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Character Association and Path Analysis of Promising Rice Genotypes under Different Planting Methods

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ABSTRACT

The present study was undertaken with 26 promising genotypes to determine the degree of association between yield, yield components and quality characters and their direct and indirect effects on grain yield in different planting methods. Analysis of variance revealed highly significant mean squares due to genotypes for all traits studied, indicating the existence of sufficient variation among the genotypes. Results on character associations and path analysis revealed correlation co-efficients and path co-efficients of similar direction and magnitude respectively, in all the planting methods studied for most of the characters. Positive and significant association of ear bearing tillers per plant, grains per panicle and 1000 seed weight was observed with grain yield per plant under all the methods studied. 1000-seed weight had also exhibited high positive direct effect with grain yield per plant under all the planting methods and hence is identified as an effective selection criterion for grain yield improvement in transplanting, SRI and wet direct seeding methods of planting.

Key words: *Correlation, Path analysis, Quality traits , Rice, Yield, yield components, .*

Rice is one of the principal food crops and one third of the world's population and two thirds of the Indian population is utilizing rice as staple food. However, yield has been reported to vary with the change in planting method (Lal, 2003), as grain yield is a complex character highly influenced by environment and is the end product of multiplicative interaction between various yield components (Grafius, 1956). Success of any breeding programme for yield improvement in different environments therefore depends on the efficiency of selection in the respective environment. However, for successful selection, it is necessary to study the nature of association of the character in question with other relevant traits in each environment. In this context, correlation studies provide reliable information on nature and extent of relationship between characters and information on association between economically important traits. Path coefficient analysis helps in partitioning of correlation coefficients into the direct and indirect effects of various characters on grain yield. It provides an effective means of finding out the direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and also measures the relative importance of each causal factor (Wright 1921). In this context, the present work has been undertaken to study the character associations between yield, yield components and quality traits and their direct and indirect effects on grain yield under different planting methods popular in rice to provide basis for effective selection and yield improvement.

MATERIALS AND METHODS

Experimental material for the present investigation comprised of 26 promising rice genotypes developed at Regional Agricultural Research Station, Maruteru; ARS, Bapatla and ARS, Nellore. The crop was raised under irrigated condition during *kharif* 2017. The field was ploughed and puddled thrice until fine tilth was obtained. In wet direct seeding, beds were prepared in well puddled soil and seeds were broadcasted manually on beds. For transplanting, nursery was raised separately and 30 days old seedlings were transplanted in the main field with spacing of 20×15 cm. In both wet direct seeding and normal transplanting a thin film of 3 to 4 cm water was maintained up to flowering and 4 to 5 cm of water was maintained in the field from flowering to two weeks before harvest. In SRI method, 12 days old young seedlings having two leaves were transplanted in the main field with no standing water at 25×25 cm row to row and plant to plant spacing. At each hill, only one seedling was transplanted. All recommended practices were followed to raise a healthy crop. Observations were recorded on grain yield per plant and yield component characters, namely, days to 50 % flowering, days to maturity, plant height, ear bearing tillers per plant, panicle length, grains per panicle, 1000 seed weight and quality traits, namely, hulling per cent, milling per cent, HRR and L/B ratio for each genotype, in each replication, following standard procedures under each planting method. The data collected was subjected to standard

Table 1. Analysis of variance (ANOVA) for yield, yield components and quality traits in different planting methods

Source of variation	Mean sum of squares												
	Degrees of freedom	Days to 50% flowering	Days to maturity	Plant height	Ear bearing tillers per plant	Panicle length	Grains per panicle	1000 seed weight	Grain yield	Hulling	Milling	HRR	L/B ratio
E1 = Transplanting													
Replications	2	10.21	14.71	67.77	0.05	1.69	19.73	0.71	2.35	0.49	0.08	3.33	0.01
Genotypes	25	311.04**	260.35**	203.04**	0.98**	15.41**	5587.18**	22.80**	17.68**	6.93**	7.42**	26.66**	0.14**
Error	50	4.13	4.95	28.80	0.27	5.37	271.36	0.39	2.21	0.94	2.60	3.16	0.00
E2 = SRI method													
Replications	2	6.01	6.04	22.34	0.75	6.58	70.31	0.30	3.31	1.02	5.44	5.46	0.00
Genotypes	25	344.25**	244.92**	152.40**	6.28**	14.62**	5417.13**	19.87**	9.40**	4.48**	9.57**	27.51**	0.13**
Error	50	5.69	7.96	32.66	0.59	2.62	291.24	0.17	4.20	0.89	1.84	1.77	0.00
E3 = Wet direct seeding													
Replications	2	9.94	10.94	4.30	0.41	2.54	237.50	0.36	12.00	0.81	0.62	9.65	0.02
Genotypes	25	316.84**	313.12**	276.01**	0.70**	5.99**	6895.09**	20.48**	26.70**	7.34**	8.50**	9.83**	0.13**
Error	50	4.64	4.51	25.19	0.19	2.01	378.66	1.26	4.66	1.47	4.08	5.58	0.01

*, ** significant at 5 and 1% levels, respectively

Table 2. Correlation among yield, yield components and quality traits studied under different planting methods

Character	r	Days to maturity	Plant height	Ear bearing tillers per plant	Panicle length	Grains per panicle	1000 seed weight	Hulling	Milling	HRR	L/B Ratio	Grain yield
Days to 50% flowering	r_t	0.9828**	0.16994	-0.146	0.4918**	0.4556**	-0.06892	-0.1511	-0.0348	0.3620**	-0.148	0.089
	r_s	0.9334**	0.0857	-0.0406	0.5923**	0.3743**	-0.1218	-0.1951	-0.1408	0.4224**	-0.1374	0.0522
	r_w	0.9760**	-0.0451	-0.2005	0.4480**	0.4648**	0.0125	-0.1197	0.0283	0.3618**	-0.1268	-0.0354
Days to maturity	r_t		0.17955	-0.1073	0.4981**	0.4129**	-0.05547	-0.1749	0.0042	0.4033**	-0.193	0.0655
	r_s		0.0554	-0.0195	0.5439**	0.3714**	-0.1086	-0.1616	-0.1554	0.4436**	-0.1309	0.0668
	r_w		-0.0594	-0.1616	0.4244**	0.4544**	0.0462	-0.122	0.0085	0.3406**	-0.1566	-0.0257
Plant height	r_t			0.13219	0.1823	0.2248*	0.3963**	-0.2524*	-0.0678	0.1408	0.0725	-0.0917
	r_s			0.0738	0.0483	0.2322*	0.3689**	-0.2511*	-0.0597	0.1865	0.145	-0.1825
	r_w			0.148	0.1612	0.2319*	0.2629*	-0.3773**	-0.066	-0.0901	0.1504	-0.0697
Ear bearing tillers per plant	r_t				0.0087	-0.0673	0.0427	0.2025	0.1091	0.032	0.1169	0.3982**
	r_s				-0.151	0.1112	-0.0705	0.1675	0.1768	0.0295	0.0039	0.3843**
	r_w				0.0581	-0.0069	0.1924	-0.1613	-0.2204	-0.1642	-0.0564	0.3447**
Panicle length	r_t					0.5541**	-0.2212	-0.0491	-0.1173	0.2087	-0.1161	0.12
	r_s					0.2481*	-0.0064	-0.1786	0.1252	0.0584	-0.1094	-0.0167
	r_w					0.5707**	-0.3285	0.0025	0.0161	0.2109	-0.0087	0.184
Grains per panicle	r_t						-0.3064**	-0.063	0.006	0.2572*	-0.1228	0.2726*
	r_s						-0.3087**	-0.0959	-0.0645	0.2396*	-0.0925	0.2513*
	r_w						-0.2848*	0.0373	0.0412	0.2380*	0.0707	0.2320*
1000 seed weight	r_t							0.1516	0.1594	0.1699	-0.2503*	0.2377*
	r_s							0.125	0.1898	0.1497	-0.2779*	0.2521*
	r_w							0.1762	-0.0058	0.2101	-0.2952**	0.3273**
Hulling	r_t								0.6083**	0.2041	-0.0174	-0.04
	r_s								0.5067**	0.075	-0.1322	-0.1056
	r_w								0.5636**	0.2077	-0.1746	0.1811
Milling	r_t									0.4062**	-0.0001	-0.0434
	r_s									0.2397*	-0.0273	-0.0468
	r_w									0.3703**	-0.0714	0.1501
HRR	r_t										0.0917	0.154
	r_s										0.0644	0.1103
	r_w										-0.0393	0.1613
L/B ratio	r_t											-0.116
	r_s											-0.1074
	r_w											-0.005

*, ** Significant at 5 and 1% levels, respectively;

r_t - Correlation co-efficient in transplanting method

r_s - Correlation co-efficient in SRI method

r_w - Correlation co-efficient in wet direct seeding planting method

Table 3. Path analysis for yield components and quality traits on grain yield under different planting methods

Character	P	Days to 50% flowering	Days to maturity	Plant height	Ear bearing tillers per plant	Panicle length	Grains per panicle	1000 seed weight	Hulling	Milling	HRR	L/B Ratio	Grain yield
Days to 50% flowering	Pt	0.0921	0.4977	0.0346	-0.1741	0.0896	0.0609	-0.1546	-0.199	-0.1276	0.0867	-0.1173	0.089
	Ps	0.1141	-0.0232	-0.0212	0.0006	-0.0084	-0.0053	0.0017	0.0028	0.002	-0.0128	0.0019	0.0522
	Pw	-0.5652	-0.0196	0.2502	0.1806	-0.1016	-0.0046	-0.0028	0.1269	-0.0064	-0.0214	0.1285	-0.0354
Days to maturity	Pt	-0.0183	0.0326	-0.0495	0.2558	-0.1147	-0.1438	0.1862	0.1557	-0.0035	-0.3358	0.1008	0.0655
	Ps	-0.0333	0.1357	-0.0025	0.0007	-0.0194	-0.0185	0.0039	0.0058	0.0055	-0.0158	0.0047	0.0668
	Pw	-0.0085	-0.6487	0.1856	0.2114	-0.0037	-0.0039	-0.0004	0.1511	-0.0001	-0.003	0.0945	-0.0257
Plant height	Pt	-0.04	-0.0423	-0.6945	0.0811	0.0419	0.0529	0.0033	0.1999	0.1792	0.1097	0.0171	-0.0917
	Ps	-0.0397	-0.0256	-0.5832	0.0342	0.0902	0.0989	0.1709	0.1978	0.0276	-0.0864	-0.0672	-0.1825
	Pw	0.0797	0.0428	-0.4846	-0.0216	-0.0246	-0.0098	-0.0164	0.181	0.0786	0.1593	-0.0541	-0.0697
Ear bearing tillers per plant	Pt	-0.0683	-0.1606	0.0261	0.1973	0.1417	-0.0133	0.0084	0.1426	0.095	0.0062	0.0231	0.3982**
	Ps	-0.0058	-0.0028	0.0106	0.1439	-0.0217	0.016	-0.0101	0.0941	0.0254	0.0942	0.0405	0.3843**
	Pw	0.0488	0.0271	-0.0065	0.1837	-0.0026	0.0003	-0.0129	0.0374	0.0397	0.0072	0.0225	0.3447**
Panicle length	Pt	-0.1325	-0.0329	-0.012	-0.0006	0.1661	-0.0366	-0.0146	0.1032	0.086	-0.0138	0.0077	0.12
	Ps	-0.0095	-0.0271	0.0994	0.0905	-0.4398	-0.0124	-0.0004	0.0989	0.0912	-0.0029	0.0954	-0.0167
	Pw	0.0145	0.0105	0.0052	0.0019	0.1824	0.0085	0.0106	0.0001	0.0005	0.0101	-0.0603	0.184
Grains per panicle	Pt	0.0214	0.1	0.0299	-0.0179	0.1477	0.1965	-0.1817	-0.1168	0.0816	0.0446	-0.0327	0.2726*
	Ps	0.0601	0.0596	0.0343	0.0178	0.0398	0.1604	0.0014	-0.0754	-0.0503	0.0384	-0.0348	0.2513*
	Pw	0.0283	0.0193	0.069	-0.2021	0.0098	0.1975	0.055	0.0111	0.0123	0.0108	0.021	0.2320*
1000 seed weight	Pt	-0.1924	-0.0819	-0.2138	-0.2415	-0.1577	-0.2232	0.9348	0.1808	0.2263	0.165	-0.1587	0.2377*
	Ps	-0.1195	-0.1174	0.0571	-0.1513	0.001	0.0014	0.8654	0.12	0.0164	0.024	-0.445	0.2521*
	Pw	-0.1845	-0.1619	0.095	-0.1556	0.093	0.0168	0.9614	0.0237	-0.1921	0.0159	-0.1844	0.3273**
Hulling	Pt	0.2067	0.1047	0.2146	-0.0054	0.2098	0.1027	-0.004	-0.8266	-0.0352	-0.0078	0.0005	-0.04
	Ps	0.1513	0.1425	0.1555	-0.0141	0.197	0.1752	-0.0129	-0.9731	-0.0033	-0.0185	0.0948	-0.1056
	Pw	0.0168	0.0171	0.0528	0.0221	-0.0104	-0.0052	-0.0247	0.2301	-0.0789	-0.0591	0.0205	0.1811
Milling	Pt	0.2056	-0.0007	0.311	-0.0177	0.218	-0.001	-0.0259	-0.0987	-0.7622	-0.0659	0.1941	-0.0434
	Ps	0.1214	0.0816	-0.0006	-0.0018	0.0923	0.1609	-0.003	-0.0052	-0.5802	-0.0025	0.0903	-0.0468
	Pw	0.0067	0.002	-0.1565	-0.0521	0.0038	0.0072	-0.1014	0.1333	0.2364	0.0876	-0.0169	0.1501
HRR	Pt	-0.1812	-0.1891	0.0673	0.0788	-0.0584	0.0719	0.0475	0.0683	0.1136	0.1097	0.0256	0.154
	Ps	-0.0669	-0.0596	0.0335	0.0053	0.0105	0.043	0.0169	0.0135	0.023	0.0795	0.0116	0.1103
	Pw	0.0017	0.0016	-0.0404	-0.0308	0.0015	0.0011	0.001	0.001	0.0017	0.2247	-0.0018	0.1613
L/B ratio	Pt	0.2234	0.2205	-0.1114	-0.1462	0.1983	0.1124	0.1315	0.2028	0.125	-0.1145	-0.9578	-0.116
	Ps	0.0755	0.0553	-0.0058	-0.0002	0.0944	0.0837	0.0761	0.1053	0.1011	-0.0026	-0.6902	-0.1074
	Pw	0.2029	0.1035	0.0956	-0.186	-0.0502	0.0516	0.0922	0.1973	0.2116	-0.0009	-0.7226	-0.005

*, ** Significant at 5 and 1% levels, respectively;
Residual effects - 0.5980 (Transplanting), 0.5870 (SRI method) and 0.5960 (Wet direct seeding)

statistical procedures proposed by Panse and Sukhatme (1961). Correlation coefficients were calculated using the method detailed by Johnson *et al.* (1955), while the direct and indirect contribution of different yield attributes was estimated by path co-efficient analysis suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The results on analysis of variance (ANOVA) for yield, yield components and quality traits studied in different planting methods are presented in Table 1. Highly significant mean squares due to genotypes were observed for all traits, indicating the existence of sufficient variation among the genotypes for yield, yield component and quality characters in all the planting methods and therefore, a scope for effective selection in all the planting methods studied.

The correlation co-efficients for yield, yield components and quality traits studied in the present investigation are presented in Table 2. A perusal of these results revealed associations of similar magnitude and direction, in general for all the planting methods studied. Grain yield per plant was observed to be positively and significantly associated with ear bearing tillers per plant, filled grains per panicle and 1000-seed weight under all the planting methods studied, namely, transplanting, SRI and wet direct seeding, indicating an increase in grain yield with an increase in these characters. The characters are therefore identified as effective selection criteria for yield improvement under all the planting methods studied. Hence, priority should be given to these characters while making selection for yield improvement. The results are in agreement with the reports of Ramya *et al*. (2017) and Ashish *et al*. (2018). Further, non-significant association was noticed for grain yield with days to 50 per cent flowering (Ashok *et al*., 2016), days to maturity (Mahendra *et al*., 2015), plant height (Seyoum *et al*., 2012), panicle length (Sudeepthi *et al*., 2017), hulling (Nagajyothi, 2001), milling (Chamundeswari *et al*., 2014), HRR (Chamundeswari *et al*., 2014) and L/B ratio (Chamundeswari *et al*., 2014) in all the three planting methods studied, similar to the reports of earlier workers.

Studies on inter-character associations for the yield component traits revealed significant and positive associations for days to 50 per cent flowering with days to maturity (Kalyan *et al*., 2017), panicle length (Sudhir *et al*., 2017), grains per panicle (Sandhyarani, 2015) and HRR (Iswardatt *et al*., 2012); days to maturity with panicle length (Chandan *et al*., 2018), grains per panicle (Seyoum *et al*., 2012) and HRR (Iswardatt *et al*., 2012); plant height with grains per panicle (Ramya *et al*., (2017) and 1000-seed weight (Sudhir *et al*., 2017); panicle length with grains per panicle (Ramya *et al*., (2017); grains per panicle with HRR; hulling per cent with milling per cent (Mithilesh *et al*., 2017) and milling per cent with HRR (Iswardatt *et al*., 2012) in all the planting methods studied, indicating scope for simultaneous improvement of the traits, similar to the reports of earlier workers. In contrast, significant and negative relationship was observed for grains per panicle with 1000-seed weight in all the planting methods studied, probably due to competition for a common possibility, such as nutrient supply. However, their association with grain yield per plant was significant and positive, indicating the need for balanced selection for these traits while effecting improvement for grain yield. The results are in conformity with the reports of Sameera *et al*. (2016) and Lakshmi *et al*. (2017). Significant and negative associations were also observed for plant height with hulling per cent; and 1000-seed weight with HRR in all the planting methods studied. The findings are in broad agreement with the reports of Nagajyothi (2001).

Path co-efficient analysis provides an effective means of finding out the direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and also measures the relative importance of each causal factor. Hence, the study of direct and indirect effects of yield components on grain yield per plant was undertaken in the present investigation and the results obtained are presented in Table 3. A perusal of the results on path co-efficient analysis revealed path co-efficients to be of similar direction and magnitude in general for the planting methods studied, namely, transplanting, SRI and wet direct seeding. The results also revealed high residual effect for transplanting (0.5980), SRI (0.5870) and wet direct seeding (0.5960) methods of planting, indicating that the variables studied in the present investigation explained only about 40.20 (transplanting), 41.30 (SRI) and 40.40 (wet direct seeding) per cent of the variability in grain yield in the respective planting methods, and therefore other attributes, besides the characters studied are contributing for grain yield per plant. A detailed analysis of the direct and indirect effects also revealed high positive direct effect of 1000-seed weight. High positive direct effect of 1000-seed weight (Sameera *et al.* 2016 and Ashish *et al*. 2018) on grain yield was also reported earlier. The trait had also recorded significant and positive association with grain yield per plant. High direct effects of these traits therefore appear to be the main factor for its association with grain yield. Hence, the trait should be considered as an important selection criteria in all rice improvement programmes and direct selection for the trait is recommended for yield improvement in all the planting methods studied. The results are in conformity with the findings of Sudeepthi *et al.* (2017). Further, ear bearing tillers per plant and grains per panicle had recorded low and positive direct effects on grain yield per plant. The findings are in broad agreement with the reports of Ashish *et al.* (2018). However, association of these traits was noticed to be positive and significant with grain yield per plant, indicating indirect effects to be the cause of correlation and hence, the need for consideration of indirect causal factors during selections for yield improvement through these traits. Head rice recovery had also recorded low and positive direct effects coupled with non-significant associations with grain yield per plant, indicating the role of indirect effects. The results are in consonance with the findings of Suman and Ritu (2017).

High negative direct effects were recorded for plant height on grain yield per plant in the present study. Further, these traits had recorded non-significant association, with grain yield per plant, indicating the need for consideration of indirect causal factors. Low positive direct effects were also recorded for days to 50 per cent flowering and days to maturity under transplanting and SRI methods of planting. However, the effects were observed to be high and negative under wet direct seeding method of planting. Similarly, low and positive direct effects were recorded for panicle length under transplanting and wet direct seeding methods, while high negative direct effect was recorded under SRI method of planting. Hulling and milling had also recorded high negative direct effects under transplanting and SRI methods of planting, while under wet direct seeding method, these traits exhibited high positive direct effects. Association of these traits with grain yield per plant in all the planting methods studied was however, non-significant, indicating the need for consideration of indirect causal effects during selection for grain yield improvement.

CONCLUSION

Positive and significant association of ear bearing tillers per plant, grains per panicle and 1000 seed weight was observed under all the methods studied. A perusal of the results on path co-efficient revealed 1000-seed weight with high positive direct effect in addition to strong association with grain yield per plant under all the planting methods and hence is identified as an effective selection criteria for grain yield improvement in transplanting, SRI and wet direct seeding methods of planting.

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