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Correlation and path analysis in new plant type and *indica* lines of rice

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Abstract
The present study included that Line x Tester mating of nine new plant type lines that are developed in the International Rice Research Institute, Philippines and four high yielding *indica* rice varieties (*Oryza sativa* L.) of Tamil Nadu, a southern state in India. The observations recorded on ten biometrical traits were subjected to statistical analysis to study the association between yield and yield contributing traits. The studies on association of grain yield indicated that intensive selection based on number of productive tillers plant^{-1}, panicle length, number of grains panicle^{-1} and harvest index will be effective in improving grain yield as they showed positive and significant correlation with grain yield. Partitioning the correlation coefficient with direct and indirect effects revealed that number of productive tillers plant^{-1}, number of grains panicle^{-1} and 100 grain weight are the major yield contributing characters on which selection pressure has to be applied for improving grain yield.

Keywords: Rice; new plant type lines; *indica* lines; correlation studies; path analysis; yield

1. Introduction
Rice is the source of livelihoods and an essential element in the environment, supporting the web of life and biodiversity (IRRI, 2004) [10]. Major increases in area planted to rice are unlikely. Under these circumstances, we might have to resort to better management practices and most importantly to develop rice varieties with higher yield potential so as to meet the goal of increased rice production (Khush and Virk, 2002) [14].

Quantum jump in yield potential of rice during the 1960s was primarily due to the modified semi dwarf plant type with high tillering capacity, sturdy stems and dark green erect leaves with increased productivity of rice lands from 260 to 599 m tons over the past forty years. For another quantum jump in the yield potential of the rice crop, the International Rice Research Institute, has explored the possibility of further modifying the present high yielding plant type into the New Plant Type (NPT) or the Super Rice in 1989 (Khush and Virk, 2000) [14]. The new plant type was conceived with moderate tillering capacity, no unproductive tillers, 200-250 grains per panicle, 90-100 cm tall, sturdy stems, dark green thick and erect leaves, vigorous root system, 100-130 days growth duration, multiple disease and insect resistance and acceptable grain quality.

In the view of breaking the yield plateau that has been arrived at present in the modern cultivars, hybridization works have been initiated with NPT lines as one of the parents. There are also certain bottlenecks among the NPT lines, which have been identified, that result in poor grain filling and reduced biomass production. So the introduction of *indica* genes into NPT's tropical *japonica* background that is selected for their good grain filling abilities and a refinement of the original NPT line are the expected breeding strategies in the hands of the breeders. Hybrids between the NPT and the elite *indica* lines show yield advantage of 20-25% (Khush and Aquino, 1994; Peng *et al.*, 1999) [13, 20].

Grain yield in rice is a complex quantitative trait influenced by several component traits. Knowledge on association among different yield related traits is a prerequisite in developing appropriate breeding strategy that would bring about the simultaneous improvement of these traits. The advantage of path analysis is that it permits the portioning of the correlation coefficient into its components – the first component being the path coefficient (or standardized partial regression coefficient) that measures the direct effect of a predictor variable up on its response variables, the second component being the response variable through other predictor variables (Dewey and Lu, 1959) [7].

Path coefficient analysis assists plant breeders in identifying traits on which selection pressure should be given for improving yield. Hence the present study was conducted to ascertain the magnitude and direction of association of grain yield with its components involving NPT lines and *indica* rice varieties of Tamil Nadu.

2. Materials and Methods

2.1. Plant Materials

Nine New Plant Type (NPT) rice lines *viz*., IR 71700-247-1-1-2, IR 72158-11-5-2-3, IR 72165-63-2-3-3,IR 72981-92-1-1-2-2, IR 72985-65-3-1, IR 73896-51-2-1-3, IR 73907-53-3-2-2, IR 73935-51-1-3-1 and IR 75282-10-3-3-2 which were obtained from IRRI, were used as lines. Four high yielding cosmopolitan rice varieties of Tamil Nadu *viz*., ADT 45, ASD 16, IR 72 and MDU 5 were used as testers and details about the parents are presented (Table 1). When the parental lines started to flower, these were crossed in Line x Tester fashion. The parents were raised in a crossing block comprising of two rows of 2m length with a spacing of 20 x 10 cm. Three staggered sowings were taken at an interval of 15 days. All the recommended agronomic practices were carried out and crossing was taken up in Line x Tester fashion. For artificial crossing, panicles from main tillers that were likely to bloom on the next day were selected. Emasculation technique was followed as per the wet cloth method suggested by Ramiah (1953) [24]. The crossed seeds were collected from the matured panicles at full maturity. Selfing of parents was also done and selfed seeds were collected at maturity. The 36 hybrids obtained along with the 13 parents were raised in a randomized block design with three replications. The seedlings of each cross were planted in a spacing of 20x10 cm in a single row of 1.5 m length. In each replication, fifteen plants were maintained.

2.2. Data Analysis

Data were recorded in each replication on five randomly selected plants in each cross and parent for all the ten characters viz., days to 50% flowering, plant height (cm), number of tillers per plant, panicle length (cm), Number of grains panicle^{-1}, 100 grain weight (g), spikelet fertility (%), leaf area index (cm^2), harvest index (g), and single plant yield (g). The data on the ten traits were subjected to correlation analysis and path coefficient analysis suggested by Al-Jibouri *et al.*, (1958) [1], and Dewey and Lu (1959) [7], respectively to study direct contribution of different traits and nature of their relation to grain yield.

3. Experimental Results

3.1. Correlation Studies

The genotypic correlation coefficients between grain yield and its component characters and the inter correlation among different traits were presented (Table 2).

3.1.1. Correlation between grain yield and its components

All the traits except 100 grain weight (-0.073) showed positive association with single plant yield. Single plant yield recorded positive and significant association with three traits namely, number of productive tillers plant^{-1} (0.727), panicle length (0.286), number of grains panicle^{-1} (0.540) leaf area index (0.290) and positive and non-significant association with days to 50 per cent flowering (0.076), plant height (0.133), spikelet fertility (0.139) and harvest index (0.113).

3.1.2. Inter correlation among yield components

i. Days to 50 per cent flowering

Days to 50 per cent flowering expressed positive and significant association with plant height (0.338), 100-grain weight (0.345), harvest index (0.351) and positive and non-significant association with number of productive tillers plant^{-1} (0.025), panicle length (0.183), number of grains per panicle (0.047) and leaf area index (0.206). The association of days to 50 per cent flowering with spikelet fertility (-0.223) was negative and non-significant.

ii. Plant height

Positive and significant relationship was noticed between plant height and traits *viz.*, panicle length (0.358), 100-grain weight (0.256), and leaf area index (0.405). Plant height registered positive and non-significant association with grains panicle^{-1} (0.159), spikelet fertility (0.143) and harvest index (0.136), while negative and non-significant correlation with number of productive tillers plant^{-1}.

iii. Number of productive tillers plant^{-1}

Number of grains panicle^{-1} (0.278) and leaf area index (0.243) registered positive and significant association with number of productive tillers plant^{-1}. Whereas, negative and significant relationship existed between numbers of productive tillers plant^{-1} and trait like 100 grain weight (-0.431). The trait panicle length (0.175) and harvest index (0.070) showed positive and non-significant association with number of productive tillers plant^{-1} while spikelet fertility showed negative and non- significant correlation with this trait.

iv. Panicle length

Panicle length had positive and significant correlation with leaf area index (0.469) 100 grain weight (0.226) and spikelet fertility (0.247) where as positive and non-significant association was expressed by this trait with number of grains panicle^{-1} (0.092) and harvest index (0.044).

v. Number of grains panicle^{-1}

This trait showed positive and significant association with leaf area index (0.255). Positive and non-significant relationship was exhibited by number of grains panicle^{-1} with harvest index (0.157) and spikelet fertility (0.076). 100-grain weight (-0.146) exhibited negative non-significant correlation with the trait and number of grains
panicle $^{-1}$.

vi. 100 grain weight

The relationship of 100-grain weight was positive and significant with harvest index (0.273), while it was positive and non-significant with leaf area index (0.006) and spikelet fertility (0.070).

vii. Spikelet fertility

Spikelet fertility had non-significant and negative correlation with harvest index (0.033) and leaf area index (-0.097).

viii. Leaf area index

The relationship was negative and non-significant between leaf area index and harvest index (-0.071).

3.2. Path coefficient analysis

The genotypic correlation coefficients of different component characters with grain yield were partitioned into direct and indirect effects by path analysis and the results were presented

(Table 3). The direct and indirect effect of the nine characters over grain yield is presented here.

Days to 50 per cent flowering expressed positive and non-significant correlation with single plant yield (0.076). Its direct effect on grain yield was negative and negligible (-0.062). The indirect effects of days to 50 percent flowering on grain yield were positive and low through 100-grain weight (0.105). Their indirect effect via rest of the traits was negligible. Plant height showed positive and non-significant association with single plant yield (0.133). The direct effect of plant height on grain yield was positive and low (0.135). Plant height showed low and negative indirect effect on grain yield through number of productive tillers plant^{-1} (-0.103) and negligible effects through all other traits. The relationship between number of productive tillers plant^{-1} and single plant yield (0.727) was positive and significant. This trait expressed high direct effect on grain yield (0.787). It expressed low and positive indirect effects on grain yield through number of grains panicle^{-1} (0.101) and negative and low indirect effects through 100 grain weight (-0.126). Its indirect effects through the remaining characters were negligible.

Plant length exhibited positive and significant association with grain yield (0.286). The direct effect of panicle length on grain yield was negligible (0.015). Low indirect effect of panicle length on single plant yield was through number of productive tillers plant^{-1} (0.138). Its indirect effects via all other traits were negligible. Positive and significant correlation was observed between number of grains panicle^{-1} and single plant yield (0.540). Number of grains panicle^{-1} showed positive and high direct effect on grain yield (0.364). Positive and moderate indirect effect of number of grains panicle^{-1} was noticed through number of productive tillers plant^{-1} (0.219). Its indirect effects through rest of the traits were negligible. 100 grain weight had negative and non-significant relationship with single plant yield (-0.073). However, it expressed positive and high direct effect on grain yield plant^{-1} (0.306). Its indirect effects on single plant yield were negative and high through number of productive tillers plant^{-1} (-0.325). Negligible indirect effects were noticed through the remaining characters.

The relationship between spikelet fertility and single plant yield was positive and non-significant (0.139). Negligible direct effect was expressed by spikelet fertility on grain yield (0.069). This trait expressed negligible indirect effects through rest of the component characters. Leaf area index exhibited positive and significant correlation with single plant yield (0.290). Its direct effect on single plant yield was negative and negligible (-0.044). The trait exhibited only low indirect effects via number of productive tillers plant^{-1} (-0.179). Harvest index registered positive and non-significant association with single plant yield (0.113). The direct effect of harvest index on grain yield was negative and negligible (-0.08).

4. Discussion

Rice is one of the staple cereal crops of the world and 90 per cent of the world's rice is grown in Asia. It is a major source of carbohydrate and provides 80 per cent calories for more than two million people of Asia (Singh, 2002) [26]. In India, the major emphasis has been on increasing the grain yield of rice and as such the breeding goals for this crop have been made for understanding the genetics of productivity and adaptability traits and the nature and magnitude of association among such traits. The pre requisite for achieving high yields in rice depends on the identification of superior genotypes for different traits associated with yield. A clear knowledge on association of grain yield with its component traits is quite essential in improving the efficiency of selection for high yield in any breeding programme.

4.1. Correlation Studies

The yielding ability of rice is governed by polygenes. Knowledge on the association between yield and its component characters themselves can improve the efficiency of selection, because in a complex situation, selection for an optimum advance should be based on judiciously computed index. Further, the inter relationship of component characters of yield provides information about the likely consequences of selection for simultaneous improvement of desirable characters under selection. In the present study, the traits number of productive tillers plant^{-1}, panicle length, number of grains panicle^{-1} and harvest index exhibited significantly positive association with single plant yield. Similar findings were earlier reported by Sravan *et al*., (2015) [28], Kalyan *et al.,* (2017) [12] and Venkataramana and Hittalmani (2003) [30] for number of productive tillers plant^{-1}, Sravan *et al.,* (2015) [28], Hemant Sahu *et al.,* (2017) [9] and Bhattacharya and Ghosh (2004) [6] for panicle length, Sravan *et al.,* (2015) [28], Nandan *et al.,* (2010) [18] and Latha *et al.,* (2003) [15] for number of grains panicle^{-1} and Hemant Sahu *et al.,* (2017) [9], Mishra and Verma (2002) [17] and Raju *et al.,* (2003) [22] for harvest index.

Knowledge on inter relationship between yield component traits facilitates breeder to decide upon the intensity and direction of selection pressure to be given on related traits for the simultaneous improvement of these traits. In the present investigation, days to 50 per cent flowering exhibited positively significant correlation with plant height, 100 grain weight and leaf area index which was in conformity with the finding of Hemant Sahu *et al.,* (2017) [9] for plant height and Raju *et al.,* (2003) [22] for leaf area index. Positive and significant correlation was observed in number of productive tillers plant^{-1} with number of grains panicle^{-1} and harvest index. This was in accordance with the report of Kalyan *et al.,* (2017) [12] and Janardhanam *et al.,* (2001) [11] for number of grains panicle^{-1} and Nayak *et al.,* (2004) [19] for harvest index. Significant and positive relationship was noticed in panicle length with spikelet fertility and harvest index. This was earlier reported by Bateshwar kumar and Ramesh (1998) [5] for spikelet fertility. Number of grains panicle^{-1} had positive and significant relationship with harvest index, which was in conformity with the finding of Nayak *et al.,* (2004) [19]. The trait 100 grain weight was observed to have positive and significant association with leaf area index which was earlier reported by Annadurai (2001) [2]. From this discussion, it may be suggested that the traits number of productive tillers plant^{-1}, number of grains panicle^{-1}, panicle length and harvest index have to be considered while selection for high yield as they expressed positive and significant correlation with grain yield. A positive inter correlation was also noticed between these traits. Hence, a balance should be maintained while selecting for these traits. This will bring up improvements in the yielding potential and also the traits themselves.

4.2. Path coefficient analysis

Correlation studies permit a measure of relationship between two traits only. Only partitioning the genotypic correlation coefficient into direct and indirect effects by path coefficient analysis could arrive at the actual contribution of an attribute and its influence through other characters. This will be very

much helpful in giving due weightage to important yield attributes under selection pressure. In the present study, number of productive tillers plant^{-1}, number of grains panicle^{-1} and 100 grain weight had high direct effects on grain yield. Similar findings were also reported by Basavaraja *et al.*, (2011) [4] and Goswami (2000) [8] for number of productive tillers plant^{-1}, Nandan *et al.,* (2010) [18], Latha *et al.,* (2003) [15] for number of grains panicle^{-1}and Vanniarajan *et al.,* (1996) [29] and Goswami (2000) [8] for 100 grain weight.

The trait number of grains panicle^{-1} influenced grain yield *via* number of productive tillers plant^{-1} that was in accordance with the report of Nandan *et al.,* (2010) [18]. Most of the traits expressed low to moderate indirect effects on grain yield through number of productive tillers plant^{-1}. Likewise, days to 50 per cent flowering and plant height showed low indirect effects through 100 grain weight and number of productive tillers plant^{-1} respectively. Harvest index had low indirect effect on yield *via* number of productive tillers plant^{-1} as reported by Meenakshi and Amirthadevarthinam (1999) [16]. Hence, the three traits namely, number of productive tillers plant^{-1}, number of grains panicle^{-1} and 100 grain weight are the major yield contributing traits and have to be given importance in the selection process for improvement in yield. The findings are similar to the research of (Arumugachamy *et al.,* 1993; Rajeswari and Nadarajan, 1996; Shivani and Sree Rama Reddy 2000; Venkataramana and Hittalmani 2003; Raju *et al.,* 2004; Sarawagi *et al.,* 2000) [3, 21, 27, 30, 23, 25].

Table 1: Details of parents taken for the experiment

S. No	Parent	Designation of Parent	Parentage	Origin
1	IR 71700-247-1-1-2	L_1	IR66159-164-5-3-5 / IR64	International Rice Research Institute, Philippines.
2	IR 72158-11-5-2-3	L_2	BG90-2 / 1R67962-84-2-2-2	IRRI, Philippines
3	IR 72165-63-2-3-3	L_3	IR44962-161-2-4-4 / 1R 68022-3-2-2	IRRI, Philippines
4	IR 72981-92-1-1-2-2	L_4	IR71605-1-1-1-3-2 / 1R 66738-118-1-2	IRRI, Philippines
5	IR 72985-65-3-1	L_5	PSBRC2 / IR 67962-84-2-2	IRRI, Philippines
6	IR 73896-51-2-1-3	L_6	BG90-2 / IR67962-84-2-2	IRRI, Philippines
7	IR 73907-53-3-2-2	L_7	IR43 / IR 68011-15-1-1	IRRI, Philippines
8	IR 73935-51-1-3-1	L_8	IR65629-157-3-2-3-2-1 / IR69132-17-2-2-2	IRRI, Philippines
9	IR 75282-10-3-3-2	L_9	IR67966-84-2-3-2 /IR68450-36-3-2-2-3	IRRI, Philippines
10	ADT 45	T_1	IR 50 / ADT 37	Tamil Nadu Rice Research Institute, Aduthurai.
11	ASD 16	T_2	ADT 31 / CO 39	Rice Research Station, Ambasamudram.
12	IR 72	T_3	IR 19661-9-2-3 /IR 15795-199-3-3	International Rice Research Institute, Philippines.
13	MDU 5	T_4	IR 9129-209-2-2-2-1 *O. glaberrima* / Pokkali	Agricultural College and Research Institute, Madurai.

Table 2: Genotypic correlation coefficients between different traits

Character	Days to 50 per cent flowering	Plant height	Number of productive tillers plant^{-1}	Panicle length	Number of grains panicle^{-1}	100 grain weight	Spikelet fertility	Leaf area index	Harvest index	Single plant yield
Days to 50 per cent flowering	1.000	0.338*	0.025	0.183	0.047	0.345*	-0.223	0.206	0.351*	0.076
Plant height		1.000	-0.131	0.358*	0.159	0.256*	0.143	0.405*	0.136	0.133
Number of productive tillers plant^{-1}			1.000	0.175	0.278*	-0.431*	-0.030	0.243*	0.070	0.727*
Panicle length				1.000	0.092	0.226	0.247*	0.469*	0.044	0.286*
Number of grains panicle^{-1}					1.000	-0.146	0.076	0.255*	0.157	0.540*
100 grain weight						1.000	0.070	0.006	0.273*	-0.073
Spikelet fertility							1.000	-0.097	-0.033	0.139
Leaf area index								1.000	-0.071	0.113
Harvest index									1.000	0.290*

*Significant at 5 % level

Table 3: Direct and indirect effects of yield components as partitioned by path analysis

S. No.	Character	Days to 50 per cent flowering	Plant height	Number of productive tillers plant^{-1}	Panicle length	Number of grains panicle^{-1}	100 grain weight	Spikelet fertility	Leaf area index	Harvest index	Single plant yield
1	Days to 50 per cent flowering	-0.062	0.046	0.02	0.003	0.017	0.105	-0.015	-0.009	-0.028	0.076
2	Plant height	-0.021	0.135	-0.103	0.006	0.058	0.078	0.010	-0.018	-0.011	0.133
3	Number of productive tillers plant^{-1}	-0.002	-0.018	0.787	0.003	0.101	-0.126	-0.002	-0.011	-0.006	0.727*
4	Panicle length	-0.011	0.048	0.138	0.015	0.034	0.069	0.017	-0.021	-0.004	0.286*
5	Number of grains panicle^{-1}	-0.003	0.021	0.219	0.001	0.364	-0.045	0.005	-0.011	-0.013	0.540*
6	100 grain weight	-0.021	0.034	-0.325	0.003	-0.053	0.306	0.005	0.00	-0.022	-0.073
7	Spikelet fertility	0.014	0.019	-0.023	0.004	0.028	0.022	0.069	0.004	0.003	0.139
8	Leaf area index	-0.013	0.055	0.192	0.007	0.093	0.002	-0.007	-0.044	0.006	0.290*
9	Harvest index	-0.022	0.018	0.055	0.001	0.057	0.083	-0.002	0.003	**-0.08**	0.113

*Significant at 5 % level, Residual effect =0.2482, Diagonal values denote the direct effects

5. Conclusion

The present investigation concluded that the analysis on the association of grain yield with ten different traits indicated that number of productive tillers plant^{-1}, panicle length, number of grains panicle^{-1} and harvest index had significant and positive correlation with grain yield. This means that simultaneous selection of these three characters was imperative for yield improvement. Partitioning the correlation coefficient with direct and indirect effects revealed that number of productive tillers plant^{-1}, number of grains panicle^{-1} and 100 grain weight are the foremost yield contributing characters on which selection pressure has to be applied for improving grain yield. Therefore, focus and thought should be set in the selection of a plant with higher number productive tillers with higher number of filled grains per panicle, possessing heavy superior seeds with consumer-acceptability which would be advantageous for selection to appreciate higher yield.

6. References

1. Al-Jibouri HR, Miller PA, Robinson HF. Genotypic and environmental variances and co-variances in an upland cotton cross of inter specific origin. Agron. J. 1958; 50:633-636.
2. Annadurai A. Association analysis in hybrid rice. Ann. Agric. Res. New Series. 2001; 22:420-422.
3. Arumugachamy S, Vivekanandan P, Subramanian M. Character association and path coefficient analysis in ratoon rice. Oryza. 1993; 30:30-32.
4. Basavaraja T, Gangaprasad S, Dhusyantha Kumar BM, Shilaja H. Correlation and path analysis of yield and yield attributes in local rice cultivars (*Oryza sativa L.*), Electronic J. Plant Breed. 2011; 2:523-526.
5. Bateshwar K, Ramesh B. Genetic variability, character association and path analysis of yield and yield characters in rice. J. Cytol. Genet. 1998; 33:125-129.
6. Bhattacharya S, Ghosh SK. Association among yield related traits of twenty- four diverse landraces of rice. Crop Res. 2004; 27:90-93.
7. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J 1959; 51:515-518.
8. Goswami SB. Yield potential of direct sown upland traditional rice cultivars in pre-humid climate of West Bengal. Oryza. 2000; 37:327-331.
9. Hemant S, Ritu RS, Verulkar SB. Genetic variability and character association study for different morphological traits and path analysis for grain yield of rice under irrigated and rainfed condition. Electronic J Plant Breed. 2017; 8:38-45.
10. IRRI. Progress in preparation and implementation of IYR 2004. Concept paper. IRRN, 2004, 19-27.
11. Janardhanam V, Nadarajan N, Jebaraj S. Correlation and path analysis in rice (*Oryza sativa* L.). Madras Agric. J 2001; 88:719-720.
12. Kalyan B, Radha Krishna KV, Subba Rao LV. Correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.) genotypes. Int. J Curr. Microbiol. App. Sci. 2017; 6:2425-2430.
13. Khush GS, Aquino RC. Breeding tropical japonicas for hybrid rice production. In: Hybrid Rice Technology: New Developments and Future Prospects. Virmani, S. S. IRRI, Los Banos, Philippines, 1994, 33-36.
14. Khush GS, Virk PS. Rice breeding. Achievements and future strategies. Crop Improv. 2000; 27:115-144.
15. Latha J, Venuprasad R, Shashidhar HE, Shailaja H. Correlation and path coefficient analysis in rice cultivars adapted to rainfed low land of southern Karnataka. Mysore J Agric. Sci. 2003; 37:115-121.
16. Meenakshi T, Amirthadevarathinam A. Combining ability for yield and physiological characters in semi-dry rice. Oryza, 1999; 36:111-113.
17. Mishra LK, Verma RK. Correlation and path coefficient analysis for morphological and quality traits in rice (*Oryza sativa* L.). Plant Archives. 2002; 2:275-284.
18. Nandan R, Sweta, Singh SK. Character association and path analysis in rice (*Oryza sativa L.*) genotypes. World Journal of Agricultural Sciences. 2010; 6:201-206.
19. Nayak AR, Chaudhury D, Reddy JN. Studies on variability and character association in scented rice on various environments. Indian J Agric Res. 2004; 38:250-255.
20. Peng S, Cassman KG, Virmani SS, Shetty J, Khush GS. Yield potential trends of tropical rice since the release of IR 8 and the challenge of increasing rice yield potential. Crop Sci. 1999; 39:1552-1559.
21. Rajeswari S, Nadarajan N. Character association and path analysis in rice (*Oryza sativa* L.). Crop Res. 1996; 11:189-193.
22. Raju CHS, Rao MVB, Sudarshanam A. Associations in physiological growth parameters of rice hybrids. Madras Agric. J. 2003; 90:621-624.
23. Raju CHS, Rao MVB, Sudarshanam W. Genetic analysis and character association in F_2 generation of rice. Madras Agric. J. 2004; 91:66-69.
24. Ramiah K. Rice Breeding and Genetics, ICAR. New Delhi, Monograph, 1953, 19.
25. Sarawagi AK, Rastogi NK, Verma R, Wade LJ. Character association in improved shallow rainfed low land rice lines. Oryza. 2000; 37:271-276.
26. Singh SK. Combining ability studies for yield and its component in rice (*Oryza sativa L.*). Madras Agric. J. 2002; 89(1-3):157-161.
27. Shivani D, Sree Rama Reddy N. Correlation and path analysis in certain rice (*Oryza sativa* L.) hybrid. Oryza, 2000; 37:183-186.
28. Sravan T, Jaiswal HK, Showkat A, Waza Kumari P. Analysis of Variability and Character Association in Indigenous Aromatic Rice (*Oryza sativa L.*). Electronic J. Plant Breed. 2016; 7:159-164.
29. Vanniarajan C, Rangasamy P, Ramalingam J, Nadarajan N, Arumugampillai M. Studies on genetic variability in hybrid rice derivatives. Crop Res. 1996; 12:24-27.
30. Venkataramana P, Shailaja H. Factors determining grain yield in early generation of rice (*Oryza sativa* L.) under non submergence condition. Mysore J Agric *Sci.* 2003; 37:38-44.