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Genetic Variability, Path Analysis, Character Association for Yield and its Attributing Traits in F_2 Population of Cross BPT-5204 × IET-21214 in Rice (*Oryza sativa* L.)

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Abstract The present investigation in rice (*Oryza sativa* L.) was undertaken during *kharif*, 2015 to study variability parameters, character association and path analysis and identification of transgressive segregants in respect of grain yield and its component traits in F_2 population of BPT5204 × IET21214 crosses. The distribution pattern of F_2 populations indicated large number of genes with dominance based complementary interaction in the inheritance of total tillers per plant, number of panicles per plant, number of grains per panicle, grain yield per plant and L:B ratio in both crosses but duplicate type of interaction was noticed for days to 50% flowering, panicle length, number of spikelets per panicle, spikelets fertility, test weight, grain length and grain breadth, panicle length and harvest index in BPT5204 × IET21214. GCV and PCV values were relatively higher with high heritability coupled with high genetic advance for total tillers per plant, productive tillers per plant and grains per panicle and grain yield per plant in both the crosses indicating additive gene action in their genetic control. Grain yield per plant was exhibited significant positive correlation with plant height, total tillers per plant, number of panicles per plant, panicle length, number of spikelets per panicle, number of grains per plant and spikelets. Path analysis in F_2 generation of indicated the positive direct effect of total tillers per plant, number of panicles per plant, grains per panicle and panicle length and harvest index on grain yield.

Keywords Transgressive segregation, Heritability, Variability, Association.

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Introduction

Globally, rice is cultivated on an area of 161.4 million hectare and production of 506.3 million tonnes with a productivity of 3.14 tonnes per hectare. In India, area under rice cultivation is 44 million hectare and production of about 104.0 million tonnes with the productivity of about 2.40 tonnes per hectare. In Karnataka, it is being cultivated in an area of 13.43 lakh ha with a production of 39.53 lakh tonnes and productivity of 3.09 tonnes per ha. In Southern Transition Zone, the total geographical area is 13.09 lakh ha comprising of 14 taluks coming under Shivamogga. Davanagere, Chikmagalur, Hassan and Mysore districts. Annual rainfall of the zone ranges from 611.70

to 1053.90 mm. It consists irrigated paddy area of 1.50 lakh ha with a production of 4.20 lakh tonnes and productivity 2.71 tonnes per hectare [1]. The success of any breeding program depends upon the genetic variability present in the base population and relationship of various characters towards yield. Improvement in any trait is solely depends on the amount of variability present in the base material of that trait. Heritability is the heritable portion of phenotypic variance. It is a good index of the transmission of the characters from parents to offspring. Genotypic coefficient of variation together with heritability estimate would give the best picture of the amount of advance to be expected from the selection [2]. Relatively high heritability and genetic advance estimates for the desired traits helps in advancing the potential segregating generations to develop desirable recombinant in bred lines and commercial cultivars [3]. Several genetic parameters viz., analysis of variance of each mean value, phenotypic and genotypic variances, phenotypic and genotypic coefficient of variation, broad sense heritability (h^2) and genetic gain on which the breeding methods are formulated for its further improvement. The extent of variability is measured by genotypic coefficient of variance and phenotypic coefficient of variance which provide information about relative amount of variation in different characters. Yield is a complex polygenic quantitative trait and composed of several components. Some of which affect the yield directly while others contributes indirectly. Correlation studies provide an opportunity to study the magnitude and direction of association of yield with its direct and indirect components and also among various components. Correlation and path analysis thus help in identifying suitable selection criteria for improving the yield.

Materials and Methods

The present investigation was carried out during *kharif* 2015 at Agricultural and Horticultural Research Station (AHRS), UAHS, Kathalagere, University of Agricultural and Horticultural Sciences, Shivamogga. The experimental material for the present investigation comprised of F_2 population viz., BPT5204 × IET21214 and parents as checks. Observations on quantitative traits were recorded on 20 randomly chosen plants of non-segregating populations viz., parents (BPT5204, IET21214), while in case of F_2 segregating populations, data was recorded on 450 competitive plants in F_2 population BPT5204 × IET21214 cross excluding border plants. Observations taken on the quantitative traits like plant height (cm), Days to 50% flowering, Total tillers per plant, Number of panicles per plant, Panicle length (cm), Number of spikelets per panicle, Number of filled grains per panicle, Spikelet fertility (per cent), Grain yield per plant (g), Harvest index, Test weight (1000-grain weight in grams), Grain length (mm), Grain breadth (mm), L:B ratio and Grain shape. The data subjected to INDOSTAT software to estimate genetic coefficient of variation (%), phenotypic coefficient of variation (%), Heritability (%) (Broad sense), Genetic Advance and Genetic Advance as percent of mean [3]. The estimates for variability treated as per the categorization. Heritability and genetic advance as percent of mean estimated. Correlation was done and path analysis (direct and indirect effect) done according to standard criteria.

Results and Discussion

Availability of genetic variability is prerequisite for genetic improvement of a crop. Yield being a quantitative character is mainly influenced by large number of genes that are highly influenced by environmental factors. The variability is the sum total of hereditary effects of concerned genes as well as environmental influence. Hence, the variability is partitioned into heritable and non-heritable components with suitable genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance as per cent mean (GAPM). The estimation of these variability parameters helps the plant breeder in achieving the required crop improvement by selection. The range in mean value reflects the extent of phenotypic variability present in breeding material. The values include genetic, environmental and genotype × environmental interaction components. So, the estimation of genetic (heritable) and environmental (non heritable) components of the total variability was required to identify the probable parents. Thus, in the present study coefficient of variability, heritability and predicted genetic advance was compiled with respect to growth, yield and its components (Table 1). Heritabil-

Table 1. Variability parameters for 14 yield and its attributing characters in F_2 population of the cross BPT5204 × IET21214.

Characters	PCV%	GCV%	h^2bs %	GAM%	Minimum	Maximum
Plant height (cm)	6.25	5.65	81.86	10.55	76.50	115.50
Days to 50% flowering	9.30	8.96	92.71	17.78	82.00	114.00
Total tillers per plant	29.46	24.29	67.98	41.28	5.00	27.0
Number of panicles per plant	30.49	24.42	64.14	40.30	5.00	24.0
Panicle length (cm)	11.80	10.37	77.25	18.80	16.00	30.0
Number of spikelets per panicle	28.54	27.58	93.36	54.91	70.00	376.00
Number of grains per panicle	30.92	30.43	96.82	61.68	40.00	364.00
Spikelet fertility (%)	7.26	6.59	82.51	12.35	57.14	98.5
Grain yield per plant (g)	30.16	28.79	91.11	56.63	13.00	68.5
Test weight (g)	7.80	6.94	79.07	12.72	16.22	25.1
Harvest index	15.33	14.60	90.75	28.70	0.20	0.5
Grain length (mm)	3.53	3.21	82	6.01	7.43	8.9
Grain breadth (mm)	5.35	4.76	79.06	8.75	1.97	2.8
L:B ratio	6.05	5.23	74.71	9.34	2.98	4.1

ity estimates along with genetic gain would be more useful than the former alone in predicting the effectiveness of selection. Therefore, it is essential to consider the predicted genetic advance along with heritability estimate as a tool in selection program for better efficiency. The range of variability was high for total tillers per plant, number of panicles per plant, number of spikelets per panicle, number of grains per panicle and grain yield per plant in both the crosses but plant height, days to 50% flower, panicle length, spikelet fertility, test weight, harvest index, grain length, grain breadth and L : B ratio which exhibited low to moderate amount variability in both the crosses. This suggested possibility of improvement of the highly variable characters created by segregation and recombination, whereas, it may not be equally effective for a character, which exhibited narrow range of variability. Low PCV and GCV values in the cross BPT5204 × IET21214 with negligible difference between them indicating low genetic variability as well as less influence of environment. The trait exhibited high heritability coupled with moderate to high genetic advance expressed as the per cent of mean in both the crosses indicating role of non-additive gene action in its genetic control. Days to 50% flowering exhibited low values of GCV and PCV and difference between them was relatively narrow in both the crosses which indicated low variability and less influence of environment in the expression of this trait. Broad sense heritability was high coupled with moderate genetic advance as percent of mean indicating predominant role of non-additive gene action in both the crosses. Total tillers per plant reveals higher values of GCV and PCV in both the crosses. High heritability coupled with high genetic advance as per cent of mean exhibited by this trait in both the crosses indicated predominant role of additive gene action in selection of desirable segregants. Number of panicles per plant showed higher estimates of GCV and PCV with high difference between them indicating more environmental influence on expression of this trait in both the crosses [4] have also reported results of similar trend for this trait. Both broad sense heritability and genetic advance as per cent of mean observed to be higher in both the crosses which indicated predominant role of additive gene action and greater scope of further improvement of this trait through simple selection. The heritability estimates was higher coupled with moderate genetic advance expressed as per cent of mean indicating predominant role of non-additive gene action in both crosses. Number of spikelets per panicle exhibited higher values of GCV and PCV. High heritability coupled with high genetic advance as per cent of mean exhibited by this trait in both the crosses idicated predominant role of additive gene action in selection of desirable segregants. [5]. The cross registered high PCV and GCV for grains per panicle with negligible difference indicating the least environmental influence in the expression of this trait higher values of GCV and PCV [6]. Broad sense heritability and genetic advance estimates were also higher in both the crosses indicating usefulness of

Table 2. Estimates of phenotypic correlation coefficients of grain yield with its component characters as well as among the component characters in BPT5204 × IET21214 F_2 population of rice. X1 Plant height (cm), X2 Days to 50% flowering, X3 Total tillers per plant, X4 Number of panicles per plant, X5 Panicle length (cm), X6 Number of spikelets per panicle, X7 Number of grains per panicle, X8 Spikelet fertility (%), X9 Test weight (g), X10 Harvest index, X11 Grain length (mm), X12 Grain breadth (mm), X13 L : B ratio.

Character	X1	X2	X3	X4	X5	X6	X7
X1	1	0.038	-0.002	0.002	0.817**	0.383**	0.345**
X2		1	0.060	0.065	0.024	0.036	0.054
X3			1	0.931**	0.013	-0.077	-0.081
X4				1	0.019	-0.076	-0.085
X5					1	0.455**	0.422**
X6						1	0.982**
X7							1
X8							
X9							
X10							
X11							
X12							
X13							

Table 2. Continued.

Character	X8	X9	X10	X11	X12	X13	X14
X1	0.044	0.109*	0.182**	0.015	0.154**	-0.124**	0.146**
X2	0.118*	0.050	0.013	0.052	0.086	-0.43	0.081
X3	-0.090	-0.024	-268**	0.009	0.147**	-0.120*	0.580**
X4	-0.110*	-0.050	-233**	-0.023	0.118*	-0.116*	0.606**
X5	-0.009	0.187**	0.238**	0.018	0.253**	0.206**	0.228**
X6	0.234**	0.053	0.333**	0.069	0.131**	0.079	0.241**
X7	0.394**	0.051	0.359**	0.077	0.124**	-0.068	0.267**
X8	1	0.033	0.290**	0.068	0.012	0.029	0.221**
X9		1	0.061	0.231**	0.358**	-0.182**	0.016
X10			1	0.0934*	0.117*	-0.051	0.507**
X11				1	0.084	0.512**	0.035
X12					1	-0.809**	0.205**
X13						1	-0.160**

this trait in selection of desirable segregants due to its genetic control by additive gene action. Spikelets fertility showed low PCV and GCV with broad sense heritability estimates was higher coupled with moderate genetic advance expressed. Reported similar results with respect to heritability. Both PCV and GCV values were higher for grain yield with considerable difference between them in both the crosses, indicating wide variability and substantial environmental influence on the expression of this trait. However, this trait recorded high level of broad sense heritability coupled with high genetic advance expressed as per sent of mean in both the crosses. Phenotypic and genotypic coefficients of variability was low for test weight in both crosses [7]. Test weight showed high heritability estimates in cross, but low and moderate genetic advance as per cent of mean for this character in cross BPT5204 × IET21214. Phenotypic and genotypic coefficients of variability observed was moderate for harvest index [8]. Harvest index showed high heritability estimates in both crosses [9] where as high genetic advance as per cent of mean for this character. Grain length, grain breadth and L : B ratio in both crosses exhibited low PCV and GCV values with high heritability [10] but low genetic advance as per cent of mean was noticed for these trait.

Character association and path analysis.

The phenotype of a plant is the result of interaction

Table 3. Estimates of direct and indirect effects of component characters on grain yield in F_2 generation of the cross BPT5204 × IET21214. Residual effect = 0.3890. Where, Figures in bold letter represent direct effect. X1 Plant height (cm), X2 Days to 50% flowering, X3 Total tillers per plant, X4 Number of panicles per plant, X5 Panicle length (cm), X6 Number of spikelets per panicle, X7 Number of grain per panicle, X8 Spikelet fertility (%), X9 Test weight (g), X10 Harvest index, X11 Grain length (mm), X12 Grain breadth (mm), X13 L:B ratio.

Trait	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	**-0.030**	-0.001	0.0007	-0.0001	-0.024	-0.011	-0.010	0.001	-0.003	-0.005	-0.0005	-0.004	0.003
X2	0.0004	**0.009**	0.0006	0.0006	0002	0.0003	0.0005	0.001	0.005	0.001	0.0005	0.0008	-0.004
X3	-0.008	0.022	**0.371**	0.346	0.004	-0.028	-0.030	-0.033	-0.009	-0.099	0.003	0.054	-0.044
X4	0.001	0.027	0.394	**0.423**	0.008	-0.032	-0.036	-0.047	-0.021	-0.098	-0.009	0.050	-0.049
X5	0.052	0.001	0.0008	0.001	**0.063**	0.029	0.026	-0.0006	0.011	0.015	0.001	0.016	-0.013
X6	0.038	0.003	-0.007	-0.007	0.045	**0.099**	0.097	0.023	0.005	0.033	0.006	0.013	-0.007
X7	-0.020	-0.003	0.004	0.0050	-0.024	-0.057	**0.058**	-0.022	-0.030	-0.020	-0.004	-0.007	0.004
X8	-0.005	0.013	-0.010	-0.012	-0.001	0.026	0.044	**0.112**	-0.038	0.032	0.007	0.001	0.003
X9	-0.0005	-0.0002	0.0001	0.0002	-0.0009	-0.0003	-0.0002	-0.0002	**-0.004**	-0.0003	-0.001	-0.001	0.0000
X10	0.119	0.008	-0.175	-0.152	0.155	0.2175	0.234	0.189	0.039	**0.652**	0.060	0.076	-0.033
X11	0.0002	-0.0006	-0.0001	0.0003	-0.0002	-0.0008	-0.0009	-0.0008	-0.002	-0.001	**-0.012**	-0.001	-0.006
X12	-0.002	-0.001	-0.0026	-0.002	-0.004	-0.002	-0.002	-0.002	-0.006	-0.002	-0.001	**-0.017**	0.014
X13	0.003	0.001	0.003	0.003	0.006	0.002	0.002	-0.0009	0.005	0.001	-0.0016	0.025	**-0.031**
R valu	0.146	0.081	0.580	0.606	0.228	0.241	0.267	0.221	0.016	0.507	0.035	0.205	-0.160

of a large number of factors (Table 2). Hence final yield is the sum of total effect of several component factors. Therefore, it is important to know the extent and nature of inter-relationship prevailing between grain yield and its component characters and also among themselves. Character associations may vary with environmental conditions. Association of economically important yield components of quantitative nature is quite useful as basis of selection. Since breeder has to handle a very large population in achieving the objectives, it is impossible to evaluate the population for each and every quantitative traits. Therefore, it is necessary to have the estimates of correlation of yield with other traits for which the genotypes could be assessed visually or measured easily. Thus correlation analysis helps in examining the possibility of improving yield through indirect selection of its component traits which are highly correlated with yield. In the present study, character associations among all the characters related to grain yield in F_2 population of BPT5204 × IET21214 were estimated and the results obtained are discussed below. Grain yield per plant exhibited significant and positive association with important yield components like plant height, total tillers per plant, number of panicles per plant, panicle length, and number of spikelets per panicle, number of grains per plant and spikelet fertility. Grain breadth showed significant and positive association with grain yield in both crosses. Harvest index had significant and positive association with grain yield in both crosses. Days to 50% flowering shown non-significant and positive association was observed in BPT5204 × IET21214. Non-significant and positive association was noticed for test weight. Grain length showed non-significant and positive association with grain yield was observed in BPT5204 × IET21214 population.

Path analysis

Path analysis is a useful technique to understand more clearly the association among different variables considering simple correlation coefficients. It helps to partition the overall association of particular variables with dependent variable in to direct and indirect effects (Table 3). When the influence of a set of variables on the dependent variable is to be understood, it is possible with the help of path analysis that estimates the extent of direct contribution of a particular variable and the extent of its indirect contribution through other variables in a set to the total influence it has on the dependent variable.While dealing with a more complex character like yield, it enables the breeders to identify the important component traits of such a nature so that differential emphasis can be laid on such component characters for selection. Path analysis was carried out in both the crosses using all the component traits. Path analysis for grain yield indicated positive direct effect of number of panicles per plant and number of grains per panicle on grain yield [4]. Positive correlation of number of panicles per plant with grain yield was also due to low positive indirect effect on grain yield via plant height and panicle length. Grains per panicle had positive indirect effect via, total tillers per plant and number of panicles per plant on grain yield. Days to 50% flowering showed positive direct effect on grain yield. But low positive and indirect effect on grain yield through all characters except L:B ratio. Total tillers per plant showed high positive direct effect on grain yield. It had indirect positive effect on grain yield through number of panicles per plant, panicle length and days to 50% flower. Number of spikelets per panicle showed positive direct effect on grain yield. Positive indirect effect was observed through number of grains per panicle, panicle length, spikelet fertility, plant height, test weight, harvest index, grain length and grain breadth. On the other hand, panicle length showed low positive direct effect and positive in direct effect via grains per panicle, plant height and productive tillers per plant resulting in high positive significant correlation with grain yield. Panicle length, number of spikelets per panicle and spikelet fertility had positive direct effect on grain yield and positive indirect effect on grain yield through grain per panicle. Test weight showed negative direct effect on grain yield. Small and negligible negative indirect effect of test weight on yield was registered through panicle length, number of spikelets per panicle and number of grains per panicle [10]. Positive indirect effect on grain yield via test weight, panicle length, grain breadth and grain length. Grain length, grain breadth and L : B ratio showed negative direct effect on grain yield. Grain length had indirect positive effect on grain yield through plant height and number of panicles per plant. Grain breadth showed indirect positive effect on grain yield via L : B ratio. L : B ratio showed direct negative effect on grain yield. It had indirect positive effect through plant height, panicle length and grain breadth [11].

F_2 population of cross BPT5204 × IET21214 was evaluated for 14 yield and yield component traits. Results of the experiment on variability indicated a scope for improvement of grain yield through selection. Further, studies on character association and path co-efficient revealed the importance of productive tillers per plant. Panicles per plant and test weight as well as spikelets fertility as selection criteria for effective yield improvement. The study also indicated the need for balanced selection in light of negative association of number of filled grain per plant, days to 50% flowering with grain yield per plant; and number of filled grains per panicle with 1000-grain weight in crop yield improvement programs.

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