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# Variability, Correlation and Path Analysis in Slender Grain Genotypes of Rice (*Oryza sativa* L.)

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**ABSTRACT**

The present investigation was undertaken with 30 slender grain genotypes in rice to study variability, character association between yield and yield components and their direct and indirect effects on grain yield. The results revealed high GCV, PCV, heritability and genetic advance as per cent mean for ear bearing tillers per plant, panicle length, grains per panicle, test weight, grain yield per plant, protein content and zinc content. Significant positive correlation and high positive direct effect on grain yield was recoded for the yield contributing characters, namely, ear bearing tillers per plant, panicle length, grains per panicle, test weight, protein and zinc content indicating the effectiveness of these traits in improvement of yield in slender grain genotypes with good nutritional quality.

**Keywords:** *Character association, path analysis, slender grain rice, grain yield, nutritional quality*

Rice is the most important food crop of the world and is the second largest cereal crop after wheat. It is referred to as global grain and is a staple food for 50 % of the world's population and two thirds of the Indian population (Singh *et al*., 2020). In the recent years, with the increase in purchasing power of the people, demand for slender grain rice has increased tremendously both in the domestic as well as international market. Hence, development of high yielding slender grain rice varieties with good grain quality is required. Information on the extent of variability in the slender grain material along with heritability and genetic advance of the traits would aid in the formulation of effective improvement strategies. Further, studies on correlation and path analysis would aid in the identification of effective selection criteria for improvement of grain yield along with grain quality. In this context, the present investigation was undertaken to study the variability, heritability, genetic advance, character associations and path coefficients of grain yield, yield components and quality characters of slender grain rice genotypes.

## MATERIAL AND METHODS

The experimental material comprised of 30 slender grain rice genotypes obtained from Agricultural Research Station, Bapatla. The genotypes were sown during *kharif* 2020 at ARS, Bapatla. All recommended package of practices were adopted to raise a healthy nursery and 20 days old seedlings were transplanted in the main field laid out in Randomized Block Design (RBD) with three replications. Each genotype was transplanted separately in five rows of 4.5 m length by adopting a spacing of 20 cm between rows and 15 cm between plants. Recommended package of practices were adopted throughout the crop growth period and need based plant protection measures were taken up to raise a healthy crop. Observations were recorded on five randomly selected plants for grain yield per plant and the yield component traits, namely, plant height, productive tillers per plant, panicle length and grains per panicle. However, days to 50 per cent flowering was recorded on plot basis. Test weight and quality traits, namely, hulling percentage, milling percentage, head rice recovery percentage, amylose content, protein content, zinc content and iron content were obtained from a random grain sample drawn from each plot in each genotype and replication using standard procedures. The data collected was subjected to standard statistical procedures given by Panse and Sukhatme (1967). The genotypic and phenotypic coefficients of variations in addition to the estimates of heritability and genetic advance were computed adopting the procedures outlined by Burton and Devane (1953) and Johnson *et al*. (1955), respectively. Correlation was worked out using the formulae suggested by Falconer (1964). Partitioning of the correlation coefficients into direct and indirect effects was carried out using the procedure suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Characterization of path coefficients was carried out as suggested by Lenka and Mishra (1973).

## RESULTS AND DISCUSSION

The estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance as per cent of mean (GAM) are presented in Table 1 and Fig. 1-2. A perusal of the results revealed maximum range of variability for grains per panicle (185-302), while minimum range (3.14-3.92) was recorded for the volume expansion ratio. Further, higher PCV, compared to GCV was noticed for all the traits studied in the present investigation, indicating the influence of environment. Similar findings were reported earlier by Sudeepthi *et al.* (2020) and Singh *et al*. (2020). High estimates of PCV and GCV (>20%) were also observed for ear bearing tillers per plant (Bhushan *et al.*,2019); panicle length (Srilakshmi *et al.,* 2018), grains per panicle (Singh *et al*., 2020), test weight, protein content and zinc content, similar to the findings of earlier workers. Further, moderate estimates (10-20%) of PCV and GCV were observed for the traits, namely, days to 50 per cent flowering and iron content. These results are in accordance with the findings of Singh *et al.* (2020) for days to 50 per cent flowering. In contrast, low (<10%) estimates of genotypic and phenotypic coefficients of variation were observed in the present study for hulling percentage, milling percentage, head rice recovery percentage, volume expansion ratio and amylose content indicating low heritability for these characters in the present experimental material and therefore little scope for the improvement of these traits.

High estimates of heritability (>60%) were recorded for days to 50 per cent flowering, plant height, ear bearing tillers per plant, panicle length, grains per panicle, test weight, grain yield per plant, protein content, iron content and zinc content traits studied, while moderate estimates of heritability (30-60%) were observed for water uptake and amylose content. A perusal of the results on genetic advance as per cent of mean revealed high values (>20%) for days to 50 per cent flowering, ear bearing tillers per plant, panicle length, grains per panicle, test weight, grain yield per plant, protein content, iron content and zinc content. The results are in accordance with the results of (Singh *et al*., 2020). Further, moderate estimates (10-20%) of genetic advance as per cent of mean were observed for plant height and water uptake.

High heritability coupled with high genetic advance as percent of mean was recorded for days to 50 per cent flowering, ear bearing tillers per plant, panicle length, test weight, grains per panicle, grain yield per plant and quality traits namely, protein content, iron content and zinc content indicating predominance of additive gene effects. However, plant height had recorded high heritability coupled with moderate genetic advance as per cent of mean indicating the role of additive and non-additive gene effects for the characters. Further, the information on genetic variation along with heritability and genetic advance estimated has been reported to give better idea about the efficiency of selection (Burton and Devane, 1953). In the present investigation, ear bearing tillers per plant, panicle length, grains per panicle, test weight, protein and zinc content had recoded high PCV, GCV, heritability and genetic advance as per cent of mean and hence, simple direct phenotypic selection is inferred to be highly effective for improvement of these traits.

Character associations for grain yield, yield component traits and quality parameters were also studied and the results obtained are presented in Table 2. A perusal of these results revealed positive and significant association of grain yield per plant with ear bearing tillers per plant, panicle length, grains per panicle (Singh *et al.*, 2020), test weight, protein and zinc content (Sridevi, 2018) indicating scope for simultaneous improvement of grain yield and nutritive quality. Studies on inter-character association for the yield component and quality traits revealed significant and positive association of days to 50 per cent flowering with plant height (Saha *et al*., 2019); test weight with zinc content (Singh *et al*., 2020); hulling percentage with milling percentage (Singh *et al*., 2020) and head rice recovery percentage (Chowdhury *et al*., 2016); head rice recovery percentage with iron content (Rathod, 2017); and iron content with amylose content (Sridevi, 2018), indicating a scope for simultaneous improvement of these traits through selection. In contrast, significant negative association was observed for the days to 50 per cent flowering with panicle length; plant height with zinc content; ear bearing tillers per plant with test weight (Singh *et al*., 2020) and zinc content; panicle length with head rice recovery percentage; grains per panicle with test weight; milling percentage with iron content; iron content with zinc content; and zinc content with amylose content indicating a need for balanced selection, while effecting simultaneous improvement for the traits.

Path coefficient analysis provides an effective means of finding out the direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and also measures the relative importance of each causal factor. Hence, the study of direct and indirect effects of traits on grain yield per plant was undertaken in the present investigation and the results obtained are presented in Table 3 and Fig. 3. A perusal of these results revealed residual effect of 0.3530 indicating that the traits considered in the experiment explained only about 64.70 per cent of the variability observed for grain yield per plant and hence, other attributes besides the characters studied are also contributing for grain yield per plant. A detailed analysis of the direct and indirect effects revealed high (>0.30) positive direct effect for ear bearing tillers per plant, panicle length, grains per panicle, test weight, protein content and zinc content in addition to significant and positive association with grain yield per plant (Singh *et al*., 2020). High direct effects of the traits, therefore appear to be the main factor for their association with grain yield per plant. Hence, these traits should be considered as important selection criterion for grain yield improvement in slender grain rice improvement programmes. Further, quality traits, namely, hulling and milling percentage, head rice recovery percentage, water uptake and amylose

**Table 1. Variability, heritability, and genetic advance of mean for yield, yield components and quality characters in slender grain rice genotypes**

| S. No. | Character | Mean | Range | | PCV | GCV (%) | Heritability (%) | Genetic advance as per cent of mean |
|---|---|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | (%) | | | |
| 1 | Days to 50 per cent flowering | 108.00 | 91.00 | 142.00 | 12.81 | 12.45 | 94.51 | 24.94 |
| 2 | Plant height (cm) | 104.67 | 79.47 | 135.70 | 9.80 | 9.04 | 85.00 | 17.16 |
| 3 | Ear bearing tillers per plant | 12.00 | 9.00 | 14.00 | 30.99 | 29.62 | 91.36 | 58.33 |
| 4 | Panicle length (cm) | 22.36 | 19.67 | 25.33 | 21.80 | 21.20 | 94.61 | 42.49 |
| 5 | Grains per panicle | 251.00 | 185.00 | 302.00 | 23.49 | 22.40 | 90.96 | 44.01 |
| 6 | Test weight (g) | 15.98 | 13.40 | 18.77 | 26.87 | 25.63 | 90.95 | 50.35 |
| 7 | Grain yield per plant (g) | 15.63 | 11.46 | 21.99 | 27.39 | 26.33 | 92.42 | 52.14 |
| 8 | Hulling percentage | 80.82 | 76.07 | 85.59 | 3.56 | 1.72 | 23.40 | 1.72 |
| 9 | Milling percentage | 68.71 | 64.80 | 72.17 | 3.54 | 1.60 | 20.42 | 1.49 |
| 10 | Head rice recovery percentage | 55.85 | 47.62 | 63.97 | 8.79 | 3.86 | 19.30 | 3.49 |
| 11 | Protein content (%) | 7.23 | 4.52 | 9.77 | 22.52 | 21.32 | 89.59 | 41.56 |
| 12 | Iron content (ppm) | 6.61 | 4.49 | 8.85 | 14.55 | 12.55 | 74.37 | 22.39 |
| 13 | Zinc content (ppm) | 14.40 | 12.60 | 16.68 | 24.04 | 23.55 | 95.99 | 47.54 |
| 14 | Water uptake (ml) | 142.44 | 109.39 | 175.15 | 14.59 | 9.35 | 41.44 | 12.33 |
| 15 | Volume expansion ratio | 3.44 | 3.14 | 3.92 | 7.37 | 3.83 | 26.94 | 4.09 |
| 16 | Amylose content (%) | 22.09 | 18.97 | 24.92 | 8.52 | 4.94 | 33.63 | 5.90 |

PCV = Phenotypic coefficient of variation; GCV = Genotypic coefficient of variation

**Table 2. Correlation coefficients for grain yield, yield components and quality characters in slender grain rice genotypes**

| Character | PH | EBT | PL | GPP | TW | HP | MP | HRR | PC | IC | ZC | WU | VER | AC | GYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFF | 0.3490** | -0.0623 | -0.2900* | -0.0384 | 0.1707 | 0.0143 | 0.0659 | 0.0622 | -0.0946 | -0.1798 | 0.0912 | 0.0277 | -0.0386 | -0.1722 | -0.0216 |
| PH | | -0.0764 | -0.1179 | -0.1787 | -0.0191 | 0.0701 | 0.179 | 0.0765 | 0.1076 | -0.0953 | -0.2920* | 0.0152 | -0.069 | -0.1398 | -0.0923 |
| EBT | | | 0.0197 | -0.0938 | -0.4240** | -0.0067 | -0.0248 | -0.0993 | -0.204 | -0.0614 | -0.2530* | -0.0045 | -0.0427 | 0.1411 | 0.3608** |
| PL | | | | 0.1882 | 0.1271 | -0.0918 | -0.0439 | -0.2140* | 0.0779 | -0.1424 | 0.0171 | 0.129 | 0.0093 | 0.0217 | 0.2682* |
| GPP | | | | | -0.2460* | -0.0836 | -0.0647 | -0.112 | 0.1759 | 0.0924 | 0.0413 | -0.0324 | 0.1073 | 0.1322 | 0.5697** |
| TW | | | | | | -0.1335 | -0.0571 | 0.0917 | 0.0508 | -0.0533 | 0.3530** | -0.0044 | 0.0118 | -0.0828 | 0.3596** |
| HP | | | | | | | 0.2960* | 0.2320* | 0.0166 | 0.1754 | -0.0918 | -0.1683 | 0.1891 | -0.0126 | 0.1476 |
| MP | | | | | | | | 0.1836 | 0.0648 | -0.2510* | -0.2790* | 0.132 | 0.0534 | -0.0228 | 0.1469 |
| HRR | | | | | | | | | -0.0147 | 0.3350* | -0.2022 | 0.0067 | 0.0071 | 0.1908 | 0.1229 |
| PC | | | | | | | | | | 0.0702 | -0.1873 | -0.0176 | -0.0069 | 0.0865 | 0.2310* |
| IC | | | | | | | | | | | -0.3210* | -0.1059 | 0.0107 | 0.2860* | -0.088 |
| ZC | | | | | | | | | | | | -0.0459 | 0.1614 | -0.2400* | 0.3556** |
| WU | | | | | | | | | | | | | 0.0083 | 0.0809 | 0.1943 |
| VER | | | | | | | | | | | | | | -0.0255 | -0.0734 |
| AC | | | | | | | | | | | | | | | 0.0671 |

*,** Significant at 1 and 5 per cent levels, respectively

**DFF**=Days to 50 per cent flowering, **PH**=Plant height, **EBT**=Ear bearing tillers per plant, **PL**=Panicle length, **GPP**= Grains per panicle, **TW**=Test weight, **HP**=Hulling percentage, **MP**=Milling percentage, **HRR**=Head rice recovery percentage, **PC**=Protein content, **IC**=Iron content, **ZC**=Zinc content, **WU**=Water uptake, **VER**=Volume expansion ratio, **AC**=Amylose content, **GYP**=Grain yield per plant.

**Table 3. Direct and indirect effects of yield component characters and quality traits on grain yield in slender grain rice genotypes**

| Character | DFF | PH | EBT | PL | GPP | TW | HP | MP | HRR | PC | IC | ZC | WU | VER | AC | GYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFF | -0.0376 | -0.0031 | 0.0023 | 0.0109 | 0.0014 | -0.0042 | -0.0005 | -0.0025 | -0.0023 | 0.0036 | 0.0068 | -0.0034 | -0.001 | 0.0015 | 0.0065 | -0.0216 |
| PH | -0.0068 | -0.3194 | 0.0915 | 0.0023 | 0.0354 | 0.002 | -0.0014 | -0.0035 | -0.0015 | -0.0021 | 0.0018 | 0.0057 | -0.0003 | 0.1013 | 0.0027 | -0.0923 |
| EBT | -0.0097 | -0.0119 | 0.3554 | 0.1937 | -0.0146 | -0.0659 | -0.001 | -0.0039 | -0.0154 | -0.0317 | -0.0095 | -0.0393 | -0.0007 | -0.0066 | 0.0219 | 0.3608** |
| PL | -0.0403 | -0.0164 | 0.0027 | 0.3392 | 0.0062 | 0.0177 | -0.0128 | -0.0061 | -0.0298 | 0.0029 | -0.0198 | 0.0024 | 0.018 | 0.0013 | 0.003 | 0.2682* |
| GPP | 0.0083 | 0.0981 | 0.0147 | -0.0296 | 0.5572 | -0.0387 | 0.0131 | 0.0102 | 0.0176 | -0.0276 | -0.0145 | -0.0065 | 0.0051 | -0.0169 | -0.0208 | 0.5697** |
| TW | 0.0056 | -0.0009 | -0.0207 | 0.0062 | 0.012 | 0.3487 | -0.0065 | -0.0028 | 0.0045 | 0.0025 | -0.0026 | 0.0172 | -0.0002 | 0.0006 | -0.004 | 0.3596** |
| HP | 0.0041 | 0.0123 | -0.0012 | -0.0161 | -0.0147 | -0.0234 | 0.0752 | 0.0519 | 0.0406 | 0.0029 | 0.0307 | -0.0161 | -0.0295 | 0.0331 | -0.0022 | 0.1476 |
| MP | 0.0384 | 0.0268 | -0.003 | -0.0054 | -0.0079 | -0.007 | 0.0362 | 0.0221 | 0.0224 | 0.0079 | 0.0306 | -0.034 | 0.0161 | 0.0065 | -0.0028 | 0.1469 |
| HRR | 0.0125 | 0.0154 | -0.02 | -0.0431 | -0.0226 | 0.0185 | 0.0467 | 0.037 | 0.1015 | -0.003 | 0.0074 | -0.0407 | 0.0005 | 0.0014 | 0.0114 | 0.1229 |
| PC | -0.026 | 0.0296 | -0.0561 | 0.0214 | 0.0484 | 0.014 | 0.0046 | 0.0178 | -0.004 | 0.3051 | 0.0193 | -0.0515 | -0.1048 | -0.0106 | 0.0238 | 0.2310* |
| IC | 0.0788 | 0.0417 | 0.0269 | 0.0624 | -0.1405 | 0.0233 | -0.1769 | -0.1216 | -0.1466 | -0.2308 | 0.4382 | 0.1406 | 0.0464 | -0.0047 | -0.1252 | -0.088 |
| ZC | -0.0082 | 0.1362 | 0.0227 | -0.1179 | -0.0637 | -0.0317 | 0.0082 | 0.0251 | 0.0182 | 0.0168 | 0.0288 | 0.3099 | 0.0041 | -0.0145 | 0.0216 | 0.3556** |
| WU | 0.0037 | 0.1721 | -0.0006 | 0.0172 | -0.0043 | -0.0006 | -0.0224 | 0.0176 | 0.0009 | -0.0023 | -0.0141 | -0.0061 | 0.0133 | 0.0011 | 0.0188 | 0.1943 |
| VER | 0.0228 | 0.0051 | 0.0036 | -0.0007 | -0.0079 | -0.0009 | -0.0139 | 0.0039 | -0.0005 | 0.0075 | -0.0008 | -0.0118 | -0.0006 | -0.0733 | 0.0019 | -0.0734 |
| AC | -0.0558 | -0.0128 | 0.1124 | 0.002 | 0.0121 | -0.0076 | -0.0012 | 0.0021 | 0.0175 | 0.0079 | 0.0261 | -0.122 | 0.0074 | -0.0083 | 0.0915 | 0.0671 |

*,** Significant at 5 and 1 per cent levels, respectively; Residual effect = 0.3530; Diagonal and bold values are direct effects while, off-diagonal values are indirect effects

**DFF**=Days to 50 per cent flowering, **PH**=Plant height, **EBT** =Ear bearing tillers per plant, **PL**=Panicle length, **GPP**= Grains per panicle, **TW**=Test weight, **HP**=Hulling percentage, **MP**= Milling percentage, **HRR**=Head rice recovery percentage, **PC**=Protein content, **IC**=Iron content, **ZC**=Zinc content, **WU**=Water uptake, **VER**=Volume expansion ratio, **AC**=Amylose content, **GYP**=Grain yield per plant

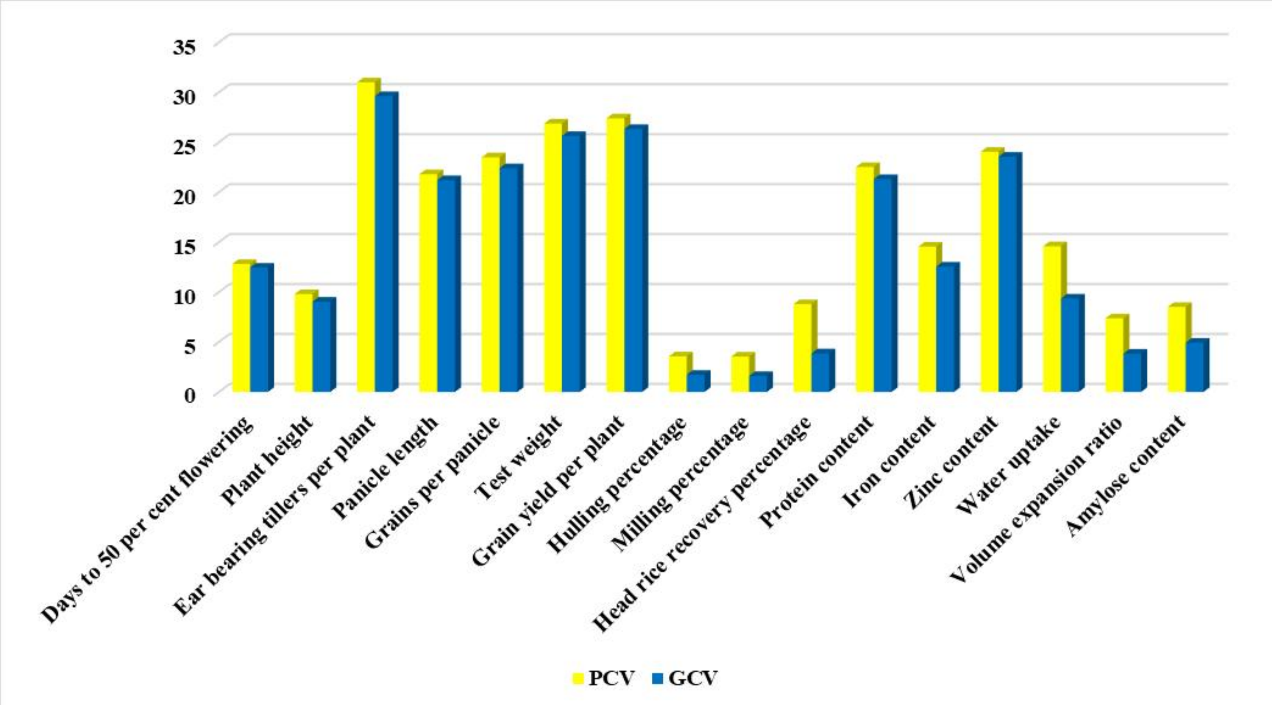


**Fig 1. Phenotypic and genotypic coeffients of variation for yield, yield components and quality characters in slender grain rice genotypes**

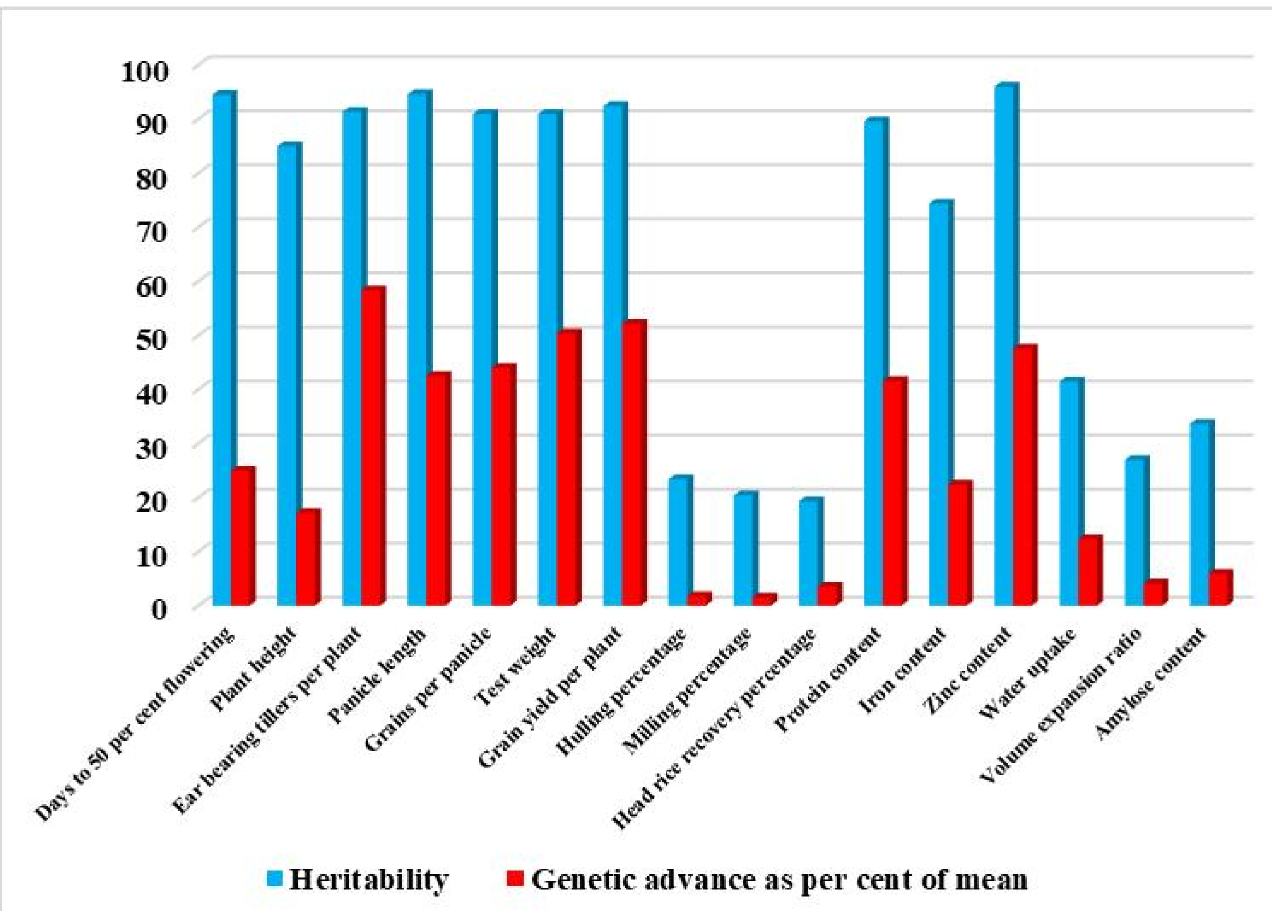


**Fig 2. Heritability and Genetic advance as per cent mean for yield, yield components and quality characters for slender grain rice**

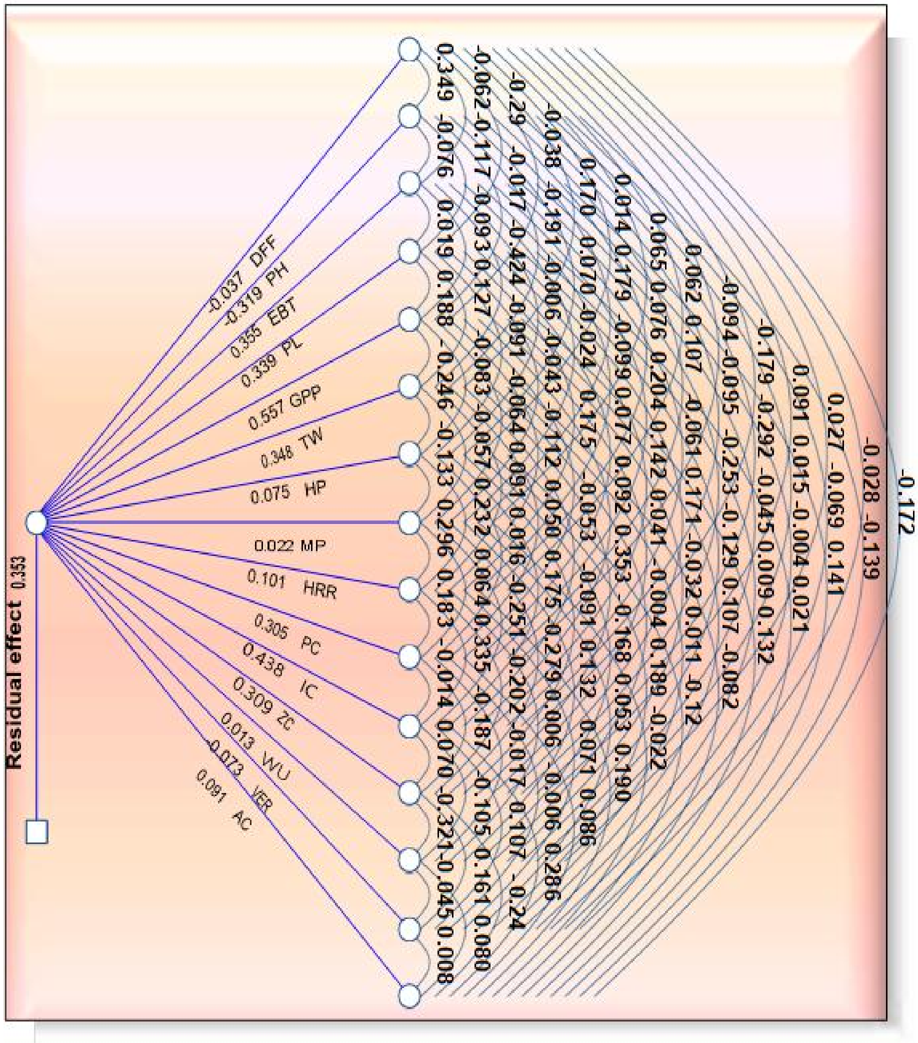


**Fig. 3. Direct and indirect effects on grain yield per plant**

**DFF**=Days to 50 per cent flowering, **PH**=Plant height, **EBT** =Ear bearing tillers per plant, **PL**=Panicle length, **GPP**= Grains per panicle, **TW**=Test weight, **HP**=Hulling percentage, **MP**=Milling percentage, **HRR**=Head rice recovery, **AC**=Amylose content, **PC**=Protein content, **ZC**=Zinc content, **IC**=Iron

content had recorded low to moderate positive direct effects on grain yield per plant. However, association of these traits was noticed to be positive with grain yield per plant indicating indirect effects to be the cause of correlation and hence, the need for consideration of indirect causal factors during selections for yield improvement through these traits.

## CONCLUSION

In conclusion, results revealed that high PCV, GCV, heritability and genetic advance as per cent mean was observed for ear bearing tillers per plant, panicle length, grains per panicle, test weight, protein content and zinc content in addition to significant positive correlation and high positive direct effect on grain yield per plant indicating their importance as effective selection for criteria for grain yield improvement in slender grain rice genotypes.

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