004	0.090	-0.066	-0.203	-0.180	-0.063	-0.225	0.174	-0.093	-0.082	0.046	0.528**
Panicle weight (g)	G					0.380*	0.359*	0.659**	0.220	0.626**	0.459**	0.499**	0.136	0.122	-0.050	0.165	0.006	0.042	0.735**
	P					0.329*	0.283	0.471**	0.223	0.498**	0.392*	0.417**	0.120	0.117	-0.055	0.152	0.036	0.013	0.640**
Panicle length (cm)	G						-0.325*	0.155	0.252	0.427**	0.192	0.182	0.338*	-0.058	0.275	0.451**	-0.070	0.336*	0.109
	P						-0.090	0.364*	0.322*	0.431**	0.157	0.132	0.249	-0.018	0.180	0.326*	-0.055	0.236	0.231
No. of primary branches	G							0.547**	0.528**	0.337*	-0.179	-0.054	-0.503**	0.092	-0.444**	-0.483**	0.137	-0.451**	0.200
	P							0.543**	0.514**	0.370*	-0.136	-0.032	-0.445**	0.078	-0.387*	-0.426**	0.095	-0.374*	0.190
No. of secondary branches	G								0.579**	0.509**	-0.066	0.092	-0.287	-0.098	-0.167	-0.214	-0.032	-0.157	0.595**
	P								0.600**	0.558**	-0.026	0.070	-0.228	-0.066	-0.140	-0.185	-0.052	-0.115	0.454**
Floret No./panicle	G									0.632**	-0.366*	-0.307	-0.291	-0.304	0.028	-0.186	-0.097	-0.061	0.139
	P									0.747**	-0.268	-0.253	-0.237	-0.255	0.030	-0.144	-0.076	-0.046	0.231
No. of grains panicle^{-1}	G										0.473**	-0.103	-0.118	-0.173	0.036	-0.122	-0.169	0.027	0.301
	P										0.422**	-0.093	-0.092	-0.143	0.035	-0.086	-0.123	0.020	0.349*
Fertility %	G											0.231	0.227	0.159	0.017	0.074	-0.105	0.115	0.170
	P											0.213	0.221	0.160	0.009	0.077	-0.079	0.097	0.178
1000 grains weight (g)	G												0.283	0.633**	-0.263	0.383*	0.592**	-0.237	0.290
	P												0.265	0.585**	-0.250	0.353*	0.531**	-0.217	0.222
Grain length (mm)	G													-0.062	0.724**	0.906**	-0.186	0.731**	0.030
	P													-0.045	0.709**	0.904**	-0.158	0.705**	0.015
Grain breadth (mm)	G														-0.718**	0.048	0.869**	-0.633**	-0.094
	P														-0.721**	0.067	0.861**	-0.640**	-0.077
Grain L/B ratio	G															0.600**	-0.687**	0.927**	0.069
	P															0.580**	-0.677**	0.921**	0.051
Kernel length (mm)	G																0.002	0.642**	0.010
	P																0.037	0.608**	0.001
Kernel breadth (mm)	G																	-0.759**	-0.057
	P																	-0.764**	-0.042
kernel L/B ratio	G																		0.025
	P																		0.014

*Note: *, ** Significant at 5 % and 1%level, respectively; G: Genotypic correlation coefficient, P: Phenotypic correlation coefficient*

Table 4: Path coefficient analysis showing direct (diagonal bold) and indirect effects of component traits on grain yield of rice

Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of panicle plant^{-1}	Panicle weight (g)	Panicle length (cm)	No. of primary branches	No. of secondary branches	Floret No. panicle^{-1}	No. of grains Panicle^{-1}	Fertility %	1000 grains weight (g)	Grain length (mm)	Grain breadth (mm)	Grain L/B ratio	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Yield correlation
Days to 50 % flowering	**0.467**	-0.328	0.016	0.060	0.056	-0.249	0.153	0.065	0.036	-0.028	-0.040	-0.055	1.306	1.597	-3.049	-1.824	-3.135	5.071	0.117
Days to maturity	0.328	**-0.467**	-0.006	0.021	0.050	-0.272	0.182	0.171	0.023	0.465	-0.383	-0.085	1.559	1.333	-3.259	-1.896	-2.937	5.284	0.110
Plant height	-0.035	-0.014	**-0.216**	-0.209	0.475	0.171	0.245	0.327	0.313	-0.871	0.015	-0.135	-0.554	0.321	-0.200	1.441	-0.269	-0.483	0.323*
No. of panicle plant^{-1}	0.043	-0.015	0.069	**0.655**	-0.262	-0.241	-0.117	-0.065	-0.016	0.743	-0.505	0.117	0.319	-1.377	1.643	-0.823	0.958	-0.729	0.396*
Panicle weight	0.031	-0.027	-0.120	-0.202	**0.849**	0.263	0.179	0.373	0.170	-1.427	0.651	-0.257	-0.558	0.544	-0.351	1.166	-0.049	-0.499	0.735**
Panicle length	-0.168	0.183	-0.053	-0.228	0.323	**0.694**	-0.163	0.087	0.195	-0.974	0.271	-0.094	-1.388	-0.260	1.925	3.177	0.617	-4.034	0.109
No. of primary branches	0.143	-0.170	-0.106	-0.153	0.305	-0.225	**0.500**	0.309	0.409	-0.768	-0.253	0.028	2.063	0.409	-3.099	-3.407	-1.211	5.427	0.200
No. of secondary branches	0.054	-0.141	-0.125	-0.075	0.561	0.107	0.273	**0.566**	0.449	-1.160	-0.094	-0.048	1.178	-0.436	-1.170	-1.511	0.285	1.882	0.595**
Floret No. panicle^{-1}	0.022	-0.014	-0.087	-0.014	0.186	0.175	0.264	0.328	**0.775**	-1.442	-0.519	0.158	1.195	-1.359	0.193	-1.314	0.860	0.729	0.139
No. of grains panicle^{-1}	0.006	0.095	-0.082	-0.213	0.532	0.296	0.168	0.288	0.489	**-2.281**	0.669	0.053	0.484	-0.774	0.255	-0.857	1.494	-0.322	0.301
Fertility %	-0.014	0.126	-0.002	-0.233	0.390	0.133	-0.089	-0.037	-0.284	-1.078	**1.417**	-0.119	-0.931	0.708	0.119	0.520	0.925	-1.382	0.170
1000 grains weight	0.050	-0.077	-0.056	-0.148	0.424	0.126	-0.027	0.052	-0.238	0.235	0.328	**-0.516**	-1.163	2.827	-1.838	2.697	-5.232	2.846	0.290
Grain length	-0.148	0.177	-0.029	-0.051	0.116	0.235	-0.251	-0.163	-0.226	0.268	0.322	-0.146	**-4.104**	-0.275	5.057	6.391	1.646	-8.788	0.030
Grain breadth	0.167	-0.139	-0.015	-0.202	0.103	-0.040	0.046	-0.055	-0.236	0.395	0.225	-0.327	0.253	**4.468**	-5.014	0.341	-7.677	7.613	-0.094
Grain L/B ratio	-0.204	0.217	0.006	0.154	-0.043	0.191	-0.222	-0.095	0.021	-0.083	0.024	0.136	-2.971	-3.207	**6.987**	4.228	6.071	-11.142	0.069
Kernel length	-0.121	0.126	-0.044	-0.076	0.141	0.313	-0.242	-0.121	-0.144	0.277	0.105	-0.197	-3.720	0.216	4.190	**7.051**	-0.017	-7.723	0.010
Kernel breadth	0.166	-0.155	-0.006	-0.071	0.005	-0.048	0.068	-0.018	-0.075	0.386	-0.148	-0.306	0.765	3.883	-4.801	0.014	**-8.835**	9.123	-0.057
Kernel L/B ratio	-0.197	0.205	-0.008	0.039	0.035	0.233	-0.226	-0.088	-0.047	-0.061	0.163	0.122	-3.000	-2.829	6.475	4.529	6.703	**-12.024**	0.025

*Note: *, ** Significant at 5 % and 1%level, respectively; Residual effect = 0.24723*

The correlation coefficient between grain breadth and grain yield per plant was negative but its direct effect was positive and high. In order to make full use of high direct effect of grain breadth a restricted simultaneous selection model is to be followed i.e. restriction are to be imposed to nullify the undesirable indirect effects.

Kernel length imparted the highest positive direct effect on grain yield per plant, which is masked by its high negative indirect effects via kernel L/B ratio, grain length and number of primary branches per panicle, led to non-significant positive correlation with grain yield. In this regard also a restricted simultaneous selection model is to be followed to make selection effective for kernel length and restriction are to be imposed mainly on kernel L/B ratio, grain length and number of primary branches per plant to nullify their undesirable indirect effect.

The panicle weight and number of panicle per plant were significantly correlated with grain yield per plant but they had small direct effect. Therefore, indirect effects of panicle weight and number of panicle per plant through other component characters were mainly responsible for the production of such correlation coefficient. In this circumstance, indirect selection through such characters should be practiced for yield improvement in rice.

REFERENCES

Anjaneyulu, M., Reddy, D. R. and Reddy, K. H. P. 2010. Genetic variability, heritability and genetic advance in rice (*Oryza sativa* L.). *Res. Crops*, **11:** 415-16.

Panwar, A., Dhaka, R. P. S. and Kumar, V. 2007. Genetic variability and heritability studies in rice. *Adv. Pl. Sci.*, **20:** 47-49.

Bihari, P. K., Richharia, A. K. and Sahu, R. S. 2004. Genetic advance for yield attributes in aromatic rice. *J. Appl. Biol.*, **14:** 1-5.

Chaubey, P. K. and Singh, R. P. 1994. Genetic variability, correlation and path analysis of yield components of rice. *Madras Agril. J.*, **81:** 468-70.

Choudhury, P. K. D. and Das, P. K. 1997. Genetic variability, correlation and path coefficient analysis in deep water rice. *J. Agril. Sci. Soc. North- East India*, **10:** 155-57.

Karthikeyan, P., Anbuselvam, Y., Elangaimannan, R. and Venkatesan, M. 2009. Variability and heritability studies in rice (*Oryza sativa* L.) under coastal salinity. *Electronic J. Pl. Breed.*, **1:** 196-98.

Kishore, N. S., Babu, V. R., Ansari, N. A. and Prasad, A. R. 2008. Genetic variability, heritability and genetic advance in rice (*Oryza sativa* L.) genotypes of different eco-geographical regions. *Res. Crops*, **9:** 147-50.

Kumar, P. and Ramesh, B. 2008. Genetic variability and character associations in rice. *Progressive Agric.*, **8:** 260-62.

Madhavilatha, L., Sekhar, M. R., Suneetha, Y. and Srinivas, T. 2005. Genetic variability, correlation and path analysis for yield and quality traits in rice (*Oryza sativa* L.). *Res. Crops*, **6:** 527-34.

Nayak, A. R., Chaudhury, D. and Reddy, J. N. 2002. Genetic variability, heritability and genetic advance in scented rice. *Indian Agriculturist*, **46:** 45-47.

Raut, K. R., Harer, P. N. and Yadav, P. S. 2009. Genetic variability and character association in rice (*Oryza sativa* L.). *J. Maharashtra Agril. Univ.*, **34:** 174-78.

Sankar, P. D., Sheeba, A. and Anbumalarmathi, J. 2006. Variability and character association studies in rice (*Oryza sativa* L.). *Agril. Sci. Digest*, **26:** 182-84.

Sarkar, K. K., Bhutia, K. S., Senapati, B. K., Roy, S. K., Panda, S. and Mondal, A. B. 2005. Genetic variability and relationships between grain yield and its component traits in rice (*Oryza sativa* L.). *Env.& Ecol.*, **23S:** 702-706.

Sarma, M. K., Richharia, A. K. and Agarwal, R. K. 1996. Variability, heritability, genetic advance, and genetic divergence in upland rice. *Int. Rice Res. Notes*, **21:** 25-26.

Sawant, D. S., Patil, S. L. and Bhave, S. G. 1994. Variability, heritability and genetic advance in pure lines of lowland rice. *Ann. Agril. Res.*, **15:** 27-30.

Senapati, B. K., Pal, S., Roy, S., De, D. K. and Pal, S. 2009. Selection criteria for high yield in early segregating generation of rice (*Oryza sativa* L.) crosses. *J. Crop and Weed*, **5:** 12-14.

Singh, S. and Choudhary, B. S. 1996 Variability, heritability and genetic advance in cultivars of rice (*Oryza sativa* L.). *Crop Res. Hisar*, **12:** 165-67.

Singh, S. P., Singhara, G. S., Parray, G. A. and Bhat, G. N. 2005. Genetic variability and heritability in rice (*Oryza sativa* L). *Env. & Ecol.*, **23S:** 549-51.

Singh, R. P., Kumar, M. S. and Madhavilatha, L. 2007. Variability and relationship studies of yield and yield attributing traits in diverse lines of international irrigated observational nursery of rice (*Oryza sativa* L.). *J. Res. ANGRAU*, **35:** 16-22.

Vishwakarma, D. N., Lalji, Maurya, D.M. and Maurya, K. N. 1989. Heritability and genetic advance for yield and its components in rice (*Oryza sativa* L.). *N. D. J. Agril. Res.*, **4:** 37-39.

Yadav, R. K. 1992. Genetic variability, correlation studies and their implication in selection of high yielding genotypes of rice. *Adv. Pl. Sci.*, **5:** 306-12.