Studies on genetic parameters, correlation and path analysis for yield attributes and Iron content in a backcross population of rice [*Oryza sativa* (L.)]

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**Abstract**

In any crop breeding program, the effective selection of traits that are associated with yield depends on the information on nature and magnitude of variation in the traits and its response to the environment. A study was conducted to determine the variability, heritability, correlation and path analysis of yield and yield components in BC$_1$F$_2$ generation of backcross combination, CO 51 × RPHP 48. The population was developed in order to introgress the high iron content in CO 51 background. The narrow difference between GCV and PCV indicates that there was a meagre influence of environment on the expression of 12 traits studied. Broad sense heritability was high for grain iron content and low for kernel length/breadth ratio. Grain yield was found to be significant and positively correlated with the number of productive tillers per plant, panicle weight, the number of grains per panicle and 100 seed weight indicating yield improvement can be achieved through improvement of these traits. The results of genotypic path analysis revealed that the number of productive tillers per plant and kernel length had a high positive direct effect which could be considered as good selection criteria for yield improvement.

**Key words**

Rice, BC$_1$F$_2$, Yield components, Correlation, Path coefficient

**INTRODUCTION**

Rice (*Oryza sativa* L.) is one of the crucial staple cereal crops for more than 50% population and also it is called as “Global grain”. In developing countries, people often rely on rice as their sole source of nutrition. About 51 nutrients are essential for human to lead a healthy life (Ross, 2003). Lack of any of the nutrients can cause several physiological disorders and nutritional deficiency syndromes. Among the different micronutrients, Iron has a profound influence on human wellbeing. The average content of Iron in rice grains is 1.2mg/100g (Mallimar et al., 2015). Malnutrition due to Iron deficiency is widely prevalent in developing countries where rice is a staple food.

Rice is mainly selected for nutritional improvement because Fe deficiency anemia is a critical problem in rice eating countries. The third agricultural revolution increases the grain production but decreases the availability of micronutrient content (Ross, 2003). In order to enhance the nutritional quality and yield through selection, the knowledge on genetic variability and the magnitude of heritable traits are needed for better selection. The character association and path coefficient analysis helps in the elucidation of traits related to yield improvement and in traits based plant breeding programmes.

**MATERIALS AND METHODS**

The variety CO 51 is a high yielding short duration variety, popular in Tamil Nadu and RPHP 48 is an iron
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rich variety. In order to introgress iron content in CO 51 background, a backcross population was developed. The BC$_1$F$_2$ seeds of backcross combination viz., CO 51 X (CO 51x RPHP 48) along with the parents were evaluated at Anbil Dharmalingam Agricultural College and Research institute, Trichy during September, 2019. All the entries were raised in rows of three meter length with a spacing of 20 × 15 cm following all the recommended agronomic package of practices. Observations on 12 quantitative traits viz., days to 50% flowering, plant height, the number of productive tillers per plant, panicle length, panicle weight, the number of grains per panicle, 100 seed weight, kernel length, kernel breadth, kernel length/breadth ratio, single plant yield and grain iron content were recorded in 100 plants selected at random from the population. Iron content of the grain samples were estimated by Atomic Absorption Spectrophotometer at 248.3 nm after digestion using triple acid mixture.

Broad sense heritability (h$^2$) was calculated as per the procedure suggested by Lush (1940) and genetic advance as per cent of mean (GAM) was estimated based on the formula proposed by Johnson et al. (1955). Correlation coefficients and path coefficients were estimated as per the methods suggested by Pearson (1897 and Dewey and Lu (1959) respectively using TNAUSTAT software.

RESULT AND DISCUSSION

The data on mean performance along with different variability parameters for all the characters indicated the existence of variability in the population (Table 1). The character, the number of grains per panicle showed a higher range of variation (31-128) followed by plant height (64 – 146 cm). High variation for grain iron content (8.6 -62.9µg/g) was also recorded with a mean of 22.78µg/g. The presence of such wide range of variation indicated the existence of large genetic variation among the individuals. Apart from the mean performance for a trait, the extent of variability created in the population measures the potentiality of a cross.

Estimates of nature and magnitude of genotypic and phenotypic variability present in a population plays a key role in formulation of successful breeding programme. The estimates of genotypic and phenotypic coefficient of variation for different quantitative characters for BC$_1$F$_2$ population (Table 1) showed that the phenotypic coefficient of variation was greater than those of genotypic coefficient of variation for all the traits. Similar result was reported by Sadhegi (2011) which proved the masking effect of environment. However, the highest PCV (53.2) and GCV (35.53) was recorded for the number of productive tillers/ plant followed by grain iron content (PCV: 45.21 and GCV: 45.1) and the number of grains per panicle (PCV: 35.68 and GCV: 33.83). Purusothoaman et al. (2014), Kujur et al. (2019) and Saha et al. (2019) reported similarly for the number of productive tillers / plant in rice and Babu et al. (2012) for grain iron content. This showed that these characters are major contributors to the total variability. The traits plant height, panicle length and 100 seed weight had moderate GCV and PCV indicating selective breeding could be done for these characters. The studies of Kujur et al., (2019) for plant height, Mohanasundaram et al. (2019) for 100 seed weight and Purusothoaman and Geetha (2014) and Patil et al. (2015) for panicle length supports the present findings. Low PCV and GCV were

| Traits                          | Mean | Range | Phenotypic Coefficient of Variance | Genotypic Coefficient of Variance | Heritability | Genetic advance | Genetic Advance as per cent of mean |
|---------------------------------|------|-------|-----------------------------------|-----------------------------------|-----------|----------------|-----------------------------------|
| Days to 50 % flowering          | 85.51| 82.0  | 91.0                              | 2.84                              | 2.26      | 63.38          | 3.17                             | 3.70                             |
| Plant height (cm)               | 98.33| 64.0  | 146.0                             | 17.57                             | 13.64     | 60.24          | 21.40                            | 21.81                            |
| Number of productive tillers per plant | 3.99 | 1.0   | 14.0                              | 53.22                             | 35.53     | 44.56          | 1.94                             | 48.86                            |
| Panicle length (cm)             | 20.6 | 12.0  | 27.5                              | 16.35                             | 14.78     | 81.32          | 5.64                             | 27.39                            |
| Panicle weight (g)              | 1.60 | 0.67  | 2.6                               | 27.95                             | 26.51     | 90.00          | 0.82                             | 51.82                            |
| Number of grains per panicle    | 59.23| 31.0  | 128.0                             | 35.68                             | 33.83     | 89.89          | 39.14                            | 66.08                            |
| 100 seed weight (g)             | 2.05 | 1.3   | 2.6                               | 17.58                             | 11.94     | 46.15          | 0.34                             | 16.72                            |
| Kernel length (mm)              | 7.00 | 5.8   | 7.9                               | 6.54                              | 4.73      | 52.38          | 0.49                             | 7.06                             |
| Kernel breadth (mm)             | 2.20 | 1.8   | 2.5                               | 8.01                              | 6.54      | 66.66          | 0.23                             | 11.01                            |
| Kernel L/B ratio                | 3.25 | 2.4   | 4.2                               | 9.23                              | 5.32      | 33.33          | 0.20                             | 6.33                             |
| Grain Iron content (µg/g)       | 22.78| 8.6   | 62.9                              | 45.21                             | 45.18     | 99.84          | 7.98                             | 93.01                            |
| Single plant yield (g)          | 17.16| 12.2  | 32.0                              | 23.41                             | 23.00     | 96.53          | 21.18                            | 46.55                            |

https://doi.org/10.37992/2020.1103.144
observed for days to 50% flowering, kernel length, kernel breadth and kernel length/breadth ratio which showed that the variability for these characters was meagre. These results were in accordance with Prabhu et al. (2017) for days to 50% flowering and Mohanasundaram et al. (2019) for kernel length and length/breadth ratio.

The amount of heritable variation present in the population assumes greater importance to achieve gain in selection programme. Most of the characters showed high heritability (above 60). It is very high for grain iron content (99.84) followed by single plant yield (96.53). The GAM was higher for iron content (93.01). The least values for $h^2$ (33.3) and GAM (6) was observed in kernel length/breadth ratio. Mohanasundaram et al. (2019), Patil et al. (2015) and Sala et al. (2012) reported similar results for grain iron content and single plant yield. In this study, the highest values of heritability and genetic advance were obtained for panicle weight, the number of grains per panicle and panicle length indicating that these traits could be governed by additive gene action. This is in accordance with the results of Rajesh et al. (2019) and Devi et al. (2019) for panicle weight.

The correlated response of certain characters was known to occur while the selection is imposed on another character (Falconer, 1964). The results of simple phenotypic correlation may not be reliable for selection programme as there may be influence of environment on these traits. Genotypic correlation estimates heritable part of the variation and identifies true relationship between various traits under study (Fiyz et al., 2011). High significant and positive correlations of single plant yield with the number of productive tillers per plant, panicle weight, the number of grains per panicle, 100 seed weight and plant height at genotypic level was observed in the present study (Table 2). These observations support the earlier findings of Ajmera et al. (2017) and Priya et al. (2017) for plant height and the number of productive tillers per plant, Venkatesh et al. (2018) and Uppal et al. (2019) for panicle weight.

![Table 2. Genotypic Correlation Coefficients of different traits in BC$_2$F$_2$ population of CO 51 X RPHP 48](https://doi.org/10.37992/2020.1103.144)

|          | DFF | PH   | NPT/P | PL    | PW   | NG/P | 100SW | KL    | KB   | KLBR | IRON  | SPY  |
|----------|-----|------|-------|-------|------|------|-------|-------|------|------|-------|------|------|
| DFF      | 1   | -0.115 | -0.110 | -0.049 | -0.139 | -0.037 | -0.065 | 0.122 | 0.106 | -0.020 | 0.014 | -0.213 |
| PH       | 1   | 0.350$^*$ | 0.247$^*$ | 0.321$^*$ | 0.340$^*$ | 0.296$^*$ | -0.257 | -0.0331 | -0.137 | -0.042 | 0.307$^*$ |       |
| NPT/P    | 1   | 0.226$^{**}$ | 0.70$^*$ | 0.732$^*$ | 0.246$^*$ | -0.170 | -0.078 | -0.040 | -0.050 | 0.664$^*$ |       |
| PL       | 1   | 0.296$^*$ | 0.217$^{**}$ | 0.205$^{**}$ | -0.169 | 0.052 | -0.160 | 0.096 | 0.184$^{**}$ |       |
| PW       | 1   | 0.845$^*$ |   | 0.171 | -0.119 | -0.069 | -0.020 | -0.037 | 0.460$^*$ |       |
| NG/P     | 1   | 0.226$^{**}$ | -0.191 | -0.158 | 0.015 | -0.061 | 0.515$^*$ |       |
| 100SW    | 1   | -0.295 | -0.060 | -0.156 | 0.042 | 0.399$^*$ |       |
| KL       | 1   | 0.221$^*$ | 0.494$^*$ | 0.044 |       | -0.018 |
| KB       | 1   | 0.044 | -0.732 | 0.241$^*$ | -0.018 |
| KLBR     | 1   | -0.179 | 0.005 |       |       |
| IRON     | 1   | -0.107 | |       |       |
| SPY      | 1   |       | |       |       |

*Significant at 5%, * *Significant at 1%

DFF- Days to 50 % flowering, PH- Plant height (cm), NPT/P- Number of productive tillers per plant, PL- Panicle length (cm), PW- Panicle weight (g), NG/P- Number of grains per panicle,100SW-100 seed weight (g),KL- Grain length (mm),KB- Grain breadth (mm),LBR- L/B ratio, IRON- Grain iron content (µg/g),SPY- Single plant yield (g)

Number of grains per panicle exhibited a highly significant and positive correlation at genotypic level with panicle weight (0.84) followed by the number of productive tillers/plant (0.73) indicating their contribution towards yield improvement. Days to 50% flowering was negatively correlated with all traits except kernel length, kernel breadth and grain iron content. The correlogram depicted a strong positive correlation between panicle weight and the number of productive tillers per plant whereas kernel length/breadth ratio and kernel breadth showed a significant and negative correlation (Fig. 1). The single plant yield had a moderate correlation with panicle weight, the number of grains per panicle and 100 seed weight. The empty squares in the figure represent a non significant correlation between the traits.
Fig 1. Correlogram visualizing the correlation in yield and its attributing traits in BC₁F₂ population of CO 51 X RPHP 48

Circles and Squares – corresponds to relative correlation (r) values; Squares- Genotypic correlation; Circle – Phenotypic correlation; Dark colour- high correlation values; Light colour- low correlation values; Red colour – Negative correlation; Blue colour – Positive correlation

Table 3. Path analysis of various different traits in BC₁F₂ population of CO 51 X RPHP 48

|      | DFF  | PH   | NPT/P | PL   | PW   | NG/P | 100SW | KL   | KLB  | IRON | SPY |
|------|------|------|-------|------|------|------|-------|------|------|------|-----|
| DFF  | -0.1806 | -0.0046 | -0.0632 | -0.0016 | 0.028 | -0.0082 | -0.0184 | 0.0585 | -0.0303 | 0.008 | -0.0016 | -0.2139 |
| PH   | 0.0208 | 0.0399 | 0.2006 | 0.0082 | -0.0645 | 0.075 | 0.0833 | -0.1232 | 0.0094 | 0.0539 | 0.0045 | 0.3079* |
| NPT/P| 0.02  | 0.014 | 0.5723 | 0.0075 | -0.1418 | 0.1613 | 0.0691 | -0.0818 | 0.0224 | 0.016 | 0.0053 | 0.6643* |
| PL   | 0.0089 | 0.0099 | 0.1298 | 0.0332 | -0.0594 | 0.0479 | 0.0575 | -0.0814 | -0.0151 | 0.063 | -0.0102 | 0.1842** |
| PW   | 0.0252 | 0.0128 | 0.4046 | 0.0098 | -0.2005 | 0.1861 | 0.0482 | -0.0573 | 0.0199 | 0.0082 | 0.0039 | 0.4608* |
| NG/P | 0.0067 | 0.0136 | 0.4193 | 0.0072 | -0.1695 | 0.2202 | 0.0636 | -0.0916 | 0.0452 | -0.006 | 0.0065 | 0.5152* |
| 100SW| 0.0118 | 0.0118 | 0.1408 | 0.0068 | -0.0344 | 0.0499 | 0.2806 | -0.1417 | 0.0172 | 0.0614 | -0.0045 | 0.3998* |
| KL   | -0.022 | -0.0103 | -0.0977 | -0.0056 | 0.024 | -0.0421 | -0.083 | 0.4793 | -0.063 | -0.1937 | -0.0047 | -0.0187 |
| KB   | -0.0192 | -0.0013 | -0.0451 | 0.0018 | -0.014 | 0.0349 | -0.017 | 0.1061 | -0.2847 | 0.2871 | -0.2555 | -0.0188 |
| KLB  | 0.0037 | 0.0055 | 0.0234 | 0.0053 | 0.0042 | 0.0034 | -0.044 | 0.2369 | 0.2086 | -0.3918 | 0.019 | 0.0058 |
| IRON | -0.0027 | -0.0017 | -0.0287 | 0.0032 | 0.0074 | -0.0136 | 0.0119 | 0.0211 | -0.0687 | 0.0703 | -0.1059 | -0.1073 |

**RESIDUE** = 0.6512
Bold figures indicate direct effects

DFF- Days to 50 % flowering, PH- Plant height (cm), NPT/P- Number of productive tillers per plant, PL- Panicle length (cm), PW- Panicle weight (g), NG/P- Number of grains per panicle, 100SW-100 seed weight (g), KL- Grain length (mm), KB- Grain breadth (mm), LBR- L/B ratio, IRON- Grain Iron content (µg/g), SPY- Single plant yield (g)
Uppal et al. (2019) and Parimala et al. (2020) for the number of grains per panicle. The high positive indirect effect on single plant yield was from the number of productive tillers per plant via the number of grains per panicle followed by the number of productive tillers per plant via panicle weight. Thus indirect selection for these traits would be beneficial in enhancing the yield potential of rice varieties.

The direct effects of days to 50% flowering, panicle weight, kernel breadth, kernel length/breadth ratio and grain iron content were negative. Similar results were reported by Nagesh et al. (2012) and Rajamadhan et al. (2011) for grain iron content whereas Yadav et al. (2010), Pankaj Garg et al. (2010), Rajamadhan et al. (2011), Babu et al. (2012), Yadav and Panday (2012) for days to 50% flowering. The traits panicle weight and kernel length/breadth ratio had an indirect positive influence on single plant yield. In current research, the residual effect is 0.6512 showing that the characters involved in present study contributed almost 35% of variability influencing to the dependent variable i.e., single plant yield. The higher residual value of in the study indicates that apart from the traits considered, there could be several other morphometric traits which could have a significant influence in expression of yield.

Eventhough, higher values of PCV were recorded than GCV, the difference was very narrow for almost all the characters studied indicating the least influence of the environment. However, the characters, the number of productive tillers per plant, grain iron content and the number of grains per panicle showed a wide range of variation. High heritability with high GAM was exhibited by grain iron content and single plant yield in this population. Due to a significant and positive association with yield, the three traits viz., the number of productive tillers per plant, panicle weight and the number of grains per panicle have to be considered as major characters while selecting the genotypes for yield improvement. Direct positive association towards grain yield was contributed by the traits the number of productive tillers per plant, kernel length and 100 seed weight in the population and selection for these traits would be effective to enhance the yield potential.

REFERENCES

Ajmera, S., S. Sudheer Kumar, and V. Ravindrababu. 2017. Character association analysis for grain Iron and Zinc concentrations and grain yield components in rice genotypes. International Journal of Pure and Applied Biosciences 5(4): 940-945. [Cross Ref]

Abdul Fiyaz, R., Ramya, K. T., Chikkalingaiah, A. B., Gireesh, C., and Kulkarni, R. S. 2011. Genetic variability, correlation and path coefficient analysis studies in rice (Oryza sativa L.) under alkaline soil condition. Electronic Journal of Plant Breeding, 2(4), 531-53.

Babu, V. Ravindra, K. Shreya, Kuldeep Singh Dangi, G. Usharanidi, and A. Siva Shankar. 2012. Correlation and path analysis studies in popular rice hybrids of India. International Journal of Scientific and Research Publications. 2(3) : 1-5.

Bhadru, D., V. TirumalaRao, Y. Chandra Mohan, and D. Bharatith. 2012. Genetic variability and diversity studies in yield and its component traits in rice (Oryza sativa L.). SABRAO J. Breed. Gen. 44 (1): 129-137.

Devi, K. Rukmini, B. Satish Chandra, V. Venkanna, and Y. Hari. 2019. Variability, correlation and path studies for yield and quality traits in irrigated upland rice (Oryza sativa L.). Journal of Pharmacognosy and Phytochemistry. 8 (6): 676-684.

Dewey, D. R. and K. Lu. 1959. A Correlation and Path Coefficient Analysis of Components of Crested Wheatgrass Seed Production 1. Agronomy J., 51(9): 515-518. [Cross Ref]

Falcooner, D.S. 1964. Introduction to quantitative genetics. Oliver and Boyd, London, p.365.

Johnson, H. W., H.F. Robinson, and R.E. Comstock. 1955. Estimate of genetic and environmental variability in Soybeans. Agronomy J., 47(2):314–318. [Cross Ref]

Kujur, Monica Jyoti, G. K. Koutu, R. Shiv Rama Krishnan, and Yogendra Singh. 2019. Genetic variability of agro-morphological traits in traditional varieties of rice (Oryza sativa L.) from Madhya Pradesh, India. International Journal of Chemical Studies. 6: 1693-1700.

Lush, J. L. 1940. Intra-sire correlations or regressions of offspring on dam as a method of estimating heritability of characteristics. J. Animal Sci., 40(1): 293-301

Mohan Sundaram, K., S. Rajeswari, R. Saraswathi, and P. Jeyaparakash. (2019). Genetic variability studies for yield and its Components and quality traits with high iron and zinc content in segregating population of rice (Oryza sativa L.). International Journal of Chemical Studies. 7(3): 800-805.

Mallimar, Maddeppa, P. Surendra, Ramaling Hundekar, Mahantesh Jogi, and Mahantesh Chougaleand Sneha Lakkangoudar. 2016. Correlation studies for micronutrients, yield and yield components in F3 population of rice (Oryza Sativa L.). Res. Environ. Life Sci 9(9): 1140-1142.

Nagesh, Ravindrababu, V., Usharanidi, G and Reddy, T.D. 2012. Grain iron and zinc association studies in rice (Oryza sativa L.) F, progenies. Archives of Applied Science Research. 4 (1): 696-702.

https://doi.org/10.37992/2020.1103.144
Patil, Rajendragouda, J. R. Diwan, J. M. Nidagundi, R. Lokesh, M. V. Ravi, M. B. Boranayak, and S. Dikshith. 2015. Genetic diversity of brown rice for iron and zinc content. *Electronic Journal of Plant Breeding*. 6(1): 196-203.

Pankaj Garg., Pandey, D.P and Dhirendrasingh. 2010. Correlation and Path Analysis for Yield and its Components in Rice (*Oryza sativa* L.). *Crop Improvement*. 37 (1): 46-51.

Parimala, K., CH Surender Raju, AS Hari Prasad, S. Sudheer Kumar, and S. Narender Reddy. 2020. Studies on genetic parameters, correlation and path analysis in rice (*Oryza sativa* L.). *Journal of Pharmacognosy and Phytochemistry*. 9(1): 414-417.

Pearson, K. 1897. Mathematical contributions to the theory of evolution on a form of spurious correlation which may arise when indices are used in the measurement of organs. *Proc. R. Soc. Lond.*, 60(359-367): 489-498. [Cross Ref]

Prabhu, S. M., N. Meenakshi Ganesan, P. Jeyaprakash, R. Selvakumar, and N. K. Prabhakaran. 2017. Assessment of Genetic Variability Studies among the Backcross Populations in Rice (*Oryza sativa* L.). *International Journal of Pure and Applied Sciences*. 5 (4): 368-372. [Cross Ref]

Priya, Ch Santhi, Y. Suneetha, D. Ratna Babu, and V. R. Rao. 2017. Inter-relationship and path analysis for yield and quality characters in rice (*Oryza sativa* L.). *International Journal of Science, Environment and Technology*. 6 (1): 381-390.

Purusothoaman, R., and S. Geetha. 2014. Assessment of genetic diversity based on morphological, grain Fe and Zn content in rice. *Electronic Journal of Plant Breeding*. 5 (2) : 144-151.

Rajamadhan R, R. Eswaran and A. Anandan. 2011. Investigation of correlation between traits and path analysis of rice (*Oryza sativa* L.) grain yield under coastal salinity. *Electronic Journal of Plant Breeding*. 2(4):538-542.

Sadeghi, Seyed Mustafa. 2011. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in landrace rice varieties. *World Applied Sciences Journal*. 13 (5): 1229-1233.

Saha, Setu Rani, Lutful Hassan, Md Ashraful Haque, Mirza Mofazzal Islam, and Md Rasel. 2019. Genetic variability, heritability, correlation and path analyses of yield components in traditional rice (*Oryza sativa* L.) landraces. *Journal of the Bangladesh Agricultural University*. 17 (1): 26-32. [Cross Ref]

Sala, M., Kumar, C.R. and Geetha, S. 2015. Variability studies for quality traits in rice with high iron and zinc content in the segregating population. *Rice Genomics and Genetics*. 6(4): 11-14.

Uppal, Shivani, Arushi Arora, Sanjeev Gautam, Suman Singh, R. J. Choudhary, and S. K. Mehta. 2019. Magnetically retrievable Co-doped Fe$_3$O$_4$ nanoparticles as scaffolds for the removal of azo dyes. *RSC advances*. 9( 40): 23129-23141. [Cross Ref]

Vengatesh, M., and R. Govindarasu. 2018. Studies on correlation and path analysis in rice (*Oryza sativa* L.) Genotypes. *Electronic Journal of Plant Breeding*. 9 (4): 1570-1576. [Cross Ref]

Welch, R. M., and Graham, R. D. 2004. Breeding for micronutrients in staple food crops from a human nutrition perspective. *Journal of experimental botany*, 55(396), 353-364. [Cross Ref]

Yadav SK, Pandey P, Kumar B. Suresh BG. 2011. Genetic architecture, inter-relationship and selection criteria for yield improvement in rice. *Pak J Biol Sci.* ,14(9):540-545. [Cross Ref]