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TITLE-THE DIRECT AND INDIRECT EFFECTS OF DIFFERENT COMPONENT TRAITS ON YIELD IN SHORT GRAIN AROMATIC RICE (*Oryza sativa* L.) OF ODISHA

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ABSTRACT
The present study was undertaken with the objective to determine the direct and indirect effects of different component traits on grain yield using path coefficient analysis to sort out the most promising genotypes for their future use in thirty indigenous aromatic rice cultivars. The experiment was carried out with 26 land races and 4 aromatic checks which were evaluated in randomized block design with two replications. The 1000-grain weight exhibited maximum positive direct effect on grain yield both at genotypic and phenotypic level. Out of different characters under study, panicle numbers/plant, total grains/panicle, days to 50% flowering and days to maturity exerted greatest indirect effect on yield via other traits. Single plant yield, days to maturity, 1000-grain weight had maximum contribution to genetic divergence.

INTRODUCTION

Rice (*Oryza sativa* L.) (2n = 24) belongs to the family, Poaceae and sub family Oryzoidea, is one of the major staple food consumed by 70% of the world's population. It is estimated that not even 15 % of the potential diversity has been utilized. Thousands of valuable allelic variations of traits of economic significance remain unutilized in nearly all crop plants. Aromatic rice constitutes a small but special group of rice which is considered best in quality. These aromatic rice constitute an important source of genetic variation for utilization in breeding of high yielding aromatic rice varieties and hybrids. They are also adapted to local conditions in areas where in non-basmati grown areas and have very strong aroma under the prevailing warmer climate during grain maturity period. But, unfortunately, these valuable gifts of nature have somehow not got the necessary attention of rice scientists and traders, including exporters, to the extent that Basmati has commanded. As a result in the last several years many valuable aromatic rice varieties have either disappeared or are in the process of disappearing which needs to be addressed to conserve, characterize as well as utilize these valuable genetic resources in various rice breeding programs. Similar works were carried out by Pandey *et al*. (2012), Reddy *et al*. (2013), Ganapati *et al*. (2014), Lingaraja *et al*. (2015). The variability analysis can also be obtained from studies of Chakravarty *et al*. (2013) and Vhora *et al*. (2013).

Our study is involved with the aromatic and short and fine grain traditional landraces of rice locally cultivated by farmers those were either not used, or poorly used as parents in the rice-breeding program. These germplasm can function as the source of alternative genetic pools to the improved varieties. Thus, thirty locally available short and fine grained aromatic rice of Odisha were evaluated for the path coefficient analysis to assess the direct and indirect effects of different component traits present in them.

MATERIALS AND METHODS

The present investigation entitled "Genetic divergence and character association in short grain aromatic rice (*Oryza sativa* L.) of Odisha" was carried out at Rice Research Station, Department of Plant Breeding and Genetics, OUAT, Bhubaneswar during kharif 2017. Geographically, the place is located at about 24.00ºN latitude and 90.25ºE longitude with an elevation of 8.4 meters from the sea level and is characterized by subtropical climate. The soil of the experimental site was clay loam in texture. The objectives of the investigation were to estimate the extent of genetic variability, character association, genetic advance and to have a productive insight into the genetic diversity existing in a set of thirty short grain aromatic rice genotypes including 4 check varieties (Table 1).

Experimental details

The field trial comprising 30 rice germplasm was sown in an individual plot under suitable nursery condition at EB-1 Rice Research Station, OUAT. After the development of seedlings the healthy seedlings (21-24 days) were transplanted in the

main plot with inter and intra row distance of 20 × 15 cm respectively with gross plot size 1000 m2 in a randomized block design replicated twice. The recommended fertilizer dose of 50 kg N, 40 kg P2O5 and 40 kg K2O per hectare was applied as per the scheduled recommended practices. The recommended agronomic practices and plant protection measures whenever necessary were applied from sowing to the harvesting stage for raising a good crop.

Characters Studied

Observations were recorded for ten metric traits taking five competitive plants selected randomly from middle rows of each plot, where as characters like plot yield and days to 50 % flowering were recorded on plot basis and number of effective tillers was observed on square meter basis.

The test genotypes are were evaluated for yield and its components and the data on the following characters were recorded in each replication

Days to 50% flowering (DF)

Period in number of days was recorded when panicles were found to emerge out of the boot leaf in about 50% of the tillers in the experimental plot.

Days to maturity (DM)

Period in number of days recorded from sowing to harvest when in 80% - 85% of panicles of the plants in the plot turned yellow to brownish in color.

Plant Height (PH)

Height from the base of the plant to the tip of top most (tallest) panicle measured in cm.

Flag Leaf Area (FLA)

It was measured to the nearest square centimeter by multiplying the conversion factor (0.725) to the product of the length (measured in centimeter from the juncture to the tip of the leaf lamina) and breadth measured in centimeter where it is maximum) of the flag leaf. This was averaged over five sample flag leaves.

Panicle numbers/plant (PN)

It was recorded as the number of tillers per plant/ hill and recorded on 5 plant samples.

Panicle Length (PL)

Length of panicle from the ciliate base to the tip of the topmost panicle of the main culm measured in cm.

Total grains/panicle (TG)

It was recorded as the average number of total grains counted from the panicles of five plant samples.

Fertile grains/panicle (FG)

It was recorded as the average number of fertile grains counted from the panicles of five sample tillers.

1000-grain weight (1000-GW)

It was recorded by taking weight of well developed

1000-grains at about 14% grain moisture level and expressed in grams (g).

Grain yield/plant (PY)

It was recorded as the average weight of the grains (g) collected from the 5 sample plants in gram at about 14% moisture level.

Path Coefficient analysis

The path coefficient analysis is a type of cause and effect relationship among the various correlated characters. Path coefficients are standardized partial regression coefficients, which individually provide a measure of the direct effect of a causal factor on the effect variable. These permit partitioning of the correlation between a causal factor and. the effect variable into components of direct and indirect effects, and thus give a better picture of the associations of the causal factors with the effect variables.

In the present investigation, grain yield per plant was taken as the 'effect' with other characters related to yield as the causal factors.

The path coefficients were obtained by solving the following simultaneous equations, which give the basic relationship between correlation and path coefficients in a system of correlated causes (Wright, 1921; Dewey and Lu, 1959).

r1.10 =P1.10 + r1.2 P2.10 + r1.3 P3.10 +... .....+ r1.9 P9.10

r2.10 = r2.1 P1.10 + P2.10 + r2.3 P3.10 + ...+ r2.9 P9.10

r3.10 = r3.1 P1.10 + r3.2 P2.10 + P3.10 + ...+ r3.9 P9.10

.....

.....

r9.10 = r9.1 P1.10+ r9.2 P2.10 + r9.3 P3.10 +.....+ P9.10

Where,

rij is the coefficient of correlation between ith and jth characters and P is the path coefficient (direct effect) of the ith character on yield.

The solutions for path coefficients, direct and indirect effects of the causal factors were estimated as the values of the individual terms of above equation before in the R.H.S.

The coefficient of determination (R^2) and the residual effect (P11.R) were calculated as follows.

I = P211.R1. + Piy.riy

$R^2 = \sum$ Piy riy4

$$\sqrt{1-\sum p_{iy}r_{iy}}$$

$$\sqrt{1-(p_{1.11}+r_{1.11}+p_{2.11}r_{2.11}+p_{3.11}r_{3.11}+.....+p_{10.11}r_{10.11}}$$

The path analysis at the phenotypic level with the same cause and effect relationship was computed using the phenotypic correlation as stated earlier.

RESULTS AND DISCUSSION

Path analysis has been used to organize the relationship between predicted variable and responsible variables. To understand the direct and indirect effects of each character on grain yield and the application of selection pressure in a better way for yield improvement, partitioning of correlation coefficient into direct and indirect effects through path

Table 1: Path co-efficient analysis of direct (diagonal) and indirect effects of various traits on grain yield per plant

Characters		DF	DM	PH	FLA	PN	PL	TG	FG	1000-GW	PY (Plant Yield)
Days to flowering	rp	-0.016	-0.051	0.018	0.001	0.095	0.01	0.017	0.077	0.064	0.215
(DF)	rg	-0.062	-0.053	0.024	0.002	0.112	0.011	-0.012	0.121	0.083	0.225
Days to Maturity	rp	-0.011	-0.072	0.04	-0.006	0.186	0.016	0.007	0.001	0.1	0.26
(DM)	rg	-0.043	-0.077	0.051	-0.011	0.214	0.018	-0.005	0.004	0.115	0.266
Plant Height (cm)	rp	0.003	0.028	-0.102	0.013	-0.028	0.006	0.035	0.133	0.071	0.158
(PH)	rg	0.11	0.03	-0.131	0.023	-0.03	-0.007	-0.022	0.194	0.076	0.159
Flag leaf area(cm2)	rp	-0.001	0.012	-0.036	0.036	-0.334	-0.027	0.011	0.026	0.371	0.058
(FLA)	rg	-0.002	0.014	-0.046	0.065	-0.374	-0.029	-0.007	0.032	0.406	0.059
Panicles/hill	rp	-0.002	-0.022	0.005	-0.02	0.6	0.031	0.043	0.147	-0.302	0.479
(PN)	rg	-0.011	-0.025	0.006	-0.037	0.66	0.035	-0.028	0.223	-0.334	0.489
Panicle Length(cm) (PL)	rp	-0.002	-0.016	-0.008	-0.013	0.257	0.073	0.038	0.142	-0.201	0.27
	rg	-0.008	-0.017	-0.011	-0.024	0.293	0.079	-0.024	0.206	-0.222	0.271
Total Grains/ Panicle (TG)	rp	-0.002	-0.004	-0.028	0.003	0.202	0.022	0.127	0.488	-0.272	0.536
	rg	-0.009	-0.005	-0.036	0.005	0.236	0.024	-0.08	0.706	-0.298	0.543
Fertile grains/ panicle (FG)	rp	-0.002	0	-0.027	0.002	0.172	0.02	0.121	0.513	-0.297	0.502
	rg	-0.01	0	-0.034	0.003	0.2	0.022	-0.076	0.735	-0.331	0.508
1000-grain weight	rp	-0.001	-0.01	-0.01	0.018	-0.247	-0.02	-0.047	-0.208	0.732	0.207
(1000-GW)	rg	-0.007	-0.011	-0.013	0.003	-0.28	-0.22	0.03	-0.309	0.788	0.21

coefficient analysis is very important.

During the present investigation the path analysis was carried at both genotypic and phenotypic level, which is presented in Table 1. The results obtained there from are presented below.

It was observed from the path coefficient analysis that the 1000-grain weight exhibited maximum positive direct effect on grain yield both at genotypic and phenotypic level, followed by panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length and flag leaf area. The other traits like days to 50% flowering, days to maturity and plant height exhibited negative direct effect on grain yield. It is interesting to note that total grains/panicle has both positive and negative direct effect on yield. Out of different characters under study panicle numbers/plant, total grains/panicle, days to 50% flowering and days to maturity exerted greatest indirect effect on yield via other traits.

Thus from the foregoing observations on direct and indirect effects, the traits like 1000-grain weight, panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length, flag leaf area, panicle numbers/plant, total grains/panicle, days to 50% flowering and days to maturity may be considered as important selection criteria for realization of high and stable yields in rice.

The correlation coefficient between characters like panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length, flag leaf area, panicle numbers/plant, total grains/panicle, days to 50% flowering exhibited more or less similar direct effect indicating that correlation explains the true relationship and therefore direct selection through these traits would be effective.

The correlation coefficient was found to be positive and the direct effect was negative or negligible for traits like days to 50% flowering, days to maturity and plant height, indicating that the indirect effects seem to be the cause of correlation. In such situation the indirect causal factors need to be considered simultaneously for selection.

The correlation coefficient was found to be negative and the direct effect was positive for traits like1000-grain weight, panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length and flag leaf area days to 50% flowering, days to maturity. Under these circumstances, a restricted selection model is followed, *i.e.* restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of direct effects.

The residual effect was estimated to be 0.502 on phenotype and 0.460 on genotype thus indicating that 50.2% and 46% of total phenotypic and genotypic variability respectively was contributed by above mentioned variables.

Path analysis has been used to organize the relationship between predicted variables and responsible variables. To understand the direct and indirect effects of each character on grain yield and the application of selection pressure in a better way for yield improvement, partitioning of correlation coefficient into direct and indirect effects through path coefficient analysis is very important. It has been observed that the path coefficients worked out in different sets of characters as well as different cultural conditions show remarkable difference in direct and indirect effects of the component characters on grain yield. Therefore, selection of characters for computation of path analysis becomes essential to obtain reliable information. Different component traits which have direct bearing on yield were considered for computation of path analysis and the results obtained there from are discussed below.

It was observed from the path coefficient analysis that the 1000-grain weight exhibited maximum positive direct effect on grain yield both at genotypic and phenotypic level, followed by panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length and flag leaf area. Out of different characters under study panicle numbers/plant, total grains/panicle, days to 50% flowering and days to maturity exerted greatest indirect effect on yield via. other traits.

Thus from the foregoing observations on direct and indirect

effects, the traits like 1000-grain weight, panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length, flag leaf area, panicle numbers/plant, total grains/panicle, days to 50% flowering and days to maturity may be considered as important selection criteria for realization of high and stable yields in aromatic rice. These findings in relation to different component traits were in agreement with published report on path analysis by Pandey *et al*. (2012), Reddy *et al*. (2013), Ganapati *et al*. (2014), Lingaraja *et al*. (2015) and Patil *et al*. (2016)

The correlation coefficient between characters like panicle numbers/plant, fertile grains/panicle, total grains/panicle, panicle length, flag leaf area, panicle numbers/plant, total grains/panicle, days to 50% flowering exhibited more or less similar direct effect indicating that correlation explains the true relationship and therefore direct selection through these traits would be effective.

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