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Research Article

Character association and path coefficient analysis for yield and its component traits in slender grain rice (*Oryza sativa L.*)

Kalpataru Nanda[1*], D. N. Bastia[2] and Ashutosh Nanda[3]
[1*]Kalpataru Nanda, Department of Plant Breeding and Genetics, O.U.A.T, Bhubaneswar
[2]D.N. Bastia, Professor, Department of Plant Breeding and Genetics, O.U.A.T, Bhubaneswar-751003
[3]Ashutosh Nanda, Department of Bioinformatics, O.U.A.T, Bhubaneswar
[*]**E-Mail**-babul.nanda.1995@gmail.com

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Abstract
An investigation was carried out at Rice Research Station, O.U.A.T., Bhubaneswar evaluating thirty-two genotypes with an objective to determine the degree of association between yield and it`s component characters and their direct, indirect effects on grain yield in slender grain rice. The results from the correlation studies showed that grain yield had the highest estimates of positive correlation both at genotypic and phenotypic level with the number of effective tillers/plant (r_p=0.853, r_g=0.997) followed by the number of filled grains/panicle (r_p =0.816, r_g =0.835). Path analysis studies reported that high direct contribution to yield was manifested by the number of filled grains per panicle (0.538) followed by the number of effective tillers/plant (0.513). The number of effective tillers/plant also exhibited the highest indirect effect on grain yield via the number of filled grains per panicle (0.275). This indicated that the simultaneous selection of these characters would be fruitful for yield improvement in slender grain rice.

Keywords
Correlation, path analysis, selection, slender grain rice, component characters

Introduction

Rice, the staple food for billions of Asian people, not only serves as their source of food and nutrition but also occupy a pivotal role in livelihood security of millions of poor Asians. Such dependency makes it a sensitive crop whose fall and rise in price could potentially make or break a government. India has the world's largest area under rice i.e., about 44 Mha and the second-highest production i.e., about 165Mt at the productivity of 3.65 t/ha. Production of rice has increased more than five times since 1950-51. The source of growth is mostly in yield increment, which has increased by 3.6 times and marginally area which has increased by 1.4 times during the period (Pathak *et al.,* 2018). With the growing population, it becomes a headache for the governments to ensure the food security of its people. Every year a lump sum of money is spent on research for the improvement of quality and yield of rice to keep up with the ever-increasing demand. The current report on rice yield improvement shows a declining trend in the yield increment and is predicted to reach a yield plateau in the near future. Such a situation demands the plant breeders to explore and evaluate a lot of germplasm for understanding the association of yield with its component traits to use it in future hybridization programme. Correlation studies provide information on the nature and extent of association between yield and its component traits and thus can help the breeder in deciding the magnitude and direction of selection for the improvement of the character. Path coefficient analysis further partitions the correlation coefficients into direct and indirect effects enabling plant breeders to rank the genetic attributes according to their contribution. The current study was undertaken to find out the nature of the relationship of grain yield with its yield components, direct and indirect contribution of these components towards grain yield and to identify better combinations of such yield components as selection criteria for developing high yielding slender-grain rice genotypes.

Materials and Methods

The present experiment was carried out using twenty-nine elite breeding lines from the experimental materials of Station Yield Trial - Slender Grain rice along with three established check varieties viz., Ranidhan, Samba mahsuri, and Jajati. The experiment was laid out at EB-1, Rice Research Station, O.U.A.T., Bhubaneswar during 2016 Kharif season. The details of the parentage and the origin of the test entries are given in Table 1. The experimental materials were put in a Randomized Block Design with two replications and raised in plots each measuring 1.53m^2 in area.

The plants were raised in three rows with each row consisting of seventeen plants. The row-to-row and plant-to-plant spacing was maintained at 20cm x 15cm and recommended crop management practices were followed. Observations were recorded for nine metric traits taking five competitive plants selected randomly from middle rows of each plot; whereas characters like plot yield and days to 50 % flowering were recorded on a plot basis. The characters studied were plant height, days to 50% flowering, number of effective tillers/plant, flag leaf area, panicle length, number of fertile grains/panicle, fertility %, 100-grain weight, and plot yield. The replicated data were subjected to statistical analysis; the mean values over replications were used for finding correlation coefficient following Singh and Chaudhary (1979). The estimates of correlation coefficients were then used in path analysis studies for finding the direct and indirect effects following the method suggested by Dewey and Lu (1959).

Results and Discussion

Since yield is a complex character entwined with several other characters and is much influenced by the environment, the practice of selection based on yield alone will often result in retrograde or less optimum progress in isolating superior genotypes (Manjunatha *et al.* 2017). Therefore, plant breeders have to exercise indirect selections through component characters for attaining yield improvement. Studies on character association provide information on nature and direction of selection thereby helping the plant breeder in making an efficient selection strategy to strike an economic and reliable balance between various characters. An attempt has been made in this investigation to estimate the degree of association of character pairs, which would facilitate selection of genotypes where a balanced combination of characters is associated with the increased yield. The magnitude and nature of the association of characters at genotypic and phenotypic levels are presented in Table 2.

In general, the estimates of genotypic correlation were higher than that of phenotypic correlation, indicating a strong inherent association between the traits. However, the phenotypic and genotypic correlations indicated similar trends. Similar results have been reported by Behera *et al.* (2017), Hossain *et al.* (2015), Kalyan *et al.* (2017). The results in table 2 showed that grain yield had the highest estimates of positive correlation both at genotypic and phenotypic level with the number of effective tillers/plant (r_p = 0.853, r_g =0.997) followed by the number of filled grains/panicle (r_p =0.816, r_g =0.835), fertility % (r_p =0.548, r_g =0.633), panicle length (r_p = 0.361, r_g =0.390) and days to 50% flowering (r_g =0.366). Therefore a selection of such characters will indirectly boost the grain yield. Similar results were reported by Lakshmi *et al.* (2017), Kalyan *et al.* (2017). The rest of the characters had a non-significant correlation with yield.

Days to 50% flowering had significant positive correlation with the number of effective tillers/plant (r_p=0.426, r_g =0.583). Plant height had significant positive correlation with panicle length (r_p= 0.401, r_g =0.439) and a significant negative correlation with number of effective tillers/plant (r_g =-0.447). Flag leaf area had significant positive correlation with number of effective tillers/plant (r_g =0.357) and panicle length (r_p= 0.766, r_g =0.857). Number of effective tillers/plant had significant positive correlation with panicle length (r_p = 0.353, r_g =0.559), number of filled grains/panicle (r_p= 0.512, r_g =0.691), fertility percentage (r_p= 0.469, r_g =0.673) and grain yield (r_p = 0.853, r_g =0.997). Number of filled grains/panicle had significant positive correlation with fertility percentage (r_p= 0.464, r_g =0.490), grain yield (r_p =0.816, r_g =0.835) and a significant negative correlation with 100-grain weight (r_g =-0.352).

In the current investigation, character association studies reported a significant influence of component characters on yield but could not indicate whether the association of the yield-related traits with yield is due to their direct effect on yield or is a consequence of their indirect effect via some other traits. In such a case splitting the total correlation into direct and indirect effects of cause as devised by wright (1921) would give more meaningful interpretation to the cause of the association between the dependent variable like yield and independent variables like yield components (Madhukar *et al.* 2017). The direct effect of component traits on yield shows a true association and selection of such traits would bring improvement in yield. But when the yield is influenced by some component traits as a consequence of their indirect effect via some other traits, selection of the trait through which the indirect effect has been exerted is beneficial for the improvement of yield. In the present study, phenotypic correlation coefficients were used for carrying out path coefficient analysis for finding the direct and indirect effects of component characters on grain yield. A low residual effect (0.213) obtained in the present investigation indicates that the component characters had contributed around 95 % of variability towards yield. Similar trends were also stated by

Manjunatha *et al.* (2017), Ch. Santhi Priya *et al.* (2017).

It was revealed from the Table 3 that high direct contribution to yield was manifested by the number of filled grains per panicle (0.538) followed by the number of effective tillers/plant (0.513), 100-grain weight (0.158) and Days to 50% flowering (0.141). Such characters are truly associated with yield and their selection would directly help in increasing the crop yield. Similar results have been reported by Behera *et al.* (2017), Lakshmi *et al.* (2017), Premkumar (2015), Rathod *et al.* (2017).

The number of effective tillers/plant exhibited the highest indirect effect on yield via the number of filled grains per panicle (0.275), closely followed by the number of filled grains per panicle which exhibited the indirect effect on yield via the number of effective tillers/plant (0.262). Fertility % also showed an indirect effect on yield via the number of filled grains/panicle (0.250). This shows that selection for characters like the number of filled grains per panicle and the number effective tillers/plant would indirectly help in increasing the crop yield. These findings are in agreement with works on path analysis by Ch. Santhi Priya *et al.* (2017), Behera *et al.* (2017), and Prasad *et al.* (2017).

Selection of yield per se is not reliable as it is much influenced by the environment. Therefore, indirect selections through component characters became important in breeding for yield improvement. Studies on character associations not only help to understand physical linkage but also provide information on nature and direction of selection. In the present study on character association, the number of filled grains/panicle, number of effective tillers/plant, fertility % and panicle length showed a significant positive association with grain yield. This revealed that selection based on these characters bears relevance to grain yield. Observations on the direct and indirect effects of different traits on grain yield concluded that the traits like the number of filled grains per panicle, the number of effective tillers/plant and, 100-grain weight should be considered as important selection criteria for the realization of higher yield. Both character association and path analysis studies in the above experiment concluded that characters like the number of effective tillers and number of filled grains/ panicle are closely associated with grain yield and are directly or indirectly affecting it. Hence selection of a plant with a high number of effective tillers and a high number of filled grains/panicle would effectively result in higher yield.

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Table 1. Details of the 32 rice genotypes used in the study

Sl.No.	Genotype Designation	Cross Combination	Kernel Length (mm)	Kernel Breadth (mm)	L/B Ratio	Grain Type
1	**OR2659-5**	IR 72 / Martha fine	5.26	1.63	3.22	**SS**
2	**OR2659-7**	IR 72 / Martha fine	5.3	1.69	3.13	**SS**
3	**OR2674-13**	CRMS 32A / OR 1889-5	5.41	1.65	3.27	**SS**
4	**OR2674-14-1**	CRMS 32A / OR 1889-5	6.28	1.52	4.13	**LS**
5	**OR2675-1-1**	CRMS 32A / OR2324-18	6.4	1.73	3.69	**LS**
6	**OR2675-1-2**	CRMS 32A / OR2324-18	6.49	1.69	3.84	**LS**
7	**OR2675-2-1**	CRMS 32A / OR2324-18	6.57	1.6	4.1	**LS**
8	**OR2675-2-2**	CRMS 32A / OR2324-18	6.48	1.6	4.05	**LS**
9	**OR2675-2-3**	CRMS 32A / OR2324-18	6.27	1.5	4.18	**LS**
10	**OR2675-2-4**	CRMS 32A / OR2324-18	6.48	1.61	4.02	**LS**
11	**OR2675-2-5**	CRMS 32A / OR2324-18	6.53	1.5	4.35	**LS**
12	**OR2675-2-6**	CRMS 32A / OR2324-18	6.57	1.6	4.1	**LS**
13	**OR2675-3-1**	CRMS 32A / OR2324-18	6.29	1.61	3.9	**LS**
14	**OR2675-3-2**	CRMS 32A / OR2324-18	6.52	1.85	3.52	**LS**
15	**OR2675-4-1**	CRMS 32A / OR2324-18	6.38	1.6	3.98	**LS**
16	**OR2675-5-1**	CRMS 32A / OR2324-18	5.88	1.66	3.54	**SS**
17	**OR2675-5-2**	CRMS 32A / OR2324-18	6.47	1.6	4.04	**LS**
18	**OR2675-6-4**	CRMS 32A / OR2324-18	5.82	1.55	3.75	**SS**
19	**OR2675-6-7**	CRMS 32A / OR2324-18	6.23	1.75	3.56	**LS**
20	**OR2676-1-1**	CRMS 32A / OR 234519	6.23	1.5	4.15	**LS**
21	**OR2676-1-2**	CRMS 32A / OR 2345-19	6.08	1.6	3.8	**LS**
22	**OR2676-1-4**	CRMS 32A / OR 2345-19	6.17	1.53	4.03	**LS**
23	**OR2676-2-3**	CRMS 32A / OR 2345-19	6.34	1.58	4.01	**LS**
24	**OR2676-2-4**	CRMS 32A / OR 2345-19	6.19	1.81	3.41	**LS**
25	**OR2676-2-5**	CRMS 32A / OR 2345-19	6.12	1.46	4.19	**LS**
26	**OR2676-2-6**	CRMS 32A / OR 2345-19	6.2	1.45	4.27	**LS**
27	**OR2676-3-1**	CRMS 32A / OR 2345-19	6.11	1.44	4.24	**LS**
28	**OR2676-3-2**	CRMS 32A / OR 2345-19	6.33	1.51	4.19	**LS**
29	**OR2676-4-2**	CRMS 32A / OR 2345-19	6.1	1.55	3.73	**LS**
30	**Ranidhan**	Swarna / ORR 48-1	5.1	1.96	2.6	**MS**
31	**Samba mahsuri**	GEB 24 / T(N) 1	4.96	1.77	2.8	**MS**
32	**Jajati**	Rajeswari / T 141	5.39	1.85	2.91	**MS**

***SS - Short slender, MS - Medium slender, LS – Long slender**

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Table 2. Estimates of phenotypic and genotypic correlation coefficient of yield and its component traits

Characters		Days to 50% flowering	Plant height (cm)	Flag leaf area (cm²)	No. of effective tillers/plant	Panicle length (cm)	No. of filled grains / panicle	Fertility %	100 grains weight (g)
Plant height(cm)	r_p	-.251							
	r_g	-.268							
Flag leaf area (cm²)	r_p	.227	.280						
	r_g	.241	.256						
No. of effective tillers/plant	r_p	.426**	-.242	.278					
	r_g	.583**	-.447*	.357*					
Panicle length (cm)	r_p	.045	.401*	.766**	.353*				
	r_g	.056	.439*	.857**	.559**				
No. of filled grains/panicle	r_p	.148	.127	.042	.512**	.205			
	r_g	.151	.112	.031	.691**	.198			
Fertility %	r_p	-.081	-.102	-.162	.469**	-.030	.464**		
	r_g	-.108	-.204	-.254	.673**	-.028	.490**		
100 grains weight (g)	r_p	-.273	-.018	.157	.042	.157	-.343	.086	
	r_g	-.280	-.020	.167	.040	.173	-.352*	.106	
Grain yield (q/ha)	r_p	**.345**	**.005**	**.196**	**.853****	**.361***	**.816****	**.548****	**-.045**
	r_g	**.366***	**-.006**	**.229**	**.997****	**.390***	**.835****	**.633****	**-.052**

r≥0.349 Significant at 5% level, r≥ 0.449 Significant at 1% level

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Table 3. Direct and indirect effects of component traits on yield at the phenotypic level

Characters	Days to 50% Flowering	Plant Height (cm)	Flag leaf Area (cm^2)	No. of effective tillers/plant	Panicle length (cm)	No. of Filled grains/ panicle	Fertility %	100-grain wt. (g)	Grain yield (q/ha)
Days to 50% flowering	**.141**	-.025	-.025	.218	.004	.080	-.004	-.043	.345
Plant height (cm)	-.035	**.101**	-.031	-.124	.034	.068	-.005	-.003	.005
Flag leaf area (cm^2)	.032	.028	**-.111**	.143	.065	.023	-.008	.025	.196
No. of effective tillers/plant	.060	-.025	-.031	**.513**	.030	.275	.024	.007	.853
Panicle length (cm)	.006	.041	-.085	.181	**.084**	.110	-.002	.025	.361
No. of Filled grains/panicle	.021	.013	-.005	.262	.017	**.538**	.024	-.054	.816
Fertility %	-.011	-.010	.018	.240	-.003	.250	**.051**	.014	.548
100-grain weight(g)	-.039	-.002	-.017	.022	.013	-.184	.004	**.158**	-.045

P(R) = .213 (residual effect) **R SQR (%) = 95.47**

Bold values are direct effects