Evaluation of Recombinant Inbred Lines (F_8) of Sabita/Sambamahsuri Derivatives for Quality Characters

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Abstract

Study on genetic variation and interrelationship of different quality characters was carried out using twenty-three recombinant inbred lines (RILs) of Sabita/Sambamahsuri derivatives developed at Regional Research Station, Bidhan Chandra Krishi Vishwavidyalaya, sub-centre - Chakdaha, Nadia, West Bengal along with four check varieties viz. Swarna sub-1, Dhanarasi, Sambamahsuri and Sabitain RBD with two replications. Grain yield and eight quality characters were studied and statistical analysis carried out for the estimation of GCV, PCV, heritability (BS), genetic advance and correlation coefficient for all characters. It was observed from grain quality performance that the genotypes S_17 (81.235%) was superior in hulling percentage and S_11 (69.235% and 59.825%) for milling percentage and head rice recovery. Among the selected genotypes, S_1, S_7, S_9, S_10, S_12, S_13, S_18, S_21 and S_22 reported intermediate (20% - 25%) amylose content. Analysis of variance revealed highly significant differences among the genotypes for all the characters under study. Alkali spreading (26.667% and 27.657%) value exhibited highest estimates of GCV and PCV. High heritability coupled with high genetic advance as percentage of mean was observed for amylose content (99.310% and 43.201%), volume expansion ratio (98.985% and 36.493%) and alkali spreading value (92.970% and 52.967%). Grain yield plant^{-1} exhibited significant positive correlation with hulling percentage, milling percentage and head rice recovery and showed negative significant correlation with water uptake ratio and alkali spreading value. Therefore, direct selection would be effective for quality improvement of rice against these characters.

Keywords
Rice, quality parameters, GCV, PCV, Heritability, Genetic advance and Correlation

Introduction

Rice (*Oryza sativa* L.) is the most widely consumed staple food for more than 60% of global population; especially in Asia. More than 90% of the world’s rice is grown and consumed in Asia. Rice accounts for between 35-60% of the caloric intake of three billion Asians (Guyer *et al.*, 1998). Although yield improvement is considered to be the prime objective of any breeding programme but after achieving self-sufficiency in crop production, quality traits became important consideration of rice breeding in India (Mishra, 2004). With increase in yield, there is also a need to look into the quality aspects to have a better consumers’ acceptance, which determine the profit margin of rice growers which in turn dictates the export quality and foreign exchange in India (Dhanwani *et al.*, 2013). The many diverse uses of rice both domestically and for export, require the
quality be evaluated according to its suitability for specific end uses (Sonowal and Barooah, 2015). The large spectrum of genetic variability in segregating populations depends on the level of genetic diversity among genotypes offer better scope for selection. Information on GCV, PCV, heritability, genetic advance and genotypic correlation coefficient would be helpful for tailoring a sound breeding programme. Selection for improvement of milling, cooking, eating and processing qualities is crucial to get consumers’ preference and industrial standard.

Chikkalingaiah et al., (1999) derived information on mean, range, GCV, PCV and heritability from eight quality traits like grain length, grain breadth, L/B ratio, Kernel elongation ratio, amylose content, milling recovery, test weight as well as plant characters in 23 scented and one non-scented genotypes. They reported high heritability and genetic advance coupled with large genetic variability for amylose content, milling recovery, total number of tillers and total number of effective tillers. Binodh et al., (2007) analysed 55 rice cultures for 14 quality parameters. High heritability with moderate to high GA and GCV and PCV were observed for all the quality characters, except for linear elongation ratio. Kishore et al., (2008) studied genetic variability and heritability of different yield and grain quality characters for 70 rice genotypes. They obtained significant genotypic differences for all the 18 characters studied. The characters, namely, days to 50% flowering, plant height, head rice recovery percentage, L/B ratio, kernel length after cooking, elongation ratio, volume expansion ratio, water uptake, alkali spreading value and gel consistency were less affected by environment. High heritability coupled with high GA was exhibited by characters like days to 50% flowering, plant height and water uptake and gel consistency.

The present study is to find out superior genotypes of rice suitable for the gangetic plains of West Bengal. In this context, keeping the prior points in view, the present investigation was undertaken to assess the recombinant inbred lines of Sabita/Sambamahsuri derivatives, to identify the promising genotypes in F₈ progenies of Sabita/Sambamahsuri derivatives, to determine the genetic variability present in recombinant inbred lines of Sabita/Sambamahsuri derivatives and to understand the interrelationship among different traits for selection of desirable genotypes.

Materials and Methods

The experiment was conducted at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during kharif, 2015 in RBD with two replications. The experimental materials consisted of twenty-three F₈ recombinant inbred lines (RILs) of Sabita/Sambamahsuri derivatives and four checks viz. Swarna sub-1, Dhanarasi, Sambamahsuri and Sabita. RILs were developed at RRS, NAZ, Bidhan Chandra Krishi Vishwavidyalaya, SC-Chakdaha, Nadia. The Progenies were designated according to selection number and they are listed in Table-1. Each genotype was grown in 5 m² plot with the spacing of 20 × 20 cm and recommended management practices were followed to obtain good harvest. The seed was dehusked in a Satake laboratory huller and polished in a Satake Rice Polisher. The polished seed obtained was then utilized for the analysis of eight quality traits namely Hulling percentage (%), milling percentage (%) and head rice recovery (%) according to Nayak et al., (2003), amylose content (%) following the method of Juliano (1971), water uptake ratio, kernel elongation ratio and volume expansion ratio according to Patil et al., (2012) and alkali spreading value
as suggested by Little et al., (1958) along with grain yield plant. The data were used for statistical analysis following appropriate computer based statistical software (OPSTAT) for the estimation of analysis of variance, mean, range, genotypic, phenotypic and environmental variance, GCV, PCV, heritability (BS), genetic advance and correlation coefficient for all characters.

Results and Discussion

Mean performance of twenty-three lines of Sabita/Sambamahsuri derivatives along with check varieties has been presented in Table-2. A wide variation was observed for hulling percentage (67.330% to 81.235%). S17 registered highest hulling percentage (81.235%) followed by S21 (80.465%), S19 (80.435%) and S23 (79.650%) respectively, while the minimum hulling percentage was observed in Sambamahsuri followed by Swarna sub-1. Milling percentage varied from 57.360% to 69.235%. S11 possessed highest value (69.235%) for milling percentage followed by S12 (69.200%), S6 (68.950%) and S19 (68.410%) respectively while the minimum value recorded for Sambamahsuri followed by Dhanrasi in this regard. A high degree of variation (44.492% to 59.825 %) was observed for head rice recovery percentage. The maximum head rice recovery percentage was observed in S11 (59.825%) followed by S16 (59.620%) and S12 (59.587%) respectively, while minimum value of this trait was recorded for Sambamahsuri (44.492%) followed by S22 (54.509%). Amylose content ranged from 10.792% to 26.304%. Varieties with intermediate amylose content are preferred by most rice consumers. Among the selected genotypes S1, S7, S9, S10, S12, S13, S18, S21 and S22 reported intermediate amylose content. Sabita recorded highest amylose content followed by S19 and the minimum amylose content recorded in S17 followed by S23 and S4 respectively. The range for the water uptake ratio was found to be 1.300 to 1.674. The maximum water uptake ratio was observed in S23 followed by S20, Swarna sub 1 and Sambamahsuri respectively while the minimum water uptake ratio observed in S3 followed by S11, S16 and S21 respectively. The range for volume expansion ratio was found to be 1.815 to 3.540. Most of the variety possessed moderate degree of volume expansion ratio. Sonowal and Barooah (2015) obtained moderate degree of volume expansion ratio in their experiment. The maximum value for volume expansion ratio was recorded in the S23 followed by S5, while minimum value recorded in S10 followed by S12. Kernel elongation ratio ranged from 1.167 to 1.657. The maximum kernel elongation ratio was recorded for S1 followed by S5 and the minimum value was recorded for S12 followed by S3. The observed range for alkali spreading value was 2 to 5. The highest alkali spreading value recorded in S7, Dhanrasi, Sambamahsuri and Sabita while the lowest value obtained in S5 and S19 in this regard.

Analysis of variance

Analysis of variance (Table-3) showed significant differences among the genotypes for all the characters under study. Similar results in rice were also reported by Yadav et al., (2002), Singh et al., (2006) and Sharma and Sharma (2007) in their experiment. So there is a large scope to bring about qualitative improvement in rice selection. Roy et al., (2009) observed conspicuous variability in quality parameters of rice.

Genetic parameters of quality and its attributing characters

The mean, range, phenotypic, genotypic and environmental variances, coefficient of variance (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of
variance (PCV), heritability (BS), genetic advance (GA) and genetic advance as percentage of mean against twenty-three genotypes along with check varieties are presented in Table-4.

Significant variation for all the characters was noted and this may help to identify desirable genotype on the basis of different quality parameters. In general the phenotypic variances were higher than the respective genotypic variances. Most of the quality character showed a small difference between phenotypic variance and genotypic variance suggested less influence of environment on these characters namely, head rice recovery, amylose content, water uptake ratio, volume expansion ratio, kernel elongation ratio and alkali spreading value. The environmental variance for kernel elongation ratio was recorded zero indicating no influence of environment on this trait.

The relative values of genotypic and phenotypic coefficient of variation provide important information on the magnitude of variation. All the quality characters under study showed slight difference in GCV and PCV. Kole et al., (2008) and Dhanwani et al., (2013) also reported slight difference in GCV and PCV for quality traits. Alkali spreading value (26.667% and 27.657%) exhibited the highest estimates of GCV and PCV followed by amylose content (21.044% and 21.177%). The high magnitude of GCV and PCV (>20%) for the above traits suggested the presence of high degree of variability and so better scope for the improvement through simple selection. Presence of high genetic variability for alkali spreading value may help in developing superior flaky cooked rice. In this regard, Veerabhadran et al., (2009) reported high GCV and PCV for Alkali spreading value.

Moderate GCV and PCV (10-20%) was observed for volume expansion ratio (17.805% and 17.896%). This indicates the existence of moderate variability for this character, which could be exploited for improvement through selection in advanced generations. Low GCV and PCV (<10%) were observed for hulling percentage (3.408% and 3.710%), milling percentage (3.696% and 4.119%), head rice recovery percentage (5.047% and 5.179%), water uptake ratio (6.848% and 7.038%) and kernel elongation ratio (7.837% and 7.974%). This indicates narrow genetic base for these characters. Improvement in these characters can be brought about by hybridization or induced mutagenesis to widen genetic base followed by pedigree selection in advanced generations. Umadevi et al., (2010) and Gampala et al., (2015) reported low GCV and PCV for hulling percentage.

| S. No. | Selection No. | S. No. | Selection No. | S. No. | Selection No. |
|-------|---------------|-------|---------------|-------|---------------|
| 1.    | S1            | 10.   | S10           | 19.   | S19           |
| 2.    | S2            | 11.   | S11           | 20.   | S20           |
| 3.    | S3            | 12.   | S12           | 21.   | S21           |
| 4.    | S4            | 13.   | S13           | 22.   | S22           |
| 5.    | S5            | 14.   | S14           | 23.   | S23           |
| 6.    | S6            | 15.   | S15           | 24.   | Swarna sub1** |
| 7.    | S7            | 16.   | S16           | 25.   | Dhanrasi**    |
| 8.    | S8            | 17.   | S17           | 26.   | Sambamahsuri* |
| 9.    | S9            | 18.   | S18           | 27.   | Sabita*       |

*=Parental checks  ** =Check varieties
Table 2: Mean Performance of 23 RILs of Sabita/Sambamahsuri derivatives for different quality characters

| S. N. | Selection number | Hulling percentage (%) | Milling percentage (%) | Head rice recovery (%) | Amylose content (%) | Water uptake ratio | Volume expansion ratio | Kernel elongation ratio | Alkali spreading value | Grain yield plant⁻¹ (g) |
|-------|------------------|------------------------|------------------------|-----------------------|-------------------|-------------------|------------------------|------------------------|------------------------|------------------------|
| 1     | S₁               | 75.875                 | 67.500                 | 57.513                | 22.094            | 1.464             | 3.106                  | 1.657                  | 2.500                  | 29.900                 |
| 2     | S₂               | 78.525                 | 66.215                 | 57.974                | 19.603            | 1.491             | 2.997                  | 1.399                  | 3.000                  | 30.055                 |
| 3     | S₃               | 76.540                 | 66.165                 | 57.395                | 14.863            | 1.300             | 2.052                  | 1.181                  | 3.000                  | 29.500                 |
| 4     | S₄               | 78.660                 | 67.010                 | 57.745                | 13.757            | 1.368             | 3.166                  | 1.434                  | 4.000                  | 28.680                 |
| 5     | S₅               | 78.310                 | 65.595                 | 57.606                | 14.632            | 1.552             | 3.372                  | 1.491                  | 2.000                  | 25.355                 |
| 6     | S₆               | 77.375                 | 68.950                 | 57.348                | 18.672            | 1.545             | 2.887                  | 1.414                  | 4.000                  | 26.660                 |
| 7     | S₇               | 76.005                 | 64.165                 | 58.397                | 23.235            | 1.497             | 2.467                  | 1.411                  | 5.000                  | 23.785                 |
| 8     | S₈               | 78.680                 | 68.385                 | 58.988                | 14.943            | 1.385             | 2.419                  | 1.351                  | 3.000                  | 28.915                 |
| 9     | S₉               | 77.840                 | 66.968                 | 56.634                | 20.738            | 1.521             | 3.257                  | 1.325                  | 3.000                  | 23.445                 |
| 10    | S₁₀              | 79.200                 | 66.600                 | 54.730                | 23.082            | 1.379             | 1.815                  | 1.325                  | 4.000                  | 27.100                 |
| 11    | S₁₁              | 78.445                 | 69.235                 | 59.825                | 18.310            | 1.332             | 2.249                  | 1.222                  | 3.000                  | 32.515                 |
| 12    | S₁₂              | 78.225                 | 69.200                 | 59.587                | 22.175            | 1.350             | 2.002                  | 1.167                  | 2.500                  | 30.735                 |
| 13    | S₁₃              | 78.540                 | 65.975                 | 58.459                | 22.129            | 1.424             | 2.248                  | 1.320                  | 3.000                  | 27.270                 |
| 14    | S₁₄              | 78.125                 | 63.635                 | 58.786                | 14.026            | 1.352             | 2.456                  | 1.226                  | 4.000                  | 25.085                 |
| 15    | S₁₅              | 77.575                 | 66.870                 | 58.008                | 16.714            | 1.372             | 2.294                  | 1.264                  | 4.000                  | 30.675                 |
| 16    | S₁₆              | 77.125                 | 67.490                 | 59.620                | 17.314            | 1.337             | 2.429                  | 1.211                  | 3.000                  | 31.245                 |
| 17    | S₁₇              | 81.235                 | 67.180                 | 56.508                | 10.792            | 1.396             | 2.256                  | 1.311                  | 2.500                  | 29.870                 |
| 18    | S₁₈              | 78.760                 | 66.990                 | 58.785                | 20.466            | 1.420             | 2.607                  | 1.263                  | 2.500                  | 27.945                 |
| 19    | S₁₉              | 80.435                 | 68.410                 | 58.640                | 26.108            | 1.441             | 2.248                  | 1.284                  | 2.000                  | 30.695                 |
| 20    | S₂₀              | 76.785                 | 68.320                 | 57.104                | 19.068            | 1.623             | 3.181                  | 1.348                  | 2.500                  | 27.905                 |
| 21    | S₂₁              | 80.465                 | 68.125                 | 55.228                | 22.306            | 1.338             | 2.237                  | 1.284                  | 3.500                  | 28.945                 |
| 22    | S₂₂              | 77.605                 | 62.930                 | 54.509                | 21.517            | 1.397             | 2.325                  | 1.237                  | 3.000                  | 24.105                 |
| 23    | S₂₃              | 79.650                 | 68.000                 | 54.812                | 13.726            | 1.674             | 3.540                  | 1.439                  | 4.000                  | 31.625                 |
| 24    | Swarna sub 1**  | 71.795                 | 66.635                 | 57.170                | 24.323            | 1.576             | 3.065                  | 1.313                  | 3.000                  | 29.075                 |
| 25    | Dhanarsi**      | 74.900                 | 62.033                 | 55.836                | 21.551            | 1.560             | 3.128                  | 1.287                  | 5.000                  | 28.625                 |
| 26    | Sambamahsuri*   | 67.330                 | 57.360                 | 44.492                | 21.010            | 1.570             | 2.939                  | 1.335                  | 5.000                  | 22.050                 |
| 27    | Sabita*         | 76.590                 | 64.175                 | 56.001                | 26.304            | 1.421             | 2.825                  | 1.374                  | 5.000                  | 29.195                 |

Mean C.D. 2.347 2.492 1.378 0.703 0.049 0.099 0.040 0.511 3.370

* = Parental checks ** = Check varieties

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### Table 4: Variability and Genetic Parameters for Quality Characters of Sabita/Sambamahsuri Derivatives

| S. N. | Characters                              | Mean       | Range                | Variance |          |          |          |          |          |          |          |
|-------|-----------------------------------------|------------|----------------------|----------|----------|----------|----------|----------|----------|----------|----------|
|       |                                         |            |                      | Phenotypic | Genotypic | Environment | CV     | GCV     | PCV     | h² (BS) | GA (%)   |
| 1.    | Hulling percentage (%)                  | 77.429     | 67.330-81.235        | 8.252    | 6.963    | 1.289    | 1.466   | 3.408    | 3.710    | 84.380   | 4.994    | 6.449    |
| 2.    | Milling percentage (%)                  | 66.300     | 57.360-69.235        | 7.458    | 6.006    | 1.452    | 1.818   | 3.696    | 4.119    | 80.528   | 4.530    | 6.833    |
| 3.    | Head rice recovery (%)                  | 56.952     | 44.492-59.825        | 8.701    | 8.261    | 0.440    | 1.170   | 5.047    | 5.179    | 94.942   | 5.769    | 10.130   |
| 4.    | Amylose content (%)                     | 19.387     | 10.792-26.304        | 16.761   | 16.645   | 0.116    | 1.753   | 21.044   | 21.117   | 99.310   | 8.375    | 43.201   |
| 5.    | Water uptake ratio                      | 10.447     | 1.300-1.674          | 0.011    | 0.010    | 0.001    | 1.622   | 6.848    | 7.038    | 94.693   | 0.199    | 13.728   |
| 6.    | Volume expansion ratio                  | 20.651     | 1.815-3.540          | 0.225    | 0.223    | 0.002    | 1.805   | 17.805   | 17.896   | 98.985   | 0.967    | 36.493   |
| 7.    | Kernel elongation ratio                 | 10.329     | 1.167-1.657          | 0.012    | 0.011    | 0.000    | 1.474   | 7.837    | 7.974    | 96.582   | 0.211    | 15.865   |
| 8.    | Alkali Spreading Value                  | 30.000     | 2.00-5.00            | 0.869    | 0.808    | 0.061    | 7.333   | 26.667   | 27.657   | 92.970   | 1.785    | 52.967   |
| 9.    | Grain yield Plant¹ (g)                  | 28.184     | 22.050-32.52         | 8.696    | 6.037    | 2.659    | 5.786   | 8.718    | 10.463   | 69.422   | 4.217    | 14.963   |

### Table 5: Genotypic and Phenotypic Correlation Coefficients between Quality Characters of Sabita/Sambamahsuri Derivatives

| S. N. | Characters                              | Milling percentage (%) | Head rice recovery (%) | Amylose content (%) | Water uptake ratio | Volume expansion ratio | Kernel elongation ratio | Alkali spreading value | Grain yield plant¹ (g) |
|-------|-----------------------------------------|------------------------|-----------------------|---------------------|-------------------|-----------------------|------------------------|-----------------------|-----------------------|
| 1.    | Hulling percentage (%)                  | G 0.735**             | 0.664                 | -0.298*             | -0.401**          | -0.317*               | -0.069                 | -0.440**              | 0.488                 |
|       |                                         | P 0.634**             |                       | -0.277*             | -0.376**          | -0.294*               |                       | 0.415**              | 0.357**              |
| 2.    | Milling percentage (%)                  | G 0.755**             |                       | -0.155              | -0.213            | -0.157                |                       | 0.024                 | 0.625**              | 0.705**              |
|       |                                         | P 0.685**             |                       | -0.146              | -0.208            | -0.150                |                       | 0.006                 | 0.547**              | 0.613**              |
| 3.    | Head rice recovery (%)                  | G -0.130              | 0.388**               | -0.216              | -0.117            | -0.116                |                       | 0.477**              | 0.519**              |                      |
|       |                                         | P -0.124              |                       | 0.101               | -0.126            | -0.011                |                       | 0.139                 | -0.001               | -0.140               |
| 4.    | Amylose content (%)                     | G 0.113               |                       | -0.019              | -0.028            | 0.055                 |                       | 0.155                 | -0.287               |                      |
|       |                                         | P 0.799**             |                       | -0.505              | -0.146            | 0.117                 |                       | -0.261               | -0.172               |                      |
| 5.    | Water uptake ratio                      | G 0.792**             |                       | 0.639               | 0.112             | 0.054                 |                       | 0.045                 | -0.118               |                      |
|       |                                         | P 0.637**             |                       | 0.673**             | -0.024            | -0.116               |                       | 0.045                 | -0.118               |                      |
| 6.    | Volume expansion ratio                  | G 0.634**             |                       | 0.673**             | -0.024            | -0.116               |                       | 0.045                 | -0.118               |                      |
|       |                                         | P 0.637**             |                       | 0.673**             | -0.024            | -0.116               |                       | 0.045                 | -0.118               |                      |
| 7.    | Kernel elongation ratio                 | G 0.634**             |                       | 0.673**             | -0.024            | -0.116               |                       | 0.045                 | -0.118               |                      |
| 8.    | Alkali spreading value                  | G -0.337**            |                       | -0.116              | -0.164            |                       |                       | -0.274               |                      |                      |
|       |                                         | P -0.337**            |                       | -0.116              | -0.164            |                       |                       | -0.274               |                      |                      |

* = Significant at 1% level  
** = Significant at 5% level
Table 3: Analysis of variance for different quality characters of Sabita/Sambamahsuri derivatives (Mean Sum of Square)

| S. No. | Characters                      | Source of Variance with d.f. |
|-------|---------------------------------|------------------------------|
|       |                                 | Replication (1) | Genotype (26) | Error (26) |
| 1.    | Hulling percentage (%)          | 5.0850           | 15.2150**     | 1.2890     |
| 2.    | Milling percentage (%)          | 13.582           | 13.463**      | 1.4520     |
| 3.    | Head rice recovery (%)          | 5.6260           | 16.9610**     | 0.4400     |
| 4.    | Amylose content (%)             | 0.0250           | 33.4050**     | 0.1160     |
| 5.    | Water uptake ratio              | 0.0001           | 0.0200**      | 0.0010     |
| 6.    | Volume expansion ratio          | 0.0020           | 0.4480**      | 0.0020     |
| 7.    | Kernel elongation ratio         | 0.0001           | 0.0220**      | 0.0001     |
| 8.    | Alkali spreading Value          | 0.0120           | 1.5380**      | 0.0550     |
| 9.    | Grain yield plant⁻¹ (g)         | 45.9450          | 14.7330*      | 2.6590     |

*=Significant at 1% level  **=Significant at 5% level  Note: Figure in parenthesis are degrees of freedom

Fig.1 Hulling, Milling and Head rice recovery percentage of RILs of Sabita/Sambamahsuri derivatives along with check varieties
The heritability estimates were classified as suggested by Johnson et al., (1955). High heritability (BS) was observed for all the characters under study. Such findings were corroborated earlier by Binodh et al., (2007) and Veerabhadhiram et al., (2009). Although, the presence of high heritability value indicated the effectiveness of selection based on phenotypic performance, it doesn’t show any indication to the amount of genetic progress for selecting the best individuals which is possible by using the estimates of genetic advance (GA).

Estimates of heritability and genetic advance (as suggested by Johnson et al., 1955) would be helpful in predicting the genetic gain under selection. Amylose content, volume expansion ratio and alkali spreading value exhibited high heritability coupled with high GA as percentage of mean, this suggested predominant role of additive gene action for controlling these characters. Therefore, there is an enormous possibility to get the development of superior grain quality with flaky cooked rice to satisfy the consumers’ demands. In this regard, high heritability with high GA (%) was reported by Veerabhadhiran et al., (2009) for volume expansion ratio and amylose content, Dhanwani et al., (2013) for alkali spreading value and Nirmaladevi et al. (2015) for amylose content.

Head rice recovery, water uptake ratio, kernel elongation ratio and grain yield plant⁻¹ recorded high heritability along with moderate GA as a percentage of mean indicated the role of additive as well as non-additive gene action for controlling these characters. Thus these characters cannot be
improved simply through selection but selection followed by hybridization would be effective. In this regard, Nirmaladevi et al., (2015) reported high heritability with medium genetic advance for kernel elongation ratio. Hulling percentage and milling percentage recorded high heritability with low genetic advance as percent of mean indicated the role of non-additive gene action. Thus, selection for these characters would not be effective so these characters can be improved by recombination of superior genotypes. The high heritability was being exhibited due to favourable environment rather than genotype. Nirmaladevi et al., (2015) reported high heritability with low genetic advance for hulling percentage.

**Character association**

Correlation coefficient measures the mutual relationship between various traits and determines the traits on which selection would be effective. Complete knowledge on interrelationship of plant character with other characters is of paramount importance to the breeder for making improvement in complex qualitative characters for which direct selection is not much effective. Hence, association analysis was undertaken to determine the direction of selection. The genotypic and phenotypic correlation coefficients are presented in Table-4. Hulling percentage showed positive significant correlation with milling percentage, head rice recovery and grain yield plant$^{-1}$ representing the genotype with high hulling percentage possesses high milling percentage and head rice recovery. Thus, improvement of these characters can be made by selection of any of the single trait. Similar results were reported by Nayak et al., (2003) and Nirmaladevi et al., (2015) and it showed negative significant correlation with amylose content, water uptake ratio, volume expansion ratio and alkali spreading value. Milling percentage showed positive significant correlation with head rice recovery and grain yield plant$^{-1}$ while negative significant correlation was observed with alkali spreading value. Head rice recovery percentage exhibited significant positive correlation with grain yield plant$^{-1}$ at both genotypic and phenotypic level while it showed negative significant correlation with water uptake ratio and alkali spreading value. Amylose content recorded negative significant correlation with hulling percentage at both genotypic and phenotypic level. Water uptake ratio showed significantly positive correlation with volume expansion ratio and kernel elongation ratio and negative significant correlation with grain yield plant$^{-1}$. Kernel elongation had positive significant correlation with water uptake ratio and volume expansion ratio. Alkali spreading value showed negative significant correlation with grain yield plant$^{-1}$. It was found that grain yield plant$^{-1}$ exhibited significant positive correlation with hulling percentage, milling percentage and head rice recovery. With this result the expectation can be made that a high yielding genotype will recover high percentage of head rice and showed negative significant correlation with water uptake ratio and alkali spreading value.

The present investigation highlighted the differential performance of selected RILs of Sabita/Sambamahsuri derivatives were none of the genotype showed superiority over the check varieties for all characters. It was observed from grain quality performance that the genotypes S$^{17}$ was superior in hulling percentage, S$^{11}$ for milling percentage and head rice recovery followed by S$^{12}$. The amylose content and alkali spreading value determines the texture of cooked rice. Varieties with intermediate amylose content and alkali spreading value are preferred by most rice consumers. Among the selected genotypes S$_1$, S$_7$, S$_9$, S$_{10}$, S$_{12}$, S$_{13}$, S$_{18}$, S$_{21}$ and S$_{22}$ reported intermediate amylose content.
High estimates of PCV and GCV were obtained for alkali spreading value followed by amylose content, volume expansion ratio and lowest in this regard were obtained for hulling percentage and milling percentage. High heritability coupled with high GA% were observed for amylose content, volume expansion ratio and alkali spreading value revealed the involvement of additive genes for controlling these characters. Therefore, direct selection would be effective for quality improvement of rice against these characters. The correlation study highlighted the importance of hulling percentage, milling percentage, head rice recovery, kernel elongation ratio and volume expansion ratio.

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