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RESEARCH ARTICLE

Correlation and path coefficient analysis in F_2 families of rice (*Oryza sativa* L.) under direct seeded condition

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Abstract

The present study was carried out in the heterogeneous rice populations of 30 cross combinations in F_2 generation at Agricultural College and Research Institute, Madurai during *kharif* 2012. Association analysis revealed that, the traits *viz.*, productive tillers per plant and panicle length showed positive and significant association with grain yield in both generations. Therefore, selection pressure exerted in any of these traits will lead to the simultaneous improvement of other traits and finally increasing yield. The path coefficient analysis revealed that the direct effects were found to be very high for 100 grain weight, spikelet fertility and days to 70% RWC contributed maximum towards enhanced grain yield. Panicle length and filled grains per panicle showed high indirect effect on yield, this trait affecting yield mainly through plant height and spikelet fertility indirectly. Therefore, selection pressure exerted in the positive side on these characters will result in increased grain yield.

Key words: Rice, correlation, association, yield, F_2 generation

Introduction

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. It has been estimated that the world will have to produce 60% more rice by 2030 than what it produced in 1995 (FAO, 2002). 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. The knowledge on the nature and magnitude of genetic variation in respect of quantitative characters like yield and its components is essential for effective crop improvement. Selection of high yielding varieties based only on grain yield will not be much effective unless adequate information on genetic parameters are available to formulate hybridization and selection program for further improvement because the estimate of the mean serves as a basis for eliminating the undesirable genotypes (Nikhil *et al.*, 2014). 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.

Correlation and path analysis establish the extent of association between yield 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 (Nikhil *et al.,* 2014). Ultimately, this kind of analysis could help the breeder to design his 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 rice genotypes for yield improvement under direct seeded condition in the segregating generation (F_2).

Materials and Methods

The experiment was conducted in *kharif* 2012 at Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai, Tamil Nadu. The experimental materials consist of 30 cross combinations of rice which were grown in Randomized Block Design (RBD) with three replications. The development and evaluation of F_1s was done during *kharif* 2011. Seeds of F_2 generation of 30 cross combinations of rice obtained from the germplasm collection which were maintained in the Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai. The thirty F_2 cross combinations and nineteen parents were raised in a Randomized Block Design replicated twice. Field was thoroughly prepared and each genotype was raised in a 3 m^2 plot by direct seeding in a main field at a spacing of 30cm between rows and 15cm between plants. Eighty five plants were maintained per entry per replication. Each entry consisted of four rows with twenty one hills per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop. The biometrical observations were recorded on five competitive plants from each genotype selected at random per replication. Thus, a total of one hundred and fifty plants in F_2 progenies in each cross were utilized for recording observations.

Observations were recorded on five competitive plants for plant height, 1) productive tillers, 2) panicle length, 3) filled grains, 4) 100-grain weight, 5) spikelet fertility, 6) days to 70% relative water content, 7) leaf rolling, 8) leaf drying, 9) chlorophyll stability index, 10) root length, 11) dry root weight, 12) root volume, 13) root-shoot ratio, 15) harvest index and 16) grain yield per plant. The genotypic correlation coefficients between yield and yield components as well as among the yield components were worked out. From the anal sis of variance and covariance tables, the corresponding genotypic variances and co-variances were calculated by using the mean square values and mean sum of products as suggested by Al-Jibouri*et al.,* (1958). The relative influence of 15 components on yield by themselves (direct effects) and through other traits (indirect effects) was evaluated by the method of path coefficient analysis as suggested by Dewey and Lu (1959). The simple correlation coefficients already estimated at genotypic level were utilized for this purpose. By keeping yield as dependent variable and other 15 traits as independent variables, simultaneous equations which express the basic relationship between path coefficients were solved to estimate the direct and indirect effects. The direct and indirect effects were classified based on the scale given by Lenka and Misra (1973).

Table 1: The parents and their crosses involved in F_2 generation

Symbols	Parents involved
Cross 1	IR 73328A x IR 79200
Cross 2	COMS 24A x MAS 26
Cross 3	COMS 24A x IR 79582
Cross 4	IR 73328A x IR 69726
Cross 5	COMS 14A x BI 33
Cross 6	COMS 24A x IR 79200
Cross 7	IR 70369A x IR 80402
Cross 8	COMS 14A x IR 80286
Cross 9	IR 70369A x BI33
Cross 10	IR 70369A x IR 79200
Cross 11	IR 70369A x IR 7925
Cross 12	IR 70369A x IR 05N496
Cross 13	COMS 24A x IR05N496
Cross 14	COMS24A x KMP 105
Cross 15	COMS 24A x IR 69726
Cross 16	IR 73328A x IR 80402
Cross 17	IR 73328A x KMP 105
Cross 18	IR 73328A x IR 79200
Cross 19	IR 73328A x IR 05N496
Cross 20	IR 73328A x IR 81178
Cross 21	IR 73328A x IR 80402
Cross 22	IR 73328A x MAS 26
Cross 23	IR 79128A x IR 69726
Cross 24	IR 79128A x IR 79200
Cross 25	IR 79128A x KMP 105
Cross 26	IR 79128A x BI 33
Cross 27	IR 79156A x IR 79200
Cross 28	IR 79156A x IR 05N496
Cross 29	IR 79156A x IR 80402
Cross 30	IR 79156A x MAS 26

Results and discussion

Correlation Studies

The phenotypic correlation with grain yield was positive and highly significant for characters spikelet fertility (0.71), filled grains/panicle (0.68), plant height (0.58), harvest index (0.52), productive tillers/plant (0.51), and panicle length (0.41) and positive and non-significant for characters 100 grain weight (0.30), root/shoot ratio (0.27),days to 70% RWC (0.22) and chlorophyll stability index (0.06) and negative and non-significant for characters leaf drying (-0.27), root volume (-0.27), leaf rolling (-0.15), dry root weight (-0.14) and root length (-0.06) (Table 2).

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Table 2. Phenotypic correlation coefficients of different characters with grain yield/plant in F_2 generation

Characters	Plant height	Reproductive tillers	Panical length	Filled grains	100 grain weight	Spikelet fertility	Relative water content	Leaf rolling	Leaf drying	Chlorophyll stability index	Root length	Dry root weight	Root volume	Root shoot ratio	Harvest index	Grain yield /plant
Plant height	1.00	0.44*	0.50**	0.29	0.03	0.28	0.03	0.02	-0.33	0.06	-0.05	-0.25	-0.12	0.08	0.35	0.58**
Reproductive tillers		1.00	0.49**	0.41*	0.14	0.44*	-0.09	-0.23	-0.47**	0.11	0.04	-0.34	-0.54**	0.22	0.12	0.51**
Panical lenght			1.00	0.47**	0.25	0.32	0.03	-0.04	-0.20	-0.03	0.05	-0.40*	-0.23	0.28	0.19	0.41**
Filled grains				1.00	0.35	0.86*	0.37*	-0.30	-0.20	0.09	0.00	-0.06	-0.06	0.28	0.53**	0.68**
100 grain weight					1.00	0.21	-0.04	0.00	-0.08	0.00	0.05	-0.15	-0.06	0.08	0.47**	0.30
Spikelet fertility						1.00	0.37*	-0.28	-0.18	0.14	-0.02	0.06	-0.11	0.34	0.55**	0.71**
Relative water content							1.00	-0.01	0.04	0.16	-0.09	0.23	0.14	0.08	0.20	0.22
Leaf rolling								1.00	-0.15	-0.28	-0.04	-0.38*	-0.14	-0.03	-0.23	-0.15
Leaf drying									1.00	0.11	0.18	0.44*	0.48**	-0.37*	0.04	-0.27
Chlorophyll stability index										1.00	0.30	0.24	-0.03	-0.28	0.15	0.06
Root lenght											1.00	0.06	0.24	-0.23	0.11	-0.06
Dry root weight												1.00	0.29	-0.11	0.13	-0.14
Root volume													1.00	-0.34	0.01	-0.27
Root shoot ratio														1.00	0.06	0.27
Harvest index															1.00	0.52**
Grain yield/plant																1.00

*Significant at 5% level ; ** Significant at 1% level; Residual Effect – 0.2173

The trait plant height showed positive and significant association with grain yield/plant in F_2 generation. In F_2, Shanthi and Singh (2000), Raju *et. al., (*2004) and Bhavana and Seetharamaiah (2006) in rice genotypes revealed the same relationship. The trait plant height had negatively non-significant association with grain yield/plant as previously reported by Anbumalarmathi and Nadarajan (2008) in rice genotypes.

In accordance with the findings of Pannu *et. al.*, (2000), number of productive tillers per plant was found to be positive and highly significant correlation with grain yield in F_2 as reported by Ganesan *et. al.*, (1998). Similar results were already been reported by Gunasekaran *et. al.*, (2010) in rice genotypes. The association between panicle length and grain yield was positive and significant. These results were in agreement with the finding of Gupta *et. al.*, (1999) in F_2 (Table 2). Positive and highly significant association between filled grains per panicle and grain yield was recorded in F_2 generation. Similar results were already been reported by Gupta *et. al.*, (1999) in F_2. The association of 100 grain weight with yield was found to be positive and non-significant. Similar findings were already been reported by Yogameenakshi and Vivekanandan (2010) and Javed Iqbal Watoo *et. al.*, (2010). In F_2 generation, the association of spikelet fertility with yield was found to be positive and highly significant. These results are in accordance with the findings of Jayasudha and Deepak Sharma (2010), Mukul Kumar *et. al.*, (2009) in F_2 generation of rice. Positive and non-significant association between days to 70% RWC and grain yield was recorded in F_2 generation. Similar results were already been reported by Siva Prasad et al (2009) in rice population. In accordance with the findings of Manickavelu (2004), leaf rolling was found to be negative and non-significantly correlated with grain yield in F_2 population as reported by Sheeba (2005) in rice genotypes. The correlation of leaf drying with yield was found to be negative and non significant in F_2 (Table 2). These results are in accordance with the findings of Zulquarnain Haider *et. al.*, (2012) in rice cultures and Yogameenakshi and Vivekanandan (2010) in F_2 generation of rice. In accordance with the finding of Ganapathy and Ganesh (2008) in rice population chlorophyll stability index was found to be positively non significantly correlated with grain yield in F_2. The trait root length showed negative and non-significant association with grain yield/ per plant in both generations as previously reported by Michael Gomez and Rangasamy (2002) in rice cultures.

With the remaining root traits, grain yield per plant had non-significant negative relationship, which is in conformity with the earlier finding of Michael Gomez and Rangasamy (2002). The results indicated the selection possibilities for productive tillers per plant and panicle length exhibited positive significant association with yield. Hence, simple phenotypic mass selection could be exerted in the positive side on these traits will result in increased grain yield. The remaining trait showed either positive or negative non-significant association denoted that the independent nature of the traits, due to genotypic influence governing the association with grain yield (Rangaswamy *et. al.*, 1987).

Inter correlation among yield components

The present study revealed that plant height was positively related to productive tillers per plant, panicle length, filled grains per panicle, 100 grain weight, spikelet fertility, leaf rolling, chlorophyll stability index, root/shoot ratio and harvest index in F_2 generation except for dry root weight in rice population.

Similar association has already been reported for plant height with productive tillers per plant by Suman *et. al.,* (2006), for panicle length Gunasekaran *et. al.,* (2010), for 100 grain weight Kole *et. al.,* (2008), for spikelet fertility, Ganapathy *et. al.,* (2010) for leaf rolling, Priya (2003) for chlorophyll stability index, Yogameenakshi (2002) for root/shoot ratio, Priya (2003), for harvest index Michael Gomez and Rangasamy (2002).The trait productive tillers per plant was positively inter correlated with panicle length, filled grains per panicle, 100 grain weight, spikelet fertility, chlorophyll stability index, root length, root/shoot ratio and harvest index in F_2 generation except for days to 70% RWC, leaf drying, dry root weight and root volume. These results are in accordance with the findings of Sivaprasad *et. al.,* (2009) for panicle length, Anbumalarmathi and Nadarajan (2008) for 100 grain weight, Malarvizhi *et. al.,* (2009) for chlorophyll stability index, Anbumalarmathi and Nadarajan (2008) for root/shoot ratio and Yogameenakshi (2002) for harvest index.

The trait panicle length was positively inter correlated with filled grains per panicle, 100 grain weight , spikelet fertility, days to 70% RWC, root length, root/shoot ratio and harvest index in F_2 generation. The association of filled grains per panicle with spikelet fertility, days to 70% relative water content and harvest index was found positive for this trait. The present investigation revealed that the trait 100 grain weight showed positive and significant inter correlation with harvest index. The trait spikelet fertility was positively inter-correlated with days to 70% RWC, harvest index in F_2. The trait days to 70% RWC was positively inter correlated with harvest index, root / shoot ratio, dry root weight in F_2 generation under aerobic condition. Leaf rolling had negative and significant inter correlation with root volume in F_2 generation under direct seeded situation. Leaf drying had positive inter correlation with chlorophyll stability index and root volume. The present investigation revealed that, root length showed positive inter correlation with all root traits *viz.*, dry root weight, root volume, harvest index except root/shoot ratio in F_2 generation.

Path coefficient analysis

Path coefficient analysis is done in order to study the direct and indirect effects of individual component characters on the dependent variable yield. Study of path coefficient analysis enables breeders to concentrate on the variable which shows high positive direct effect on grain yield, ultimately we can reduce the time in looking for more number of component traits by restricting selection to important traits. In the present study, in F_2 generation the characters viz., plant height, spikelet fertility and root length had positive very high direct effect on grain yield per plant while 100 grain weight, days to 70% relative water content had high direct effects on grain yield per plant (Table 3). The characters viz., panicle length, chlorophyll stability index, root volume had negatively very high direct effects on grain yield per plant. Whereas, productive tillers per plant, leaf rolling, leaf drying, root/shoot ratio, and harvest index had negative high direct effect on grain yield per plant. These are in accordance with the findings of (Sarawgi *et al.,* 2000) for plant height, Michael Gomez and Rangasamy (2002) for days to 70 % relative water content, and also for productive tillers per plant, Surek and Beser (2003) for grain weight, Yogameenakshi *et al.* (2004) for root/shoot ratio and panicle length Kayvan Agahi *et. al.,* (2007) for 100 grain weight, Jayasudha and Deepak Sharma (2010) for spikelet fertility.

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Table 3.Direct and indirect effects of different characters on grain yield in F_2 generation

Characters	Plant height	Reproductive tillers	Panical length	Filled grains	100 grain weight	Spikelet fertility	Relative water content	Leaf rolling	Leaf drying	Chlorophyll stability index	Root length	Dry root weight	Root volume	Root shoot ratio	Harvest index	'r'
Plant height	1.48	-0.45	-0.88	-0.00	0.04	0.37	0.01	-0.03	0.29	-0.05	-0.04	-0.02	0.15	-0.07	-0.20	0.58**
Reproductive tillers	0.70	-0.95	-0.91	-0.00	0.15	0.63	-0.03	0.17	0.37	-0.10	0.04	-0.03	0.77	-0.18	-0.07	0.54**
Panical lenght	0.95	-0.63	-1.37	-0.00	0.19	0.53	0.00	0.02	0.37	0.42	0.09	-0.03	0.39	-0.27	-0.15	0.51**
Filled grains	0.44	-0.42	-0.78	-0.01	0.28	1.14	0.21	0.30	0.18	-0.20	0.01	-0.00	0.08	-0.25	-0.31	0.68**
100 grain weight	0.09	-0.19	-0.36	-0.00	0.75	0.31	-0.01	0.01	0.06	-0.06	0.06	-0.01	0.08	-0.09	-0.30	0.32
Spikelet fertility	0.42	-0.46	-0.56	-0.01	0.18	1.31	0.22	0.26	0.17	-0.32	-0.02	0.00	0.14	-0.29	-0.32	0.72**
Relative water content	0.04	0.05	-0.01	-0.00	-0.02	0.55	0.51	0.04	-0.08	-0.33	-0.09	0.02	-0.20	-0.08	-0.13	0.24
Leaf rolling	0.05	0.18	0.03	0.00	-0.01	-0.37	-0.02	-0.92	0.08	0.54	-0.02	-0.03	0.21	-0.01	0.14	-0.15
Leaf drying	-0.91	0.76	1.08	0.00	-0.09	-0.48	0.09	0.15	-0.47	-0.39	0.37	0.08	-1.27	0.58	-0.02	-0.51**
Chlorophyll stability index	0.04	-0.06	0.35	-0.00	0.03	0.25	0.10	0.30	-0.11	-1.65	0.55	0.02	0.07	0.30	-0.16	0.06
Root lenght	-0.05	-0.03	-0.10	-0.00	0.03	-0.02	-0.04	0.01	-0.14	-0.75	1.21	0.00	-0.32	0.21	-0.05	-0.06
Dry root weight	-0.40	0.38	0.56	0.00	-0.11	0.07	0.13	0.36	-0.40	-0.51	0.06	0.09	-0.41	0.08	-0.07	-0.15
Root volume	-0.17	0.55	0.40	0.00	-0.05	-0.14	0.08	0.14	-0.45	0.08	0.29	0.02	-1.33	0.29	-0.00	-0.26
Root shoot ratio	0.13	-0.22	-0.46	-0.00	0.08	0.47	0.05	-0.02	0.33	0.62	-0.31	-0.0	0.47	-0.81	-0.03	0.29
Harvest index	0.52	-0.13	-0.35	-0.00	0.39	0.74	0.12	0.23	-0.02	-0.46	0.12	0.01	-0.01	-0.04	-0.57	0.53**

*Significant at 5% level; ** Significant at 1% level; Residual Effect- 0.2173

Conclusion

In summary we conclude that, the traits viz., productive tillers per plant and panicle length showed positive and significant association with grain yield in both generations. Therefore, selection pressure exerted in the positive side on these characters will result in increased grain yield. In F_2 generation, days to 70% RWC, chlorophyll stability index and root length were found to have either positive or negative non-significant association with grain yield. Inter-correlations among the important yield contributing characters viz., productive tillers per plant, panicle length and filled grains per

panicle were positively inter-correlated with each other. Therefore, selection pressure exerted in any of these traits will lead to the simultaneous improvement of other traits and finally increasing yield. The negative inter-correlations were noticed with productive tillers per plant and leaf rolling in both generations. Partitioning the correlation estimates into direct and indirect effects was done using path coefficient analysis. The direct effects were found to be very high for 100 grain weight, spikelet fertility and days to 70% RWC contributed maximum towards enhanced grain yield. Panicle length and filled grains per panicle showed high indirect effect on yield, this trait affecting yield mainly through plant height and spikelet fertility indirectly. Hence the traits viz., plant height, 100 grain weight, spikelet fertility, days to 70% relative water content and root length are the major yield contributing traits under drought conditions and should be considered for improving yield under direct seeded conditions.

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