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Genetic variability and Character Association for Yield and Yield Attributing Traits in Rice

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ABSTRACT: Rice straw, which is mainly composed of cellulose, hemicellulose and lignin, can be used as potential source of bioethanol production. Rice straw is also used for mushroom production and as cattle feed. Rice genotypes having high biomass can suitably be used for these purposes. To identify potential rice varieties having high biomass, an experiment was designed taking twenty-one advanced breeding lines during Kharif-2020. Significant differences were observed for all the twelve characters studied. High estimates of PCV and GCV were recorded for Panicle exertion, number of filled grains, straw yield plant^{-1} and grain yield plant^{-1}. The estimates of GCV and PCV values for panicle exertion, panicle number, secondary branches panicle^{-1}, number of filled grains, panicle length, primary branches panicle^{-1}, straw yield and grain yield showed greater difference. The estimates of PCV and GCV values for plant height, days to flowering and 100-grain weight showed lower difference. High heritability was observed for plant height, days to 50% flowering and 100-grain weight. High genetic advance as percent of mean was observed for panicle exertion. The estimates of phenotypic and genotypic correlations showed that primary branches panicle^{-1}, secondary branches panicle^{-1}, number of filled grains and test weight with grain yield at genotypic level were positive and highly significant. The results pertaining to genotypic path coefficient analysis revealed that secondary branches panicle^{-1} registered the highest positive direct effect, followed by straw yield, 100-grain weight, panicle exertion, number of filled grains, panicle length and primary branches panicle^{-1}. Hence, these characters can be taken as parameters while doing selection in segregating generations of crosses in order to develop high yielding and having high biomass genotypes.

Keywords: Correlation coefficient, genetic advance, heritability, straw yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops belonging to the tribe oryzae of the family Gramineae (Poaceae). The cultivated rice is diploid having 24 chromosomes (2n = 2x = 24). It ranks first among the three major cereals, followed by wheat and maize. *O. sativa* and *O. glaberrima* are believed to have evolved independently from a common ancestor *O. perennis*. The genus *Oryza* contains 25 recognized species. Of which 23 are wild species and two, *O. sativa* and *O. glaberrima* are cultivated (Morishima 1984; Vaughan, 1994; Brar and Khush 2003). In 2016, the global production of rice has been estimated to be at the 741 million tonnes, led by China and India with a combined 50% of the total. Rice provides 21% of global human per capita energy and 15% of per capita protein. In developing countries, rice accounts for 715 kcal/capita/day, 27 per cent of dietary energy supply, 20 per cent of dietary protein and 3 per cent of dietary fibre. The straw available after harvest has the potential of generating biofuel, as it is a store house of cellulose, the raw material for biofuel production.

In any plant breeding programme, availability of large genetic variability in the crop species is the first step to select better performing types among the divergent group. First attempts are made to utilize the variability present in the germplasm pool and when maximum utilization causes exhaustion of such variability, additional variability can be generated be means of conventional and non-conventional innovative approaches. Plant breeder have to find significant correlations among yield and yield component traits, and effect of yield component traits on grain and straw yield to predict the superior cross combinations as well as to select ideal plant types with high yield. Correlation along with path analysis helps in identifying suitable selection criteria for yield improvement. So, the present study was undertaken to know the correlation among yield contributing traits and their association with both grain and straw yield.

MATERIALS AND METHODS

The present investigation was carried out with twenty-one advanced breeding lines derived from eight different cross combinations. Thirty-day old single seedling per hill was transplanted in randomized complete block design (RCBD) with three replications. Each plot consists of 5 rows each with 20 plants with a spacing of 20 cm × 15 cm spacing. Observations were recorded on following twelve different quantitative characters *viz.* plant height, days to flowering, flag leaf area, panicle exertion, panicle length, panicle number, primary branches panicle^{-1}, secondary branches panicle^{-1}, grain number panicle^{-1}, 100-grain weight, straw yield plant^{-1} and grain yield plant^{-1}.

RESULTS AND DISCUSSIONS

The knowledge of genetic variability present in a population for the characters under study is of paramount importance for the success of any plant breeding programme. The estimates of genotypic and phenotypic coefficients of variance ranged from 13.62 and 14.39 in plant height to 23.80 and 32.78 in grain yield (Table 1). Panicle exertion, number of filled grains, straw yield and grain yield plant^{-1} showed high estimates of PCV and GCV. Similar results have been reported for grain number (Krishna *et al.*, 2014) head rice recovery (Manivelan *et al.,* 2022) and grain yield (Krishna *et al.*, 2014). Traits like flag leaf area, panicle number, secondary branches panicle^{-1} showed high estimates of PCV and moderate estimates of GCV. Moderate estimates of PCV and GCV were found in plant height and 100-grain weight. Similar results have been reported for 100-grain weight (Sameera *et al.*, 2016) and number of tillers per plant, number of productive tillers per plant, hundred seed weight (Manivelan *et al.,* 2022). Low estimates of PCV and GCV were found for days to flowering, panicle length and primary branches panicle^{-1}. Similar results have been reported for panicle length (Sameera *et al.,* 2016; Gayatonde *et al.,* 2017). The estimates of GCV and PCV values for panicle exertion, panicle number, secondary branches panicle^{-1}, number of filled grains, straw yield, panicle length, primary branches panicle^{-1} and grain yield showed greater difference which indicated the greater role of environmental factors influencing these characters. The estimates of PCV and GCV values for plant height, days to flowering and 100-grain weight showed lower difference which indicates less sensitivity of these characters towards the fluctuating environments.

The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. The estimates of heritability in broad sense (Table 1) were high for plant height (89.6%), days to 50% flowering (87.8%) and 100-grain weight (75.1%) which revealed that these characters are less influenced by environment and there could be greater correspondence between phenotypic and breeding values. Similar results have been reported for plant height (Chozin *et al.,* 2017; Mamata *et al.,* 2018); days to 50% flowering (Kahani and Hittalmani 2015; Mamata *et al.*, 2018); 100-grain weight (Govintharaj *et al.*, 2016; Mahesh Babu *et al.*, 2017; Mamata *et al.*, 2018) days to 50% flowering number of tillers per plant, plant height, grain yield per plant (Reddy Basu *et al.*, 2022). The estimates of heritability were moderate for flag leaf area, panicle exertion, panicle length, number of primary branches, secondary branches panicle^{-1}, number of filled grain and grain yield plant^{-1}. Similar results have been reported for flag leaf area (Kahani and Hittalmani 2015); panicle length (Kumar and Senapati 2013; Govintharaj *et al.*, 2016; Chozin *et al.*, 2017); number of primary branches (Monohara and Singh 2013); number of secondary branches (Kumar and Senapati 2013; Ketan and Sarkar 2014); number of filled grains (Krishna *et al.,* 2014; Savitha and Kumari 2015; Mamata *et al.*, 2018) and grain yield plant^{-1} (Savita and Kumari 2015; Govintharaj *et al.,* 2016; Chozin *et al.,* 2017). Panicle number and straw yield showed low heritability. Similar results have been reported for panicle number (Krishna *et al.*, 2014).

The genetic advance as per cent of mean (GAM) is a useful indicator of the progress that could be expected as a result of exercising selection on the pertinent population. Genetic advance as a per cent of mean (Table 2) was high for panicle exertion (83.08) and moderate for plant height (26.56), flag leaf area (31.18), secondary branches panicle^{-1} (29.48), number of filled grains (31.31), straw yield (27.84) and grain yield plant^{-1} (35.63), and low for days to flowering (6.99), panicle length (12.85), panicle number (18.63), primary branches panicle^{-1}(11.34) and 100-grain weight (20.84). Moderate GAM was reported earlier for plant height (Mamata *et al.*, 2018), flag leaf area (Yadav *et al.*, 2010;), secondary branches panicle^{-1} (Kumar and Senapati 2013;), number of filled grains (Govintharaj *et al.*, 2016; Mamata *et al.*, 2018) and grain yield (Yadav *et al.*, 2010. Low estimates of GAM were observed for panicle length (Govintharaj *et al.*, 2016; Chozin *et al.*, 2017; Mahesh Babu *et al.*, 2017; Mamata *et al.*, 2018); panicle number (Kumar *et al.*, 2007) and 100-grain weight (Mamata *et al.*, 2018). Heritability in conjunction with genetic advance gives an indication of the nature of gene action. The estimates of the above two parameters for plant height, flag leaf area and panicle exertion indicate the preponderance of additive gene action. Therefore, these characters will respond to selection.

Yield is a complex trait and is the ultimate product of a number of contributing traits. Direct selection of yield shows low effectiveness. The degree of correlation among the characters is important. Therefore, association among characters was undertaken to determine the direction of selection and the number of characters to be considered in improving the yield. The estimates of phenotypic and genotypic correlations (Table 2) showed that primary branches panicle^{-1}, secondary branches panicle^{-1}, number of filled grains and test weight with grain yield at genotypic level are positive and highly significant. A strong correlation of grain yield with these traits indicates that the improvement in grain yield would be possible through selection of these traits. Similar results have been reported for primary branches panicle^{-1} (Rai *et al.*, 2013), grain number (Nandeshwar *et al.*, 2010; Sameera *et al.*, 2016) and 100-grain weight (Surek and Besar 2005; Ramaya *et al.*, 2012). Plant height exhibited highly positive significant correlation with flag leaf area, panicle length, secondary branches panicle^{-1} at both genotypic and phenotypic levels and positive non-significant correlation with days to flowering and panicle exertion. Flag leaf area showed positive significant correlation with primary and secondary branches panicle^{-1}, grain number panicle^{-1} at both genotypic and phenotypic levels and with straw yield at genotypic level. Correlations of panicle length with primary branches panicle^{-1}, secondary branches panicle^{-1} and straw yield were highly positive and significant at genotypic level and positive non-significant with number of filled grains. Panicle number exhibited highly negative significant association with secondary branches panicle^{-1} at genotypic level. Primary branches panicle^{-1} showed highly positive significant correlation with secondary branches and grain number panicle^{-1} at both genotypic and phenotypic level. Association between secondary branches panicle^{-1} and grain number was positive and highly significant. Grain number showed positive and highly significant correlation with 100-grain weight both at genotypic and phenotypic level and 100-grain weight showed highly positive significant correlation with straw yield at genotypic level. Plant height had negative non-significant correlation with panicle number (Rabindra Babu *et al.,* 2012) and positive significant correlation with number of filled grains (Patel *et al.*, 2018). Panicle number was negatively correlated with grain yield (Yadav *et al.*, 2010). Primary branch panicle^{-1} had positive significant correlation with grain number (Rai *et al.*, 2013). Grain number had positive significant correlation with 100-grain weight (Patel *et al.,* 2018). Panicle length had negative non-significant correlation with 100-grain weight (Kohnaki *et al.,* 2013). The genotypic correlation coefficients were higher than phenotypic correlation coefficient in majority cases. This indicated a strong inherent association between the characters studied and suppressive effect of the environment modified the phenotypic expression of these traits by reducing phenotypic correlation values (Johnson *et al.*, 1955). However, the correlation study revealed that number of primary branches panicle^{-1}, secondary branches panicle^{-1}, number of filled grains and 100-grain weight were the most important characters to be considered in the selection for improvement of rice yield in the population under investigation

Genotypic pathway associations of yield attributing characters are presented in Table 3. Correlation is partitioned into direct and indirect effects through genotypic path coefficient analysis. The low residual effect (0.19) for the genotypic path analysis indicated that the 81% variability in grain yield was contributed by the eleven characters.

The results pertaining to genotypic path coefficient analysis revealed that (Table 3) secondary branches panicle^{-1} (0.781) registered the highest positive direct effect, followed by straw yield (0.419), 100-grain weight (0.362), panicle exertion (0.360), number of filled grains (0.203), panicle length (0.174) and primary branches panicle^{-1} (0.111). Secondary branches panicle^{-1} showed positive direct effect and positive indirect effects through all the characters except plant height, days to 50% flowering and flag leaf area resulting positive highly significant correlation with grain yield.

Straw yield exerted positive direct effect and positive indirect effects through panicle length, panicle number, number of primary branches, number of secondary branches, number of filled grains, 100-grain weight which was counterbalanced by negative indirect effects through plant height, days to flowering, flag leaf area and panicle exertion resulting positive non-significant correlation with grain yield. Positive direct effect of 100-grain weight and its positive indirect effects via panicle exertion, number of primary branches, number of secondary branches, number of filled grains and straw yield resulted positive and highly significant correlation with grain yield. Panicle exertion showed positive direct effect and indirect positive effects through days to flowering, panicle number, number of primary branches, number of secondary branches, grain number and 100-grain weight which was reduced by negative indirect effect via plant height, flag leaf area and panicle length resulting positive but non-significant correlation with grain yield. Number of primary branches registered positive direct effect and positive indirect effects through all the traits except plant height, days to 50% flowering and flag leaf area resulting positive highly significant correlation with grain yield. Number of filled grains had positive direct effect and indirect positive effects via most of the component characters which resulted positive and highly significant correlation with grain yield Panicle length showed positive direct effect and positive indirect effects via number of panicles, number of primary branches, number of secondary branches, grain number and 100-grain weight which was counterbalanced by negative indirect effects via some traits resulting positive non-significant correlation with grain yield. Plant height (-0.584), days to flowering (-0.305), flag leaf area (-0.650), panicle number (-0.042) showed negative direct effect on grain yield. Large positive direct effect has been reported for secondary branches panicle^{-1} (Rai *et al.*, 2013), 100-grain weight (Ramaya *et al.,* 2012; Patel *et al.*, 2018), number of filled grains (Kohnaki *et al.*, 2013; Rai *et al.*, 2013; Venkanna *et al.*, 2014), panicle length (Patel *et al.*, 2018). Negative direct effects for plant height (Rabindra Babu *et al.*, 2012) and panicle number have been reported. The results of path analyses reveal that selection of secondary branches and grain number panicle^{-1} and 100-seed weight with restricted selection on panicle number will increase grain yield in this population.

Table 1: Genetic parameters for twelve quantitative characters in advanced breeding lines of rice.

Characters	Grand mean	Range		Coefficient of variation (%)		Heritability (%)	Genetic advance	Genetic advance as percent of mean
		Min	Max	GCV	PCV			
Plant height (cm)	130.69	96.73	156.54	13.62	14.39	89.60	34.71	26.56
Days to flowering	121.46	111	128.00	3.62	3.96	87.80	8.48	6.99
Flag leaf area (cm^2)	27.01	20.32	39.09	18.45	22.50	67.30	8.42	31.18
Panicle excretion (cm)	3.19	1.03	7.65	49.46	60.77	66.30	2.65	83.08
Panicle length (cm)	23.33	19.47	26.39	7.74	9.61	64.90	3.00	12.85
Panicle number	9.29	5.33	11.00	13.71	20.78	43.50	1.73	18.63
Number of Primary branches	10.94	9.68	13.55	7.08	9.11	60.40	1.24	11.34
Number of Secondary branches	24.12	14.95	35.75	18.88	24.90	57.50	7.11	29.49
Grain number panicle^{-1}	108.78	74.45	165.45	20.53	27.75	54.70	34.05	31.31
Test weight (g)	1.92	1.44	2.41	11.78	13.59	75.10	0.40	20.89
Straw yield per plant^{-1} (g)	42.57	25.93	67.05	20.67	31.30	43.20	11.85	27.84
Grain yield per plant^{-1} (g)	16.84	10.95	29.19	23.80	32.78	52.70	6.00	35.63

Table 2: Genotypic(G) and Phenotypic(P) correlation of twelve quantitative characters.

Characters		Days to 50% flowering	Flag leaf area($cm^{2)}$	Panicle exertion (cm)	Panicle length (cm)	Panicle number	Primary branches Panicle^{-1}	Secondary branches Panicle^{-1}	Grain panicle^{-1}	100-grain Weight(g)	Straw yield(g)	Grain yield(g)
Plant height(cm)	G	0.10	0.67**	0.32	0.64**	-0.52*	0.64**	0.76**	0.68**	0.30	0.54*	0.33
	P	0.11	0.57**	0.30	0.57**	-0.37	0.50*	0.59**	0.49*	0.26	0.37	0.22
Days to flowering	G		0.18	-0.02	0.17	-0.05	0.34	0.10	-0.35	0.09	0.58**	-0.07
	P		0.22	0.01	0.21	-0.008	0.24	0.08	0.07	0.11	0.28	-0.005
Flag leaf area (cm^2)	G			0.21	0.36	-0.73**	0.50*	0.76**	0.77**	0.31	0.85**	0.35
	P			0.15	0.37	-0.52*	0.43*	0.48*	0.54*	0.28	0.28	0.18
Panicle exertion(cm)	G				-0.39	-0.33	0.01	0.18	0.51*	0.41	-0.008	0.37
	P				-0.24	-0.20	0.03	0.15	0.41	0.28	0.08	0.26
Panicle length(cm)	G					-0.09	0.56**	0.55**	0.12	-0.06	0.66**	0.14
	P					-0.11	0.37	0.35	0.13	0.02	0.30	0.11
Panicle number	G						-0.24	-0.67**	- 0.60**	0.10	-0.11	-0.07
	P						-0.25	-0.39	-0.35	0.13	0.09	0.29
Primary branches panicle^{-1}	G							0.80**	0.66**	0.42	0.68**	0.61**
	P							0.53*	0.45*	0.26	0.20	0.36
Secondary branches panicle^{-1}	G								0.85**	0.29	0.52*	0.58**
	P								0.62**	0.18	0.28	0.35
Grain number panicle^{-1}	G									0.56**	0.41	0.65**
	P									0.22	0.14	0.38
Test weight(g)	G										0.65**	0.76**
	P										0.32	0.57**
Straw yield(g)	G											0.28
	P											0.20

Table 3: Genotypic path coefficient analysis eleven characters on yield.

Character	Plant height	Days To flowering	Flag Leaf area	Panicle exertion	Panicle length	Panicle Plant^{-1}	Primary branches panicle^{-1}	Secondary Branches Panicle^{-1}	Grain Panicle^{-1}	Test weight	Straw yield	Correlation With grain Yield
Plant height	**-0.584**	-0.033	-0.442	0.116	0.111	0.022	0.072	0.599	0.139	0.109	0.228	0.337
Days to flowering	-0.063	**-0.305**	-0.121	-0.008	0.030	0.002	0.038	0.080	-0.007	0.036	0.246	-0.071
Flag leaf area	-0.397	-0.057	**-0.650**	0.079	0.064	0.031	0.056	0.599	0.158	0.113	0.360	0.355
Panicle exertion	-0.187	0.006	-0.142	**0.360**	-0.069	0.014	0.002	0.141	0.104	0.151	-0.003	0.377
Panicle length	-0.375	-0.053	-0.239	-0.143	**0.174**	0.004	0.063	0.434	0.026	-0.024	0.280	0.147
Panicle Plant^{-1}	0.305	0.105	0.478	-0.120	-0.016	**-0.042**	-0.027	-0.529	-0.123	0.040	-0.050	-0.070
Primary branches panicle^{-1}	-0.377	-0.105	-0.328	0.006	0.099	0.010	**0.111**	0.627	0.135	0.154	0.286	0.618**
Secondary branches Panicle^{-1}	-0.448	-0.031	-0.499	0.065	0.097	0.029	0.089	**0.781**	0.173	0.108	0.219	0.582**
Grain Panicle^{-1}	-0.401	0.011	-0.506	0.185	0.022	0.026	0.074	0.667	**0.203**	0.205	0.172	0.657**
Test weight	-0.175	-0.030	-0.202	0.151	-0.011	-0.005	0.047	0.232	0.115	**0.362**	0.273	0.756**
Straw yield	-0.317	-0.179	-0.559	-0.003	0.116	0.005	0.075	0.409	0.083	0.236	**0.419**	0.286

Residual effect =0.1912; *, ** Significant at p = 0.05 and p=0.01, respectively ; Bold figures indicate direct effect

CONCLUSIONS

Considerable high magnitude of variation was observed in terms of yield, plant height and other yield contributing traits, which revealed that the selected segregants had possessed high grain yield with semi-dwarf to medium stature, high tillering behaviour with resistance to lodging. These lines could be further evaluated for different biofuel characters.

FUTURE SCOPE

Seeds from the promising advanced breeding lines can be forwarded to next generation for further evaluation and extensive testing under different geographical locations with different agronomic management practices.

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