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# Correlation and Path Analysis for Yield and Quality Characters in Rice (*Oryza sativa* L.)

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**Abstract** Field experiment was conducted using thirty two rice genotypes during the Kharif season of 2009 at the wetland farm of S.V Agricultural College, Tirupati to estimate correlation coefficients and path analysis for grain yield and yield contributing traits in rice. The experiments were laid down in a randomized complete block design with three replications. Highly significant ($p<0.01$) variation was obtained for almost all the characters studied. Character association analysis revealed significantly positive association of grain yield per plant with harvest index, days to maturity and number of grains per panicle. Correlations among yield components were positive, encouraging rapid improvement of yield. Path analysis revealed that kernel elongation ratio, kernel length, harvest index and days to maturity have shown high positive direct effects on grain yield.

**Keywords** Correlation; Path analysis; Yield; Quality traits; Rice

## Introduction

Rice is an important food crop in India. Genotype and environmental factors have extensive effects on growth and yield of rice. Most of the characters of interest to breeder are complex and result of the interaction of a number of components (Sarawgi et al., 1997).The world population is expected to reach 8 billion by 2030 and rice production must be increased by 50% in order to meet the growing demand (Khush and Brar, 2002). In order to meet the fastest growing demand for rice grain, development of high yielding genotypes with desirable agronomic traits for diverse ecosystem is therefore a necessity. Hence, rice breeders are interested in developing cultivars with improved yield and other desirable agronomic characters. Yield is a complex character and composed of several components. Some of which affect the yield directly while others contribute indirectly. Hence, the study of relationships among quantitative traits is important for assessing the feasibility of joint selection for two or more traits instead of selection of secondary traits on genetic gain for the primary trait under consideration. Path coefficient analysis partitions the genetic correlation between yield and its component traits direct and indirect effects and hence has effectively been used in identifying useful traits as selection criteria to improve grain yield in rice (Sadeghi, 2011). Hence, the present study was undertaken to know the inter-relation among different yield contributing characters and their association with grain yield.

### Results and Discussion

The analysis of variance (Table 1) indicated that the genotypes differed significantly for all the characters which further ascertain that there is considerable variation present in the thirty two genotypes of rice. Genotypic correlations in general were high as compared to their phenotypic correlations indicated strong inherent association between the characters. Genotypic and phenotypic correlation coefficients of the characters studied are presented in (Table 2). Grain yield per plant showed positive significant correlation with harvest index, days to maturity and number of grains per panicle. This indicated that all these characters were important for yield improvement. These results were in consonance with the earlier reports of Shashidhar et al.,(2005), Krishna Tandekar et al., (2008) for harvest index; Krishna Naik et al., (2005), Akhtar et al., (2011) for number of grains per panicle and days to maturity. It indicated that grain yield could be increased whenever there was an increase in

characters that showed positive and significant association with grain yield. Hence, these characters could be considered as criteria for selection for higher yield as these were mutually and directly associated with grain yield. It was observed that days to 50 per cent flowering, number of effective tillers per plant, kernel length, kernel L/B ratio, kernel length after cooking, kernel elongation ratio, 1000-grain weight were recorded non-significant positive association with grain yield per plant.

Table 1 Analysis of variance for fourteen characters in 32 rice genotypes

| S.No. | Character | Mean sum of squares | | |
|---|---|---|---|---|
| | | Replications (df=2) | Treatments (df=31) | Error (df=62) |
| 1. | Days to 50% flowering | 1.937 | 266.795** | 1.636 |
| 2. | Days to maturity | 1.125 | 272.353** | 1.232 |
| 3. | Number of effective tillers per plant | 8.781 | 915.890** | 6.397 |
| 4. | Plant height (cm) | 0.281 | 8.250** | 1.037 |
| 5. | Panicle length (cm) | 0.582 | 33.120** | 1.039 |
| 6. | Number of grains per panicle | 61.562 | 4539.923** | 37.227 |
| 7. | Kernel length (mm) | 0.005 | 0.108** | 0.004 |
| 8. | Kernel breadth (mm) | 0.002 | 0.219** | 0.015 |
| 9. | Kernel L/B ratio | 0.009 | 2.455** | 0.003 |
| 10. | Kernel length after cooking (mm) | 0.003 | 0.063** | 0.009 |
| 11. | Kernel elongation ratio | 1.767 | 30.606** | 1.227 |
| 12. | 1000-grain weight(g) | 50.875 | 197.791** | 20.320 |
| 13. | Harvest index (%) | 0.001 | 0.566** | 0.039 |
| 14. | Grain yield per plant (g) | 4.845 | 38.425** | 2.963 |

Note: * Significant at 5%, ** Significant at 1%

Days to 50 per cent flowering had significant positive association with days to maturity (Madhavilatha, 2002), number of grains per panicle (Swain and Reddy, 2006) and kernel L/B ratio (Nayak et al., 2001), while significant negative association with kernel breadth (Madhavilatha, 2002). Days to maturity registered significant positive association with number of grains per panicle (Madhavilatha, 2002) and kernel breadth. Plant height had significant positive association with panicle length (Krishna Naik et al. 2005) and kernel breadth(Reddy et al. 1997)indicating the increase in panicle length and kernel breadth could be positive, with increase in plant height. Number of effective tillers per plant was positively significant with harvest index (Yogameenakshi et al. 2004). Kernel length showed positively significant with kernel L/B ratio and kernel length after cooking. Kernel length after cooking was positively significant with kernel elongation ratio. Similar observations were reported by Sarkar et al., 2007 for the above mentioned characters. Correlation studies conclude that harvest index, days to maturity and number of grains per panicle showed positive and significant association with grain yield and also among themselves indicating that simultaneous selection for these characters would result in improvement of yield.

Path coefficient analysis revealed that kernel elongation ratio (Tarasatyavathi et al.,2001) exerted the highest positive direct effect on grain yield followed by kernel length ( Jogindar Reddy, 2004), harvest index (Shashidar et al., 2005), days to maturity (Debchoudhary and Das, 1998), panicle length and 1000-grain weight (Vinothini Ananda and Kumar, 2005), plant height and number of grains per panicle (Manonmani and Ranganathan, 2006) (Table 3)**,** indicating the selection for these characters are likely to bring about on overall improvement in grain yield per plant directly. Kernel length after cooking showed negative direct effect on grain yield followed by kernel breadth and days to 50 per cent flowering (Swain and Reddy, 2006), kernel L/B ratio, number of effective tillers per plant (Chitra et al., 2005).

Kernel elongation ratio showed considerable low positive indirect effects via days to maturity and number of effective tillers per plant. Kernel length exerted moderate positive indirect effects via harvest index (Ganesan et al. 1997). Harvest index, 1000-grain weight and number of grains per panicle showed high positive indirect effects

Table 2 Phenotypic ($r_p$) and Genotypic ($r_g$) correlation coefficients among grain yield per plant and its components in rice

| S. No. | Characters | | Days to 50% flowering | Days to maturity | Plant height | Number of effective tillers/ plant | Panicle length | Number of grains / panicle | Kernel length | Kernel breadth | Kernel length/ breadth ratio | Kernel length after | Kernel Elongation ratio | 1000 grain weight | Harvest index | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Days to 50% flowering | $r_p$ | 1.0000 | 0.8231** | -0.0280 | 0.1351 | -0.0395 | 0.4558** | 0.0988 | -0.4052* | 0.4114* | 0.2942 | 0.2397 | -0.1141 | 0.0727 | 0.2328 |
| | | $r_g$ | 1.0000 | 0.8385** | -0.0308 | 0.1550 | -0.0387 | 0.4625** | 0.1002 | -0.4308* | 0.4258* | 0.2983 | 0.2489 | -0.1260 | 0.0857 | 0.2690 |
| 2. | Days to maturity | $r_p$ | | 1.0000 | -0.2241 | 0.1589 | 0.0403 | 0.5808** | 0.0369 | -0.3971* | 0.3585* | 0.2226 | 0.2067 | -0.0805 | 0.1945 | 0.3500* |
| | | $r_g$ | | 1.0000 | -0.2273 | 0.1796 | 0.0487 | 0.5911** | 0.0387 | -0.4222* | 0.3732* | 0.2227 | 0.2106 | -0.0807 | 0.2217 | 0.4041* |
| 3. | Plant height | $r_p$ | | | 1.0000 | -0.1867 | 0.5226** | -0.1033 | -0.0197 | 0.4376* | -0.3544* | -0.0980 | -0.0931 | 0.1528 | -0.2764 | -0.0580 |
| | | $r_g$ | | | 1.0000 | -0.2413 | 0.5394** | -0.1084 | -0.0210 | 0.4731** | -0.3728* | -0.0983 | -0.0945 | 0.1461 | -0.3281 | -0.0669 |
| 4. | Number of effective | $r_p$ | | | | 1.0000 | -0.0975 | -0.0711 | 0.3106 | -0.0464 | 0.2566 | 0.1071 | -0.1163 | 0.1212 | 0.3710* | 0.0765 |
| | | $r_g$ | | | | 1.0000 | -0.1576 | -0.0761 | 0.3820* | -0.0469 | 0.3126 | 0.1450 | -0.1255 | 0.1958 | 0.4672** | 0.0344 |
| 5. | Panicle length | $r_p$ | | | | | 1.0000 | -0.1057 | -0.1092 | 0.1922 | -0.2375 | -0.2192 | -0.1824 | -0.0657 | -0.3072 | -0.0956 |
| | | $r_g$ | | | | | 1.0000 | -0.1155 | -0.1252 | 0.2252 | -0.2682 | -0.2234 | -0.1820 | -0.0834 | -0.3899* | -0.1353 |
| 6. | Number of grains / | $r_p$ | | | | | | 1.0000 | 0.1665 | -0.0822 | 0.2097 | 0.1093 | -0.0145 | 0.2930 | 0.3249 | 0.3261 |
| | | $r_g$ | | | | | | 1.0000 | 0.1750 | -0.0876 | 0.2195 | 0.1096 | -0.0186 | 0.3035 | 0.3946* | 0.3811* |
| 7., | Kernel length | $r_p$ | | | | | | | 1.0000 | 0.0804 | 0.6263** | 0.4756** | -0.2190 | 0.2868 | 0.2634 | 0.0890 |
| | | $r_g$ | | | | | | | 1.0000 | 0.0749 | 0.6384** | 0.4900** | -0.1863 | 0.3162 | 0.3128 | 0.1063 |
| 8. | Kernel breadth | $r_p$ | | | | | | | | 1.0000 | -0.7219** | -0.0243 | -0.0921 | 0.4451* | 0.0714 | -0.0871 |
| | | $r_g$ | | | | | | | | 1.0000 | -0.7171** | -0.0257 | -0.0863 | 0.4909** | 0.1035 | -0.1129 |
| 9. | Kernel length/ | $r_p$ | | | | | | | | | 1.0000 | 0.3505* | -0.0744 | -0.1341 | 0.1283 | 0.1408 |
| | | $r_g$ | | | | | | | | | 1.0000 | 0.3651* | -0.0577 | -0.1358 | 0.1500 | 0.1776 |
| 10. | Kernel length after | $r_p$ | | | | | | | | | | 1.0000 | 0.7522** | 0.1085 | 0.0643 | 0.1142 |
| | | $r_g$ | | | | | | | | | | 1.0000 | 0.7638** | 0.1160 | 0.0810 | 0.1324 |
| 11. | Kernel Elongation | $r_p$ | | | | | | | | | | | 1.0000 | -0.0835 | -0.1254 | 0.0728 |
| | | $r_g$ | | | | | | | | | | | 1.0000 | -0.0933 | -0.1420 | 0.0839 |
| 12. | 1000 grain weight | $r_p$ | | | | | | | | | | | | 1.0000 | 0.3267 | 0.2095 |
| | | $r_g$ | | | | | | | | | | | | 1.0000 | 0.3894* | 0.2546 |
| 13. | Harvest index | $r_p$ | | | | | | | | | | | | | 1.0000 | 0.4982** |
| | | $r_g$ | | | | | | | | | | | | | 1.0000 | 0.4884** |
| 14. | Grain yield/ plant | $r_p$ | | | | | | | | | | | | | | 1.0000 |
| | | $r_g$ | | | | | | | | | | | | | | 1.0000 |

Note: *, ** Significant at 5% and 1% level, respectively

Table 3 Phenotypic (P) and Genotypic (G) path co-efficient analysis for grain yield per plant and its components in rice

| S. No. | Characters | | Days to 50% flowering | Days to maturity | Plant height | Number of effective tillers/ | Panicle length | Number of grains / panicle | Kernel length | Kernel breadth | Kernel length/ breadth ratio | Kernel length after cooking | Kernel Elongation ratio | 1000 grain weight | Harvest index | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Days to 50% flowering | P | -0.0907 | 0.2686 | -0.0039 | -0.0170 | -0.0040 | 0.0068 | 0.2345 | -0.1260 | 0.2253 | -1.2003 | 0.9051 | -0.0060 | 0.0403 | 0.2328 |
| | | G | -0.0020 | 0.2374 | -0.0045 | -0.0364 | -0.0088 | 0.0038 | 0.5017 | 0.2899 | -0.2406 | -2.0998 | 1.5873 | -0.0171 | 0.0583 | 0.2690 |
| 2. | Days to maturity | P | -0.0746 | 0.3263 | -0.0312 | -0.0199 | 0.0041 | 0.0087 | 0.0876 | -0.1235 | 0.1964 | -0.9080 | 0.7807 | -0.0042 | 0.1077 | 0.3500* |
| | | G | -0.0017 | 0.2832 | -0.0331 | -0.0422 | 0.0111 | 0.0048 | 0.1935 | 0.2841 | -0.2109 | -1.5675 | 1.3430 | -0.0110 | 0.1508 | 0.4041* |
| 3. | Plant height | P | 0.0025 | -0.0731 | 0.1391 | 0.0234 | 0.0534 | -0.0015 | -0.0468 | 0.1361 | -0.1941 | 0.3999 | -0.3517 | 0.0080 | -0.1530 | -0.0580 |
| | | G | 0.0001 | -0.0644 | 0.1457 | 0.0567 | 0.1231 | -0.0009 | -0.1054 | -0.3184 | 0.2107 | 0.6920 | -0.6029 | 0.0198 | -0.2231 | -0.0669 |
| 4. | Number of effective tillers/ plant | P | -0.0122 | 0.0518 | -0.0260 | -0.1255 | -0.0100 | -0.0011 | 0.7375 | -0.0144 | 0.1405 | -0.4368 | -0.4391 | 0.0063 | 0.2054 | 0.0765 |
| | | G | -0.0003 | 0.0509 | -0.0352 | -0.2350 | -0.0360 | -0.0006 | 1.9126 | 0.0315 | -0.1767 | -1.0205 | -0.8005 | 0.0266 | 0.3177 | 0.0344 |
| 5. | Panicle length | P | 0.0036 | 0.0131 | 0.0727 | 0.0122 | 0.1021 | -0.0016 | -0.2593 | 0.0598 | -0.1301 | 0.8941 | -0.6887 | -0.0034 | -0.1701 | -0.0956 |
| | | G | 0.0001 | 0.0138 | 0.0786 | 0.0370 | 0.2282 | -0.0009 | -0.6270 | -0.1515 | 0.1516 | 1.5723 | -1.1610 | -0.0113 | -0.2651 | -0.1353 |
| 6. | Number of grains / panicle | P | -0.0413 | 0.1895 | -0.0144 | 0.0089 | -0.0108 | 0.0149 | 0.3954 | -0.0256 | 0.1148 | -0.4458 | -0.0549 | 0.0153 | 0.1799 | 0.3261 |
| | | G | -0.0009 | 0.1674 | -0.0158 | 0.0179 | -0.0264 | 0.0081 | 0.8762 | 0.0589 | -0.1240 | -0.7712 | -0.1186 | 0.0412 | 0.2683 | 0.3811* |
| 7. | Kernel length | P | -0.0090 | 0.0120 | -0.0027 | -0.0390 | -0.0111 | 0.0025 | 2.3747 | 0.0250 | 0.3431 | -1.9402 | -0.8271 | 0.0150 | 0.1458 | 0.0890 |
| | | G | -0.0002 | 0.0109 | -0.0031 | -0.0897 | -0.0286 | 0.0014 | 5.0074 | -0.0504 | -0.3608 | -3.4484 | -1.1879 | 0.0429 | 0.2127 | 0.1063 |
| 8. | Kernel breadth | P | 0.0367 | -0.1296 | 0.0608 | 0.0058 | 0.0196 | -0.0012 | 0.1910 | 0.3110 | -0.3954 | 0.0990 | -0.3478 | 0.0233 | 0.0395 | -0.0871 |
| | | G | 0.0009 | -0.1196 | 0.0689 | 0.0110 | 0.0514 | -0.0007 | 0.3751 | -0.6729 | 0.4052 | 0.1812 | -0.5504 | 0.0666 | 0.0703 | -0.1129 |
| 9. | Kernel length/ breadth ratio | P | -0.0373 | 0.1170 | -0.0493 | -0.0322 | -0.0243 | 0.0031 | 1.4873 | -0.2245 | 0.5477 | -1.4297 | -0.2811 | -0.0070 | 0.0710 | 0.1408 |
| | | G | -0.0009 | 0.1057 | -0.0543 | -0.0735 | -0.0612 | 0.0018 | 3.1966 | 0.4826 | -0.5651 | -2.5699 | -0.3678 | -0.0184 | 0.1020 | 0.1776 |
| 10. | Kernel length after cooking | P | -0.0267 | 0.0726 | -0.0136 | -0.0134 | -0.0224 | 0.0016 | 1.1294 | -0.0075 | 0.1920 | -4.0795 | 2.8405 | 0.0057 | 0.0356 | 0.1142 |
| | | G | -0.0006 | 0.0631 | -0.0143 | -0.0341 | -0.0510 | 0.0009 | 2.4534 | 0.0173 | -0.2063 | -7.0381 | 4.8713 | 0.0157 | 0.0551 | 0.1324 |
| 11. | Kernel Elongation ratio | P | -0.0217 | 0.0675 | -0.0129 | 0.0146 | -0.0186 | -0.0002 | -0.5201 | -0.0286 | -0.0408 | -3.0686 | 3.7762 | -0.0044 | -0.0694 | 0.0728 |
| | | G | -0.0005 | 0.0596 | -0.0138 | 0.0295 | -0.0415 | -0.0002 | -0.9326 | 0.0581 | 0.0326 | -5.3758 | 6.3777 | -0.0127 | -0.0965 | 0.0839 |
| 12. | 1000 grain weight | P | 0.0103 | -0.0263 | 0.0213 | -0.0152 | -0.0067 | 0.0044 | 0.6811 | 0.1384 | -0.0735 | -0.4425 | -0.3152 | 0.0524 | 0.1809 | 0.2095 |
| | | G | 0.0003 | -0.0229 | 0.0213 | -0.0460 | -0.0190 | 0.0025 | 1.5834 | -0.3304 | 0.0767 | -0.8164 | -0.5953 | 0.1357 | 0.2648 | 0.2546 |
| 13. | Harvest index | P | -0.0066 | 0.0635 | -0.0384 | -0.0466 | -0.0314 | 0.0049 | 0.6255 | 0.0222 | 0.0703 | -0.2624 | -0.4735 | 0.0171 | 0.5536 | 0.4982** |
| | | G | -0.0002 | 0.0628 | -0.0478 | -0.1098 | -0.0890 | 0.0032 | 1.5663 | -0.0696 | -0.0848 | -0.5700 | -0.9055 | 0.0529 | 0.6799 | 0.4884** |

Note: Residual effect (phenotypic) = 0.0817, Residual effect (Genotypic) = 0.07, Bold:Direct effects, Normal:Indirect effects * Significant at P = 0.05 level, ** Significant at P = 0.01 level

on grain yield per plant through kernel length, similarly days to maturity via kernel elongation ratio, panicle length and plant height via kernel length after cooking. The residual effect results was 0.0702 indicated that he contribution of component characters on grain yield was 92.98%, by the fourteen characters studied in path analysis, the rest 07.02% was the contribution of other factors such as traits not studied.

Path analysis concluded that kernel elongation ratio, kernel length, harvest index, 1000-grain weight, days to maturity and panicle length were the most important characters which could be used as selection criteria for effective improvement of grain yield. Therefore, due weightage should be given on these characters during selection for pedigree breeding work.

## 2. Materials and Methods

A field experiment was conducted with 32 rice (*Oryza sativa* L.) genotypes at the wetland farm of S.V Agricultural College, Tirupati which is situated at an altitude of 182.90 m above mean sea level, 13 ℃N latitude and 79 ℃E longitude during *Kharif* 2009. Seeds of the 32 genotypes were sown in raised nursery bed and thirty days old seedlings of each genotype were transplanted by adopting a spacing of 20 cm between rows and 15 cm between plants within row in a randomized block design with three replications. Each genotype was grown in 3 rows with a plot size of 2.4 $m^2$. The crop was grown with the application of recommended dose of chemical fertilizers at the rate of 120 kg N, 60 kg $P_2O_5$ and 60 g $K_2O$ per hectare in the form of urea, single super phosphate and muriate of potash. The recommended agronomical practices and plant protection measures were followed to ensure normal crop. Five competitive plants were selected randomly from the center row of each genotype in each replication and observations were recorded for characters like, number of effective tillers per plant, plant height, panicle length, number of grains per panicle, 1000-grain weight, kernel length, kernel breadth, kernel length/breadth ratio, kernel length after cooking, kernel elongation ratio, harvest index and grain yield per plant except days to 50% flowering and days to maturity, whereas the latter two characters were recorded on plot basis. Panicle and grain characters were recorded on five panicles of selected plants. The quality characters were estimated as per the standard evaluation system in rice. The kernel length, kernel breadth, kernel length after cooking was measured using grain vernier. The data recorded for all the characters were subjected to analysis of variance technique on the basis of model proposed by Panse and Sukhatme (1961). Correlation analysis was computed as per Karl Pearson (1932) and the partitioning of correlation coefficient into direct and indirect effects (path analysis) was carried out using the procedure suggested by Dewey and Lu (1959).

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