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Trait association studies to determine selection indices in two F_3 segregating populations of rice (*Oryza sativa* L.) under aerobic condition

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ABSTRACT

Correlation studies with F_3 segregating populations derived from MAS145 X MAS946-1 and IR64 × IM 192 crosses of rice indicated that panicle length followed by harvest index, panicle weight, plant height at 30 days after transplanting and productive tillers per plant, showed significant positive association with yield per plant. Path analysis studies revealed that harvest index, plant height at 30 days after transplanting, total number of tillers per plant, days to fifty percent flowering exerted maximum positive direct effect on pod yield per plant. Therefore during selection main attention need to be given for traits like plant height at 30DAT, productive tillers/plant, panicle weight, panicle length and harvest index. Based on these characters, top five superior families viz., A16-5, A24-16, A8-14, A3-5 and A2-3 in MAS145 X MAS946-1cross and B21-15, B12-6, B1-3, B5-18 and B18-14 in IR 64 × IM 192 cross are selected and advanced. Hence, combination of these traits could be used as selection indices and prime importance has to be given for this selection index during selection in segregating population for development of superior high yielding varieties suitable for aerobic condition thereby we could achieve sustainable rice production.

Key words: *Aerobic condition, correlation, F_3 family, path analysis, rice*

INTRODUCTION

Rice is a semi-aquatic cereal adapted to variety of climates ranged from flooded to aerobic condition. It plays a pivotal role in Indian economy being the staple food for two third of the population. India stands second with 108.0 million tons as China occupies the first place with 144.0 million tons in the world's production table of 479.3 million tons (Kumar et al., 2013). It frequently faces abiotic stresses in all these ecosystems except irrigated ecosystem (Manjappa et al., 2014). To keep up the rice production during irrigation water shortage, alternate methods of cultivation of rice is essential (Hittalmani and Shivashankar, 1987). One such strategy is cultivation of rice under aerobic situation (Venkataravana and Hittalmani, 1999). Aerobic rice has been considered a promising rice cultivation system as water scarcity is increasing in the world. Compared with lowland rice, water requirement in aerobic rice is reduced by more than 50 per cent, and water productivity increases by 60 per cent. Hittalmani and Shivashankar (1987) demonstrated that rice could be cultivated in dry sowing (aerobic) involving crosses using local rice of Karnataka. Aerobic method of rice cultivation is characterized by growing rice in well aerated soil environment during the entire period of crop production. Aerobic rice requires 50-60 per cent less water and gives equal or higher yields than grown in irrigated puddled situation (Naresh babu et al., 2010; Gandhi et al., 2011a; Gandhi et al., 2011b), it requires less labour compared to traditional cultivation practices of rice. As grain yield is dependent on many yield contributing traits as well as on the environmental influence. The selection based on only yield performance may create confusion and give a biased result. Therefore, study on the nature and degree of association of yield contributing component traits with yield assumes greater importance for fixing up characters that are likely to play a decisive role in influencing yield. As more variables are included in the correlation study, the associations become more complex. In such a situation, the path coefficient analysis provides an effective means of finding out direct and indirect causes and effects of association and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each factor (Khare et al., 2014). Thus, the present investigation was undertaken to develop selection index by assessing association among the traits, their path coefficient for grain yield and component traits.

MATERIAL AND METHODS

Plant material and experimental site

The experimental material for the present study composed of 35 and 30 F_3 families derived from MAS145 X MAS946-1 and IR 64 X IM 192 crosses respectively. Experiment was conducted at experimental plots of MAS lab, Department of Genetics and Plant Breeding, UAS Bangalore, Karnataka in *Kharif* 2014. The experiment was laid out in augmented design (Federer, 1961) in 7(2 x 1.5m) blocks under aerobic condition. Row to row and plant to plant spacing was maintained at 20 x 15 cm. The recommended agronomic practices were followed. The Scheme of development of superior F_3 families is shown in Fig. 1.

Aerobic rice cultivation

Aerobic rice cultivation involves direct sowing of seeds in un-puddled land with a spacing of 30 cm × 25 cm. Irrigation was given at 5 days interval to maintain soil moisture at field capacity throughout the crop growth. The soil is maintained under aerobic condition unlike the anaerobic condition in puddled soils with standing water in irrigated transplanted rice. During reproductive stage the irrigation is given once in 3 days interval (Raghavendra and Hittalmani, 2015). Remaining cultural practices were done as per recommended package of practices for aerobic rice developed by UAS, Bangalore.

Observations recorded

The progenies were evaluated for 15 yield and yield attributing characters *viz.,* plant height at 30 DAT (cm), days to 50 % flowering, plant height at maturity (cm), productive tillers per plant, total number of tillers per plant, spikelet fertility (%), panicle exsertion (cm), number of spikelets per panicle, panicle length (cm), panicle weight (g), days to maturity, harvest index, biomass (g), 1000-grain weight (g), grain yield/plant (g). Twenty plants were selected at random for each line from each family under aerobic condition for recording observations as per Standard Evaluation System for rice (SES, 1996).

Statistical analysis

The data generated were analyzed for estimating the correlation coefficients suggested by Snedecor and Cochran (1965). Direct and indirect effects of yield components on yield were computed through path coefficient analysis as suggested by Dewey and Lu (1959) using WINDOSTAT version 9.0.

RESULTS AND DISCUSSION

Study of association of yield components with yield assumes special importance and forms basis for selecting desired strains. Correlation coefficient measures the magnitude and direction of association among the characters. The genotypic correlations between different characters within a plant often arise because of either genetic linkages or pleiotropy, it is important to the breeders to establish and understand the existing relationship between the yield and yield contributing characters

MAS145 X MAS946-1 cross

The correlation and path analysis details for all the traits in families derived from MAS145 X MAS946-1 cross are furnished in Table 1 and Table 2, respectively. Grain yield was highly significant and positively associated with panicle length (0.875) followed by with harvest index (0.586), biomass (0.449), panicle weight (0.445), plant height at maturity (0.436), plant height at 30 days after transplanting (0.396) and productive tillers per plant (0.379). Hence, these traits could be used for selection and improvement of yield. Similar results were obtained by Sinha et al. (2004), Kishore et al. (2008), Akinwale et al. (2011), Buvaneshwari et al. (2015) and Kahani and Hittalmani, 2016. Path analysis revealed that seven out of 14 characters had positive and direct effect on grain yield at phenotypic level. The characters which had positive direct effects are biomass (1.389), panicle weight (0.646), harvest index (0.641), total

Table 1. Estimates of phenotypic correlation coefficients for 15 quantitative characters studied in F_3 families derived from MAS 145 / MAS 946-1 Rice cross

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_1	1.000	-0.184	-0.394	0.375*	0.327*	0.079	-0.268	0.163	0.168	0.087	0.780***	-0.384*	0.113	0.009	-0.265
X_2		1.000	0.889**	-0.095	-0.087	0.299	0.232	0.251	0.436**	0.086	-0.174	0.188	0.159	0.369*	0.396*
X_3			1.000	-0.265	-0.259	0.233	0.212	0.081	0.319	-0.083	-0.245	0.361*	-0.083	0.164	0.436*
X_4				1.000	0.976***	-0.094	0.151	0.198	0.235	-0.117	0.201	-0.214	0.524**	0.404*	0.357*
X_5					1.000	-0.125	0.201	0.192	0.222	-0.130	0.148	-0.238	0.477**	0.504**	0.197
X_6						1.000	-0.290	0.127	0.302	0.014	0.132	0.146	0.062	-0.098	0.147
X_7							1.000	0.193	-0.080	-0.195	-0.188	0.256	0.035	0.497***	0.312*
X_8								1.000	0.385*	0.390*	0.091	-0.274	0.447**	0.231	0.098
X_9									1.000	0.049	-0.014	-0.076	0.185	0.073	0.875***
X_{10}										1.000	-0.077	-0.740**	0.668**	0.040	0.445*
X_{11}											1.000	-0.108	-0.064	-0.207	-0.180
X_{12}												1.000	-0.437**	-0.171	0.586**
X_{13}													1.000	0.316	0.449**
X_{14}														1.000	0.379*
X_{15}															1.000

*significance at 5%, **significance at 1% and *** significance at 0.1% level, X_1-Days to 50 % flowering, X_2-Plant height at 30 DAT (cm), X_3-Plant height at maturity(cm), X_4-Productive tillers per plant, X_5-Total number of tillers per plant, X_6- Number of spikelets per panicle, X_7-Spikelet fertility (%), X_8-Panicle exsertion (cm), X_9-Panicle length (cm), X_{10}-Panicle weight (g), X_{11}-Days to maturity, X_{12}-Harvest index, X_{13}-Biomass (g), X_{14}-1000grain weight (g), X_{15}- Grain yield/plant (g)

Table 2. Estimates of phenotypic correlation coefficients for 15 quantitative characters studied in F_3 families derived from IR 64 /IM 192 Rice cross

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_1	1.000	-0.382*	-0.113	-0.084	-0.081	0.123	0.111	-0.020	-0.004	-0.187	0.809***	0.192	-0.177	-0.058	-0.103
X_2		1.000	0.401*	-0.096	-0.098	0.104	-0.166	0.218	-0.368*	0.104	-0.245	-0.250	-0.036	-0.004	0.391*
X_3			1.000	0.450*	0.451*	0.400*	-0.410*	0.190	-0.134	0.091	0.136	-0.409*	0.232	-0.182	-0.369*
X_4				1.000	0.999***	0.231	-0.292	0.416*	-0.026	-0.224	-0.112	-0.084	0.340	-0.305	0.368*
X_5					1.000	0.222	-0.307	0.417*	-0.031	-0.213	-0.104	-0.093	0.349	-0.296	0.369*
X_6						1.000	-0.132	-0.133	0.006	-0.081	0.257	0.048	0.018	-0.113	0.019
X_7							1.000	-0.416*	0.046	-0.102	0.027	0.310	-0.211	0.043	0.136
X_8								1.000	0.133	-0.086	0.023	-0.187	0.148	-0.148	-0.013
X_9									1.000	-0.078	-0.040	0.173	0.005	-0.125	0.266
X_{10}										1.000	-0.217	-0.847***	0.809***	0.344	0.388*
X_{11}											1.000	0.169	-0.310	0.045	-0.155
X_{12}												1.000	-0.760***	-0.232	0.584**
X_{13}													1.000	0.138	0.060
X_{14}														1.000	0.374*
X_{15}															1.000

*significance at 5%, **significance at1% , *** significance at 0.1% level, X_1-Days to 50 % flowering, X_2-Plant height at 30 DAT (cm), X_3-Plant height at maturity(cm), X_4-Productive tillers per plant, X_5-Total number of tillers per plant, X_6- Number of spikelets per panicle, X_7-Spikelet fertility (%), X_8-Panicle exsertion (cm), X_9-Panicle length (cm), X_{10}-Panicle weight (g), X_{11}-Days to maturity, X_{12}-Harvest index, X_{13}-Biomass (g), X_{14}-1000grain weight (g), X_{15}- Grain yield/plant (g)

number of tillers per plant (0.098) and days to fifty percent flowering (0.093). The high direct effect of these traits appeared to be the main factors due to their strong association with yield. Hence, direct selection for these traits would be effective. Similar results were reported by Venkanna et al. (2014), Vikram singh et al. (2013) whereas plant height at maturity (-0.111), productive tillers per plant (-0.531), plant height at 30 days after transplanting (0.101), number of spikelets/ panicle (-0.050) and panicle exsertion (-0.033), had the highest negative effect with yield. These results were in accordance with Kiani et al., 2012 except for number of spikelets/panicle.

IR 64 × IM 192 cross

The correlation and path analysis details for all the traits in families derived from IR 64 × IM 192 cross are furnished in Table 3 and Table 4, respectively. Correlation study revealed that there was significant and positive association at phenotypic level between grain yield and harvest index (0.584), plant height at 30 days after transplanting (0.391), panicle weight (0.388), productive tillers per plant (0.368) and total number of tillers per plant (0.368) hence these

Table 3. Estimates of direct and indirect effects of yield components on grain yield at phenotypic level in F_3 families of MAS 145/MAS 946-1 Rice cross

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	0.0937	-0.0173	-0.0369	0.0352	0.0306	0.0074	-0.0251	0.0152	0.0157	0.0081	0.0731	-0.0361	0.0106	0.0008
X_2	-0.0187	-0.531	0.0899	-0.0097	-0.0088	0.0303	0.0235	0.0254	0.0441	0.0087	-0.0176	0.0191	0.0161	0.0373
X_3	0.0440	-0.0993	-0.1118	0.0296	0.0290	-0.0260	-0.0237	-0.0091	-0.0357	0.0093	0.0274	-0.0404	0.0092	-0.0183
X_4	-0.1996	0.0507	0.1409	0.101	-0.5186	0.0497	-0.0803	-0.1050	-0.1249	0.0621	-0.1068	0.1139	-0.2784	-0.2148
X_5	0.0322	-0.0086	-0.0256	0.0963	0.0987	-0.0123	0.0198	0.0189	0.0219	-0.0129	0.0146	-0.0235	0.0471	0.0497
X_6	-0.0040	-0.0151	-0.0117	0.0047	0.0063	-0.0504	0.0146	-0.0064	-0.0152	-0.0007	-0.0067	-0.0073	-0.0031	0.0049
X_7	-0.0215	0.0187	0.0171	0.0121	0.0162	-0.0234	0.0805	0.0155	-0.0064	-0.0157	-0.0151	0.0207	0.0028	0.0400
X_8	-0.0054	-0.0083	-0.0027	-0.0065	-0.0063	-0.0042	-0.0064	-0.0331	-0.0128	-0.0129	-0.0030	0.0091	-0.0148	-0.0077
X_9	0.0029	0.0076	0.0056	0.0041	0.0039	0.0053	-0.0014	0.0067	0.0174	0.0009	-0.0002	-0.0013	0.0032	0.0013
X_{10}	-0.0562	-0.0558	0.0537	0.0755	0.0843	-0.0090	0.1260	-0.2522	-0.0320	0.6462	0.0495	0.4782	-0.4316	-0.0259
X_{11}	-0.0423	0.0094	0.0133	-0.0109	-0.0080	-0.0072	0.0102	-0.0050	0.0008	0.0042	-0.0543	0.0059	0.0034	0.0112
X_{12}	-0.2469	0.1213	0.2320	-0.1373	-0.1525	0.0935	0.1648	-0.1758	-0.0490	-0.4745	-0.0695	0.6412	-0.2797	-0.1092
X_{13}	0.1571	0.2206	-0.1149	0.7274	0.6623	0.0856	0.0492	0.6210	0.2565	0.9278	-0.0882	-0.6060	1.3892	0.4392
X_{14}	-0.0007	-0.0295	-0.0131	-0.0323	-0.0403	0.0078	-0.0398	-0.0185	-0.0059	-0.0032	0.0166	0.0136	-0.0253	-0.0800
Partial R^2	-0.0249	0.0299	-0.0264	-0.1364	0.0194	-0.0074	0.0251	-0.0032	0.0013	0.0937	0.0098	0.3763	0.6235	-0.0103

R^2= 0.975, Residual effect =0.1718 ,values bolded are direct effects and rest are indirect effects, X_1-Days to 50 % flowering, X_2-Plant height at 30 DAT (cm), X_3-Plant height at maturity(cm), X_4-Productive tillers per plant, X_5-Total number of tillers per plant, X_6- Number of spikelets per panicle, X_7-Spikelet fertility (%), X_8-Panicle exsertion (cm), X_9-Panicle length (cm), X_{10}-Panicle weight (g), X_{11}-Days to maturity, X_{12}-Harvest index, X_{13}-Biomass (g), X_{14}-1000grain weight (g), X_{15}- Grain yield/plant (g)

Table 4. Estimates of direct and indirect effects of yield components on grain yield at phenotypic level in F_3 families of IR 64 / IM 192 rice cross

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	-0.0024	0.0009	0.0003	-0.0002	0.0002	-0.0003	-0.0003	0.0000	0.0000	0.0004	-0.0019	-0.0005	0.0004	0.0001
X_2	-0.0215	0.0562	0.0225	-0.0054	-0.0055	0.0059	-0.0093	0.0122	-0.0207	0.0058	-0.0137	-0.0140	-0.0020	-0.0002
X_3	0.0094	-0.0333	-0.0831	-0.0374	-0.0375	-0.0332	0.0340	-0.0158	0.0111	-0.0076	-0.0113	0.0340	-0.0192	0.0151
X_4	0.1930	0.2187	-1.0296	2.2863	-2.2833	-0.5282	0.6680	-0.9519	0.0604	0.5111	0.2560	0.1931	-0.7778	0.6982
X_5	-0.1437	-0.1745	0.8010	1.7734	1.7757	0.3939	-0.5445	0.7410	-0.0544	-0.3776	-0.1851	-0.1650	0.6200	-0.5263
X_6	-0.0040	-0.0034	-0.0131	-0.0076	-0.0073	-0.0327	0.0043	0.0043	-0.0002	0.0026	-0.0084	-0.0016	-0.0006	0.0037
X_7	-0.0044	0.0066	0.0164	-0.0117	0.0123	0.0053	-0.0400	0.0166	-0.0019	0.0041	-0.0011	-0.0124	0.0084	-0.0017
X_8	0.0014	-0.0151	-0.0132	-0.0289	-0.0289	0.0092	0.0288	-0.0693	-0.0092	0.0060	-0.0016	0.0130	-0.0103	0.0103
X_9	0.0000	0.0030	0.0011	0.0002	0.0003	-0.0001	-0.0004	-0.0011	+0.0082	0.0006	0.0003	-0.0014	0.0000	0.0010
X_{10}	0.2483	-0.1374	-0.1208	0.2964	0.2819	0.1068	0.1348	0.1144	0.1037	+1.3257	0.2870	1.1228	-1.0728	-0.4556
X_{11}	0.0024	-0.0007	0.0004	-0.0003	-0.0003	0.0008	0.0001	0.0001	-0.0001	-0.0006	0.0029	0.0005	-0.0009	0.0001
X_{12}	0.1833	-0.2382	-0.3910	-0.0808	-0.0888	0.0461	0.2960	-0.1791	0.1645	-0.8097	0.1617	0.9560	-0.7264	-0.2212
X_{13}	-0.3635	-0.0739	0.4756	0.6982	0.7165	0.0365	-0.4322	0.3040	0.0111	1.6606	-0.6360	-1.5593	2.0522	0.2831
X_{14}	0.0046	0.0003	0.0146	0.0245	0.0238	0.0091	-0.0035	0.0119	0.0101	-0.0276	-0.0036	0.0186	-0.0111	-0.0804
Partial R^2	-0.0002	-0.0220	0.0265	-0.8187	0.6376	-0.0006	-0.0054	0.0009	-0.0022	0.4740	-0.0005	0.5582	0.1228	0.0220

R^2 = 0.9902, Residual effect = 0.0991, values bolded are direct effects and rest are indirect effects, X_1-Days to 50 % flowering, X_2-Plant height at 30 DAT (cm), X_3-Plant height at maturity(cm), X_4-Productive tillers per plant, X_5-Total number of tillers per plant, X_6- Number of spikelets per panicle, X_7-Spikelet fertility (%), X_8-Panicle exsertion (cm), X_9-Panicle length (cm), X_{10}-Panicle weight (g), X_{11}-Days to maturity, X_{12}-Harvest index, X_{13}-Biomass (g), X_{14}-1000grain weight (g), X_{15}- Grain yield/plant (g)

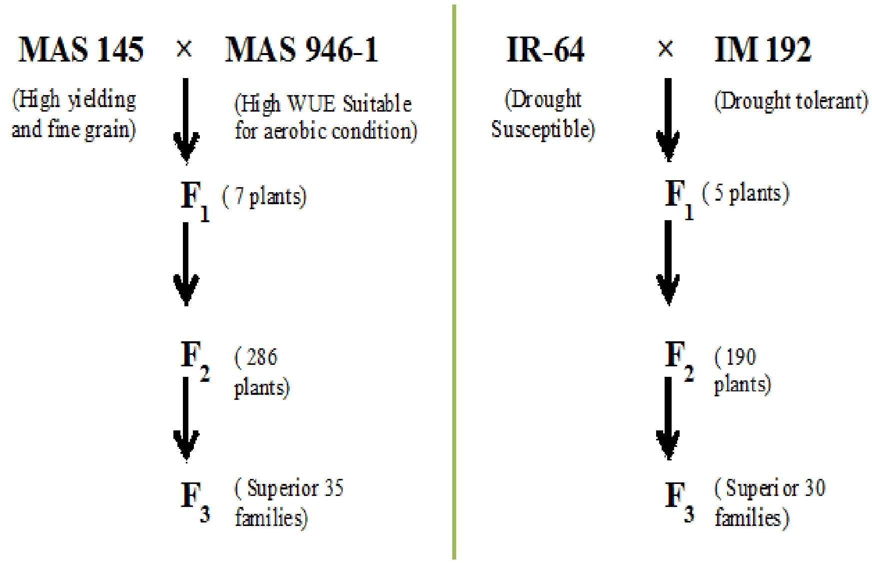

Fig.1. Scheme of development of superior F_3 families derived from MAS 145 X MAS946-1 and IR-64 X IM-192 crosses in rice

characters contribute more towards yield. Similar results were reported by Manjunath et al. (2012), Norain et al. (2014), Bhuvaneshwari et al. (2015) and Savitha and Ushakumari (2015). Path analysis revealed that eight out of 14 characters had positive and direct effect on grain yield at phenotypic level. The characters which had maximum positive direct effects are productive tillers per plant (2.28), biomass (2.05), total number of tillers per plant (1.07), harvest index (0.956) and panicle length (0.08). The high direct effect of these traits appeared to be the main factors due to their strong association with yield. Hence, direct selection for these traits would be effective. These results were inaccordance with Vikram singh et al. (2013) and Islam et al. (2015) whereas plant height at maturity (-0.083), 1000 grain weight (-0.080) panicle exsertion (-0.069) and spikelet fertility (-0.04) had the highest negative effect with yield. Similar results were reported by Kiani et al. (2012) and Norain et al. (2014).

CONCLUSION

A perusal of the results obtained from character association and path coefficient analysis, revealed the importance of traits *viz.*, productive tillers/plant, total tillers/ plant, panicle weight, panicle length and harvest index in yield improvement under aerobic condition. Based on these characters, top five superior families *viz.*, A16-5, A24-16, A8-14, A3-5, A2-3 inMAS145 X MAS946-1cross and B21-15, B12-6, B1-3, B5-18, B18-14 in IR 64 × IM 192 cross were selected and advanced. Hence, combination of these traits could be used as selection indices and prime importance has to be given for this selection index during selection in segregating population. As careful selection during early segregating population is necessary to identify superior segregants for advancing to next generation to attain homozygosity. Examination of the results obtained from character association and path coefficient analyses, revealed that productive tillers/plant, panicle weight, panicle length and harvest index as significant influence on grain yield and they could serve as good selection indices for improving the rice yield under limited moisture conditions.

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