Selection Criteria for Identification of High Yielding Rice (*Oryza sativa* L.) Genotypes under Aerobic Cultivation

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Ten rice genotypes were evaluated to study the genetic variability, correlation and path analysis under aerobic conditions for selection of high yielding genotypes. The experiment is carried out in RCBD with 3 replications and the data is analysed in SPAR 2.0, Past 4.01 and OPSTAT for variability, correlation and path analysis respectively. The phenotypic and genotypic coefficients of variation were high for the number of productive tillers per plant, the number of filled grains per panicle, 1000-grain weight, biological yield and grain yield indicating the possibility of genetic improvement through direct selection for these traits. The magnitude of difference between PCV and GCV was less for the traits indicating little influence of environment. High heritability coupled with high genetic advance was recorded for the number of productive tillers per plant, the number of filled grains per panicle, 1000-grain weight, spikelet fertility, biological yield and grain yield indicating a preponderance of additive gene action, which provide excellent scope for further improvement by selection. Significant positive association of grain yield with number of productive tillers per plant, panicle length, number of filled grains per panicle, 1000-grain weight, spikelet

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fertility and biological yield was observed. Path analysis revealed the traits, number of filled grains per panicle exerted highest positive direct effect on grain yield followed by 1000-gain weight and number of productive tillers per plant. Thus, these traits which contribute to the grain yield under aerobic condition could be exploited for further breeding programme.

**Keywords:** Rice; aerobic; genetic variability; correlation; path analysis; yield.

### 1. INTRODUCTION

Rice is unique among the major food crops in its ability to grow in a wide range of hydrological situations, soil types, and climates. Rice is life for millions of people who survive in Asia. To meet the demand of growing population annual rice production should be increased. This increase in production has to come despite the declining resources like land and water, which is a daunting task. More than 50% of the water used for irrigation in Asia is used for cultivation of Rice [1]. About 3000-5000 litres of water is consumed for the production of one kg of rice [2]. Rice cultivation is a water intensive enterprise. The increasing water scarcity highlights the need to improve the water productivity of rice, and its ability to tolerate periods of water shortage, to ensure adequate food for future generations.

To deal with the emerging water shortage and maintaining sustainable rice production Aerobic rice is a promising approach. Aerobic rice production is a revolutionary way of growing rice in well-drained, non-puddled, and non-saturated soils without stagnant water. This system uses only 50% of the water required for irrigated rice production [3]. Nevertheless, moisture is absolutely necessary for good crop growth and to attain good grain yield. For successful cultivation of aerobic rice, proper water management is the key and moisture stress at any period of growth reduces the yield [4]. Aerobic rice is targeted to water-short areas where there is irrigation but where the water supply is insufficient for growing lowland rice and to rainfed areas where rainfall is sufficient to bring the soil water content close to field capacity. These areas can be uplands, upper slopes, and lowlands in a toposequence [5]. Aerobic rice cultivation will curb methane production and saves water without affecting productivity. It is the time to save water from the irrigated system of rice cultivation by adopting the aerobic rice cultivation [6]. The present research focuses on selecting the genotypes based on the phenotypic characters with high yields under aerobic conditions.

### 2. MATERIALS AND METHODS

#### 2.1 Experimental Design and Planting Materials

The present experiment under study was laid out at Regional Sugarcane and Rice Research Station, Rudrur during Khair, 2019. The experiment consisted of 9 genotypes and a check MTU1010 and layout was Randomized Complete Block Design (RCBD) with three replications. The plot size of 10.0m² with a spacing of 20cm x 15cm. All the recommended package of practices was adopted besides providing necessary prophylactic plant protection measures to raise a good crop.

#### 2.2 Data Collection and Statistical Analysis

Data was recorded for days to 50% flowering, plant height (cm), number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, 1000-grain weight (g), spikelet fertility (%), biological yield(kg/ha), harvest index and grain yield (kg/ha). Five plants were randomly selected and were evaluated for yield and yield contributing traits except for days to 50% flowering and it was recorded on a plot basis. The mean data after computing for each character was subjected to statistical analysis using software SPAR 2.0 version for analysis of variance (ANOVA), estimation of genotypic variance (G2g), phenotypic variance (p2g), phenotypic coefficient of variation (PCV%), genotypic coefficient of variation (GCV%) and heritability in broad sense (h2b). Genetic advance as per cent of mean were calculated according to the formula suggested by Burton [7] and Johnson et al. [8]. Correlation analysis was carried out through Past 4.01 version software and Path analysis through OP STAT.

### 3. RESULTS AND DISCUSSION

The analysis of variance for ten genotypes including check is presented in Table 1. The
analysis of variance revealed that the mean sum of squares due to treatments was highly significant for all the characters indicating the existence of sufficient variability in the material among themselves for characters studied. There was a narrow range of differences between PCV and GCV suggesting traits were least influenced by the environment.

3.1 Genetic Variability of Quantitative Traits

Days to 50% flowering recorded a general mean of 87.0 days ranging from 81.0 days (RDR1162) to 97.0 days (RDR1200) as shown in Table 2. Out of all the genotypes RDR-1162 was early flowering. The plant height ranged from 68.8 cm (MTU1010) to 81.4 cm (RDR-1931) with an average of 74.3 cm. The number of productive tillers per plant showed a mean of 9.0 ranging from 6.0 (RDR1221) to 12.0 (RDR1935). Panicle length was shortest in RDR1221 (19.6 cm) and longest in genotype RDR1935 (24.0 cm) with an average of 22.0 cm. A maximum number of filled grains per panicle was minimum in RDR1221 (92.0) to 141.0 (RDR1935). The 1000-grain weight varied from 14.3 g (RDR1221) to 23.4 g (RDR1935). Highest spikelet fertility was in RDR1935 (85.3%) and lowest in RDR1221 (67.3%). Biological yield ranged from 7759.2 kg/ha (RDR1162) to 3838.3 kg/ha (RDR1221) with an average of 6456.09 kg/ha. Harvest index recorded low for RDR1232 (45.2) and high for RDR1935 (85.3%) with a mean of 48.6. The grain yield ranged from 2010.3 kg/ha (RDR1935) with a general mean of 48.6.

The magnitude of the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits which may be due to higher degree of interaction of genotypes with the environment. The phenotypic and genotypic coefficients of variation were high for number of productive tillers per plant (20.91% & 20.14%), number of filled grain per panicle (20.53% & 20.09%), 1000-grain weight (21.65% & 21.24%), biological yield (22.27% & 21.71%) and grain yield (21.66% & 20.83%) respectively, as shown in Table 2. These traits indicate the existence of wider genetic variability among the genotypes and for these traits narrow range of differences between PCV and GCV were observed suggesting traits were least influenced by the environment. High PCV & GCV for various traits in the study agree with [9,10,11]. The traits with low PCV and GCV were recorded for days to 50% flowering (4.91% & 4.78%), plant height (7.74% & 7.12%), panicle length (6.31% & 5.96%), spikelet fertility (8.99% & 8.65%) and harvest index (6.48% & 5.94%) respectively. Low values indicated the need for the creation of variability either by hybridization or mutation followed by selection. Similar findings were also reported by [12,13].

All the characters reported high estimates of heritability indicating that the environmental effects least influenced them, however selection for improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, the heritability values along with estimates of genetic advance would be more useful on correlating selection criteria than heritability alone [8]. In the present study, high heritability coupled with high genetic advance was recorded for the number of productive tillers per plant, number of filled grains per panicle, 1000-grain weight, spikelet fertility, biological yield and grain yield as presented in Table 2. These characters with high

### Table 1. Analysis of variance

| S. No. | Characters                      | Replications (d.f.=2) | Treatments (d.f.=9) | Error (d.f.=18) |
|-------|-------------------------------|----------------------|---------------------|-----------------|
| 1     | Days to 50 % flowering        | 0.70                 | 56.25*              | 1.03            |
| 2     | Plant height (cm)             | 31.35                | 70.76**             | 14.39           |
| 3     | Number of productive tillers / plant | 0.15           | 5.64*               | 1.11            |
| 4     | Panicle length (cm)           | 2.27                 | 2.70*               | 1.45            |
| 5     | Number of filled grains / panicle | 6.30              | 635.49**            | 49.59           |
| 6     | 1000-grain weight (g)         | 8.25                 | 741.36**            | 56.84           |
| 7     | Spikelet Fertility (%)        | 1.99                 | 133.60**            | 3.49            |
| 8     | Biological yield (kg/ha)      | 680591.19            | 5836255.61**        | 281800.95       |
| 9     | Harvest Index                 | 6.99                 | 20.83**             | 4.01            |
| 10    | Grain yield (kg/ha)           | 61908.05             | 1303026.80**        | 43456.84        |

*Significant at 5 percent level, **Significant at 1 percent level.
Table 2. Estimation of range and genetic parameters for 10 characters in rice (*Oryza sativa* L.)

| S. No. | Characters                        | Mean   | Range  | Coefficient of Variation (%) | Heritability ($h^2$) % | Gen. Adv as percent of Mean (at 5%) |
|--------|----------------------------------|--------|--------|-------------------------------|------------------------|------------------------------------|
|        |                                  |        | Min    | Max                           | Phenotypic             | Genotypic                          |
| 1      | Days to 50 % flowering           | 87.00  | 81.00  | 97.00                         | 4.91                   | 4.78                               | 94.68                             | 12.63                            |
| 2      | Plant height (cm)                | 74.36  | 68.80  | 81.40                         | 7.74                   | 7.12                               | 76.62                             | 16.57                            |
| 3      | Number of productive tillers/plant| 9.00   | 6.00   | 12.00                         | 20.91                  | 20.14                              | 77.47                             | 43.98                            |
| 4      | Panicle length (cm)              | 22.09  | 19.60  | 24.00                         | 6.31                   | 5.96                               | 62.41                             | 14.28                            |
| 5      | Number of filled grains/panicle   | 120.00 | 92.00  | 141.00                        | 20.53                  | 20.09                              | 79.74                             | 41.56                            |
| 6      | 1000-grain weight (g)            | 19.25  | 14.30  | 23.40                         | 6.31                   | 5.96                               | 62.41                             | 14.28                            |
| 7      | Spikelet Fertility (%)           | 76.22  | 67.30  | 85.30                         | 8.99                   | 8.65                               | 92.53                             | 21.37                            |
| 8      | Biological yield (kg/ha)         | 6456.09| 3883.8 | 7759.2                        | 22.27                  | 21.71                              | 86.79                             | 45.30                            |
| 9      | Harvest Index                    | 48.62  | 45.20  | 52.60                         | 6.48                   | 5.94                               | 58.25                             | 13.65                            |
| 10     | Grain yield (kg/ha)              | 3139.04| 2010.3 | 4069.3                        | 21.66                  | 20.83                              | 90.62                             | 43.31                            |

Table 3. Correlation analysis among yield and yield contributing traits in aerobic rice genotypes

| Characters                        | Days to 50 % flowering | Plant height (cm) | Number of productive tillers/plant | Panicle length (cm) | Number of filled grains/panicle | 1000-grain weight (g) | Spikelet Fertility (%) | Biological yield (kg/ha) | Harvest Index | Grain yield (kg/ha) |
|-----------------------------------|-------------------------|-------------------|-----------------------------------|--------------------|---------------------------------|-----------------------|------------------------|------------------------|----------------|-------------------|
| Days to 50 % flowering            | 1.00                    | -0.030            | -0.054                            | -0.045             | -0.048                          | -0.039                | 0.158                  | -0.052                 | 0.166          | -0.094            |
| Plant height (cm)                 | 1.00                    | 0.323             | 0.271                             | 0.215              | 0.181                           | 0.306                 | 0.119                  | -0.079                 | 0.113          |                  |
| Number of productive tillers/plant| 1.00                    | 0.470**           | 0.310*                            | 0.215*             | 0.417**                         | 0.512**               | 0.064                  | 0.412**                |                |                  |
| Panicle length (cm)               | 1.00                    | 0.662**           | 0.350*                            | 0.300*             | 0.240*                          | 0.284*                | 0.081                  | 0.530**                |                |                  |
| Number of filled grains/panicle   | 1.00                    | 0.492**           | 0.216*                            | 0.307*             | 0.042                           | 0.691**               |                        |                        |                |                  |
| 1000-grain weight (g)             | 1.00                    | 0.313*            | 0.204*                            | 0.090              | 0.523**                         | 0.418**               |                        |                        |                |                  |
| Spikelet                          | 1.00                    | 0.302*            | 0.038                             |                    |                                 |                        |                        |                        |                |                  |
Table 4. Path analysis among yield and yield contributing traits in aerobic rice genotypes

| Characters                      | Days to 50% flowering | Plant height (cm) | Number of productive tillers/plant | Panicle length (cm) | Number of filled grains/panicle | 1000-grain weight (g) | Spikelet fertility (%) | Biological yield (kg/ha) | Harvest Index | Grain yield (kg/ha) |
|---------------------------------|------------------------|------------------|------------------------------------|---------------------|-------------------------------|-----------------------|------------------------|------------------------|----------------|---------------------|
| Fertility (%)                   |                        |                  |                                    |                     |                               |                       |                        |                        |                |                     |
| Biological yield (kg/ha)        |                        |                  |                                    |                     |                               |                       |                        |                        |                | 1.00                |
| Harvest Index                   |                        |                  |                                    |                     |                               |                       |                        |                        |                | 0.117              |
| Grain yield (kg/ha)             |                        |                  |                                    |                     |                               |                       |                        |                        |                | 1.00                |
| *Significant at 5 percent level, **Significant at 1 percent level
heritability coupled high genetic advance show additive gene action, provide good scope for further improvement. These results are in similarity with [14,11,13]. Days to 50% flowering, plant height, panicle length and harvest index exhibited high heritability coupled with moderate genetic advance which indicates these traits are under the control of both additive and non-additive gene action. These are in accordance with [15,11,16].

### 3.2 Association Studies

In present the study an attempt is made to estimate the nature and magnitude of correlation of character pairs, which would facilitate selection of genotypes where a balance combination of characters is associated with the increased productivity. Grain yield showed a significant positive association with the number of productive tillers per plant (0.412**), panicle length (0.530**), number of filled grains per panicle (0.691**), 1000-grain weight (0.532**), spikelet fertility (0.418**) and biological yield (0.328*) as shown in Table 3, indicating the importance of characters in yield improvement. Results are in accordance with [17,10,18,19]. This trait showed positive association with plant height (0.113) and harvest index (0.117). The results are in similarity with [20]. A negative correlation was observed between grain yield and days to 50% flowering. This agrees with [21,18].

Days to 50% flowering showed a positive association with spikelet fertility (0.158) and harvest index (0.166) and negative correlation with plant height (-0.030), the number of productive tillers per plant (-0.054), panicle length (-0.045), the number of filled grains per panicle (-0.048), 1000-grain weight (-0.039) and biological yield (-0.052). Plant height exhibited positive association with number of productive tillers per plant (0.323), panicle length (0.271), number of filled grains per panicle (0.215), 1000-grain weight (0.181), spikelet fertility (0.306) and biological yield (0.119) and showed negative association with harvest index (-0.079). The number of productive tillers per plant of reported significant positive association with panicle length (0.470*), number of filled grains per panicle (0.310*), 1000-grain weight (0.215*), spikelet fertility (0.417**) and biological yield (0.512**) and a positive association with harvest index (0.064). Whereas panicle length showed a significant positive association with the number of filled grains per panicle (0.662**), 1000-grain weight (0.350*), spikelet fertility (0.300*) and biological yield (0.240*) and positive association with harvest index (0.081). The number of filled grains per panicle reported a significant positive association with 1000-grain weight (0.492**), spikelet fertility (0.216**) and biological yield (0.307*) and positive correlation with harvest index (0.042). 1000-grain weight exhibited a significant positive association with spikelet fertility (0.313**) and biological yield (0.204*) and positive correlation with harvest index (0.090). Significant positive association of spikelet fertility was observed with biological yield (0.302*) and positive correlation with harvest index (0.038).

### 3.3 Path Analysis

The genetic architecture of grain yield is based on the balance or overall net effect produced by various yield components interacting with one another. The total correlation between yield and its component characters may be sometimes misleading, as it might be an over-estimate or under-estimate because of its association with other characters. Hence, indirect selection by correlated response may not be sometimes fruitful. When many characters are affecting a given character, splitting total correlation into direct and indirect effects of cause as devised by [22], would provide more meaningful interpretation to the cause of the association between the dependent variable like yield and independent variables like yield component characters. This kind of information will be help formulate the selection criteria.

Path coefficient analysis revealed the trait, the number of filled grains per panicle (0.615) exerted a highest positive direct effect on grain yield followed by 1000-grain weight (0.531) and the number of productive tillers per plant (0.468) (Table 4) indicating that the selection for these characters was likely to bring about an overall improvement in yield directly. Therefore, it is suggested that preference should be given to these characters in the selection programme to isolate superior genotypes with the genetic potentiality for high yield. These results were in accordance [17,21,10,19]. The direct positive effects of the remaining characters were low to be considered of any consequence. On the other hand, negative direct effect on grain yield was recorded by days to 50% flowering (-0.310), plant height (-0.298), biological yield (-0.156) and harvest index (-0.125).

### 4. CONCLUSION

The present study revealed a high level of variability for number of productive tillers per
plant, number of filled grains per panicle, 1000-grain weight, biological yield and grain yield. There were direct positive associations between grain yield and number of productive tillers per plant, panicle length, number of filled grains per panicle, 1000-grain weight, spikelet fertility and biological yield, indirect selection for which would be effective to enhance the yield potential. The trait, number of filled grains per panicle exerted a highest direct positive effect on grain yield per plant, while a negative direct effect on grain yield was recorded by days to 50% flowering, plant height, biological yield and harvest index. The outcomes from the present investigation will help in the selection of high yielding genotypes based on quantitative characters under aerobic conditions and these genotypes can be cultivated by the farmers with only 50% of water required for transplanted rice. The farmer can go for the cultivation of the other crops using the saved irrigations.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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