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Association Studies for Yield Components, Physico-chemical and Nutritional Quality Parameters in Colored Rice (*Oryza sativa* L.)

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A B S T R A C T

The present study was undertaken with an objective to determine the degree of association and magnitude of direct and indirect effects between grain yield and other yield components, physico-chemical & nutritional quality traits. Character association studies revealed that panicle length and test weight showed significant positive correlation while days to 50% flowering, alkali spreading value and L/B ratio exhibited significant negative relationship with grain yield/plant. Test weight followed by spikelet fertility percentage and panicle length manifested positive direct effects on grain yield/plant.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in tropics as well as parts of temperate regions in the world. It is the staple food of more than three billion people (Bhattacharjee *et al.*, 2002) in 39 countries that comprises of nearly half of the world's population. Rice is the only cereal, cooked and consumed as a whole grain and quality considerations are much more important than for any other food crops (Hossain *et al.*, 2009). Increased income levels and self-sufficiency induced rice availability for consumption has brought a shift in the consumer as well as market preferences for better grain quality. Nowadays, whole grain pigmented rice has been categorized as one of the potent functional foods since it contains high amounts of phenolic compounds (Yawadio *et al.*, 2007). In addition, colored rice contains higher levels of proteins, vitamins and minerals than common white rice while red rice is good source of fibre, antioxidants, magnesium and iron. Yield is a complex character and dependent on many component traits. Hence, in the present study an attempt was made to study the association between yield and yield contributing characters and quality traits along with direct and indirect effects of yield attributing characters and quality traits on grain yield.

Materials and Methods

The experiment was carried out during *Kharif*, 2017 at Agricultural College Farm, Bapatla, Andhra Pradesh. The experimental material consisted of 26 released/advanced genotypes developed at Agricultural Research Station, Bapatla and the varieties released from ARS Pattambi, Kerala. Among the 26 genotypes studied seven had normal light brown pericarp color (BPT 5204, BPT 2270, BPT 2295, BPT 2782, BPT 2595, BPT 2660 and BPT 2776), eight genotypes possess red pericarp color (Aathira, Samyuktha, MattaTriveni, Jyothi, BPT 3111, Annapurna, Harsha and BPT 3139) and the remaining had black/purple pericarp. These genotypes were evaluated in randomized block design with three replications under dry direct sowing by following manual dibbling method. Each treatment was represented by 5 rows of 3m length in each replication with a spacing of 20cm between rows and 15cm between plants. All recommended cultural practices were followed for raising the crop. Observations were recorded on ten plants selected at random per genotype per replication on 18 yield and quality traits *viz*., days to 50% flowering, panicle length (cm), plant height (cm), ear bearing tillers per plant, grain yield per plant (g), test weight (g), number of filled grains per panicle, total number of grains per panicle, spikelet fertility (%,) solid loss, water uptake, volume expansion ratio, alkali spreading value, length/breadth ratio, amylose content (%), protein content, Zinc content and Fe content. The dehusked samples were utilized for estimation of quality parameters by following standard procedures delineated by Little *et al.*, (1958), DRR (2006), Sidhu *et al.*, (1975) and Juliano (1971). Phenotypic and genotypic correlations were worked out by using the formulae suggested by Falconer (1964). Path coefficient analysis suggested by Wright (1921) and elaborated by Dewey and Lu (1959) was used to calculate the direct and indirect contribution of various traits on grain yield.

Results and Discussion

The phenotypic and genotypic correlation coefficients of different yield components and quality parameters were given in table 1. Among the yield components, ear bearing tillers (0.424** &0.498**) and panicle length (0.277** & 0.358**) exhibited positive and significant association with grain yield/plant while days to 50% flowering (-0.469** & -0.582**) manifested negative and significant relationship suggesting that among the material under study, the genotypes which flowered earlier recorded higher grain yield/plant,

These results were in accordance with the findings of Bhati *et al.,* (2015) and Chowdhury *et al.,* (2016). Days to 50% flowering recorded negative association with plant height and test weight while it's association with ear bearing tillers was positive and significant (0.380** and 0.750**) indicating that the genotypes which flowered earlier recorded more ear bearing tillers and also possessed slender grain. Sharma and Sharma also reported similar findings.

The trait panicle length manifested significant and positive relationship with filled grains/panicle (0.340 and 0.450**), total grains/panicle (0.340** and 0.420**) and spikelet fertility percentage (0.364 and 0.420**) both at phenotypic and genotypic levels respectively suggesting that the genotypes with longer panicle accommodated more number of grains as well as more number of filled spikelets/panicle. These results are in corroboration with the findings of Veni *et al*., (2013).

Table.1 Estimates of phenotypic & genotypic correlation coefficients among yield, yield components and quality traits in rice (*Oryza sativa* L.)

		DFF	PL	PH	EBT	TW	FGP	TGP	SF(%)	SL	WU	VER	ASV	L/B	AC	PC	Zn	Fe	GY
DFF	**P**	1.000	-0.380**	-0.190	0.380**	-0.600**	-0.030	-0.020	-0.089	0.063	0.370**	0.220*	0.440**	0.340**	0.018	-0.420**	-0.70**	-0.300**	-0.469**
	G	1.000	-0.530**	-0.230*	0.750**	-0.660**	0.014	0.015	0.005	0.070	0.400**	0.280*	0.570**	0.450**	0.025	-0.45**	-0.81**	-0.390**	-0.582**
PL	**P**		1.000	0.360**	-0.220**	0.033	0.340**	0.340**	0.064	0.300**	-0.180	-0.390**	-0.066	0.012	-0.170	0.190	0.330**	0.240*	0.277*
	G		1.000	0.510**	-0.510**	0.000	0.450**	0.420**	0.420**	0.360**	-0.220*	-0.480**	-0.091	-0.063	-0.210	0.230*	0.440**	0.240*	0.358**
PH	**P**			1.000	-0.320**	0.240*	-0.002	-0.020	0.095	0.110	0.082	-0.160	-0.42**	0.100	0.036	0.220*	0.140	0.100	0.161
	G			1.000	-0.400**	0.290**	-0.004	-0.035	0.220*	0.120	0.090	-0.190	-0.54**	0.090	0.043	0.240*	0.180	0.150	0.145
EBT	**P**				1.000	-0.310**	-0.021	-0.008	-0.065	0.031	0.200	0.270*	0.120	0.110	0.048	-0.150	-0.36**	-0.180	-0.003
	G				1.000	-0.510**	-0.087	-0.097	0.110	0.076	0.330**	0.530**	0.350**	0.140	0.111	-0.280*	-0.61**	-0.290*	0.115
TW	**P**					1.000	-0.320**	-0.320**	-0.11	-0.220*	-0.230*	-0.170	-0.64**	-0.380**	0.270*	0.240*	0.330**	0.180	0.424**
	G					1.000	-0.370**	-0.390**	-0.100	-0.230*	-0.230*	-0.180	-0.77**	-0.550**	0.300**	0.250*	0.360**	0.200	0.498**
FGP	**P**						1.000	0.980**	0.380**	0.230*	-0.055	-0.075	0.180	0.130	-0.064	-0.039	0.130	0.080	-0.037
	G						1.000	0.990**	0.58**	0.260*	-0.0610	-0.120	0.310**	0.180	-0.100	-0.035	0.180	0.150	-0.079
TGP	**P**							1.000	0.240*	0.180	-0.038	-0.099	0.170	0.130	-0.066	-0.060	0.130	0.086	-0.068
	G							1.000	0.500**	0.200	-0.039	-0.140	0.320**	0.150	-0.100	-0.060	0.170	0.150	-0.114
SF %	**P**								1.000	0.350**	-0.152	0.140	0.067	0.040	-0.021	0.082	0.052	-0.012	0.161
	G								1.000	0.610**	-0.280*	0.180	0.066	0.360**	-0.110	0.150	0.110	0.110	0.216
SL	**P**									1.000	0.026	-0.250*	0.072	-0.025	-0.120	0.470**	0.008	-0.003	0.029
	G									1.000	0.034	-0.290**	0.086	-0.032	-0.130	0.480**	0.010	-0.007	0.036
WU	**P**										1.000	0.190	0.150	0.290*	-0.170	-0.060	-0.110	-0.140	-0.201
	G										1.000	0.230*	0.190	0.390**	-0.180	-0.061	-0.120	-0.160	-0.226*
VER	**P**											1.000	0.080	0.260*	-0.088	-0.180	-0.004	-0.042	0.0003
	G											1.000	0.079	0.400**	-0.100	-0.190	0.000	-0.048	0.033
ASV	**P**												1.000	0.110	-0.38**	-0.210	-0.30**	-0.140	-0.264*
	G												1.000	0.650**	-0.40**	-0.250*	-0.36**	-0.230*	-0.383**
L/B	**P**													1.000	-0.150	-0.044	-0.025	-0.060	-0.224*
	G													1.000	-0.210	-0.062	-0.066	-0.120	-0.306**
AC	**P**														1.000	0.038	-0.127	0.184	0.064
	G														1.000	0.043	-0.154	0.227*	0.075
	P															1.000	0.405**	0.282*	0.490**
PC	**G**															1.000	0.423**	0.338**	0.558**
Zn	**P**																1.000	0.321**	0.290*
	G																1.000	0.415**	0.345**
	P																	1.000	0.211
Fe	**G**																	1.000	0.282*

Significant at 5% level, ** Significant at 1% level

DFF: Days to 50%floweing; PL: Paniclelength; PH: Plant height; EBT:Ear bearing tillers; TW:Test weight; FGP: Filled grains per panicle;, TGP: Total number of grains per panicle, SF %: Spikelet fertility (%:); SL: Solid loss; WU: Water uptake; VER: Volume expansion ratio; ASV: Alkali spreading value; L/B: L/B ratio; AC: Amylose content; PC: Protein content; Zn: Zinc content; Fe: Iron content; GY: Grain yield per plant

Table.2 Direct and indirect effects of yield components and quality traits on grain yield among colored genotypes of rice (*Oryza sativa* L.)

Character	DFF	PL	PH	EBT	TW	FGP	TGP	SF (%)	SL	WU	VER	ASV	L/B	AC	PC	Zn	Fe
DFF	**0.016**	-0.006	-0.003	0.006	-0.009	-0.001	0.000	-0.001	0.001	0.006	0.003	0.007	0.005	0.000	-0.007	-0.011	-0.005
PL	-0.135	**0.351**	0.129	-0.078	0.012	0.122	0.122	0.023	0.106	-0.065	-0.139	-0.023	0.004	-0.063	0.067	0.117	0.086
PH	0.001	-0.001	**-0.003**	0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	-0.001	0.000	0.000
EBT	0.049	-0.029	-0.042	**0.129**	-0.040	-0.003	-0.001	-0.008	0.004	0.026	0.035	0.015	0.015	0.006	-0.020	-0.047	-0.023
TW	-0.041	0.002	0.017	-0.021	**0.068**	-0.022	-0.022	-0.008	-0.016	-0.016	-0.012	-0.044	-0.027	0.019	0.017	0.023	0.013
FGP	0.028	-0.294	0.002	0.018	0.272	**-0.846**	-0.837	-0.329	-0.195	0.047	0.064	-0.156	-0.113	0.055	0.034	-0.115	-0.068
TGP	-0.017	0.296	-0.018	-0.007	-0.273	0.839	**0.849**	0.210	0.157	-0.033	-0.084	0.152	0.111	-0.057	-0.51	0.111	0.074
SF (%)	-0.039	0.028	0.042	-0.029	-0.049	0.169	0.108	**0.436**	0.153	-0.066	0.061	0.029	0.018	-0.009	0.036	0.023	-0.005
SL	-0.013	-0.060	-0.022	-0.006	0.045	-0.045	-0.036	-0.069	**-0.197**	-0.005	0.050	-0.014	0.005	0.024	0.370	-0.002	0.001
WU	0.010	-0.005	0.002	0.005	-0.006	-0.001	-0.001	-0.004	0.001	**0.026**	0.005	0.004	0.007	-0.005	-0.126	-0.003	0.002
VER	0.026	-0.046	-0.019	0.032	-0.020	-0.009	-0.012	0.016	-0.030	0.023	**0.117**	0.009	0.031	-0.010	0.028	-0.003	-0.004
ASV	-0.041	0.006	0.039	-0.011	0.059	-0.017	-0.016	-0.006	-0.007	-0.014	-0.007	**-0.092**	-0.011	0.035	0.079	-0.001	-0.005
L/B	-0.055	-0.002	-0.018	-0.018	0.063	-0.022	-0.021	-0.007	0.004	-0.047	-0.044	-0.019	**-0.162**	0.024	-0.048	0.028	0.013
AC	-0.002	0.017	-0.003	-0.004	-0.026	0.006	0.006	0.002	0.011	0.016	0.008	0.036	0.014	**-0.093**	0.005	0.004	0.010
PC	-0.169	0.077	0.091	-0.063	0.100	-0.016	-0.024	0.033	0.191	-0.024	-0.074	-0.085	-0.018	0.015	**0.402**	0.012	-0.017
Zc	0.076	-0.036	-0.016	0.040	-0.036	-0.015	-0.014	-0.006	-0.001	0.013	0.001	0.033	0.003	0.014	-0.044	**-0.108**	-0.035
Fe	-0.059	0.047	0.020	-0.035	0.036	0.015	0.017	-0.002	-0.001	-0.027	-0.008	-0.027	-0.011	0.035	0.054	0.062	**0.192**
Grain yield	-0.469**	0.277*	0.162	-0.003	0.425**	-0.038	-0.069	0.162	0.029	-0.201	0.000	-0.264*	-0.224*	0.064	0.490**	0.290*	0.211
Partial r^2	-0.007	0.097	-0.001	0.000	0.029	0.032	-0.058	0.071	-0.006	-0.005	0.000	0.024	0.036	-0.006	0.197	-0.031	0.041

Diagonal bold letters indicate direct effect

DFF: Days to 50%floweing; PL: Paniclelength;PH: Plant height; EBT:Ear bearing tillers; TW:Test weight; FGP: Filled grains per panicle; TGP: Total number of grains per panicle, SF %: Spikelet fertility (%:); SL: Solid loss; WU: Water uptake; VER: Volume expansion ratio; ASV: Alkali spreading value; L/B: L/B ratio; AC: Amylose content; PC: Protein content; Zn: Zinc content; Fe: Iron content; GY: Grain yield per plant

Among the quality traits under study, total starch (0.490** & 0.558**) exhibited positive and significant relationship while L/B ratio and alkali spreading value manifested negative and significant association with grain yield/plant suggesting that genotypes with slender grain types recorded low grain yield/plant. Similar findings were previously reported by Nandan *et al.,* (2010) and Veni *et al.,* (2006). Among the nutritional parameters, protein content (0.490** & 0.558**), zinc content (0.290** & 0.345**) and iron content (0.211 & 0.222*) exhibited significant and positive association with grain yield/plant indicating the simultaneous improvement of these traits. Positive correlation of protein content with grain yield/plant was reported previously by Niveditha *et al.,* (2013).

The trait solid loss exhibited negative and significant relationship with volume expansion ratio (-0.250* & -0.290**) while it's association with protein content was significantly positive (0.470** & 0.480**) both at phenotypic and genotypic levels. The amylose content and alkali spreading value which determines the texture of cooked rice manifested a significant and negative correlation coefficient (-0.384** & -0.469**). Veni and Rani (2006) and Selvakumar *et al.,* (2014) also reported similar findings. Water uptake had a positive and significant association with volume expansion ratio (0.230*) at genotypic level and both these traits are significantly and positively correlated with L/B ratio suggesting simultaneous improvement of these traits. All the nutritional parameters studied *viz.*, protein content, zinc and iron content are positively and significantly associated with each other and also with grain yield/plant suggesting that the black and red rice genotypes studied in the present investigation possessed more nutritional value coupled with high grain yield potential. Patil *et al.,* (2015) and Chowdhury *et al.,* (2016) also reported positive and significant association of zinc and iron content.

The result of path coefficient analysis of grain yield/plant with other yield components and quality parameters was given in Table 2. The results revealed that total number of grains/panicle (0.849) followed by spikelet fertility percentage (0.436), protein content (0.402) and panicle length (0.351) manifested high direct effects on grain yield/plant suggesting selection for these traits would be more effective for bringing simultaneous improvement of grain yield. Nandan *et al* (2013) and Veni *et al.,* (2003) also reported direct effects in positive direction for grains/panicle and spikelet fertility percentage respectively. The characters *viz.*, panicle length, test weight and spikelet fertility percentage exhibited positive direct effects along with positive correlation with grain yield suggesting that simple selection for these traits would improve grain yield/plant. Hence, selection can be practiced on these traits for getting simultaneous improvement of the component characters and also grain yield. Soumiya and Venkatesan (2017), Sameera *et al.,* (2016) and Niveditha *et al.,* (2013) also reported similar results. Based on this study, it could be concluded that grain yield /plant in rice is the end product of interaction among yield contributing traits such as panicle length, test weight and spikelet fertility percentage which exhibited a true relationship by establishing significant correlation coefficient and direct effect also in the positive direction.

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