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**Research Note**

# Studies on correlation and path analysis in rice (*Oryza sativa* L.) genotypes

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**Abstract**
The experiment was carried out to study the correlation and path analysis in twenty five rice (*Oryza sativa* L.) genotypes and the observations were recorded for eight root, six physiological and nine yield related traits. Correlation studies revealed that among the traits studied, six root traits, four physiological traits and six yield related traits observed significant positive genotypic correlations with grain yield. The highest positive correlation with grain yield was recorded by root number at 15 cm. Path analysis revealed that very high magnitude of positive direct effect with grain yield was registered by root length. Very high to high magnitudes of negative direct effects were exhibited by root volume. Thus, from earlier as well as present findings of correlation and path analysis, it could be concluded that the characters *viz*., root length, root number at 15 cm, leaf area index, panicle number, panicle weight and grain weight would be the appropriate selection parameters for improvement of grain yield under aerobic rice system as these traits recorded strong positive correlation along with high magnitude of direct influence on grain yield.

**Key words**
Rice, root traits, yield traits, correlation, path analysis.

Rice (*Oryza sativa* L.) is one of the pivotal staple cereal crops feeding more than half of the world population. In view of the growing population, the basic objective of the plant breeders would always be towards yield improvement in staple food crops (Babu *et al.*, 2012). Direction and magnitude of correlation of characters under study with yield and also intercorrelation among themselves would be very useful in formulating effective selection criteria for improvement of yield for the target environment (Breese and Hayward's, 1972). Grain yield is a complex character and associated with number of component characters which they are interrelated. Such dependence often affects their relationship with yield, thereby making correlation ineffective. So, there is a need for path analysis that permits the partitioning of the correlation coefficient into its direct effect and indirect effects through other characters on yield. Partitioning the correlation into direct and indirect effects would give the information on actual contribution of each character to yield. Therefore the present study was undertaken to assess the association between the root, physiological and yield characters and their direct and indirect effects for grain yield.

The present investigation was carried out in Department of Plant Breeding and Genetics at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, during the *Kharif* season of 2014 in a Randomized Block Design (RBD) with three replications by adopting recommended cultural, agronomic and plant protection measures to healthy crop stand (DRR, 2012). Observations were recorded for the following root, physiological and yield related traits *viz.*, root length, root number at 15 cm, root number at 30 cm, root number at 45 cm, root volume, root density, root thickness, root weight, specific leaf area, total leaf area, leaf area index, relative water content, root: shoot weight ratio and root: shoot length ratio, days to flowering, plant height, panicle number, panicle length, panicle weight, grain number, spikelet fertility, grain weight and grain yield. Then the data were subjected to statistical analysis for the above character by following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis.

Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through suitable breeding programme. As the correlation assessed at the genetic level would give the realistic picture of associations existing among the characters in the absence of environmental influence, the genotypic correlation coefficients were worked out in the present study to formulate an effective and viable

selection parameter for improvement of grain yield. The genotypic correlation for root, physiological and yield related characters with grain yield was furnished in Table 1 and 1a.

Results revealed that among the root, physiological and yield related traits studied, six root traits, four physiological traits and six yield related traits observed significant positive genotypic correlations with grain yield. The highest positive correlation with grain yield was recorded by root number at 15 cm (0.799), root length (0.798), panicle weight (0.738), panicle number (0.695), root: shoot weight ratio (0.693), grain weight (0.683),root: shoot length ratio (0.662), panicle length (0.638),root weight (0.632), root thickness (0.590), root number at 45 cm (0.503), total leaf area (0.497), leaf area index (0.497),root density (0.481), grain number (0.448), and plant height (0.397). The above root, physiological and yield related traits, the strong positive correlation with yield was earlier noted under drought / aerobic conditions for root length and root: shoot weight ratio by Yogameenakshi and Vivekanandan (2010); for root weight by Babu *et al*. (2001), Yogameenakshi *et al*. (2004) and Kanbar *et al*. (2009); for total leaf area by Mohankumar *et al*. (2011) and for leaf area index by Kumar *et al*. (2014). Studies made under aerobic condition by Mohankumar *et al*. (2011), Murthy *et al*. (2011), Kanbar *et al*. (2011), Wei *et al*. (2011), Babu *et al.* (2012), Malarvizhi *et al*. (2012), Sathya and Jabaraj (2012) and Manjappa *et al*. (2014) indicated strong positive correlation of panicle number, panicle length, panicle weight, grain number and grain weight with grain yield. These previous reports confirmed the findings of the present study.

The path coefficient analysis permits the separation of direct effects from indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 1959). The direct and indirect effects for root, physiological and yield related characters with grain yield were furnished in Table 2 and 2a. Results of path analysis revealed that very high magnitude of positive direct effect with grain yield was registered by root length (3.774), leaf area index (2.756), panicle weight (1.174) and root number at 15 cm (1.160). Panicle grain weight (0.542), panicle number (0.420) and days to flowering (0.382).Very high to high magnitudes of negative direct effects were exhibited by root volume (-2.808), root density (-2.803),total leaf area (-2.152),Grain number (-0.817), specific leaf area (-0.662), root weight (-0.660),plant height (-0.587), root: shoot weight ratio (-0.431), root thickness (-0.406), spikelet fertility (-0.293),root number at 45 cm (-0.285),panicle length (-0.196), root: shoot length ratio (-0.054) and root number at 30 cm (-0.014). Relative water content had positive but negligible direct effect (0.080) with grain yield. Similar high positive direct effects were recorded earlier for root length and leaf area index by Mohankumar *et al*. (2011) and for panicle number and grain weight by Yogameenakshi and Vivekanandan (2010) and Haider *et al*. (2012) in their experiments made under drought condition. Whereas, based on studies under aerobic condition, Shet *et al*. (2012) observed high positive direct effects for panicle number and grain weight and Manjappa *et al*. (2014) for panicle number and panicle weight.

In the current investigation, root number at 45 cm, root density, root thickness, root weight, total leaf area, root: shoot weight ratio, root: shoot length ratio, panicle length and grain number showed high negative direct effects on yield. It was mainly due to their negative indirect effects registered through many of the other traits. Inspite of their high negative direct effects, their correlations with yield were strong and positive because of their high positive indirect effects on yield registered particularly through root length, root number at 15 cm, leaf area index, panicle weight and grain weight. Such a trend for root : shoot ratio, total leaf area, panicle length and grain number was also noted by Singh *et al*. (2010), Haider *et al.* (2012) and Manjappa *et al.* (2014) under aerobic condition.

Thus, from earlier as well as present findings of correlation and path analysis, it could be concluded that the characters *viz*., root length, root number at 15 cm, leaf area index, panicle number, panicle weight and grain weight would be the appropriate selection parameters for improvement of grain yield under aerobic rice system as these traits recorded strong positive correlation along with high magnitude of direct influence on grain yield.

## References

Babu, G.S., Paul, A., Lavanya, G.R., Madhukar, B., Dipak, W., Kumari, R. and Chethan, G.D. 2012. Genetic variability, character association and path analysis in rainfed upland rice germplasm (*Oryza sativa* L.). In: Proceedings of International Symposium on 100 years of rice science and looking beyond, Coimbatore, India, 9-12 January, 2012. Pp. 164-165.

Babu, R.C., Shashidhar, H.E., Lilley, J.M., Thanh, N.D., Ray, J.D., Sadasivam, S., Sarkarung,

S.,Toole, J.C.O. and Nguyen, H.T. 2001. Variation in root penetration ability, osmatic adjustment and dehydration tolerance among accessions of rice lowland and upland ecosystems. J. Plant Breeding, **120**: 233- 238.

Breese, E.L. and Haywards, M.D. 1972. The genetic basis of present breeding methods in forage crops. Euphytica, **21**: 324 – 330.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path analysis of components of crested wheat grass seed production. Agron. J., **51**: 515 – 518.

DRR. 2012. Aerobic rice trials. In: Progress Report, 2011, Vol. 1. Varietal Improvement, All India Coordinated Rice Improvement Programme (ICAR), Directorate of Rice Research, Rjendranagar, Hyderabad, India. Pp. 501.

Haider, Z., Khan, A.S. and Zia, S. 2012.Correlation and path analysis of yield components in rice (*Oryza sativa* L.) under stimulated drought conditions. American-Eurasian J. Agric. & Environ. Sci., **12(1)**: 100-104.

Kanbar, A., Kondo, K. and Shashidhar, H.E. 2011. Comparative efficiency of pedigree modified bulk and single seed descent breeding methods of selection for developing high-yielding lines in rice (*Oryza sativa* L.) under aerobic condition. Electronic J. of Plant Breeding, **2(2)**: 184-193.

Kanbar, A., Torchi, M. and Shashidhar, H.E. 2009. Relationship between root and yield morphological characters in rainfed low land rice (*Oryza sativa* L.). Cereal research communication, **37(2):** 261-268.

Kumar, S., Dwivedi, S.K., Singh, S.S., Bhatt, B.P., Mehta, P., Elanchezian, R., Singh, V.P. and Singh, O.N. 2014. Morpho-physiological traits associated with reproductive stage drought tolerance of rice (*Oryza sativa* L.) genotypes under rainfed condition of eastern indo gangetic plain. Indian J. Plant Physiol., **19(2)**:87- 93.

Malarvizhi, D., Thiyagarajan, K., Kanchanarani, R. and Vijayalakshmi, C. 2012. Morpho physiological traits associated with yield in aerobic rice hybrids. In: Proceedings of International Symposium on 100 years of rice science and looking beyond, Coimbatore, India, 9-12 January 2012. Pp. 232.

Manjappa, Uday, G. and Hittalmani, S. 2014. Association analysis of drought and yield related traits in $F_2$ population of Moroberekan / IR 64 rice cross under aerobic condition. Int. J. Agric. Sci. Res., **4(2):**79-88.

Mohankumar, M.V., Sheshshayee, M.S., Rajanna, M.P. and Udaykumar, M. 2011. Correlation and path analysis of drought tolerance traits on grain yield in rice germplasm accessions. ARPN. J. Agric. & Bio. Sci., **6(7**): 70-77.

Murthy, K.B., Kumar, A.C. and Hittalmani, S. 2011. Response of rice (*Oryza sativa* L.) genotypes under aerobic conditions. Electronic J. Plant Breeding, **2(2**):194 199.

Sathya, R. and Jebaraj, S. 2012. Genetic analysis for yield and yield component traits in aerobic rice (*Oryza sativa* L.). In: Proceedings of International Symposium on 100 years of rice science and looking beyond, Coimbatore, India, 9-12 January 2012. Pp. 162.

Shet, R.M., Rajanna, M.P., Mohankumar, M.V. and Sheshshayee, M.S. 2012. Association mapping of yield and yield related traits in rice (*Oryza sativa* L.) grown under aerobic condition. In: Proceedings of International Symposium on 100 years of rice science and looking beyond, Coimbatore, India, 9-12 January, 2012. Pp. 80-82.

Singh, A.K., Mall, A.K., Singh, P.K. and Verma, O.P. 2010. Interrelationship of genetic parameters for quantitative and physiological traits in rice under irrigated and drought conditions. Oryza, **47(2)**: 142-147.

Singh, R. K and Chaudhary, B. D.1995. Biometrical methods in quantitative genetic analysis. Kalyani Publishers New Delhi. pp. 215-218.

Wei, F., Tao, H., Lin, S., Bouman, B.A.M., Zhang, L., Wang, P. and Dittert, K. 2011. Rate and duration of grain filling of aerobic rice HD 297 and their influence on grain yield under different growing conditions. Science Asia, **37**: 98-104.

Yogameenakshi, P., Nadarajan, N. and Anbumalarmathi, J. 2004. Correlation and path analysis on yield and drought tolerance attributes in rice (*Oryza sativa* L.) under drought stress. Oryza, **41(3&4):** 68-70.

Yogameenakshi, P. and Vivekanandan, P. 2010. Association analysis in $F_1$ and $F_2$ generations of rice under reproductive stage drought stress. Electronic J. Plant Breeding, **1(4)**: 890-898.

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**Table 1. Genotypic correlation coefficients of root and physiological characters**

| Character | $RN_{15}$ | $RN_{30}$ | $RN_{45}$ | RV | RD | RT | RW | SLA | TLA | LAI | RWC | R/SW | R/SL | GY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RL** | 0.954** | 0.562** | 0.749** | 0.545** | 0.449* | 0.802** | 0.856** | 0.122 | 0.496* | 0.496* | 0.188 | 0.725** | 0.711** | 0.798** |
| **$RN_{15}$** | | 0.629** | 0.684** | 0.574** | 0.377 | 0.794** | 0.801** | 0.220 | 0.441* | 0.441* | 0.107 | 0.673** | 0.677** | 0.799** |
| **$RN_{30}$** | | | 0.299 | 0.575** | 0.032 | 0.464* | 0.468* | 0.039 | 0.132 | 0.132 | -0.095 | 0.474* | 0.426* | 0.246 |
| **$RN_{45}$** | | | | 0.568** | 0.116 | 0.687** | 0.615** | -0.018 | 0.478* | 0.477* | 0.091 | 0.592** | 0.507** | 0.503* |
| **RV** | | | | | -0.495 | 0.472* | 0.555** | -0.223 | 0.478* | 0.478* | -0.149 | 0.642** | 0.327 | 0.296 |
| **RD** | | | | | | 0.337 | 0.308 | 0.287 | -0.061 | -0.061 | 0.353 | 0.063 | 0.363 | 0.481* |
| **RT** | | | | | | | 0.752** | -0.012 | 0.483* | 0.483* | 0.161 | 0.433* | 0.249 | 0.590** |
| **RW** | | | | | | | | 0.039 | 0.691** | 0.692** | 0.138 | 0.674** | 0.511** | 0.632** |
| **SLA** | | | | | | | | | 0.287 | 0.286 | 0.018 | 0.059 | 0.292 | 0.243 |
| **TLA** | | | | | | | | | | 1.000** | -0.146 | 0.615** | 0.234 | 0.497* |
| **LAI** | | | | | | | | | | | -0.145 | 0.615** | 0.234 | 0.497* |
| **RWC** | | | | | | | | | | | | -0.120 | 0.112 | 0.082 |
| **R/SW** | | | | | | | | | | | | | 0.639** | 0.693** |
| **R/SL** | | | | | | | | | | | | | | 0.662** |

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

RL – Root length,$RN_{15}$ – Root number at 15 cm,$RN_{30}$ – Root number at 30 cm,$RN_{45}$ – Root number at 45 cm, RV – Root volume, RD – Root density, RT -Root thickness, RW – Root weight, SLA – Specific leaf area, TLA – Total leaf area, LAI – Leaf area index, RWC – Relative water content, R/SW – Root : shoot weight ratio, R/SL – Root : shoot length ratio, GY – Grain yield.

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**Table 1a. Genotypic correlation coefficients of yield characters**

| Character | DF | PH | PN | PL | PW | GN | SF | GW | GY |
|---|---|---|---|---|---|---|---|---|---|
| **RL** | -0.052 | 0.614** | 0.368 | 0.473* | 0.813** | 0.502* | 0.271 | 0.367 | 0.798** |
| **$RN_{15}$** | -0.114 | 0.592** | 0.281 | 0.509** | 0.832** | 0.494* | 0.210 | 0.393 | 0.799** |
| **$RN_{30}$** | -0.321 | 0.308 | -0.159 | 0.182 | 0.565** | 0.239 | 0.161 | 0.199 | 0.246 |
| **$RN_{45}$** | -0.028 | 0.504** | 0.179 | 0.243 | 0.681** | 0.483* | 0.386 | 0.063 | 0.503* |
| **RV** | -0.204 | 0.431* | -0.149 | 0.236 | 0.515** | 0.470* | 0.181 | 0.091 | 0.296 |
| **RD** | 0.174 | 0.201 | 0.535** | 0.271 | 0.285 | -0.002 | 0.088 | 0.302 | 0.481* |
| **RT** | 0.068 | 0.845** | 0.092 | 0.428* | 0.694** | 0.418* | 0.313 | 0.339 | 0.590** |
| **RW** | 0.182 | 0.651** | 0.101 | 0.415* | 0.726** | 0.502* | 0.165 | 0.388 | 0.632** |
| **SLA** | 0.110 | -0.155 | 0.118 | 0.059 | 0.104 | -0.090 | -0.179 | 0.005 | 0.243 |
| **TLA** | 0.242 | 0.464* | 0.087 | 0.331 | 0.468* | 0.523** | 0.159 | 0.403* | 0.497* |
| **LAI** | 0.242 | 0.465* | 0.087 | 0.331 | 0.467* | 0.523** | 0.158 | 0.404* | 0.497* |
| **RWC** | -0.024 | 0.132 | 0.138 | -0.101 | -0.106 | -0.199 | -0.296 | -0.149 | 0.082 |
| **R/SW** | -0.034 | 0.311 | 0.277 | 0.401* | 0.679** | 0.355 | 0.419* | 0.444* | 0.693** |
| **R/SL** | -0.140 | -0.111 | 0.598** | 0.194 | 0.469* | 0.248 | 0.101 | 0.232 | 0.662** |
| **DF** | | 0.110 | -0.027 | 0.046 | -0.042 | 0.137 | -0.136 | -0.169 | -0.121 |
| **PH** | | | -0.122 | 0.489* | 0.637** | 0.447* | 0.292 | 0.285 | 0.397* |
| **PN** | | | | 0.445* | 0.225 | 0.178 | 0.331 | 0.574** | 0.695** |
| **PL** | | | | | 0.670** | 0.473* | 0.588** | 0.736** | 0.638** |
| **PW** | | | | | | 0.679** | 0.548** | 0.484* | 0.738** |
| **GN** | | | | | | | 0.289 | 0.401* | 0.448* |
| **SF** | | | | | | | | 0.627** | 0.362 |
| **GW** | | | | | | | | | 0.683** |

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

RL – Root length,$RN_{15}$ – Root number at 15 cm,$RN_{30}$ – Root number at 30 cm,$RN_{45}$ – Root number at 45 cm, RV – Root volume, RD – Root density, RT -Root thickness, RW – Root weight, SLA – Specific leaf area, TLA – Total leaf area, LAI – Leaf area index, RWC – Relative water content, R/SW – Root : shoot weight ratio, R/SL – Root : shoot length ratio, DF – Days to flowering, PH – Plant height, PN – Panicle number, PL – Panicle length, PW – Panicle weight, GN – Grain number, SF – Spikelet fertility, GW – Grain weight, GY – Grain yield.

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**Table 2. Direct and indirect effects of root and physiological characters**

| Character | RL | $RN_{15}$ | $RN_{30}$ | $RN_{45}$ | RV | RD | RT | RW | SLA | TLA | LAI | RWC | R/SW | R/SL | rg with GY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RL** | **3.774** | 3.599 | 2.120 | 2.829 | 2.058 | 1.694 | 3.026 | 3.230 | 0.460 | 1.873 | 1.873 | 0.711 | 2.735 | 2.684 | 0.798** |
| **$RN_{15}$** | 1.107 | **1.160** | 0.729 | 0.794 | 0.666 | 0.438 | 0.922 | 0.929 | 0.256 | 0.511 | 0.511 | 0.124 | 0.781 | 0.785 | 0.799** |
| **$RN_{30}$** | -0.008 | -0.009 | **-0.014** | -0.004 | -0.008 | 0.000 | -0.006 | -0.006 | -0.001 | -0.002 | -0.002 | 0.001 | -0.007 | -0.006 | 0.246 |
| **$RN_{45}$** | -0.214 | -0.195 | -0.085 | **-0.285** | -0.162 | -0.033 | -0.196 | -0.175 | 0.005 | -0.136 | -0.136 | -0.026 | -0.169 | -0.145 | 0.503* |
| **RV** | -1.531 | -1.611 | -1.614 | -1.595 | **-2.808** | 1.391 | -1.325 | -1.557 | 0.626 | -1.341 | -1.343 | 0.420 | -1.804 | -0.918 | 0.296 |
| **RD** | -1.259 | -1.057 | -0.090 | -0.326 | 1.389 | **-2.803** | -0.946 | -0.865 | -0.804 | 0.170 | 0.171 | -0.989 | -0.177 | -1.019 | 0.481* |
| **RT** | -0.326 | -0.323 | -0.189 | -0.279 | -0.192 | -0.137 | **-0.406** | -0.306 | 0.005 | -0.196 | -0.196 | -0.065 | -0.176 | -0.101 | 0.590** |
| **RW** | -0.565 | -0.529 | -0.309 | -0.406 | -0.366 | -0.204 | -0.497 | **-0.660** | -0.026 | -0.457 | -0.457 | -0.091 | -0.445 | -0.338 | 0.632** |
| **SLA** | -0.081 | -0.146 | -0.026 | 0.012 | 0.147 | -0.190 | 0.008 | -0.026 | **-0.662** | -0.190 | -0.189 | -0.012 | -0.039 | -0.193 | 0.243 |
| **TLA** | -1.068 | -0.948 | -0.284 | -1.029 | -1.028 | 0.130 | -1.039 | -1.488 | -0.617 | **-2.152** | -2.152 | 0.314 | -1.324 | -0.503 | 0.497* |
| **LAI** | 1.367 | 1.214 | 0.364 | 1.315 | 1.318 | -0.168 | 1.330 | 1.907 | 0.787 | 2.756 | **2.756** | -0.401 | 1.694 | 0.644 | 0.497* |
| **RWC** | 0.015 | 0.008 | -0.008 | 0.007 | -0.012 | 0.028 | 0.013 | 0.011 | 0.001 | -0.012 | -0.012 | **0.080** | -0.010 | 0.009 | 0.082 |
| **R/SW** | -0.312 | -0.290 | -0.204 | -0.255 | -0.277 | -0.027 | -0.187 | -0.290 | -0.025 | -0.265 | -0.265 | 0.052 | **-0.431** | -0.275 | 0.693** |
| **R/SL** | -0.449 | -0.427 | -0.269 | -0.32 | -0.206 | -0.230 | -0.157 | -0.323 | -0.184 | -0.148 | -0.148 | -0.071 | -0.404 | -0.631 | 0.662** |

** Significant at 1 per cent level * Significant at 5 per cent level
Residual effect = 0.1872
Bold figures indicate direct effects $r_g$ – Genotypic correlation coefficient

RL – Root length,$RN_{15}$ – Root number at 15 cm,$RN_{30}$ – Root number at 30 cm,$RN_{45}$ – Root number at 45 cm, RV – Root volume, RD – Root density, RT -Root thickness, RW – Root weight, SLA – Specific leaf area, TLA – Total leaf area, LAI – Leaf area index, RWC – Relative water content, R/SW – Root : shoot weight ratio, R/SL – Root : shoot length ratio, GY – Grain yield.

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**Table 2a. Direct and indirect effects of yield characters**

| Character | DF | PH | PN | PL | PW | GN | SF | GW | rg with GY |
|---|---|---|---|---|---|---|---|---|---|
| **RL** | -0.196 | 2.316 | 1.390 | 1.785 | 3.07 | 1.897 | 1.023 | 1.387 | 0.798** |
| **$RN_{15}$** | -0.132 | 0.687 | 0.326 | 0.590 | 0.966 | 0.573 | 0.244 | 0.456 | 0.799** |
| **$RN_{30}$** | 0.004 | -0.004 | 0.002 | -0.003 | -0.008 | -0.003 | -0.002 | -0.003 | 0.246 |
| **$RN_{45}$** | 0.008 | -0.143 | -0.051 | -0.069 | -0.194 | -0.138 | -0.110 | -0.018 | 0.503* |
| **RV** | 0.573 | -1.211 | 0.418 | -0.661 | -1.445 | -1.319 | -0.509 | -0.255 | 0.296 |
| **RD** | -0.489 | -0.562 | -1.501 | -0.761 | -0.798 | 0.005 | -0.247 | -0.846 | 0.481* |
| **RT** | -0.028 | -0.343 | -0.037 | -0.174 | -0.282 | -0.170 | -0.127 | -0.138 | 0.590** |
| **RW** | -0.120 | -0.430 | -0.067 | -0.274 | -0.479 | -0.331 | -0.109 | -0.256 | 0.632** |
| **SLA** | -0.073 | 0.102 | -0.078 | -0.039 | -0.069 | 0.060 | 0.118 | -0.003 | 0.243 |
| **TLA** | -0.521 | -0.999 | -0.187 | -0.712 | -1.007 | -1.125 | -0.342 | -0.868 | 0.497* |
| **LAI** | 0.668 | 1.280 | 0.239 | 0.912 | 1.288 | 1.440 | 0.436 | 1.112 | 0.497* |
| **RWC** | -0.002 | 0.01 | 0.011 | -0.008 | -0.008 | -0.016 | -0.024 | -0.012 | 0.082 |
| **R/SW** | 0.015 | -0.134 | -0.120 | -0.173 | -0.293 | -0.153 | -0.180 | -0.191 | 0.693** |
| **R/SL** | 0.089 | 0.070 | -0.378 | -0.122 | -0.296 | -0.156 | -0.064 | -0.146 | 0.662** |
| **DF** | **0.382** | 0.042 | -0.010 | 0.018 | -0.016 | 0.052 | -0.052 | -0.065 | -0.121 |
| **PH** | -0.065 | **-0.587** | 0.072 | -0.287 | -0.374 | -0.263 | -0.171 | -0.167 | 0.397* |
| **PN** | -0.012 | -0.051 | **0.420** | 0.187 | 0.095 | 0.075 | 0.139 | 0.241 | 0.695** |
| **PL** | -0.009 | -0.096 | -0.087 | **-0.196** | -0.131 | -0.093 | -0.115 | -0.144 | 0.638** |
| **PW** | -0.049 | 0.748 | 0.264 | 0.786 | **1.174** | 0.797 | 0.643 | 0.568 | 0.738** |
| **GN** | -0.112 | -0.365 | -0.145 | -0.387 | -0.555 | **-0.817** | -0.236 | -0.328 | 0.448* |
| **SF** | 0.040 | -0.086 | -0.097 | -0.172 | -0.160 | -0.085 | **-0.293** | -0.184 | 0.362 |
| **GW** | -0.092 | 0.154 | 0.311 | 0.399 | 0.263 | 0.218 | 0.340 | **0.542** | 0.683** |

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

Residual effect = 0.1872

Bold figures indicate direct effects $r_g$ – Genotypic correlation coefficient

RL – Root length,$RN_{15}$ – Root number at 15 cm,$RN_{30}$ – Root number at 30 cm,$RN_{45}$ – Root number at 45 cm, RV – Root volume, RD – Root density, RT -Root thickness, RW – Root weight, SLA – Specific leaf area, TLA – Total leaf area, LAI – Leaf area index, RWC – Relative water content, R/SW – Root : shoot weight ratio, R/SL – Root : shoot length ratio, DF – Days to flowering, PH – Plant height, PN – Panicle number, PL – Panicle length, PW – Panicle weight, GN – Grain number, SF – Spikelet fertility, GW – Grain weight, GY – Grain yield.