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Path Analysis of Yield Components in Rice

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ABSTRACT

Path coefficient analysis was made on the data obtained from an experiment with 74 strains of rice. The path analysis revealed that the number of ear bearing tillers makes the largest positive and direct contribution to grain yield followed by number of grains per panicle. Length/breadth ratio and 100 grain weight have a direct influence on yield. Most of the auxiliary characters express their indirect influence on grain yield *via* these traits. Despite having exhibited direct contribution to yield, plant height has not been found to channelize its indirect influence through two biggest direct contributors. Hence, inclusion of shorter height as objective of breeding would not in any way jeopardise the breeding for improvement of ear bearing tillers and number of grains per panicle.

INTRODUCTION

Productive breeding calls for investigations not on yield as such, but also on the components of yield and protein percentage. In rice, the direct components of grain yield have been reported to be ear bearing tillers, number of grains per plant and 1000 grain weight. These components have been found to be highly corrslated with yield (Ramiah, 1953; Nagai, 1961; Bhaumik *et al*, 1971). With the help of Wright's concept of path coefficient analysis (1921), later developed and applied by Li (1948), an attempt has been made on rice strains to assess how the yield attributes exercise their impact on yield and which of them converage on yield directly and which indirectly.

MATERIALS AND METHODS

The material consisted of 74 strains, which have been selected at random, from the genetic stock collection, maintained at the Central Rice Research Institute, Cuttack. The strains have been selected to represent the two cultivated species of rice, *Oryza sativa* and *O. glaberrima*. The source of varisties is given in Table 1.

The experiment was laid out in a randomised block design with three replications during the **kharif** season (roughly April to September, sometimes crop grows even beyond September depending upon time of sowing and inherent duration characteristic of the variety) of 1970. The net plot size was .99 sq.m. Each row consisted of 12 plants. The total area covered was 219.78 sq.m. The seeds were sown on ten randomly selected plants from the two middle rows. Data were collected on the following characters : (x_1) heading duration (days), (x_2) plant height (cm), (x_3) No. of total tillers, (x_4) no. of ear bearing tillers, (x_5) panicle length (cm), (x_6) no. of spikelete per panicle, (x_7) no. of grains per panicls, (x_8) 100 grains

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Table 1 : Source of 74 rice strains used for Path analysis

Sl. No.	Strains	Origin	Sl. No.	Strains	Origin
	(a) *indica*				
1	Satika	West Bengal	41	J.B.S. – 1736	Jeypore tract,
2	Ashkata	do			Orissa
3	N_{22}	Uttar Pradesh	42	– 690	do
4	Dharial	West Bengal	43	– 197	do
5	Dular	do	44	– 920	do
6	Marichbuti	do	45	– 1187	do
7	ASD – 1	Tamilnadu	46	– 282	do
8	ADT – 27	do	47	– 1132	do
9	SLO – 16	Andhra Pradesh	48	– 929	do
10	Badkalamkati	West Bengal	49	– 208	do
11	Latisail	do	50	– 10	do
12	Radhunipagal	do	51	– 1456	do
13	Badshabhog	do	52	– 1723	do
14	Bhasamanik	do	53	– 1628	do
15	T_{141}	Orissa		(b) *japonica*	
16	H_4	Ceylon	54	Norin – 8	Japan
17	T – 90	Orissa	55	Asahi	do
18	GEB – 24	Tamilnadu	56	Norin – 41	do
19	Vijaya	High yielding variety	57	Gimbozu	do
20		evolved at CRR I, Orissa	58	Kosihikari	do
20	MNP – 283	Manipur tract, N.E. India		(c) *ponlai*	
21	– 285	do	59	Kaoshing – 136	Taiwan
22	– 276	do	60	– 137	do
23	– 212	do	61	Tainan – 5	do
24	– 254	do	62	Taichung – 65	do
25	– 243	do	63	Tainan – 3	do
26	– 274	do			
27	– 232	do		(d) *javanica*	
28	– 202	do	64	Peta	Philippines
29	– 210	do	65	Skrivimankoti	do
30	– 287	do	66	Mass	Indonesia
31	– 249	do	67	Baok	do
32	– 256	do	68	Urangurangan	do
33	– 257	do			
34	– 230	do		(e) *O. glaberrima*	
35	– 284	do	69	G – 1	Africa
36	– 291	do	70	– 10	do
37	– 298	do	71	– 21	do
38	– 228	do	72	– 12	do
39	– 260	do	73	– 32	do
40	J.B.S. – 1205	Jeypore tract, Orissa	74	– 35	do

weight, (x_9) yield per plant (g), (x_{10}) protein percentage and (x_{11}) length/breadth ratio.

With the above 74 strains, an attempt was made through path coefficient analysis, originally proposed by Wright (1921), to know the direct and indirect effects of the given ten auxiliary characters on yield. The phenotypic and genotypic correlations for this purpose were worked out as per method developed by Burton and Devane (1953). Of these, the phenotypic correlation values were utilized for the path coefficient analysis.

RESULTS

The estimates of phenotypic correlations (Table 2) show that among a total of 66 pairs of combinations, 24 pairs possessed negative values. The combinations (1) heading duration × no. of grains per panicle, (2) heading duration × yield per plant, (3) heading duration × length/breadth ratio, (4) plant height × 100 grain weight, (5) total tiller × protein percentage, (6) ear bearing tiller × protein percentage, (7) ear bearing tiller × length/breadth ratio, (8) no. of spikelets × length/breadth ratio, (9) no. of grains per panicle × length/breadth ratio, (10) 100 grain weight × yield per plant and (11) protein percentage × length/breadth ratio revealed positive but insignificant values, otherwise 'r' values in other cases were significant at 5% level. The pairs of characters showing significant negative correlations at 5% level were (1) plant height × protein percentage, (2) plant height × ear bearing tillers, (3) plant height × total tillers, (4) total tillers × panicle length, (5) no. of ear bearing tillers × panicle length, (6) panicle length × protein percentage, (7) no. of spikelets per panicle × protein percentage, (8) no. of grains per panicle × protein percentage and (9) yield per plant × protein percentage.

Genotypic correlations (Table – 2) were also found to be of similar nature as that of phenotypic correlations except for association of 100 grain weight with other characters.

Path coefficient analysis was done to study the role of mutual associations among the ten auxiliary characters in determining the causative course towards yield (Table 3). Number of ear bearing tillers had the highest indirect effect on yield. This character exercised only small positive indirect influence through other characters, its contribution to yield through total tillers being the only exception. It may be worth mentioning, though, that total tiller number bors negative direct influence on yield.

Number of grains per panicle had the next highest direct effect on yield. Panicle length and number of spikelets per panicle, which are positively correlated with yield, revealed no direct contribution to yield. On the contrary, they contributed to yield by indirectly affecting number of grains per panicle.

Length/breadth ratio occupied third position for direct contribution towards yield. Plant height registered small indirect contribution to length/breadth ratio to effect yield.

Plant height, which too had direct contribution on yield, was found to exercise indirect influence through panicle length also.

Effect of 100 grain weight on yield was found to be the least as far as positive direct values are concerned. Heading duration and protein percentage, revealing negative correlation values with yield, showed feeble ambidirectional influence on this character.

DISCUSSION

Out of the ten auxiliary characters, two namely heading duration and 100 grain weight, show no significant association with yield on the positive side. On the negative side total number of tillers also reveals insig-

Table 2 : Estimates of phenotypic and genotypic correlations among different characters of rice

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	P	.2851*	-.1172	-.2126	.5134**	.3122*	.2000	-.0390	.0232	-.2110	.2061
	G	.3167*	-.1564	-.2648*	.5929**	.3708*	.2459*	-.1541	.0221	-.3436	.2380
X_2	P		-.3660*	-.2933*	.6354**	.2798*	.2844*	.0905	.4116**	-.2801*	.4713**
	G		-.4062**	-.3252*	.6667**	.2947*	.3109*	.2958*	.4423**	-.2919*	.4902**
X_3	P			.9486**	-.2521*	-.1242	-.1659	-.1211	-.0085	.0593	.0948
	G			.9535**	-.2749*	-.1374	-.1837	-.4107**	-.0217	.0596	.0926
X_4	P				-.2417*	-.1094	-.1262	-.1093	.2833*	.0335	.1260
	G				-.2647*	-.1196	-.1345	-.3652	.3447*	.0335	.1305
X_5	P					.5593**	.5339**	-.3002	.2958*	-.3095	.2627*
	G					.5961**	.5757**	.0103	.3222*	-.3260*	.2803*
X_6	P						.9343**	-.0903	.3356*	-.2926*	.0968
	G						.9550**	-.4257**	.3873**	-.3094*	.1088
X_7	P							-.0726	.3782**	-.3012*	.0699
	G							-.3590*	.4544**	-.0222*	.0867
X_8	P								.0787	-.0289	.0419
	G								.5247**	-.0457	.3360*
X_9	P									-.2359*	.3613*
	G									-.2743*	.3971*
X_{10}	P										.0601
	G										.0617

*Significant at 5% level of probability **Significant at 1% level of probability

Table 3 Direct and indirect contribution of different characters to plant yield in rice based on path coefficient analysis

	Indirect effects										Direct effects on yield
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	
X_1		.0633	.0684	−.1535	−.0200	−.0161	−.0692	−.0028	−.0028	−.0231	−.0552
X_2	−.0157		.2137	−.2118	−.0248	−.0145	.0984	.0968	.0307	.1070	.2221
X_3	.0065	−.0813		.6850	.0098	.0064	−.0564	−.0574	−.0065	.0215	−.5838
X_4	.0117	−.0651	−.5539		.0094	.0057	−.0436	−.0079	−.0037	.0286	.7221
X_5	−.0283	.1411	.1472	−.1745		−.0289	.1847	−.0001	.0339	.0596	−.0390
X_6	−.0172	.0621	.0725	−.0790	−.0218		.3232	−.0065	.0320	0219	−.0517
X_7	−.0110	.0632	.0969	−.0911	−.0208	−.0483		−.0053	.0330	.0158	.3459
X_8	.0022	.0201	.0707	−.0789	.0001	.0047	−.0251		.0032	.0095	.0724
X_9	.0116	−.0622	−.0346	.0242	.0121	.0152	−.1042	−.0021		.0137	−.1095
X_{10}	−.0114	.1047	−.0554	.0910	−.0102	−.0050	.0242	.0030	−.0066		.2270
Residual factor											−.1293

nificant association with yield. The rest of the characters except protein percentage exhibit significant correlations with yield. Protein percentage is found to be negatively significantly correlated with yield. Govindaswamy and Ghosh (1973) have also found similar significant negative correlation between protein content and plant yield. Although, from this picture, breeding for high protein and high yield would appear to be not an easy task, still significance of such a negative correlation at only 5% level and not higher indicates possibility of a break through with the help of newer genetic recombinations as a result of hybridisation between carefully selected parents. One result in the present investigation needs being clarified to put the picture straight. This is in regard to the positive and significant correlation between plant height and yield obtained in the present study on rice. Normally, it is desired that a high yielding plant type of rice should be of short stature. However, the majority of the strains included in the present study being from relatively long statured *indica* this positive significant association between plant height and yield is inevitable. Genotypic correlations present a similar picture as above phenotypic correlations except for association of 100 grain weight with other characters. Its genetic association with the most important character, plant yield, has been found to be significantly positive. As reported by Johnson *et al* (1955). Nei (1960) and Swarup and Chaugala (1962) in other crop plants, in rice too, the present investigation shows that genotypic correlations are higher than phenotypic correlations. Nevertheless, the broad similarity between the pictures of phenotypic and genotypic correlations has been taken help of in undertaking path coefficient analysis based on phenotypic correlation coefficients only. In an earlier study on certain rice crosses, Chang and Tagumpay (1970) have also found that the genotypic correlation coefficients of the reported paired traits were identical in sign and generally greater in value than the corresponding phenotypic correlation coefficients.

Path coefficient analysis has been used in the present investigation to determine direct and indirect effects of various auxiliary characters on plant yield. The results show that the number of ear bearing tillers followed by number of grains per panicle give maximum positive direct effects on yield. As the path values depict, these two characters do not play any indirect role through other characters. However, among other characters, total tillers exert their influence on yield through ear bearing tillers, whereas two indirect paths converage through number of grains per panicle on yield, one starting with panicle length, and another starting with number of spikelets. Although plant height has registered recognisable direct effect on yield, still selection for lower height would hardly effect the character or extent of direct contribution of ear bearing tillers and number of grains per panicle, since it has not been found to exercise indirect influence on them. Thus, in the present material, maximum emphasis has to be put on selections for number of ear bearing tillers followed by stress on number of grains per panicle, in any breeding programme to increase the yield potential. Length/breadth ratio of grain and 100 grain weight which have considerable direct influence on yield may be subjected to simultaneous selection for increasing yield without in any way jeopardising the influences of other characters like ear bearing tillers and number of grains per panicle because these characters have no indirect contribution through the latter characters. The path coefficient analysis in the present study thus indicates that with emphasis on criteria like ear bearing tillers, number of grains per panicle, length/breadth ratio and 100 grain weight, breeding of an improved plant type which would even augment the panicle length would not be difficult to realise. Since length/breadth ratio of grain has more direct contribution to yield than plant height (the indirect influence of plant height on this ratio notwithstanding) and similarly since all the other three important characters behave as direct vehicles contributing to yield, breeding for reduced stature may not hamper the efficiency of these direct vehicles. In addition, it has already been argued earlier that even in the present material genetic recombination programme it self may bring the desired compromise in the manifestation of plant height. The reports of Shastry *et al* (1967) and Chang and Tagumpay (1970) are broadly in agreement with the above findings.

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