CORRELATION AND PATH ANALYSIS FOR YIELD AND QUALITY TRAITS IN DIRECT SEEDED RICE (*ORYZA SATIVA* L.)

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Abstract: Correlation and Path Coefficient analysis for 18 yield and quality traits were studied in 12 rice gentoypes under direct sown conditions. Correlation analysis indicated significant positive association of grain yield with plant height at maturity, number of ear bearing tillers/ m^2, test weight, head rice recovery, and kernel breadth. Path coefficient analysis revealed that plant height at maturity, number of ear bearing tillers, hulling recovery, head rice recovery, kernel length, elongation ratio, water uptake and gel consistency and kernel breadth exhibited high positive direct effect on grain yield. Based on the results it is concluded that plant height at maturity, ear bearing tillers/ m^2 and kernel breadth possessed both positive association and high direct effects. Hence, selection for these characters could bring improvement in grain yield.

Key words: Correlation, Path analysis, direct seeded rice, yield and quality traits.

Introduction: Rice is the world's most important food crop and a primary food source for more than one third of world's population (Parikh et al., 2012). In India, about 44 % of rice is cultivated under transplanting. Direct-seeded rice is a feasible alternative to conventional puddled transplanted rice with good potential to save water, reduce labour requirement, mitigate green-house gas emission and adapt to climatic risks. At present, the rice varieties developed/bred for transplanted conditions have been used under direct seeded situation and scientist are concentrated on development of new varieties for this method. The information regarding interactions of different traits is of high importance to a plant breeder for selecting and breeding different varieties with increased yield. Correlation studies provide us an effective basis of phenotypic selection in plant populations, where as Path Coefficient analysis evaluates the participation of each component to the resultant variable directly as well as indirectly (Dewey and Lu, 1959). Hence the present study was conducted to assess the associations among the yield and quality traits and to know the causal factors for high grain yield of rice varieties under direct seeded condition.

Materials and Methods: The present investigation was carried out with twelve popular varieties *viz.,* MTU 1010, MTU 1001, JGL 11118, JGL 17004, IR 64, MTU 3626, NLR 3042, MTU 1121, MTU 1081, MTU 1075, BPT 3291 and RNR 2465 at Andhra Pradesh Rice Research Institute & Regional Agricultural research Station, Maruteru, West Godavari during *Kharif* 2012 in Randomized Block Design (RBD) with 3 replications. Pre soaked seed was broadcasted in $12m^2$ plots adopting 12kg per acre seed rate. Need based plant protection measures were followed to raise healthy crop. Observations were recorded on 18 yield and quality characters *viz,* days to 50% flowering, plant height at maturity, number of hills/m^2, number of ear bearing tillers/ m^2 (EBT), test weight (grams), grain yield (g/m^2), kernel length (mm), kernel breadth (mm), kernel L/B ratio, hulling (%), milling (%), head rice recovery (%), volume expansion ratio (VER), elongation ratio (ER), water uptake (WU), alkali spreading value (ASV), gel consistency (mm) (GC) and amylose content (%). Quality analysis of the varieties was done as per DRR standard protocols (DRR, 2013). The data was subjected to statistical analysis for estimation of correlations (Johnson *et al.,* 1955b) and path coefficients (Dewey and Lu 1959).

Results and Discussion: The analysis of variance of 18 characters for 12 varieties revealed that the mean sum of squares due to varieties were highly significant for all the characters studied indicating sufficient genetic variability among the experimental material. Among the twelve varieties evaluated the variety MTU 1121 recorded highest grain yield (680.3 g/m^2) followed by MTU 3626 (657.2 g/m^2), NLR 3042 (627.6 g/m^2) and MTU 1075 (627.4 g/m^2). For cultivation under direct sown conditions the varieties should possess low to moderate tillering ability, non lodging nature and high grain yield. Among the varieties studied MTU 1121, MTU 3626 and MTU 1075 were not lodged under direct sown conditions, while remaining entries were lodged (table 1).

The estimates of correlation coefficients (table 2) indicated that, in general, the genotypic and the phenotypic correlation coefficients showed similar trend but genotypic correlation coefficients were of higher in magnitude than the corresponding phenotypic correlation coefficients, which might be due to masking or modifying effect of environment (Kole *et al.,* 2008). Very close values of genotypic and phenotypic correlations were observed between many character combinations such as grain yield with plant height at maturity, number of hills/m^2 and number of ear bearing tillers/m^2 and grain yield with quality traits *viz.,* Kernel L/B ratio, water uptake, alkali

spreading value and amylose content which might be due to reduction in error (environmental) variance to minor proportions as reported by Dewey and Lu (1959). Wide difference between genotypic and phenotypic correlations between grain yield and hulling, head rice recovery and gel consistency is due to dual nature of phenotypic correlation, which is determined by genotypic and environmental correlations and heritability of the characters (Falconer, 1981).

The characters *viz.,* plant height at maturity (0.3369), number of ear bearing tillers (0.3805), test weight (0.6477), hulling (0.6858), head rice recovery (0.4929), kernel length (0.3980) and kernel breadth (0.4816) exhibited positive and significant correlations with grain yield, while days to 50% flowering (0.2621), number of hills (0.1220), volume expansion ratio (0.2433), gel consistency (0.0320), alkali spreading value (0.1841) and amylose content (0.1993) had showed positive but non significant effect on grain yield. Prem Kumar *et al (*2010) also reported positive correlation of kernel breadth with grain yield where as Chakravorthy and Ghosh, 2013 noticed significant positive association of test weight (1000 grain weight) with grain yield. Only one character water uptake had shown negative and significant effect on grain yield (-0.4924) where as milling recovery (-0.0112), kernel L/B ratio (-0.1939) and elongation ratio (-0.2208) recorded negative but non significant effects. When characters having direct bearing on yield are selected, their associations with other characters are to be considered simultaneously as this indirectly effect yield. Associations among other characters indicated that number of hills was significantly and positively correlated with EBT (0.4973), which inturn showed significant positive correlations with test weight (0.3435) and kernel breadth (0.4968). Test weight had shown significant positive correlation with kernel length (0.6758), kernel breadth (0.7561) and amylose content (0.4040). Among quality parameters, head rice recovery was associated positively and significantly with plant height, hulling recovery and volume expansion ratio. Significant and positive associations were noticed between kernel breadth and days to 50% flowering, EBT/m^2 , test weight, kernel length, ASV and amylose content which reported that long duration varieties produced bolder grains than short duration varieties. Kernel length had shown significant negative effects on milling recovery (-0.5334) and water uptake (0.3538) which clearly illustrated that long grain varieties are more prone to breakage and also less water requirement for cooking. The results of correlation studies implied that the characters plant height at maturity, number of ear bearing tillers/ m^2, test weight, head rice recovery, and kernel breadth associated with high grain yield under direct sown conditions.

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. Path coefficient analysis revealed that plant height at maturity (0.5241), number of ear bearing tillers (4.9037), hulling recovery (2.3964), milling recovery (0.4898), kernel length (8.2887), elongation ratio (3.717), water uptake (3.7828) and gel consistency (8.9514) exhibited high positive direct effect on grain yield (table 4). Ravindra Babu *et al* (2012) also reported positive direct effect of ear bearing tillers on grain yield. The characters days to 50% flowering (-5.6297), number of hills/m^2 (-3.5223), test weight (-0.8490), kernel L/B ratio (-11.2115) and ASV (-10.1816) had shown negative direct effects on grain yield. The trait test weight was correlated positively and significantly with grain yield but the direct effect is highly negative. It had shown highly positive indirect effect via kernel length. Though test weight contributes more to grain yield, consumers prefer slender grain types for consumption. Hence breeders should give emphasis for slender types for consumer acceptance while selection. Critical analysis of results obtained from character association and path analysis indicated that the number of ear baring tillers/ m^2 possessed both positive association and high positive direct effects. Hence, selection for this trait could bring improvement in grain yield.

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Table 1: Mean performance twelve entries for yield and quality traits under direct seeded

No.	Entry	Days to 50% Flowering	Plant height at Maturity (cm)	Number of hills/ m^2	Ear Bearing Tillers/ $Metre^2$	Grain yield (g/m^2)	Test Weight (grams)	Hulling (%)	Milling (%)	Head Rice Recovery (%)	Kernel Length (mm)
		1	2	3	4	5	6	7	8	9	10
1	MTU 1010	85	99	71	280	574.7	25.67	79.2	67.9	57.6	6.12
2	MTU 1001	91	106	46	305	587.9	24.17	77.1	67.0	55.9	5.71
3	JGL 1118	85	82	56	262	459.4	15.80	74.4	64.9	51.1	5.81
4	JGL 17004	75	88	61	285	508.6	15.57	77.4	67.7	55.9	4.71
5	IR 64	83	100	56	336	615.4	25.17	78.7	63.8	53.9	6.22
6	MTU 3626	89	77	64	449	657.2	26.77	80.0	64.3	57.4	5.81
7	NLR 3042	83	96	63	354	627.6	16.77	77.8	69.6	59.9	5.48
8	MTU 1121	87	100	67	302	680.3	18.43	79.5	71.1	58.5	5.67
9	MTU 1081	84	101	46	215	509.5	16.20	79.9	70.0	63.2	5.59
10	MTU 1075	92	106	59	311	627.4	21.87	79.7	69.0	61.7	6.01
11	BPT 3291	94	85	66	365	552.4	18.97	79.7	72.6	52.3	5.37
12	RNR 2465	88	87	70	372	449	14.40	78.4	70.0	52.9	5.50
	Mean	86.44	93.92	60.42	319.67	570.70	19.98	78.46	68.16	56.69	5.67
	C.V.	0.85	2.94	6.02	1.65	6.12	2.31	2.34	3.66	3.34	2.46
	S.E.	0.42	1.59	2.10	3.05	201.53	0.27	1.06	1.44	1.09	0.08
	C.D. 5%	1.24	4.68	6.16	8.95	591.07	0.78	3.11	4.23	3.20	0.24
	C.D. 1%	1.68	6.36	8.37	12.17	803.37	1.06	4.23	5.75	4.35	0.32
	Range Lowest	75.00	77.00	46.00	215.00	449.33	14.40	74.36	63.80	51.10	4.71
	Range Highest	94.00	106.00	71.00	449.00	680.67	26.77	79.96	72.60	63.20	6.22

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S. No.	Entry	Kernel Breadth (mm)	Kernel L/B Ratio	Volume Expansion Ratio	Elonga-tion Ratio	Water Uptake	Alkali Spreading Value	Gel consistency (mm)	Amylose content (%)	Nature of lodging	Grain type
		11	12	13	14	15	16	17	18	19	20
1	MTU 1010	2.18	3.03	3.90	2.1	150	2.5	39.0	23.6	Partially lodged	Long slender
2	MTU 1001	2.32	2.46	3.65	2.0	263	6.0	39.0	23.8	Partially lodged	Medium slender
3	JGL 1118	2.15	2.71	3.77	1.8	280	2.0	18.0	22.0	Partially lodged	Medium slender
4	JGL 17004	1.74	2.73	3.72	2.2	288	2.0	16.0	23.0	Non lodging	Medium slender
5	IR 64	2.05	3.03	3.52	1.7	145	2.0	29.0	22.6	Partially lodged	Long slender
6	MTU 3626	2.48	2.35	3.77	1.9	238	6.0	23.0	23.9	Non lodging	Medium bold
7	NLR 3042	2.07	2.65	3.88	1.6	150	2.0	20.0	22.5	Partially lodged	Medium slender
8	MTU 1121	2.04	2.79	3.88	2.1	200	3.5	42.0	23.1	Non lodging	Medium slender
9	MTU 1081	1.88	2.97	3.82	1.9	195	3.0	37.0	21.4	Partially lodged	Medium slender
10	MTU 1075	1.99	3.02	3.65	2.2	200	5.0	56.0	21.5	Non lodging	Long slender
11	BPT 3291	2.09	2.57	3.73	1.5	113	3.0	53.0	24.3	Partially lodged	Medium slender
12	RNR 2465	1.89	2.91	3.60	2.3	288	5.5	52.0	23.0	Lodged	Medium slender
	Mean	2.07	2.77	3.74	1.94	209.16	3.54	35.33	22.89		
	C.V.	4.73	1.91	2.09	7.64	9.11	7.27	10.61	1.51		
	S.E.	0.06	0.03	0.05	0.09	11.00	0.15	2.16	0.20		
	C.D. 5%	0.17	0.09	0.13	0.25	32.27	0.44	6.35	0.59		
	C.D. 1%	0.23	0.12	0.18	0.34	43.86	0.59	8.63	0.80		
	Range Lowest	1.74	2.35	3.52	1.50	113.00	2.00	16.00	21.40		
	Range Highest	2.48	3.03	3.90	2.29	288.00	6.00	56.00	24.30		

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Table 2: Genotypic and phenotypic correlations among 18 yield and quality traits in rice under direct seeded conditions.

S No	Character	Days to 50% Flowering	Plant Height at Maturity (cm)	Hills/ Meter²	Ear Bearing Tillers/ Metre²	Test Weight (grams)	Hulling (%)	Milling (%)	Head Rice Recovery (%)	Kernel Length (mm)	Kernel Breadth (mm)	Kernel L/B Ratio	Volume Expansion Ratio	Elongation Ratio	Water Uptake	Alkali Spreading Value	Gel Consistency (mm)	Amylose Content (%)	Grain Yield (kg/ha)
1	Days to 50% Flowering	1.0000	0.0632	0.0485	0.3879*	0.3230	0.4255**	0.3154	-0.0766	0.4040*	0.5432**	-0.2696	-0.1603	-0.2187	-0.2206	0.6581**	0.7304**	0.3104	0.2621
2	Plant Height at Maturity (cm)	0.0560	1.0000	-0.4223*	-0.5089**	0.2105	0.3257*	0.2424	0.5984**	0.3583*	-0.2179	0.5070**	-0.0518	0.2101	-0.3016	0.0169	0.3719*	-0.3615	0.3369*
3	Hills/ Meter²	0.0499	-0.3449*	1.0000	0.4973**	-0.0219	0.3200	0.3242	-0.2838	-0.0603	-0.0448	0.0851	0.3231	0.1725	-0.1853	-0.0500	0.1868	0.4710**	0.1220
4	Ear Bearing Tillers/ Metre²	0.3805*	-0.4734**	0.4536**	1.0000	0.3435*	0.3817*	-0.1532	-0.2761	0.0403	0.4968**	-0.5254**	-0.2554	-0.2300	-0.0779	0.4707**	0.0468	0.5814**	0.3805*
5	Test Weight (grams)	0.3184	0.2021	-0.0199	0.3386*	1.0000	0.4606**	-0.5863**	0.0917	0.6758**	0.7561**	-0.1260	-0.1476	-0.1347	-0.3364*	0.3218	0.0547	0.4040**	0.6477**
6	Hulling (%)	0.2313	0.1080	0.1993	0.1987	0.2456	1.0000	0.2930	0.6359**	0.1659	-0.0185	0.2331	0.1764	0.1869	-0.6426**	0.3738*	0.8000**	0.2596	0.6858**
7	Milling (%)	0.2332	0.1316	0.2387	-0.1081	-0.4097	0.4779**	1.0000	0.2621	-0.5334**	-0.5435**	0.1087	0.4488**	0.1199	-0.3081	-0.0140	0.7766**	0.1167	-0.0112
8	Head Rice Recovery (%)	-0.0467	0.5048**	-0.1592	-0.2513	0.0801	0.4571**	0.2344	1.0000	0.0510	-0.1711	0.2563	0.5249**	0.2760	-0.2107	0.1141	0.1129	-0.4681**	0.4929**
9	Kernel Length (mm)	0.3906*	0.3266*	-0.0495	0.0353	0.6289**	0.1644	-0.2489	0.1495	1.0000	0.5189**	0.3412*	-0.1209	-0.1277	-0.3538*	0.1514	0.2482	-0.1367	0.3980**
10	Kernel Breadth (mm)	0.4806**	-0.1291	0.0114	0.4629**	0.6531**	0.0195	-0.3268	-0.0568	0.5002**	1.0000	-0.6285**	0.1574	-0.3848*	-0.0853	0.4563**	-0.1197	0.5367**	0.4816**
11	Kernel L/B Ratio	-0.2585	0.4819**	0.0622	-0.5086**	-0.1192	0.1519	0.1335	0.2349	0.3345	-0.5750**	1.0000	-0.1458	0.3857*	-0.2331	-0.3639*	0.3314*	-0.6031**	-0.1939
12	Volume Expansion Ratio	-0.1452	-0.0556	0.1553	-0.2049	-0.1113	0.0049	0.1989	0.2510	-0.1137	0.0815	-0.1045	1.0000	-0.1585	-0.3012	-0.3481*	-0.2350	0.0189	0.2433
13	Elongation Ratio	-0.2022	0.1755	0.1581	-0.1899	-0.1207	-0.0408	-0.0491	0.1536	-0.1495	-0.3729*	0.3735*	-0.0214	1.0000	0.6422**	0.3752*	0.2296	-0.2172	-0.2208
14	Water Uptake	-0.2222	-0.2710	-0.1940	-0.0714	-0.3051	-0.4413**	-0.3121	-0.2513	-0.3654*	-0.1056	-0.2205	-0.1217	0.5493**	1.0000	0.3909*	-0.2652	-0.1324	-0.4924**
15	Alkali Spreading Value	0.6375**	0.0103	-0.0554	0.4633**	0.3141	0.2233	-0.0074	0.0711	0.1397	0.4014**	-0.3525*	-0.2395	0.3282	0.3721*	1.0000	0.4697**	0.2760	0.1841
16	Gel Consistency (mm)	0.7051**	0.3541*	0.1957	0.0486	0.0546	0.2922	0.4122**	0.0753	0.2046	-0.0983	0.2878	-0.2278	0.2009	-0.2445	0.4459**	1.0000	0.0855	0.0320
17	Amylose Content (%)	0.2703	-0.3244	0.3526*	0.5416**	0.3719*	0.0494	-0.0163	-0.4559**	-0.1768	0.4208**	-0.5673**	0.0605	-0.1512	-0.0665	0.2588	0.0794	1.0000	0.1993
18	Grain Yield (kg/ha)	0.2028	0.3511*	0.0914	0.3543*	0.5781**	0.3232	-0.1079	0.3726*	0.3204	0.4246**	-0.1748	0.1440	-0.1342	-0.4371**	0.1716	0.0450	0.1980	1.0000

*, ** significant at P= 0.05 and 0.01 respectively

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Table 3: Genotypic path coefficients for 17 yield and quality traits in rice under direct seeded conditions.

S No	Character	Days to 50% Flowering	Plant Height at Maturity (cm)	Hills/ Meter²	Ear Bearing Tillers / Metre²	Test Weight (grams)	Hulling (%)	Milling (%)	Head Rice Recovery (%)	Kernel Length (mm)	Kernel Breadth (mm)	Kernel L/B Ratio	Volume Expansion Ratio	Elongation Ratio	Water Uptake	Alkali Spreading Value	Gel Consistency (mm)	Amylose Content (%)
1	Days to 50% Flowering	-5.6297	-0.3559	-0.2730	-2.1838	-1.8186	-2.3954	-1.7754	0.4312	-2.2742	-3.0580	1.5177	0.9022	1.2312	1.2419	-3.7049	-4.1119	-1.7477
2	Plant Height at Maturity (cm)	0.0331	0.5241	-0.2213	-0.2667	0.1103	0.1707	0.1270	0.3136	0.1878	-0.1142	0.2657	-0.0271	0.1101	-0.1580	0.0088	0.1949	-0.1895
3	Hills/ Meter²	-0.1708	1.4873	-3.5223	-1.7518	0.0770	-1.1271	-1.1418	0.9998	0.2124	0.1576	-0.2997	-1.1380	-0.6076	0.6526	0.1761	-0.6578	-1.6590
4	Ear Bearing Tillers/ Metre²	1.9022	-2.4954	2.4388	4.9037	1.6845	1.8720	-0.7515	-1.3538	0.1977	2.4360	-2.5766	-1.2524	-1.1280	-0.3818	2.3081	0.2295	2.8512
5	Test Weight (grams)	-0.2743	-0.1787	0.0186	-0.2917	-0.8490	-0.3911	0.4978	-0.0779	-0.5738	-0.6419	0.1070	0.1253	0.1143	0.2856	-0.2732	-0.0465	-0.3430
6	Hulling (%)	1.0196	0.7804	0.7668	0.9148	1.1038	2.3964	0.7022	1.5238	0.3974	-0.0443	0.5587	0.4227	0.4478	-1.5398	0.8957	1.9171	0.6222
7	Milling (%)	0.1545	0.1187	0.1588	-0.0751	-0.2871	0.1435	0.4898	0.1284	-0.2612	-0.2662	0.0532	0.2198	0.0587	-0.1509	-0.0069	0.3803	0.0571
8	Head Rice Recovery (%)	0.0392	-0.3063	0.1453	0.1413	-0.0469	-0.3255	-0.1341	-0.5118	-0.0261	0.0876	-0.1312	-0.2687	-0.1413	0.1078	-0.0584	-0.0578	0.2396
9	Kernel Length (mm)	3.3483	2.9695	-0.4998	0.3341	5.6019	1.3747	-4.4210	0.4228	8.2887	4.3011	2.8280	-1.0020	-1.0582	-2.9327	1.2549	2.0575	-1.1334
10	Kernel Breadth (mm)	-0.8300	0.3330	0.0684	-0.7591	-1.1553	0.0282	0.8305	0.2614	-0.7929	-1.5281	0.9604	-0.2405	0.5880	0.1304	-0.6973	0.1829	-0.8200
11	Kernel L/B Ratio	3.0225	-5.6842	-0.9540	5.8909	1.4130	-2.6139	-1.2189	-2.8731	-3.8252	7.0462	-11.2115	1.6347	-4.3239	2.6132	4.0796	-3.7160	6.7615
12	Volume Expansion Ratio	-0.1897	-0.0613	0.3825	-0.3023	-0.1747	0.2088	0.5313	0.6214	-0.1431	0.1863	-0.1726	1.1838	-0.1876	-0.3565	-0.4121	-0.2782	0.0224
13	Elongation Ratio	-0.8249	0.7924	0.6506	-0.8676	-0.5079	0.7048	0.4521	1.0410	-0.4815	-1.4514	1.4546	-0.5976	3.7717	2.4223	1.4150	0.8662	-0.8191
14	Water Uptake	-0.8345	-1.1407	-0.7009	-0.2946	-1.2725	-2.4307	-1.1653	-0.7970	-1.3384	-0.3228	-0.8817	-1.1393	2.4294	3.7828	1.4788	-1.0033	-0.5008
15	Alkali Spreading Value	-6.7005	-0.1716	0.5089	-4.7923	-3.2768	-3.8057	0.1425	-1.1618	-1.5415	-4.6460	3.7049	3.5447	-3.8198	-3.9804	-10.1816	-4.7823	-2.8097
16	Gel Consistency (mm)	6.5380	3.3287	1.6718	0.4189	0.4898	7.1612	6.9516	1.0109	2.2220	-1.0713	2.9669	-2.1036	2.0557	-2.3742	4.2045	8.9514	0.7655
17	Amylose Content (%)	-0.3409	0.3969	-0.5172	-0.6384	-0.4436	-0.2851	-0.1281	0.5140	0.1501	-0.5892	0.6622	-0.0207	0.2385	0.1454	-0.3030	-0.0939	-1.0980
	Grain Yield (kg/ha)	0.2621	0.3369	0.1220	0.3805	0.6477	0.6858	-0.0112	0.4929	0.3980	0.4816	-0.1939	0.2433	-0.2208	-0.4924	0.1841	0.0320	0.1993
	Partial R²	-1.4757	0.1766	-0.4299	1.8661	-0.5499	1.6435	-0.0055	-0.2523	3.2989	-0.7359	2.1744	0.2880	-0.8329	-1.8628	-1.8749	0.2866	-0.2889

R SQUARE = 1.4955, RESIDUAL EFFECT =SQRT (1- 1.4955)

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