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Research Article

Assessment of genetic variability in low land sub1 introgressed rice genotypes showing tolerance to submergence and stagnant flooding

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Abstract
The present investigation is carried out to establish the nature of relation between grain yield and yield components by partitioning the correlation coefficients between grain yield and its components into direct and indirect effects by using simple correlation and path analysis .By the help of correlation coefficients Selection index were constructed to increase the selection efficiency .A correlation coefficient and path analysis study was conducted in 51 low land Rice with tolerance to submergence and stagnant flooding for ten component characters including grain yield. The results indicated that grain yield was positively correlated with days to flowering, plant height, fertile grain number and fertility percentage indicating the importance of such traits for realization of high yield in rice. The traits like days to 50% flowering exhibited maximum positive direct effect on grain yield followed by plant height, grain yield per plant, fertility percentage and 100-grain weight, thus, indicating the importance of such traits as criteria for selection for realization of higher productivity. Using grain yield as economic criterion, ten selection indices were constructed. On the basis of selection criteria, the promising genotypes selected were IR 85086-SUB 33-3-2-1, IR 88760-SUB 93-3-3-3, Upahar, IR 88250-20-1-1-3, Jagabandhu, IR 88230-60-1-2-2, CR1009 *sub 1*, IR 87092-26-3-1-3, Savitri, IR 87098-55-2-1, Mahanadi, PSBRc 68, Swarna, Swarna-*sub 1*, PSBRc 70. evaluation of *sub 1* introgressed line in normal condition i.e. how the sub 1 lines are performing without the occurrence of flood. The genotypes like savitri-sub 1, IR 64-sub 1 , PSBRc 18- sub1 , IR 85086-SUB 33-3-2-1, IR 87439-BTN-145-2-1, IR 88228-33-3-5-2, IR 88234-STG 11-1-1-1, IR 88250-20-1-1-3, IR 88764-SUB 30-1-1-2 and IR 88776-SUB 8-1-1-2 had shown high level of submergence tolerance through screening under control conditions.

Key words
Correlation, direct effects, path analysis, Selection index, yield components

Introduction

Rice being the staple food for more than 70 percent Indians and a source of livelihood for 120-150 millions rural households, the requirement of rice production by 2030 would be around 145 million tonnes from the present level of 105 million tonnes to sustain self-sufficiency in rice. More than 60% of rice produced in India comes from Eastern regions of India. Out of the 26.8 mha rice area in eastern India, rainfed lowland rice constitutes 39% of the total rice area. About 8.0 mha of rainfed lowland areas are flood/submergence prone. Rainfed lowlands constitute highly fragile ecosystems, always prone to flash-floods and stagnant flooding submergence stress situations. Many *sub1* introgressed lines developed by marker assisted back crossing (MABC) including Swarna*sub1* and CR1009Sub1 are valuable addition to the low land rice breeding programme and these genotypes could sustain tolerance to submergence. Since submergence and stagnant flooding stresses are unpredictable, there is a need to develop new varieties with high yield and tolerance to both submergence and stagnant flooding for greater stability of production under the diverse rainfed lowland ecosystems of eastern Indian states. Under this context, for bringing success in breeding programme to develop varieties, the present investigation was undertaken in lowland rice genotypes derived from *sub1* introgressed lines to assess variability and to determine the association of yield and its contributing traits. Selection index was also constructed for increasing selection efficiency to identify superior genotypes to be utilized in further breeding programme. This selection index was constructed by 48 taking *sub1* containing genotypes and all other genotypes.

Materials and Methods

The experimental material consisted of 51 elite low land rice genotypes including *sub1* introgressed lines along with their parents, elite lines combining submergence tolerance with stagnant flooding, promising donors and four check varieties. The test genotypes were evaluated under normal situations at Rice Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during *Kharif, 2014* in RBD with two replications with the spacing of 20 x 15 cm. The recommended cultural practices were followed. Observations were recordedon the following ten yield and yield contributing characters *viz.* days to 50% flowering, plant height, panicle length, panicle number, fertile grain number, fertility percentage,100- grain weight, harvest index, grain yield per plant and plot yield. Observations were recorded in respect of ten metric traits on five competitive plants selected randomly from each plot, whereas, characters like plot yield and days to 50% flowering were recorded on plot basis. The data recorded were subjected to statistical analysis of variance technique as proposed by Panse and Sukhatme ,(1961). The phenotypic and genotypic correlation coefficients were calculated using the method given by Johnson *et al*.(1955) and path coefficient analysis we**re** worked as suggested by Dewey and Lu,(1959). Finally Selection indices were constructed using the methods developed by Smith (1936) based on discriminative function of Fisher (1936).

Results and Discussion

The analysis of variance (Table1) revealed the existence of significant differences among the genotypes for all the traits, indicating the existence of sufficient variation in the material studied. Hence, the data was further subjected to correlation and path coefficient analysis to estimate the association existing between yield and yield contributing components and direct and indirect effects of yield related traits, respectively. Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through suitable breeding programme. Phenotypic and genotypic correlations between yield and yield components were computed separately for lowland rice genotypes (Table 2).

The present investigation indicated that the genotypic correlation coefficients in general were higher than phenotypic correlation coefficients It revealed that the observed relationships among the various traits were due to genetic causes. This is in accordance with the findings of Babu *et al.* (2012), Basavaraja *et al.* (2013), Rao *et al.* (2014) and Savitha and UshaKumari (2015). Grain yield was positively correlated with days to flowering, plant height and fertility percentage both at genotypic and phenotypic levels where as the fertile grain number was positively associated with yield only at genotypic level indicating the importance of such component traits for realization of high yield in rice. These results are in accordance with Aditya and Bhartiya,(2013), Basavaraja *et al*. (2013), Haque *et al*.(2014), Rai *et al.(*2014), Pradhan *et al*.(2015) and Savitha and Usha Kumari,(2015). Panicle number and harvest index exhibited negative association with grain yield only at genotypic level but characters like fertile grain number and fertility percentage show positive association with grain yield. Therefore, it is concluded that the superior performance of promising lines from the present set of material might have been resulted due to superior expression of component traits like grain number with improved fertility rather than panicle number and harvest index.

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. During the present investigation the path analysis was carried out both at phenotypic and genotypic levels and which is presented in (Table 3) and the results obtained there from are discussed. It was observed from the path coefficient analysis that the days to 50% flowering exhibited maximum positive direct effect on grain yield followed by plant height, grain yield per plant, fertility percentage and 100-grain weight, thus, indicating the importance of such traits as criteria for selection in that order for realization of higher productivity. The other traits like panicle length, harvest index, fertile grain number and panicle number exhibited negative direct effect on grain yield. Out of different characters under study fertile grain number, fertility percentage, plant height, days to 50% flowering, grain yield per plant and 100-grain weight exerted greatest indirect effect on yield via other traits.

Thus from the foregoing observations on direct and indirect effects, the traits, like days to 50 % flowering, plant height, fertile grain number, fertility percentage, 100-grain weight and grain yield per plant may be considered as important selection criteria for realization of high and stable yields in rice. These findings in relation to different component traits were in agreement with published report on path analysis by Satheesh kumar and Saravanan ,(2012),Vanisree *et al.*(2013), Basavaraja *et al.(*2013),Ganapati *et al*.(2014), Jambhulkar *et al*.(2014) , Pradhan *et al.(*2015) and Senapati and Kumar,(2015).

Since grain yield is a complex trait, controlled by non-additive gene action and is believed to have low heritability, hence direct selection for grain yield per se is often not reliable and effective. Therefore, several workers in different crop plants have emphasized the importance of indirect selection for yield through the use of component traits governed by genes with additive effect and with strong correlation on grain yield. During the present investigation selection indices were constructed with grain yield as the economic criterion and other yield attributing characters for the construction of ten character indices. The ten character index including all the ten traits was used for the selection of genotypes.

The predicted genetic advance from different indices at 5% selection intensity ranged from 11.076 q/ha in index 1 to 11.300 q/ha in index 10. Thus in terms of predicted genetic advance, the results of the present study brought out superiority of ten character index over direct selection on yield per se. This is in general agreement with the findings of Bastia *et al*.(2008), Sabouri *et al.(*2010), Singh *et al.(*2013) and Alam *et al.*(2014) .

The plot yield and the index score of promising genotypes namely IR 85086-SUB 33-3-2-1, IR 88760-SUB 93-3-3-3, Upahar, IR 88250-20-1-1-3, Jagabandhu, IR 88230-60-1-2-2, Savitri- *sub 1*, IR 87092-26-3-1-3, Savitri, IR 87098-55-2-1, Mahanad i, PSBRc 68, Swarna, Swarna- *sub 1*, PSBRc 70, BR 11-Sub 1, IR 86256-6-2-2-2, IR 89262-SUB 5-2-3-2, IR 87118-39-1-1-6 are presented in (Table 4). It was interesting to note that the relative rankings of varieties selected on the basis of per se performance and index score differed indicating the importance of selection index over direct selection on grain yield. The promising genotypes occupying better ranking in the ten character index were selected for their future use.

Most of the published works on selection indices based on index scores reflect the genotypic worth of a particular culture and the relative efficiency has been assessed in terms of genetic advance. However, the validity of such expectations in selecting different genotypes on the basis of different selection indices is often questioned as it varies due to difference in the composition of material, selection of characters for the construction of indices and the experimental precision associated with yield measurement. Therefore, it becomes imperative to study the relative efficiency of different selection criteria and to test the validity of expected superiority of selection indices over direct selection by testing the promising genotypes through appropriate field trials.
During present investigation the results indicated that grain yield was positively correlated with days to flowering, plant height, fertile grain number and fertility percentage indicating the importance of such component traits as selection criteria for realization of high yield in rice. The traits like days to 50% flowering exhibited maximum positive direct effect on grain yield followed by plant height, grain yield per plant, fertility percentage and 100-grain weight. Thus they may be considered as important selection criteria for realization of high and stable yields in rice. Using grain yield as economic criterion, ten selection indices were constructed. On the basis of selection criteria, the promising genotypes selected were IR 85086-SUB 33-3-2-1, IR 88760-SUB 93-3-3-3, Upahar, IR 88250-20-1-1-3, Jagabandhu, IR 88230-60-1-2-2, Savitri-*sub1*, IR 87092-26-3-1-3, Savitri, IR 87098-55-2-1, Mahanadi, PSBRc 68, Swarna, Swarna*sub1*, PSBRc70. It was interesting to note that the relative rankings of varieties selected on the basis of per se performance and index score differed indicating the importance of selection index over direct selection on grain yield.

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Table 1. Analysis of variance for yield and yield components in lowland rice

Sl. No.	Characters	Mean Sum of square
1.	Days to 50% flowering	264.81**
2.	Plant height (cm)	163.37**
3.	Panicle length (cm)	6.86**
4.	Panicle number	4.17**
5.	No. of fertile grains/panicle	995.40**
6.	Fertility percentage	82.47**
7.	100-grain weight (g)	0.34**
8.	Harvest index	0.009**
9	Grain yield / plant (g)	22.54**
10.	Plot yield (q/ha)	112.58**

** significant at 1 % level of probability

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Table 2. Phenotypic and genotypic correlation coefficients among ten characters in lowland rice

Sl. No.	Characters		Plant height (cm)	Panicle length (cm)	Panicle number	No. of fertile grains/ plant (g)	Fertility percentage	100-grain weight (g)	Harvest index	Grain yield per plant (g)	Plot yield (q/ha)
1	Days to 50% flowering	Phenotypic	**0.304***	**-0.471****	**-0.152**	**0.242**	**0.306***	**-0.165**	**-0.487****	**0.041**	**0.600****
		Genotypic	0.322*	-0.485**	-0.263	0.304*	0.365**	-0.171	-0.565**	0.067	0.654**
2.	Plant height (cm)	Phenotypic		**0.243**	**-0.366****	**0.339***	**0.229**	**0.278***	**-0.223**	**0.331***	**0.476****
		Genotypic		0.221	-0.676**	0.371**	0.263	0.291*	-0.322*	0.372**	0.514**
3.	Panicle length (cm)	Phenotypic			**-0.120**	**-0.085**	**-0.182**	**0.368****	**0.111**	**0.157**	**-0.152**
		Genotypic			-0.320*	-0.244	-0.277*	0.368**	0.013	0.055	-0.205
4	Panicle number	Phenotypic				**-0.204**	**0.097**	**-0.133**	**0.285***	**0.295***	**-0.187**
		Genotypic				-0.662**	0.174	-0.246	0.051	-0.195	-0.437**
5	No. of fertile grains/plant	Phenotypic					**0.257**	**-0.390****	**0.031**	**0.348***	**0.236**
		Genotypic					0.097	-0.559**	-0.130	0.263	0.274*
6	Fertility percentage	Phenotypic						**0.113**	**0.155**	**0.252**	**0.272***
		Genotypic						0.091	0.172	0.286*	0.360**
7	100-grain weight (g)	Phenotypic							**0.246**	**0.318***	**0.060**
		Genotypic							0.235	0.333*	0.048
8	Harvest index	Phenotypic								**0.500****	**-0.263**
		Genotypic								0.347*	-0.391**
9	Grain yield/plant (g)	Phenotypic									**0.207**
		Genotypic									0.196

* and ** significant at 5 % and 1 % level of probability respectively

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Table 3. Path analysis of direct (diagonal) and indirect effects of various traits on plot yield

Characters		Days to 50% flowering	Plant height	Panicle length	Panicle number	No. of fertile grains/ Panicle	Fertility percentage	100-grain weight	Harvest index	Grain yield/ plant	Correlation with plot yield
Days to 50% flowering	Phenotypic	**0.487**	0.078	0.004	0.010	-0.009	0.015	-0.001	0.012	0.005	0.600
	Genotypic	**0.614**	0.081	-0.032	-0.37	0.085	0.013	-0.046	-0.017	-0.007	0.654
Plant height	Phenotypic	0.148	**0.257**	-0.002	0.023	-0.013	0.011	0.002	0.005	0.044	0.476
	Genotypic	0.198	**0.252**	0.015	-0.095	0.104	0.009	0.078	-0.010	-0.037	0.514
Panicle length	Phenotypic	-0.229	0.063	**-0.008**	0.008	0.003	-0.009	0.002	-0.003	0.021	-0.152
	Genotypic	-0.298	0.056	**0.066**	-0.045	-0.068	-0.010	0.099	0.000	-0.005	-0.205
Panicle number	Phenotypic	-0.074	-0.094	0.001	**-0.064**	0.008	0.005	-0.001	-0.007	0.039	-0.187
	Genotypic	-0.161	-0.170	-0.021	**0.141**	-0.185	0.006	-0.066	0.002	0.019	-0.437
No. of fertile grains/panicle	Phenotypic	0.118	0.087	0.001	0.013	**-0.038**	0.012	-0.003	-0.001	0.046	0.236
	Genotypic	0.187	0.093	-0.016	-0.093	**0.280**	0.003	-0.150	-0.004	-0.026	0.274
Fertility percentage	Phenotypic	0.149	0.059	0.001	-0.006	-0.010	**0.048**	0.001	-0.004	0.033	0.272
	Genotypic	0.224	0.066	-0.018	0.024	0.027	**0.035**	0.024	0.005	-0.028	0.360
100-grain weight	Phenotypic	-0.080	0.072	-0.003	0.008	0.015	0.005	**0.007**	-0.006	0.042	0.060
	Genotypic	-0.105	0.073	0.024	-0.035	-0.157	0.003	**0.269**	0.007	-0.033	0.048
Harvest index	Phenotypic	-0.237	-0.057	-0.001	-0.018	-0.001	0.007	0.002	**-0.024**	0.066	-0.263
	Genotypic	-0.347	-0.081	0.001	0.007	-0.036	0.006	0.063	**0.030**	-0.034	-0.391
Grain yield/ plant	Phenotypic	0.020	0.085	-0.001	-0.019	-0.013	0.012	0.002	-0.012	**0.133**	0.207
	Genotypic	0.041	0.094	0.004	-0.027	0.074	0.010	0.090	0.011	**-0.099**	0.196

Residual effect: 0.731 (Phenotypic path) Residual effect: 0.688 (Genotypic path)

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Table 4. Selection of genotypes on the basis of ten character index

Sl. No	Genotypes	Index score	Plot yield (q/ha)	Expected genetic Advance (5%)
1	IR 85086-SUB 33-3-2-1	40.63 (1)	51.90 (1)	11.300
2	IR 88760-SUB 93-3-3-3	37.13 (2)	45.62 (2)	
3	Upahar	35.83 (3)	44.59 (3)	
4	IR 88250-20-1-1-3	33.24(4)	41.96 (4)	
5	IR 88228-33-3-5-2	32.91 (5)	41.23 (5)	
6	Jagabandhu	32.68 (6)	40.21 (7)	
7	IR 88230-60-1-2-2	32.36 (7)	41.23 (6)	
8	CP1009 *sub 1*	30.96 (8)	40.21 (8)	
9	IR 87092-26-3-1-3	30.65 (9)	39.47 (10)	
10	CP1009	30.41 (10)	39.47 (11)	
11	IR 87098-55-2-1	30.26 (11)	39.76 (9)	
12	Mahanadi	29.09 (12)	36.55 (14)	
13	PSBRc 68	28.44 (13)	38.89 (12)	
14	Swarna	28.09 (14)	35.24 (17)	
15	Swarna-*sub 1*	27.94 (15)	36.55 (15)	
16	PSBRc 70	27.42 (16)	37.14 (13)	
17	BR 11- *sub 1*	27.19 (17)	34.21 (20)	
18	IR 86256-6-2-2-2	26.51 (18)	34.50 (18)	
19	IR 89262-SUB 5-2-3-2	26.13 (19)	36.55 (16)	
20	IR 87118-39-1-1-6	26.00 (20)	31.29 (27)	