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# Correlation and Path Coefficient Studies for Grain Yield and Yield Components in Rice (*Oryza sativa* L.)

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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

The current research was conducted with an objective to study the correlation between different traits and path coefficient analysis in rice. Four CMS lines were crossed with eight elite restorers in a Line × Tester design and the resultant 32 hybrids were evaluated along with the parents and two checks in a randomized block design with three replications during the *rabi* season of 2022. The data was collected on 13 quantitative characters. The results revealed that there is a significant variability in the material studied. The character association studies indicated that the trait, grain yield per plant had significant positive genotypic correlation with panicle length, number of productive tillers per plant, number of grains per panicle, 1000 grain weight, 50% flowering, plant height, kernel length, kernel breadth and head rice recovery. The path analysis studies revealed that panicle length was the major contributor for grain yield per plant followed by plant height, number of grains per panicle, days to 50% flowering, 1000-grain weight, kernel length, number of productive tillers per plant, head rice recovery and kernel breadth. These characters showed direct positive effects for grain yield per plant. The above characters can be used directly as the selection criteria in rice yield improvement programmes.

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*Keywords: Randomized block design; kernel breadth; staple food crop; annual production.*

## 1. INTRODUCTION

"Rice is a staple food crop of India and occupies pivotal place in Indian agriculture. It feeds two thirds of world`s population, providing 43 per-cent (%) of calorie requirement and 20-25% of agricultural income. The crop occupies more than 23% of gross cropped area in India i.e., about 46.38 million hectares (Mha) which is the largest in the world among all the rice growing countries. Annual production of rice in the country is around 130.29 million tonnes (Mt) (https://agricoop.nic.in/)" [1].

To meet the demands of a growing population while maintaining self-sufficiency, production must rise to 140 Mt by 2030. This is a difficult endeavour, given the plateauing tendency in high yielding cultivars' yield potential and the diminishing natural resource base. Hybrid rice is one of the most practical and easily adoptable genetic choices for increasing rice output, as the People's Republic of China has proved. As a result, rice breeding projects have turned to hybrid rice development, having been convinced of the potential of hybrid rice technology in increasing production and productivity. So far, 133 rice hybrids have been released for commercial production in India.

Correlation is a measure of the mutual relationship between two variables. Correlation analysis can help plant breeders understand how improving one characteristic leads to synchronous improvements in others. The relationship between yield and its component features is better understood through studies of the relationship between yield and its components. Phenotypic correlation indicates the degree to which the two factors are linked and is influenced by genetic and environmental connections. Meanwhile, genotypic correlation plays a crucial role in designing effective breeding strategies. Studies on the association between yield-related traits consistently showed a positive relationship between grain yield [2-4]. However, in general, genetic correlations tended to be stronger than phenotypic values [5]. The correlation coefficient-derived character association is viewed as a significant biometric method for creating a selection index. This is because it reveals how strongly traits within a group are interconnected [6]. Understanding the link between a trait, yield, and other yield-related factors would assist in choosing appropriate rice genotypes as parent plants in breeding projects.

Path coefficient analysis aids in breaking down correlation coefficients into direct effects and indirect effects, which are influenced by other variables [7,8]. Essentially, it's a standardized method of studying how different yield components are interconnected, considering a self-contained system of appropriate weighting. As per Hasan et al. [9], the approach to breeding rice relies on the degree of association and correlation between traits, as well as the kind of differences present. Combining a correlation examination with path analysis proves to be a more potent method for investigating traits contributing to yield. Having a deeper understanding of traits that are strongly linked to yield is consistently important. This is because these traits can serve as direct criteria for selection or as benchmarks to enhance the performance of new plant populations [10]. The current research was conducted to investigate the genetic factors that establish the connection between rice yield and other characteristics.

## 2. MATERIALS AND METHODS

The research was conducted at the Regional Agricultural Research Station located in Polasa, Jagtial, Telangana state, India. This station is positioned at an elevation of 243.4 meters above the average sea level, situated at 18°49'40'' N latitude and 78°56'45'' E longitude within the Northern Zone of Telangana State. The experiment was conducted during the *rabi* 2022, with the goal of examining the relationship between traits and their direct and indirect impacts on grain yield.

The experimental material consisted of a total of 46 different genotypes. This group encompassed four CMS lines *viz*., CMS 14A, CMS 23A, CMS 64A, CMS 69A, and, as well as eight testers designated as IR 63870-7-3-2-3-3R, IR 63877-43-2-1-3-1R, IR 65483-14-1-1-4-13R, IR 65514-5-2-19R-1, JGL 21005, JGL 24444, JGL 27347 and JGL 29651 and their thirty-two hybrids generated through the Line × Tester mating design introduced by Kempthorne, [11]. Two standard reference varieties, KPH 4 and KPH 468, were included for comparison. To arrange these genotypes, a randomized block design (RBD) was employed with three replications and a spacing of 20 × 15 cm. Seedlings that were 28 days old were transplanted to the main field, and all the required agricultural practices were applied to cultivate a healthy crop. Data collection involved noting down information related to grain yield, characteristics contributing to yield, and quality traits. This data was gathered from five arbitrarily chosen healthy plants for every entry within each replication, focusing on 13 distinct attributes *viz.*, days to 50% flowering, plant height (cm), panicle length (cm), number of productive tillers per plant, number of grains per panicle, 1000 grain weight (g), grain yield plant per plant (g), hulling percentage, milling percentage, head rice recovery (%), kernel length (mm), kernel breadth (mm), kernel L/B ratio. The character, days to 50% flowering was recorded on plot basis. The procedures for analysis were carried out following the guidelines presented by Singh and Chaudhary [12] for correlation coefficient analysis, and Dewey and Lu [13] for path analysis.

## 3. RESULTS AND DISCUSSION

Analysis of variance showed that the experimental material had sufficient variation. Grain yield per plant recorded significant positive correlation at genotypic level with days to 50% flowering (0.2627**), plant height (0.4319**), panicle length (0.4698**), number of productive tillers per plant (0.2110*), number of grains per panicle (0.2804**), 1000-grain weight (0.2588**), head rice recovery (0.2107*), kernel length (0.2214**) and kernel breadth (0.1468*). Whereas it had positive non-significant correlation with L/B ratio (0.0421), hulling % (0.0095), milling% (0.0079) (Table 1).

Panicle length had shown positive and significant correlation with number of grains per panicle (0.2021*), kernel length (0.1947*), L/B ratio (0.4685**) and head rice recovery (0.2553**) and negative significant association with kernel breadth (-0.3165**), whereas it showed significant and positive correlation with grain yield per plant (0.4698**). Direct selection of genotypes having long panicles favours improvement in grain yield per plant.

Number of productive tillers per plant is positively and significantly correlated with milling percentage (-0.3681**) also with grain yield per plant (0.2110*). Hence the selection based on number of productive tillers per plant is suitable as it brings simultaneous improvement in grain yield per plant.

Number of grains per panicle is an important yield contributing factor especially in hybrids, as they are characterized by larger sink size. This character exhibited positive and significant association with milling percentage (0.2748**), head rice recovery (0.4655**) and significant negative correlation with 1000 grain weight (-0.4931**), kernel length (-0.1933*), kernel breadth (-0.2754**). While it had positive and significant correlation with grain yield per plant (0.2804**).

1000-grain weight registered positive and significant association with kernel length (0.5382**) kernel breadth (0.6791**) and negative correlation association with head rice recovery (-0.4713**), L/B ratio (-0.1924*), hulling% (-0.2590**), milling% (-0.1773*) whereas it had positive significant association with grain yield per plant (0.2588**). These results are in line with the earlier reports of Babu et al*.* [14], Nikhil et al*.* [15], Lakshmi et al*.* [16], Sarwar et al. [2], Abdala et al*.* [17], Devi et al*.* [3], Prakash et al*.* [18], Kiranmayee et al*.* [19], Thorat et al*.* [20] and Nanda et al*.* [21] Islam et al*.* [22] and Singh et al [24].

Days to 50 per cent flowering showed positive significant association with plant height (0.5209**), panicle length (0.5860**), number of grains per panicle (0.1012*), L/B ratio (0.3676**), hulling% (0.2616**), milling% (0.1758*) and head rice recovery (0.3989**) and negative significant association with number of productive tillers (-0.3341**), 1000 grain weight (-0.3288**), kernel breadth (-0.3488**), whereas it showed significant positive correlation with grain yield per plant (0.2627**). Hence, these findings reveal that late flowering types may have more chance of contribution towards grains yield.

Plant height exhibited positive and significant correlation with panicle length (0.6412**), number of grains per panicle (0.3544**), L/B ratio (0.1865*), head rice recovery (0.2894**) and negative significant association with 1000 grain weight (-0.1750*) and kernel breadth (-0.1905*). Plant height recorded positive and significant association with grain yield per plant (0.4319**). This revealed that plant height is an important trait for realizing more yield and tallness is associated with problem of lodging. Plants having sturdy and medium height culms should be preferred. Babu et al*.* [14], Devi et al*.* [3], Priya et al. [23] and Osman et al. [25] also reported similar findings for days to 50 per cent flowering and plant height. Selection based on the plant height simultaneously improves grain yield per plant.

**Table 1. Phenotypic (P) and Genotypic (G) correlation coefficients of yield and quality traits in rice**

| SOURCE | | DFF | PH | PL | NPT | NGP | 1000 GW | KL | KB | L/B | HP | MP | HRR | GYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DFF** | **G** | **1.0000** | 0.5209** | 0.5860** | -0.334199 | 0.1012* | -0.3288** | 0.0188 | -0.3488** | 0.3676** | 0.2616** | 0.1758* | 0.3989** | 0.2627** |
| | **P** | **1.0000** | 0.5025** | 0.5102** | -0.3067** | 0.1024 | -0.3198** | 0.0173 | -0.3313** | 0.3322** | 0.2247** | 0.1589 | 0.3885** | 0.2444** |
| **PH** | **G** | | **1.0000** | 0.6412** | -0.1413 | 0.3544** | -0.1750* | 0.0109 | -0.1905* | 0.1865* | 0.1209 | 0.0850 | 0.2894** | 0.4319** |
| | **P** | | **1.0000** | 0.5621** | -0.1244 | 0.3447** | -0.1636 | -0.0015 | -0.1797* | 0.1614 | 0.1058 | 0.0785 | 0.2765** | 0.3918** |
| **PL** | **G** | | | **1.0000** | 0.0801 | 0.2021* | -0.0600 | 0.1947* | -0.3165** | 0.4685** | 0.0328 | 0.0115 | 0.2553** | 0.4698** |
| | **P** | | | **1.0000** | 0.0068 | 0.2101* | -0.0421 | 0.1514 | -0.2359** | 0.3344** | 0.0316 | 0.0156 | 0.2116* | 0.4143** |
| **NPT** | **G** | | | | **1.0000** | -0.0082 | 0.0653 | -0.0904 | 0.0040 | -0.1167 | -0.0997 | -0.3681** | -0.1420 | 0.2110* |
| | **P** | | | | **1.0000** | -0.0182 | 0.0593 | -0.0856 | -0.0053 | -0.0944 | -0.1100 | -0.3337** | -0.1211 | 0.1811* |
| **NGP** | **G** | | | | | **1.0000** | -0.4931** | -0.1933* | -0.2754** | 0.1130 | 0.1316 | 0.2748** | 0.4655** | 0.2804** |
| | **P** | | | | | **1.0000** | -0.4671** | 0.1790* | -0.2627** | 0.1070 | 0.1146 | 0.2495** | 0.4374** | 0.2768** |
| **1000 GW** | **G** | | | | | | **1.0000** | 0.5382** | 0.6791** | -0.1924* | -0.2590** | -0.1773* | -0.4713** | 0.2588** |
| | **P** | | | | | | **1.0000** | 0.4927** | 0.6225** | -0.1708* | -0.2169* | -0.1556 | -0.4531** | 0.2296** |
| **KL** | **G** | | | | | | | **1.0000** | 0.4081** | 0.4521** | 0.0219 | 0.2753** | -0.0476 | 0.2214** |
| | **P** | | | | | | | **1.0000** | 0.3579** | 0.4774** | 0.0378 | 0.2572** | -0.0427 | 0.2260** |
| **KB** | **G** | | | | | | | | **1.0000** | -0.6253** | -0.0701 | 0.0351 | -0.5846** | 0.1468* |
| | **P** | | | | | | | | **1.0000** | -0.6433** | -0.0691 | 0.0228 | -0.5355** | 0.1436* |
| **L/B** | **G** | | | | | | | | | **1.0000** | 0.1082 | 0.2034* | 0.5279** | 0.0421 |
| | **P** | | | | | | | | | **1.0000** | 0.1122 | 0.1898** | 0.4604** | 0.0459 |
| **HP** | **G** | | | | | | | | | | **1.0000** | 0.4800** | 0.1329 | 0.0095 |
| | **P** | | | | | | | | | | **1.0000** | 0.5624** | 0.1296 | 0.0000 |
| **MP** | **G** | | | | | | | | | | | **1.0000** | 0.3371** | 0.0079 |
| | **P** | | | | | | | | | | | **1.0000** | 0.3188** | 0.0018 |
| **HRR** | **G** | | | | | | | | | | | | **1.0000** | 0.2107* |
| | **P** | | | | | | | | | | | | **1.0000** | 0.1960* |

** Significant at 5 per cent level ** Significant at 1 per cent level*

*DFF: Days to 50% flowering, PH: Plant height (cm), PL: Panicle length (cm), NPT: Number of productive tillers per plant, NGP: Number of grains per panicle, 1000 GW: 1000 grain weight, KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: Length/Breadth Ratio, HP: Hulling percentage, MP: Milling percentage, HRR: Head rice recovery (%), GYP: Grain yield per plant (g)*

Kernel length exhibited positive and significant correlation with milling percentage (0.2753**), kernel breadth (0.4081**) and kernel L/B ratio (0.4521**) and no negative significant association, while it had recorded positive and significant correlation with grain yield per plant (0.2214**). Kernel breadth exhibited significant negatively correlated with L/B ratio (-0.6253**) and head rice recovery (-0.5846**) while it had recorded positive and significant correlation with grain yield per plant (0.1468*). With respect to L/B ratio, it exhibits positive and significant correlation with milling percentage (0.2034*) and head rice recovery (0.5279**). Khatun et al. [26], Lakshmi et al*.* [16], Islam et al*.* [22] and Kiran et al. [27] also reported similar results.

Higher hulling percentages are preferred in rice to achieve a higher proportion of economic output with less waste. This character showed positive and significant association with milling percentage (0.4800**). Milling exhibited positive and significant correlation with head rice recovery (0.3371**). Head rice recovery exhibited positive and significant correlation with grain yield per plant (0.2107*). These results are in accordance with the findings of Kumar et al*.* [28], Abdala et al*.* [17], Premkumar et al*.* [29], Ratna et al*.* [8], Edukondalu et al*.* [30] Devi et al*.* [3] and Naik et al*.* [31].

The outcomes of the path coefficient analysis for yield and its component traits (Table 2). Panicle length expressed a direct positive genotypic effect on grain yield per plant (0.1388) while its correlation was significant and positive with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.0813), plant height (0.0890), number of productive tillers per plant (0.0111), number of grains per panicle (0.0360), kernel length (0.0270), L/B ratio (0.0650), hulling percentage (0.0046), milling percentage (0.0016) and head rice recovery (0.0354) and negative indirect contribution through kernel breadth (-0.0439) and 1000-grain weight (-0.0083).

Number of productive tillers per plant expressed a direct positive genotypic effect on grain yield per plant (0.2667) while its correlation was significant and positive with grain yield per plant. It expressed positive indirect contribution through and negative indirect contribution through panicle length (0.0214), 1000 grain weight (0.0174) and kernel breadth (0.0011) and negative indirect contribution through days to 50% flowering (-0.0891), plant height (-0.0377) number of grains per panicle (-0.0022), kernel length (-0.0241), L/B ratio (-0.0311), hulling percentage (-0.0266), milling percentage (-0.0982) and head rice recovery (-0.0379).

Number of grains per panicle expressed a direct positive genotypic effect on grain yield per plant (0.4337) while its correlation was positively significant with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.0439), plant height (0.1537), panicle length (0.0877), L/B ratio (0.0490), hulling percentage (0.0571), milling percentage (0.1192) and head rice recovery (0.2019) and negative indirect contribution through number of productive tillers per plant (-0.0036), 1000-grain weight (-0.2139), kernel length (-0.0838), and kernel breadth (-0.1194).

1000 grain weight expressed a direct positive genotypic effect on grain yield per plant (0.6704) while its correlation was positively significant with grain yield per plant. It expressed positive indirect contribution through, number of productive tillers per plant (0.0438), kernel length (0.3608), and kernel breadth (0.4552) and negative indirect contribution through days to 50 per cent flowering (-0.2204), plant height (-0.1173), panicle length (-0.0402), number of grains per panicle (-0.3306), L/B ratio (-0.1290), hulling percentage (-0.1736), milling percentage (-0.1189) and head rice recovery (-0.3159). Nikhil et al*.* [15], Lakshmi et al*.* [16], Kishore et al. [32], Sarwar et al*.* [2], Prakash et al*.* [18], Hemalatha et al*.* [33], Kiranmayee et al. [19], Arulmozhi et al*.* [34] and Singh et al*.* [24] also reported similar results.

Days to 50 percent flowering recorded direct and positive genotypic effect on grain yield per plant (0.3662) and it is significant and positively correlated with grain yield per plant. It had positive indirect contribution through plant height (0.1908), panicle length (0.2146), number of grains per panicle (0.0371), kernel length (0.0069), L/B ratio (0.1346), hulling percentage (0.0958), milling percentage (0.0644) and head rice recovery (0.1461). Negative indirect contribution through, number of productive tillers per plant (-0.1223), 1000-grain weight (-0.1204) and kernel breadth (-0.1277).

Plant height expressed a direct positive genotypic effect on grain yield per plant (0.1016) and it is significant and positively correlated with grain yield per plant. It expressed positive indirect contribution through days to 50%

flowering (0.0529), panicle length (0.0651), number of grains per panicle (0.0360), kernel length (0.0011), L/B ratio (0.0189), hulling percentage (0.0123), milling percentage (0.0086) and head rice recovery (0.0294), and negative indirect contribution through, number of productive tillers per plant (-0.0143), 1000-grain weight (-0.0178), and kernel breadth (-0.0194). The results are in accordance with the findings of Babu et al. [14], Kishore et al. [32], Sarwar et al. [2], Kiranmayee et al. [19] and Arulmozhi et al. [34].

Kernel length expressed a direct positive genotypic effect on grain yield per plant (0.7960) while its correlation was significant and positive with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.0150), plant height (0.0087), panicle length (0.1550), 1000-grain weight (0.4284), kernel breadth (0.3248), L/B ratio (0.3598) hulling percentage (0.0174) and milling percentage (0.2191) and negative indirect contribution through number of productive tillers per plant (-0.0720), number of grains per panicle (-0.1539) and head rice recovery (-0.0379).

Kernel breadth expressed a direct negative genotypic effect on grain yield per plant (-0.8223) while its correlation was significant and positive with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.2868), plant height (0.1567), panicle length (0.2602), number of grains per panicle (0.2264), kernel L/B ratio (0.5142), hulling percentage (0.0576) and head rice recovery (0.4807) and negative indirect contribution through number of productive tillers per plant (-0.0033), 1000-grain weight (-0.5584), kernel length (-0.3355) and milling percentage (-0.0289).

L/B ratio expressed a direct negative genotypic effect on grain yield per plant (-1.0909) while its correlation was non-significant and positive with grain yield per plant. It expressed positive indirect contribution through number of productive tillers per plant (0.1273), 1000-grain weight (0.2099) and kernel breadth (0.6821) and negative indirect contribution through 50% flowering (-0.4010), plant height (-0.2034), panicle length (-0.5111), number of grains per panicle (-0.1233), kernel length (-0.4932), hulling percentage (-0.1181), milling percentage (-0.2219) and head rice recovery (-0.5759). These results are similar with the earlier findings of Lakshmi et al. [16], Dhurai et al. [35], Meena et al. [36], Devi et al. [3] and Priya et al. [23], Hemalatha et al. [33] and Kiran et al. [27].

Hulling percentage expressed a direct positive genotypic effect on grain yield per plant (0.0800) while its correlation was non-significant and positive with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.0209), plant height (0.0097), panicle length (0.0026), number of productive tillers per plant (0.1273), number of grains per panicle (0.0105), kernel length (0.0018), L/B ratio (0.0087) milling percentage (0.0384) and head rice recovery (0.0106) and negative indirect contribution through 1000-grain weight (-0.0207) and kernel breadth (-0.0056).

Milling percentage expressed a direct negative genotypic effect on grain yield per plant (-0.0767) while its correlation was non-significant and positive with grain yield per plant. It expressed positive indirect contribution through days to number of productive tillers per plant (0.0282) and 1000-grain weight (0.0136) and negative indirect contribution through 50% flowering (-0.0135), plant height (-0.0065), panicle length (-0.0009), number of grains per panicle (-0.0211), kernel length (-0.0211), kernel breadth (-0.0027), L/B ratio (-0.0156) hulling percentage (-0.0368) and head rice recovery (-0.0259).

Head rice recovery expressed a direct positive genotypic effect on grain yield per plant (0.3000) while its correlation was significant and positive with grain yield per plant. It expressed positive indirect contribution through days to 50% flowering (0.1197) plant height (0.0868), panicle length (0.0766), number of grains per panicle (0.1397), L/B ratio (0.1584), hulling percentage (0.0399) and milling percentage (0.1011) and negative indirect contribution through number of productive tillers per plant (-0.0426), 1000 grain weight (-0.1414), kernel length (-0.0143) and kernel breadth (-0.1754). These results are in agreement with the findings of Premkumar et al. [29], Devi et al. [3], Hemalatha et al. [33] and Naik et al. [31].

In plant breeding, it is very difficult to have whole understanding of all component traits related to grain yield. This residual effect permits accurate explanation about the pattern of interaction of other possible components of grain yield which was not included in the study. The residual effect was 0.6085 for genotypic and 0.6919 for phenotypic path coefficient. This denotes that contribution of component traits that are studied

**Table 2. Phenotypic (P) and Genotypic (G) path coefficients of grain yield and quality traits in rice (*Oryza sativa* L.)**

| SOURCE | | DFF | PH | PL | NPT | NGP | 1000 GW | KL | KB | L/B | HP | MP | HRR | GYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DFF** | **G** | **0.3662** | 0.1908 | 0.2146 | -0.1223 | 0.0371 | -0.1204 | 0.0069 | -0.1277 | 0.1346 | 0.0958 | 0.0644 | 0.1461 | 0.2627** |
| | **P** | **0.2936** | 0.1475 | 0.1498 | -0.0901 | 0.0301 | -0.0939 | 0.0051 | -0.0973 | 0.0975 | 0.0660 | 0.0467 | 0.1141 | 0.2444** |
| **PH** | **G** | 0.0529 | **0.1016** | 0.0651 | -0.0143 | 0.0360 | -0.0178 | 0.0011 | -0.0194 | 0.0189 | 0.0123 | 0.0086 | 0.0294 | 0.4319** |
| | **P** | 0.0614 | **0.1221** | 0.0687 | -0.0152 | 0.0421 | -0.0200 | -0.0002 | -0.0219 | 0.0197 | 0.0129 | 0.0096 | 0.0338 | 0.3918** |
| **PL** | **G** | 0.0813 | 0.0890 | **0.1388** | 0.0111 | 0.0360 | -0.0083 | 0.0270 | -0.0439 | 0.0650 | 0.0046 | 0.0016 | 0.0354 | 0.4698** |
| | **P** | 0.0683 | 0.0753 | **0.1339** | 0.0009 | 0.0281 | -0.0056 | 0.0203 | -0.0316 | 0.0448 | 0.0042 | 0.0021 | 0.0283 | 0.4143** |
| **NPT** | **G** | -0.0891 | -0.0377 | 0.0214 | **0.2667** | -0.0022 | 0.0174 | -0.0241 | 0.0011 | -0.0311 | -0.0266 | -0.0982 | -0.0379 | 0.2110* |
| | **P** | -0.0791 | -0.0321 | 0.0018 | **0.2578** | -0.0047 | 0.0153 | -0.0221 | -0.0014 | -0.0243 | -0.0284 | -0.0860 | -0.0312 | 0.1811* |
| **NGP** | **G** | 0.0439 | 0.1537 | 0.0877 | -0.0036 | **0.4337** | -0.2139 | -0.0838 | -0.1194 | 0.0490 | 0.0571 | 0.1192 | 0.2019 | 0.2804** |
| | **P** | 0.0385 | 0.1298 | 0.0018 | -0.0068 | **0.3766** | -0.1759 | -0.0674 | -0.0989 | 0.0403 | 0.0431 | 0.0940 | 0.1647 | 0.2768** |
| **1000 GW** | **G** | -0.2204 | -0.1173 | -0.0402 | 0.0438 | -0.3306 | **0.6704** | 0.3608 | 0.4552 | -0.1290 | -0.1736 | -0.1189 | -0.3159 | 0.2588** |
| | **P** | -0.1488 | -0.0761 | -0.0196 | 0.0276 | -0.2174 | **0.4654** | 0.2293 | 0.2897 | -0.0795 | -0.1009 | -0.0724 | -0.2108 | 0.2296** |
| **KL** | **G** | 0.0150 | 0.0087 | 0.1550 | -0.0720 | -0.1539 | 0.4284 | **0.7960** | 0.3248 | 0.3598 | 0.0174 | 0.2191 | -0.0379 | 0.2214** |
| | **P** | 0.0043 | -0.0004 | 0.0375 | -0.0212 | -0.0443 | 0.1219 | **0.2475** | 0.0886 | 0.1182 | 0.0093 | 0.0636 | -0.0106 | 0.2260** |
| **KB** | **G** | 0.2868 | 0.1567 | 0.2602 | -0.0033 | 0.2264 | -0.5584 | -0.3355 | **-0.8223** | 0.5142 | 0.0576 | -0.0289 | 0.4807 | 0.1468* |
| | **P** | 0.0092 | 0.0050 | 0.0065 | 0.0001 | 0.0073 | -0.0173 | -0.1158 | **-0.0277** | 0.0178 | 0.0019 | -0.0006 | 0.0148 | 0.1436* |
| **L/B** | **G** | -0.4010 | -0.2034 | -0.5111 | 0.1273 | -0.1233 | 0.2099 | -0.4932 | 0.6821v | **-1.0909** | -0.1181 | -0.2219 | -0.5759 | 0.0421 |
| | **P** | -0.0967 | -0.0470 | -0.0973 | 0.0275 | -0.0311 | 0.0497 | -0.1158 | 0.1872 | **-0.2911** | -0.0327 | -0.0552 | -0.1340 | 0.0459 |
| **HP** | **G** | 0.0209 | 0.0097 | 0.0026 | 0.1273 | 0.0105 | -0.0207 | 0.0018 | -0.0056 | 0.0087 | **0.0800** | 0.0384 | 0.0106 | 0.0095 |
| | **P** | 0.0122 | 0.0057 | 0.0017 | -0.0060 | 0.0062 | -0.0117 | 0.0020 | -0.0037 | 0.0061 | **0.0541** | 0.0304 | 0.0070 | 0.0000 |
| **MP** | **G** | -0.0135 | -0.0065 | -0.0009 | 0.0282 | -0.0211 | 0.0136 | -0.0211 | -0.0027 | -0.0156 | -0.0368 | **-0.0767** | -0.0259 | 0.0079 |
| | **P** | -0.0178 | -0.0088 | -0.0017 | 0.0373 | -0.0279 | 0.0174 | -0.0287 | -0.0025 | -0.0212 | -0.0628 | **-0.1117** | -0.0356 | 0.0018 |
| **HRR** | **G** | 0.1197 | 0.0868 | 0.0766 | -0.0426 | 0.1397 | -0.1414 | -0.0143 | -0.1754 | 0.1584 | 0.0399 | 0.1011 | **0.3000** | 0.2107* |
| | **P** | 0.0993 | 0.0706 | 0.0541 | -0.0309 | 0.1117 | -0.1158 | -0.0109 | -0.1368 | 0.1176 | 0.0331 | 0.0815 | **0.2555** | 0.1960* |

*Genotypic Residual effect = 0.6085* *Phenotypic Residual effect = 0.6919* *Bold values are direct effects*

*DFF: Days to 50 % flowering, PH: Plant height (cm), PL: Panicle length (cm), NPT: Number of productive tillers per plant, NGP: Number of grains per panicle, 1000 GW: 1000 grain weight, KL: Kernel length (mm), KB: Kernel breadth (mm), L/B: Length/Breadth Ratio, HP: Hulling percentage, MP: Milling percentage, HRR: Head rice recovery (%), GYP: Grain yield per plant (g)* on yield per hectare was 39.15% at genotypic level and 30.81% at phenotypic level, the rest 60.85 at genotypic level and 69.19 at phenotypic level was the contribution of other characters which were not included in the study on dependent variable.

## 4. CONCLUSION

The characters days to 50% flowering, plant height, panicle length, number of productive tillers per plant, number of grains per panicle, 1000 grain weight, kernel length, kernel breadth and head rice recovery showed significant positive genotypic correlation and would result in improvement of yield. The path analysis studies revealed that panicle length was the major contributor for grain yield per plant followed by plant height, number of grains per panicle, days to 50% flowering, 1000-grain weight, kernel length, number of productive tillers per plant, head rice recovery and kernel breadth. The characteristics listed above can be used directly as selection criteria in rice yield improvement programs.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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