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Correlation and Path Analysis Studies on Growth Characters, Yield Components, Quality Characters and Grain Yield of Scented Rice

Damini Thawait, Sanjay K. Dwivedi, Samaptika Kar and Amit Kumar Patel

ABSTRACT: *The present investigation is carried out to study the correlation and path analysis in scented long duration variety of rice (*Oryza sativa *L.). Character association of the yield attributing traits revealed significantly positive association of grain yield (q/ha) with root dry weight, number of tillers hill^{-1}, test weight, panicle length, panicle weight and dry weight. Hence, selection for these traits can improve yield. Path coefficient analysis revealed that effective tillers had the highest direct effect towards grain yield followed by tillers hill^{-1}, relative dry weight, panicle weight, test weight, water uptake and kernel length after cooking. Hence, selection for this character could bring improvement in yield and yield components.*

Key word: *Scented rice, Yield, Quality, Correlation, Path analysis*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the pivotal staple cereal crops feeding more than half of the world population. It is the staple food for over one third of the world's people (Poehlman and Sleper 1995). More than 90% of the world's rice is produced and consumed in Asia. Rice provides 75% of the calories and 55% of the protein in the average daily diet of the people (Bhuiyan *et al.*, 2002). In view of the growing population, the basic objective of the agriculturist would always be towards yield improvement in staple food crops. It has been estimated that the world will have to produce 60% more rice by 2030 than what it produced in 1995. Therefore, to increase production of rice plays a very important role in food security and poverty alleviation. Theoretically, rice still has great yield potential to be tapped and there are many ways to raise rice yield, such as building of irrigation works, improvement of soil conditions, cultural techniques and breeding of high yielding varieties. Most of the aromatic rice germplasm available in our country are low yielding, photoperiod sensitive and grown during aman season in the rain fed low land ecosystem (Begum *et al.*, 1993). Among them, it seems at present that the most effective and economic way available is to develop some resource conservation techniques to increase yield in scented rice. In world the total production of rice is 463.3 million tonnes (milled basis) in 2011–12 (Anonymous, 2012a). India is second largest producer after china and has an area of over 42.2 million hectares and production of 104.32 million tonnes with productivity of 2372 kg ha^{-1}.

In India, supply of fine and fine scented rice is very less; therefore its market is comparatively high. In India, supply of fine and fine scented rice is very less; therefore its market is comparatively high. Most of the fine scented traditional varieties are tall, low productive, low input responsive, long duration and susceptible towards the insect, pest and diseases. Due to this, farmers are unable to make their cultivation a profitable enterprise in this region. It is therefore important to achieve high yield with good quality from scented rice varieties through proper management.

Information on association of characters, direct and indirect effects contributed by each character towards yield will be an added advantage in aiding the selection process. Scented rice is the most exportable commodities which shares major position

* Om Vidya Mandir, Juna Bilaspur, Bilaspur (C. G.) 495001, *(corresponding E-mail: daminithawait@gmail.com*

** Scientist, Department of Agronomy, IGKV, Raipur-492012 (C. G.) India

*** c/o Debendra Kumar, Macchhuti, P. O. Selepur, Dist. Cuttak, Pin-754202

**** Vill.–Janghora, P. O. +TH.–Pithora, Dist – Mahasamund (CG) Pin-493551

of the total agricultural export. India is the largest exporter of quality rice next to the Thailand. The consumer mainly prefers good quality rice. The cooking quality is a complex character which is very much influenced by physicochemical characteristics of rice grain (Tomar and Nanda, 1982, Hussain *et al,* 1987). Correlation and path analysis establish the extent of association between yields and its components and also bring out relative importance of their direct and indirect effects, thus giving an obvious understanding of their association with grain yield. Ultimately, this kind of analysis could help to design selection strategies to improve grain yield. In the light of the above scenario, the present investigation is carried out with the objective of studying the character associations in scented rice for yield improvement.

MATERIAL AND METHOD

The experiment was carried out at Research Cum Instructional Farm, I.G.K.V., Raipur (C.G.) during *Kharif* 2012. The soil of experiment field was '*Inceptisols*' (sandy loam) which is locally known as '*Matasi*'. The soil was neutral in reaction and medium in fertility having low N, medium P, high K Climate of this region is sub- humid with an average annual rainfall of about 1200-1400 mm and the crop received 1315.9 mm of the total rainfall during its crop growth. The weekly average maximum and minimum temperature varied in between 25.8 °C – 31.9 °C and 12.75 °C – 25.8 °C, respectively. The experiment was laid out in randomized block design (RBD) with three replication, fourteen treatments and one variety *dubraj* and the treatments *viz.* 25 cm x 25 cm + S_1 (T_1), 25 cm x 25 cm + S_{2-3} (T_2), 25 cm x 25 cm +S_{4-5} (T_3), 25 cm x 20 cm + S_1 (T_4), 25 cm x 20 cm + S_{2-3} (T_5), 25 cm x 20 cm + S_{4-5} (T_6), 25 cm x 15 cm + S_1 (T_7), 25 cm x15 cm + S_{2-3}(T_8), 25 cm x 15 cm + S_{4-5} (T_9), 25 cm x 10 cm + S_1 (T_{10}), 25 cm x 10 cm + S_{2-3} (T_{11}), 25 cm x 10 cm + S_{4-5} (T_{12}), 20 cm x 20 cm + S_2 (T_{13}), 20 cm x 10 cm + S_{2-3} (T_{14}). Transplanting of one, two-three and three-four seedlings hill^{-1}, using seed rate of 10 kg ha^{-1}, 20 kg ha^{-1}, 35 kg ha^{-1} and 40 kg ha^{-1} at the spacing of 25 cm x 25 cm, 25 cm x 20 cm, 25 cm x 15 cm, 25 cm x10 cm, 20 cm x 20 cm, 20 cm x 10 cm respectively. The 12 days old seedlings were transplanted from T_1 to T_{13} while 23 days old seedlings were transplanted in the treatment T_{14}. Cultural operations were done as and when necessary. Crop was transplanted on (July) 23. 07. 2012 and harvested on (December) 02.12.2012. Recommended dose of nutrient was 60 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1}. The fertilizers were applied as per the treatments. Entire quantity of phosphorus and FYM was applied before transplanting. Nitrogen, Phosphorus and potassium applied through urea, single super phosphate and muriate of potash respectively. Nitrogen was applied in 3 splits (basal, tillering and panicle initiation stage (@ 50:25:25%). The quality characters were estimated by standard procedures reported like hulling and milling, head rice recovery percentage by Ghosh *et al* (1971), kernel length and breadth were measured by dial micro meter and length/breadth ratio was calculated, alkali spreading value following the method of Little *et aJ.* (1985), water uptake and volume expansion by Beachell and Stanel (1963), cooked kernel length was recorded using a graph paper and elongation ratio by the method adopted by Azeez and Shafi (1966). The plants of outer row and the extreme ends of the middle rows were excluded to avoid border effect. Observations were recorded and the data was subjected to statistical analysis. Statistical analyses for the above characters were done following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis.

RESULT AND DISCUSSION

Correlation refers to degree and direction of association between two or more than two variables. It measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement of dependent characters. Galton (1889) was first to suggest the use of correlation index to describe the association for the effectiveness of indirect selection process. Associations among different yield attributing characters with grain yield were calculated in all possible combinations at phenotypic (P) level are presented in Table 1.1. The results of the correlations study are explained as character wise: Grain yield exhibited significant positive correlation with root dry weight (0.657), number of tillers hill^{-1} (0.636), test weight (0.601), panicle length (0.594), panicle weight (0.537) and dry weight (0.535). Plant height had recorded highly positive significant correlation with panicle weight (0.684) and it showed significant positive correlation with effective tillers (0.633), water uptake (0.607), dry weight (0.588) and number of tillers hill^{-1} (0.549). The results are in accordance with the findings of Babu *et al.* (2012).

Dry weight had recorded highly significant positive genotypic correlation with effective tillers (0.847), kernel length (0.748), straw yield (0.739), KLAC (0.735), water uptake (0.674) and filled grains panicle^{-1} (0.669). It showed significant positive correlation with brown rice length (0.585), panicle length (0.582), root volume (0.579), light interception (0.562) and grain yield (0.535). Number of tillers hill^{-1} showed highly significant positive phenotypic correlation with effective tillers (0.738), filled grains panicle^{-1} (0.678), kernel length (0.678) and KLAC (0.664). It showed significant positive correlation with grain yield (0.636), water uptake (0.633) and root volume (0.594). Root volume exhibited highly significant positive correlation with effective tillers (0.778), kernel length (0.774), KLAC (0.774), grain yield (0.571). Root dry weight had recorded significant positive correlation with grain yield (0.657), test weight (0.544), panicle length (0.534). Light interception exhibited significant positive correlation with straw yield (0.604), test weight (0.537) and water uptake (0.561). Effective tillers showed highly significant positive phenotypic correlation with kernel length (0.872), KLAC (0.846), straw yield (0.729), brown rice length (0.585) and filled grains per panicle (0.680). It showed significant positive correlation with grain yield (0.568) and water uptake (0.635). The results were in unison with Reddy et al. (1995), Roy et al. (1995) and Reddy et al. (1997). Filled grain panicle^{-1} had recorded highly significant positive correlation with water uptake (0.706), straw yield (0.729) and it showed significant positive correlation with KLAC (0.654), kernel length (0.644), brown rice length (0.565) and protein content (0.533). Similar findings were reported by Sood and Siddiq, (1986) and Bhattacharya and Sowbhagya (1971). These results for number of filled grains per panicle were in accordance with Lalitha and Sreedhar (1996), Ganesan et al. (1997), Janardhanam et al. (2001), Kavitha and Reddi (2001), Yogameenakshi et al. (2004) and Sharma and Sharma (2007). Panicle length showed significant positive phenotypic correlation with grain yield (0.594), straw yield (0.593), KLAC (0.564) and kernel length (0.533). Straw yield exhibited highly significant positive correlation with water uptake (0.724), brown rice length (0.678) and it showed significant positive correlation kernel length KLAC (0.648). Grain yield had recorded significant positive correlation with water uptake (0.706), KLAC (0.554). Kernel length showed highly significant correlation with KLAC (0.981) and significant correlation with water uptake (0.679). The results were in unison with Krishnaveni et al. (2006). Brown rice length showed significant positive phenotypic correlation with Kernel length 0.612 KLAC 0.631 Water uptake 0.608, Protein content which is in line with the · findings of Juliano and Pascual (1980) and Chauhan *et al.(*1995). Kernel length exhibited highly significant positive correlation with KLAC 0.981 and it showed significant positive correlation Water uptake 0.679. which corroborates with the findings of Singh *et al* (1997). Kernel length after cooking showed significant positive phenotypic correlation with water uptake 0.660. The above findings were in agreement with the findings of Chauhan *et al* (1994).

The path analysis is standardized partial regression coefficient. They are free from unit and as such it is easy to make interpretation. Path coefficient analysis is of immense value for the breeders in two ways viz., one is to judge the direct influence of the various characters on the yield or dependent trait and secondly, it also helps in explaining the total correlation between dependent and independent traits. The concept of path analysis was developed by Wright (1921) and the technique was first used by Dewey and Lu (1959) that helps in determining yield contributing characters thus, useful in indirect selection. As simple correlation does not provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the correlations (Wright, 1921) for better interpretation of cause and effect relationship. The estimates of path coefficient analysis are furnished for yield and yield component characters in Table 3. Among all the characters. The phenotypic correlation coefficient of grain yield and its components were partitioned into direct and indirect effect taking total yield per hectare as dependent variable presented in table 1.1.

The data revealed that effective tillers (0.667) had the highest direct effect towards grain yield followed by tillers hill^{-1} (0.491), relative dry weight (0.363), panicle weight (0.287), test weight (0.240), water uptake (0.231) and Kernel length after cooking (1.199). Negative direct effects were estimated for grain length (-0.504), brown rice length (-0.465), kernel length (-0.267), straw yield (-0.155), panicle length (-0.130) and dry weight (-0.123). These findings were also corroborated by Meenakshi et al. (1999), Nayak et al. (2001), and Madhavilatha (2002). Dry weight recorded positive indirect effect on grain yield via KLAC (0.881), effective tillers (0.573), tillers hill^{-1} (0.333), water uptake (0.156) and relative dry weight (0.137). Negative indirect effect through kernel length (-0.948),

Table 1.1
Correlation Matrix among Growth, Yield Components, Quality Characters and Grain Yield of Scented Rice.

Character	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
1	0.588*	0.549*	0.434	0.343	0.218	0.336	0.633*	0.473	0.304	0.684**	0.400	0.466	0.465	0.359	0.376	0.521	0.514	0.607*	0.334
2		0.667**	0.579*	0.377	0.281	0.562*	0.847**	0.669**	0.582*	0.483	0.44	0.739**	0.535*	0.346	0.585*	0.748**	0.735**	0.674**	0.357
3			0.594*	0.347	0.142	0.371	0.738**	0.678**	0.462	0.445	0.460	0.529	0.636*	0.446	0.600*	0.678**	0.664**	0.633*	0.378
4				0.329	0.183	0.411	0.778**	0.461	0.294	0.289	0.411	0.476	0.435	0.571**	0.536	0.774**	0.774**	0.473	0.320
5					0.004	0.477	0.266	0.282	0.534*	0.393	0.544*	0.365	0.657*	0.101	0.296	0.284	0.325	0.464	0.258
6						0.389	0.286	0.183	0.281	0.248	0.250	0.390	0.178	0.286	0.223	0.219	0.240	0.399	0.313
7							0.495	0.477	0.425	0.371	0.573*	0.604*	0.410	0.381	0.525	0.387	0.446	0.561*	0.313
8								0.680**	0.447	0.434	0.481	0.729**	0.473	0.568*	0.698**	0.872**	0.846**	0.635*	0.381
9									0.431	0.457	0.443	0.666**	0.499	0.381	0.565*	0.644*	0.654*	0.706**	0.533*
10										0.467	0.419	0.593*	0.594*	-0.021	0.393	0.533*	0.564*	0.520	0.146
11											0.410	0.528	0.537*	0.295	0.391	0.337	0.372	0.529	0.419
12												0.554*	0.601*	0.298	0.415	0.478	0.512	0.486	0.534*
13													0.403	0.379	0.678**	0.658*	0.648*	0.724**	0.378
14														0.080	0.304	0.531	0.554*	0.561*	0.285
15															0.349	0.351	0.387	0.301	0.35
16																0.612*	0.631*	0.608*	0.282
17																	0.981**	0.679*	0.346
18																		0.660*	0.385
19																			0.401

* At 5% level, ** at 1 % level

1. Plant height	2. Dry weight	3. Tillers $hill^{-1}$	4. Root volume	5. Root dry weight
6. SPAD value	7. Light interception	8. Effective tillers $hill^{-1}$	9. Filled grains $panicle^{-1}$	10. Panicle length
11. Panicle weight	12. Test weight	13. Straw yield	14. Gain yield	15. Grain length
16. Brown rice length	17. Kernel length	18. KLAC	19. Water uptake	20. Protein content

Table 1.2
Path Coefficients of the Characters Contributing towards Grain Yield in Scented Rice

	PH	*DW*	*T*	*RV*	*RDW*	*SPAD*	*LI*	*ET*	*FG*	*PL*	*PW*	*TW*	*SY*	*GL*	*BRL*	*KL*	*KLAC*	*WU*	*PC*	*PCC*
PH	**-0.253**	-0.072	0.27	0.039	0.124	0.03	-0.015	0.428	0.032	-0.039	0.196	0.096	-0.072	-0.181	-0.175	-0.661	0.616	0.14	-0.039	0.465
DW	-0.149	**-0.123**	0.333	0.051	0.137	0.039	-0.026	0.573	0.045	-0.075	0.139	-0.106	-0.114	-0.174	-0.272	-0.738	0.881	0.156	-0.042	0.535*
T	-0.139	-0.084	**0.491**	0.053	0.136	0.02	-0.017	0.499	0.046	-0.06	0.128	0.11	-0.082	-0.225	-0.279	-0.86	0.796	0.146	-0.044	0.636*
RV	-0.11	-0.071	0.292	**0.089**	0.119	0.025	-0.019	0.527	0.031	-0.038	0.083	0.098	-0.074	-0.288	-0.249	-0.981	0.928	0.109	-0.037	0.435
RDW	-0.087	-0.046	0.184	0.029	**0.363**	0.001	-0.022	0.18	0.019	-0.069	0.113	0.13	-0.056	-0.051	-0.138	-0.36	0.39	0.107	-0.03	0.657*
SPAD	-0.055	-0.035	0.07	0.016	0.001	**0.139**	-0.018	0.194	0.012	-0.036	0.071	0.06	-0.06	-0.144	-0.104	-0.277	0.288	0.092	-0.037	0.178
LI	-0.085	-0.069	0.182	0.036	0.173	0.054	**-0.045**	0.335	0.032	-0.055	0.106	0.137	-0.094	-0.192	-0.244	-0.491	0.535	0.131	-0.037	0.410
ET	-0.16	-0.104	0.362	0.069	0.096	0.04	-0.022	**0.677**	0.046	-0.058	0.124	0.115	-0.113	-0.286	-0.325	-0.718	0.628	0.147	-0.044	0.473
FG	-0.12	-0.083	0.333	0.041	0.102	0.026	-0.022	0.462	**0.068**	-0.056	0.131	0.106	-0.103	-0.192	-0.262	-0.816	0.784	0.163	-0.062	0.499
PL	-0.077	-0.072	0.227	0.026	0.194	0.039	-0.019	0.302	0.029	**-0.13**	0.134	0.1	-0.092	0.01	-0.183	-0.676	0.677	0.12	-0.017	0.594*
PW	-0.173	-0.06	0.218	0.026	0.143	0.034	-0.017	0.293	0.031	-0.061	**0.287**	0.098	-0.082	-0.148	-0.182	-0.427	0.446	0.122	-0.013	0.537*
TW	-0.101	-0.054	0.226	0.036	0.197	0.035	-0.026	0.325	0.03	-0.054	0.118	**0.24**	-0.086	-0.15	-0.193	-0.605	0.614	0.112	-0.062	0.601*
SY	-0.118	-0.091	0.26	0.042	0.132	0.054	-0.027	0.493	0.045	-0.077	0.151	0.133	**-0.155**	-0.191	-0.315	-0.833	0.777	0.167	-0.044	0.403
GL	-0.091	-0.043	0.219	0.051	0.037	0.04	-0.017	0.384	0.026	0.003	0.085	0.071	-0.059	**-0.504**	-0.162	-0.445	0.464	0.07	-0.039	0.080
BRL	-0.095	-0.072	0.295	0.048	0.107	0.031	-0.024	0.472	0.038	-0.051	0.112	0.1	-0.105	-0.176	**-0.465**	-0.775	0.756	0.14	-0.033	0.340
KL	-0.132	-0.092	0.333	0.069	0.103	0.03	-0.018	0.59	0.044	-0.069	0.097	0.114	-0.102	-0.177	-0.284	**-0.823**	0.732	0.157	-0.04	0.531
KLAC	-0.13	-0.091	0.326	0.069	0.118	0.033	-0.02	0.573	0.044	-0.073	0.107	0.123	-0.1	-0.195	-0.293	-0.625	**0.581**	0.152	-0.045	0.554
WU	-0.154	-0.083	0.311	0.042	0.168	0.056	-0.025	0.429	0.048	-0.067	0.152	0.116	-0.112	-0.152	-0.283	-0.861	0.791	**0.231**	-0.047	0.561
PC	-0.084	-0.044	0.186	0.028	0.094	0.044	-0.014	0.258	0.036	-0.019	0.033	0.128	-0.059	-0.169	-0.131	-0.439	0.461	0.093	**-0.117**	0.285

RESIDUAL=0.1740 (bold figures shows direct effect)

PH- Plant height (cm) DW- Dry weight (g $hill^{-1}$) T-Tillers $hill^{-1}$ LI-Light interception ET- Effective tillers $hill^{-1}$ FG- Filled grains $panicle^{-1}$
PL- Panicle length PW- Panicle weight TW- Test weight SY- Straw yield (q ha^{-1}) GL- Grain length (cm) BRL- Brown rice length (cm)
KL- Kernel length (cm) KLAC-Kernel length after cooking (cm) WU- Water uptake (ml) PC- Protein content (%)

brown rice length (-0.272), grain length (-0.174), straw yield (-0.114) and test weight (-0.106). Tillers hill^{-1} had positive indirect effect on grain yield through KLAC(0.796), effective tillers (0.499), water uptake (0.156), relative dry weight (0.136), panicle weight (0.128). Negative indirect effect through kernel length (-0.860), brown rice length (-0.279), grain length (-0.225), plant height (-0.139). Ganesan *et al.* (1997), Nayak et al. (2001) and Madhavilatha (2002). Relative dry weight exhibited indirect positive effect on grain yield via KLAC (0.390), tillers hill^{-1} (0.184) effective tillers (0.180), test weight (0.130). Negative indirect effect via kernel length (-0.360), brown rice length (-0.138), panicle length (-0.130), straw yield (-0.056) and grain length (-0.225). Panicle length recorded indirect positive effect on grain yield via KLAC (0.677), effective tillers (0.302), tillers hill^{-1} (0.227), relative dry weight (0.136), panicle weight (0.134), test weight (0.100) and negative indirect effect recorded via kernel length (-0.676), brown rice length (-0.183), straw yield (-0.092), plant height (-0.077). The results are in accordance with Satish *et al.* (2003) and Khedikar *et al.* (2004). Panicle weight exhibited indirect positive effect on grain yield via KLAC (0.446), effective tillers (0.293), tillers hill^{-1} (0.218), relative dry weight (0.143). Negative indirect effect via kernel length (-0.427), brown rice length (-0.182), grain length (-0.148), plant height (-0.173) and straw yield (-0.082). Test weight exhibited indirect positive effect on grain yield via KLAC (0.614), effective tillers (0.325), tillers hill^{-1} (0.226), brown rice length (0.193). Negative indirect effect via kernel length (-0.605), grain length (-0.150), plant height (-0.101) and straw yield (-0.086). KLAC (0.554) had recorded positive indirect effect on grain yield through effective tillers per hill (0.573), tillers per hill (0.326), water uptake (0.152), test weight (0.123), relative dry weight (0.118). Negative indirect effect through kernel length (-0.625), brown rice length (-0.293), grain length (-0.195), plant height (-0.130). Water uptake exhibited positive indirect effect through KLAC (0.791), effective tillers per hill (0.429), tillers per hill (0.311), relative dry weight (0.168) and panicle weight (0.152). Negative indirect effect through kernel length (-0.861), brown rice length (-0.283), plant height (-0.154), grain length (-0.152). These findings were also corroborated by Ganesan *et al.* (1997), Nayak *et al.* (2001) and Madhavilatha (2002). In this present study the correlation between yield and a character due to direct effect of a character, revealed true relationship between them and direct selection for this trait would be rewarding for yield improvement. The correlation mainly due to indirect effects of the character through another component trait, indirect selection through such trait would be live in yield improvement. So the selection of the above mentioned traits having direct and indirect effect on yield may lead to improvement in yield in scented rice.

SUMMARY

Partitioning of correlation values showed that some of the characters could not produce significant correlation with single plant yield which might be either due to very high negative direct effects. Critical analysis of results obtained from character association and path analysis indicated that the grain yield exhibited significant positive correlation with root dry weight number of tillers hill^{-1}, test weight, panicle length, panicle weight and dry weight. Whereas effective tillers had the highest direct effect towards grain yield followed by tillers hill^{-1}, relative dry weight, panicle weight, test weight, water uptake and kernel length after cooking. Hence, selection for these traits could bring improvement in yield and yield components.

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