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Analysis of Yield Components on Seed Yield in F_4 Families of Rice *(Oryza sativa* L.)

Khonang Longkho and P.C. Kole

Department of Genetics and Plant Breeding, Visva-Bharati University, Sriniketan 731 236, West Bengal, India

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ABSTRACT

The experiment was conducted in a population comprising 30 F_4 families of rice (*Oryza sativa* L.) derived from 15 different crosses. The effects of 10 yield components *viz.*, plant height, panicle length, flag leaf area, panicle number, number of primary and secondary branches panicle^{-1}, spikelet number panicle^{-1}, spikelet ferilty per cent, 100-grain weight, grain yield panicle^{-1} on grain yield plant^{-1} were studied. Association studies indicated that correlations of grain yield with primary branches panicle^{-1}, secondary branches panicle^{-1}, number of spikelet and grain yield panicle^{-1} were positive and significant at both genotypic and phenotypic levels. Path analyses at both genotypic and phenotypic revealed that the direct selection for primary branches panicle^{-1} and secondary branches panicle^{-1} with restricted selection for number of panicles, length for panicle and 100-grain weight will increase the yield of rice in the population under study comprising F_4 families of rice.

Key words: *Correlation coefficient, Path coefficient, Yield components, Grain yield, F_4 families, Rice.*

Introduction

Rice is one of the most important staple foods for more than 3.5 billion people in the world. The role of rice is inevitable and it is one of the most important strategic crops for food and nutrition security globally. In India, it is the major cereal and provides 21% of global human *per capita* energy and 15% of *per capita* protein (FAO, 2012). Although it is cultivated widely in India, the current exponential growth in the population makes it insufficient and thus, its demand increases enormously. Therefore, to achieve self-sufficiency in production and to maintain price stability, more variability is required to develop new higher-yielding varieties. Variability in rice generally exists in germplasm collection and when this is often exploited to a maximum extent by way of selection, additional variability can be created by crossing the suitable parents.

Grain yield is a complex polygenic quantitative trait that is greatly affected by the environment. Hence, the selection of superior genotypes based on yield as such is not effective. Therefore, in any breeding programmes selection has to be made for the components of grain yield to ensure food security. Correlation is an important factor for selection which measures the association between characters and helps to identify important characters to be considered for making an effective selection. Correlation along with direct and indirect effects of path analysis helps in identifying suitable selection criteria for improving the yield. The present investigation was carried out in 30 F_4 families of rice derived from 15 different crosses to understand the cause-effect relationship of yield components of seed yield.

Materials and Methods

The experimental materials comprised the F_4 seeds borne on selected 30 individual F_3 plants derived from 15 different crosses (Table 1). The crop was raised during *kharif* season (July-December) in Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan. The experimental site is situated at $23^0 19'$ N latitude and 87^0 42′ E longitude and at an altitude of 58.9 m above sea level. The average rainfall ranges from 1300 to 1600 mm prevailing subtropical humid climatic conditions. The soil is sandy loam in texture with medium to low fertility status and acidic in nature, representing more or less red and lateritic soils. The seeds of 30 F_4 families were sown separately in the seedbed. Thirty-day old single seedling per hill was transplanted in randomized complete block design (RCBD) with three replications. Each plot consisted of 4 rows each with 20 plants with a spacing of 20 cm × 15 cm. Standard agronomic packages and practices were followed to raise a good and healthy crop. Data were recorded on randomly selected 20 plants from each plot in each replication. Statistical analyses were done following standard procedures.

Results and Discussion

The genotypic and phenotypic correlations between eleven quantitative characters (Table 2) revealed that grain yield exhibited significant and positive correlation at both genotypic and phenotypic levels with primary branches panicle^{-1}, secondary branches panicle^{-1}, number of spikelet and grain yield panicle^{-1}. A strong correlation of grain yield with these traits indicates that improvement in grain yield would be possible through the selection of these characters. These results were in conformity for primary branches panicle^{-1} and secondary branches panicle^{-1} (Biswash *et al*., 2015; Nath and Kole, 2021) and for the number of spikelets (Sameera *et al.,* 2016; Swapnil *et al.,* 2020; Nath and Kole, 2021). However, spikelet fertility exhibited a negative non-significant correlation with grain yield which is as per the findings of Rai *et al.* (2013).

Plant height registered positive and significant correlation at both levels with panicle length, flag leaf area, secondary branches panicle^{-1}, number of spikelets and 100-grain weight, while it showed negative and non-significant association with the number of panicles. The results of correlations of plant height are in agreement with the reports of Ria *et al.* (2015) for the number of spikelets; Swapnil *et al.* (2020), Saha *et al*. (2019) and Bhargava *et al*. (2021) for panicle length; Kishore *et al*., (2018) for 100-grain weight; and Hossain *et al*. (2018) for secondary branches panicle^{-1}. Plant height showed a negative association with the number of panicles (Ketan and Sarkar, 2014; Kishore *et al*., 2018). The results revealed that taller plants have bold seeds with less number of effective tillers and spikelet fertility.

Panicle length exhibited a positive and significant correlation at both levels with flag leaf area, secondary branches panicle^{-1}, number of spikelets and 100-grain weight. But, it revealed a negative non-significant correlation with the number of panicles, spike-

Table 1. List of 30 F_4 Families

Family No.	Pedigree of cross	Family No.	Pedigree of cross
1	Sitabhog × IET 14142 (1)	16	Kerala Sundari × IET 14143(2)
2	Sitabhog × IET 14142 (2)	17	Kerala Sundari × IET 14143 (3)
3	Sitabhog × IET 14142 (3)	18	Kerala Sundari × IET 14143 (4)
4	Sitabhog × IET 14143 (1)	19	Kerala Sundari × IET 14143 (5)
5	Sitabhog × IET 14143 (2)	20	Kerala Sundari × Kalonunia (1)
6	IET 14142 × Subhasita (1)	21	Kerala Sundari × Kalonunia (2)
7	IET 14142 × Subhasita (2)	22	Shantibhog × Kerala Sundari (1)
8	IET 14142 × Dudheswer	23	Shantibhog × Kerala Sundari (2)
9	IET 14142 × Kalonunia (1)	24	Shantibhog × Subhasita
10	IET 14142 × Kalonunia (2)	25	Shantibhog × Kalonunia
11	Shantibhog × IET 14142 (1)	26	IET 14143 × Kalonunia (1)
12	Shantibhog × IET 14142 (2)	27	IET 14143 × Kalonunia (2)
13	Kerala Sundari × IET 14142 (1)	28	IET 14143 × IET 14142 (1)
14	Kerala Sundari × IET 14142 (2)	29	IET 14143 × IET 14142 (2)
15	Kerala Sundari × IET 14143 (1)	30	Chamarmoni × Sitabhog

Table 2. Genotypic (G) and phenotypic (P) correlation for eleven quantitative characters in F_4 families of rice

Character		Panicle length (cm)	Flag leaf area (cm²)	Number of panicle	Primary branches	Secondary branches	Number of spikelet	Spikelet fertility (%)	100-grain weight (g)	Grain yield/ panicle (g)	Grain yield/ plant (g)
Plant height(cm)	G	0.82**	0.49**	-0.33	0.25	0.58**	0.50**	-0.27	0.61**	0.32	0.27
	P	0.56**	0.46*	-0.26	0.19	0.53**	0.48*	-0.23*	0.48*	0.28*	0.24
Panicle length(cm)	G		0.55**	-0.41*	0.31	0.67**	0.51**	-0.24	0.52**	0.23	0.12
	P		0.39*	-0.24	0.17	0.48*	0.38*	-0.11	0.35	0.20	0.11
Flag leaf area (cm²)	G			-0.50**	0.31	0.42*	0.34	-0.02	0.76**	0.51**	0.31
	P			-0.43*	0.25	0.35*	0.34*	-0.03	0.58**	0.45*	0.25
Number of panicle	G				-0.34	-0.23	-0.23	-0.06	-0.49**	-0.48	0.06
	P				-0.24	-0.15	-0.20	-0.07	-0.35	-0.49**	0.10
Primary branches	G					0.90**	0.88**	-0.24	0.40*	0.77**	0.73**
	P					0.73*	0.75*	-0.14	0.21	0.60**	0.60**
Secondary branches	G						0.94**	-0.35	0.47*	0.62**	0.68**
	P						0.87*	-0.30	0.32	0.53**	0.63**
Number of spikelet	G							-0.43*	0.33	0.59**	0.65**
	P							-0.39*	0.25*	0.52**	0.58**
Spikelet fertility %	G								-0.04	-0.11	-0.29
	P								-0.02	-0.05	-0.20
100-grain weight(g)	G									0.54**	0.31
	P									0.47*	0.28
Grain yield/panicle(g)	G										0.80**
	P										**0.74****

*, ** Significant at p=0.05 and P=0.01, respectively

Table 3. Genotypic path coefficient analysis of ten characters on grain yield in F_4 families of rice

Character	Plant height (cm)	Panicle length (cm)	Flag leaf area (cm²)	Number of panicle	Primary branches	Secondary branches	Number of spikelet	Spikelet fertility (%)	100-grain weight (g)	Grain yield/ panicle(g)	Correlation with grain yield
Plant height(cm)	**0.4798**	-0.312	0.156	-0.167	0.134	0.218	-0.278	0.037	-0.210	0.211	0.2692
Panicle length(cm)	0.391	**-0.383**	0.173	-0.207	0.168	0.255	-0.284	0.034	-0.181	0.155	0.1219
Flag leaf area(cm²)	0.237	-0.209	**0.316**	-0.255	0.171	0.158	-0.187	0.002	-0.262	0.342	0.3137
Number of panicle	-0.158	0.156	-0.159	**0.508**	-0.186	-0.086	0.126	0.008	0.169	-0.321	0.0564
Primary branches	0.118	-0.118	0.099	-0.174	**0.544**	0.340	-0.487	0.34	-0.139	0.513	0.7301**
Secondary branches	0.277	-0.259	0.132	-0.116	0.491	**0.377**	-0.520	0.048	-0.164	0.409	0.6768**
Number of spikelet	0.241	-0.196	0.107	-0.115	0.479	0.354	**-0.554**	0.060	-0.113	0.391	0.6526**
Spikelet fertility (%)	-0.130	0.095	-0.010	-0.030	-0.132	-0.132	0.239	**-0.138**	0.015	-0.072	-0.2902
100- grain weight(g)	0.291	-0.200	0.239	-0.248	0.219	0.178	-0.180	0.006	**-0.346**	0.358	0.3189
Grain yield/panicle(g)	0.153	-0.090	0.163	-0.245	0.421	0.233	-0.326	0.015	-0.187	**0.664**	0.8001**

Residual effect = 0.1947; *, **: Significant at p=0.05 and P=0.01, respectively; Bold figures indicate direct effects let fertility and grain yield. The positive association of panicle length with 100-grain weight is in agreement with the report of Vanishree *et al*. (2013) and Ali *et al*. (2018) for secondary branches panicle^{-1}, whereas a negative correlation of panicle length with spikelet fertility has been reported by Sameera *et al.* (2016).

Flag leaf area showed a positive significant correlation with secondary branches panicle^{-1},100-grain weight and grain yield panicle^{-1} and negative significant correlation with the number of panicle and spikelet fertility. Similar results were reported for spikelet fertility (Kafi *et al*., 2021) and for the test weight (Kafi *et al*., 2021). Primary branches panicle^{-1} showed a positive significant correlation with secondary branches panicle^{-1}, the number of spikelet, and grain yield panicle^{-1} and negative non-significant correlation with spikelet fertility. Hossain *et al*. (2018) reported similar results for secondary branches panicle^{-1} and grain yield panicle^{-1}. Secondary branches panicle^{-1} showed a positive significant correlation with number of spikelets and a negative association with spikelet fertility. Ketan and Sarkar (2014) reported similar results for number of spikelets. Number of spikelet showed positive significant correlation with grain yield panicle^{-1} and negative significant correlation with spikelet fertility. Spikelet fertility showed negative non-significant correlation with 100-grain weight and grain yield panicle^{-1}. Hundred-grain weight showed positive significant correlation with grain yield panicle^{-1} and grain yield plant^{-1}. Positive association of 100-grain weight, with grain yield panicle^{-1} is in accordance with findings of Prasad *et al.* (2015) and Bagati *et al.* (2016).

The genotypic correlation coefficients were higher than phenotypic correlation co-efficient in majority of the cases. This indicated a robust inherent association between the characters studied and the suppressive effect of the environment modified the phenotypic expression of those characters by reducing phenotypic correlation values (Johnson *et al.*, 1955). Therefore, priority should be given to those traits that has high positive correlation with grain yield such as primary branches panicle^{-1}, secondary branches panicle^{-1} and number of spikelet while making selection for yield improvement.

Path coefficient analysis

Path co-efficient analysis provides an efficient means of checking out the direct and indirect causes of association (Wright, 1921). Ten different yield components were under investigation. High direct effect along with positive and high indirect effects through other traits provides a better chance for a character to be selected in breeding programs (Gour *et al.*, 2017).

In case of genotypic path analysis (Table 3) grain yield panicle^{-1} (0.66) exhibited the highest positive direct effect followed by primary branches panicle^{-1} (0.54), number of panicles (0.50), plant height (0.48), number of secondary branches panicle^{-1} (0.38) and flag leaf area (0.316). The correlation of this character with grain yield was positive and highly significant. Positive direct effects of the aforesaid traits on grain yield indicated their importance in the improvement of grain yield. Similarly, high positive direct effect had been reported earlier for primary branches panicle^{-1} (Rai *et al.,* 2013); number of panicles (Kole *et al.,* 2008; Ria *et al*., 2015; Prasad *et al.,* 2015 and Sameera *et al.,* 2016); flag leaf area (Saha *et al*., 2019); and number of secondary panicle^{-1} (Hossain *et al*., 2018). Some traits expressed negative direct effect such as the number of spikelets (-0.55), panicle length (-0.38) and 100-grain weight (-0.37), suggesting the non-reliablility of theses traits for selection in yield improvement. Similar result were reported earlier for 100-grain weight (Ketan and Sarkar, 2014; Patroti *et al.,* 2015); and panicle length (Patroti *et al.*, 2015 and Sameera *et al.*, 2016 and Kafi *et al*., 2021). The low residual effect (0.19) for the genotypic path analysis indicated that the 81% variability in grain yield was contributed by the ten component characters.

In terms of phenotypic path coefficient analysis (Table 4), grain yield panicle^{-1} (0.87) exhibited the highest positive direct effect and significant positive association with grain yield followed by the number of panicles (0.57), secondary branches panicle^{-1} (0.16), number of spikelet (0.053), plant height (0.053), primary branches (0.045) and flag leaf area (0.023). Grain yield panicle^{-1} showed the highest positive direct effect (0.87) and positive indirect effects through all the characters except the number of panicle, 100-grain weight and panicle length. The correlation of this character with grain yield was very high and positive. Similar results were reported for number of panicles (Swapnil *et al.,* 2020), number of spikelet (Swapnil *et al.,* 2020), flag leaf area (Saha *et al.*, 2019) and secondary branches panicle^{-1} (Hossain *et al*., 2018). It exhibited negative direct effects for panicle length (-0.085), spikelet fertility (-0.038) and 100-grain weight (-0.003). The re-

Table 4. Phenotypic path coefficient analysis of ten quantitative characters on grain yield in F_4 families of rice

Character	Plant height (cm)	Panicle length (cm)	Flag leaf area (cm^2)	Number of panicle	Primary branches	Secondary branches	Number of spikelet	Spikelet fertility (%)	100-grain weight (g)	Grain yield / Panicle (g)	Correlation with grain yield
Plant height(cm)	**0.053**	-0.048	0.011	-0.151	0.009	0.088	0.025	0.009	-0.001	0.243	0.2374
Panicle length(cm)	0.030	**-0.085**	0.009	-0.136	0.008	0.080	0.020	0.004	-0.001	0.176	0.1061
Flag leaf area(cm^2)	0.025	-0.034	**0.023**	-0.245	0.012	0.058	0.018	0.001	-0.002	0.391	0.2465
Number of panicle	-0.014	0.020	-0.010	**0.575**	-0.011	-0.025	-0.011	0.003	0.001	-0.431	0.0972
Primary branches	0.010	-0.015	0.006	-0.137	**0.045**	0.122	0.040	0.005	-0.001	0.527	0.6033**
Secondary branches	0.028	-0.041	0.008	-0.87	0.033	**0.167**	0.046	0.012	-0.001	0.467	0.6301**
Number of spikelet	0.026	-0.033	0.008	-0.120	0.033	0.144	**0.053**	0.015	-0.001	0.453	0.5789**
Spikelet fertility (%)	-0.012	0.009	-0.001	-0.42	-0.006	-0.050	-0.20	**-0.038**	0.001	-0.039	-0.1997
100- grain weight (g)	0.026	-0.030	0.014	-0.206	0.009	0.053	0.0013	0.001	**-0.003**	0.407	0.2830
Grain yield/Panicle (g)	0.015	-0.017	0.010	-0.285	0.027	0.90	0.207	0.002	-0.001	**0.872**	0.7396**

Residual effect: 0.3472; *, ** : Significant at p=0.05 and P=0.01, respectively; Bold figures indicate direct effects

sidual effect (0.34) was moderate at the phenotypic path, indicating that a considerable amount of the variation in yield has been accounted for by the characters studied.

The overall results of both genotypic and phenotypic path analysis revealed that the direct selection for primary branches panicle^{-1} and secondary branches panicle^{-1} with restricted selection for number of panicles, length for panicle and 100-grain weight will increase the grain yield of rice in the population under study comprising F_4 families of rice.

Conclusion

In a nut shell, the estimates of genotype and phenotype coefficients of correlation of primary branches panicle^{-1}, secondary branches panicle^{-1}, number of spikelet and grain yield panicle^{-1} with grain yield are positive and highly significant at both the levels indicating their role in determining grain yield. The results of both genotypic and phenotypic path analysis revealed that the direction of selection for the number of panicles, primary branches panicle^{-1} and secondary branches panicle^{-1} with restricted selection for panicle length and 100-grain weight will increase the yield of rice in the segregating population comprising F_4 families of rice.

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