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Character Association and Path Analysis of Yield, Yield Components and Grain Quality Characters of Rice Cultivars

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ABSTRACT

Twenty varieties and advanced lines of rice were used to study the association and path analysis and the results revealed that, the genotypic correlations were, in general higher than the phenotypic correlations suggesting that the observed relationships among the characters were due to genetic causes. The traits viz., plant height, total number of tillers per plant, panicle length per plant, test weight, leaf area index at maximum tillering stage, kernel length, kernel breadth, kernel length after cooking, kernel linear elongation ratio, volume expansion ratio and amylose content, were found to possess significant association in desirable direction with grain yield per plant either both at genotypic and phenotypic levels. Further, it was also observed that days to 50% flowering and days to maturity exhibited negative and significant association with grain yield. Path analysis showed the true relationship of plant height, total number of tillers per plant, number of ear bearing tillers per plant, number of grains per panicle, test weight, alkali spreading value and amylose content by establishing significant positive association and positive direct effect on grain yield per plant whereas days to maturity showed true relationship by establishing significant negative association and negative direct effect on grain yield per plant.

Key Words: *Association, Path analysis and Yield parameters.*

Rice (*Oryza sativa* L.) is the second largest produced cereal in the world. Asia is the biggest rice producer accounting for more than one-third of global population supplying over half of the world's rice. India has the largest area of 43.86 million hectares under rice cultivation and ranks second with an average production of 104.32 million tonnes and productivity of 2404 kg ha^{-1}; (Ministry of Agriculture, Directorate of Economics and Statistics, 2014-15). In Andhra Pradesh, rice is cultivated in an area of 2.39 million hectares with a production of 3.36 million tonnes and productivity of 3532 kg ha^{-1} (Annual Report-ANGRAU, Guntur, 2014-15). Hence ensuring food and nutritional security is a challenging task. Thus, effective improvement in yield may be brought about through selection of yield component characters *viz;* number of productive tillers per plant, panicle length, number of grains per panicle and 1000 grain weight. These traits play an important role in modification of yield as a whole in magnitude as well as in direction. The change in one character brings about a series of changes in the other characters, since they are interrelated. Therefore, the correlation studies are of considerable importance in any selection programme as they provide degree and direction of relationship between two or more component traits.

The observed correlation between yield and its component character is the net result of direct and indirect effects of the component characters through other yield attributes on correlation coefficients need to be split into direct and indirect effects using path coefficient analysis for critical evaluation as many characters affect a given trait. Thus, the correlation and path analysis in combination can give a better insight into cause and effect relationship between different pairs of characters (Singh and Chaudhary, 1977). Considering the above aspects, path analysis for 24 characters with yield was computed to furnish information on direct and indirect contribution of various yield components to yield and to formulate a sound basis for selection in rice.

MATERIAL AND METHODS

The field experiment was laid-down to evaluate the grain yield potential of twenty rice cultivars belonging to medium and late maturity grown under lowland after the harvest of main crop during *kharif*, 2014 at Andhra Pradesh Rice Research Station (APRRI) and Regional Agricultural Research Station (RARS), Maruteru, West Godavari district, Andhra Pradesh, India. The experiment was laid out in RCBD, replicated three times, with inter-row spacing of 20 cm and intra-row spacing of 15 cm with row length of 3 m and number of rows per genotype per replication was 3 rows with a gross plot size of 2.40 sq. m and net plot size of 1.80 sq. m. Data was recorded on 24 characters, consisting of 10 yield attributing characters *viz.,* days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, number of ear bearing tillers per plant, panicle length (cm), number of grains per

panicle, test weight (g), leaf area index at maximum tillering stage, grain yield per plant (g); 6 physical quality traits such as hulling recovery, milling recovery, head rice recovery, kernel length (mm), kernel breadth (mm), kernel L/B ratio; 8 cooking and chemical quality traits such as kernel length after cooking (mm), kernel breadth after cooking (mm), kernel elongation ratio, volume expansion ratio, water uptake value (ml), gel consistency (mm), alkali digestion value and amylose content (%) by following standard procedures for quality analysis as per Directorate of Rice Research (DRR), 2006. The mean data was utilized for estimation of correlation coefficient and path analysis as per Falconer (1964) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSIONS

The phenotypic and genotypic correlation coefficients between grain yield, yield component characters and quality traits and among themselves were estimated and presented in Table 1and 2. Genotypic correlations in general are higher than phenotypic correlations indicating that the apparent associations are largely due to genetic reasons.The grain yield exhibited the highest significant and positive association with total number of tillers per plant, panicle length, test weight, leaf area index at maximum tillering stage, (0.50**) followed by ear bearing tillers (4.88**), kernel length after cookingand kernel length (0.479**), and alkali spreading value at both phenotypic level and genotypic level.Whereas, significant positive correlation was observed with plant height, kernel breadth after cooking, kernel linear elongation ratio, volume expansion ratio, gel consistency and amylose content at genotypic level only. Similar results were found with Aditya and Anuradha (2013) and Basavaraja *et al.,* (2012).Grain yield showed significant negative association with days to 50% flowering (-0.313*) and days to maturity (-0.294*) at phenotypic and genotypic level.

Inter-correlations among yield components and grain quality components resulted that days to 50% flowering showed significant positive association with days to maturity, plant height, number of grains per panicle at both genotypic and phenotypic levels. Days to maturity at both genotypic and phenotypic levels, exhibited significant positive association with plant height, number of grains per panicle, while it showed positive significant correlation with total number of tillers per plant, hulling recovery, milling recovery and head rice recovery at genotypic level (table. 1 & 2). These results were in conformity with the findings of Aditya and Anuradha (2013), Gangashetty *et al*., (2013), Basavaraja *et al.,* (2012), Datt *et al*., (2012), Ghaffar and Ghorbanal (2012) and Bhadru *et al.,* (2012).

Plant height recorded significant positive association with total number of tillers per plant, panicle length, head rice recovery, gel consistency, amylose content, at both genotypic and phenotypic levels and positive significant correlation with number of grains per panicle (0.238), kernel length after cooking (0.733**), water uptake (0.168) and grain yield per plant (1.000) at genotypic level only.Total number of tillers per plant,recorded significant positive association with number of grains per panicle, leaf area index, head rice recovery, L/B ratio, kernel linear elongation ratio at both genotypic and phenotypic levels and positive significant association with kernel length after cooking at genotypic level only.Number of ear bearing tillers per plant recorded significant positive association with leaf area index, milling recovery, head rice recovery, kernel length, kernel length after cooking, kernel linear elongation ratio, gel consistency, alkali spreading valueand grain yield per plant at both genotypic and phenotypic levels, while positive significant association with volume expansion ratio at genotypic level (Table 1 & 2).These results were in conformity with Datt *et al*., (2012) and Gangashetty *et al.,* (2013).

Panicle length exhibited significant positive association with kernel length and kernel breadth at both genotypic and phenotypic levels. It also exhibited positive significant correlation with gel consistency at genotypic level only.Number of grains per panicle recorded significant positive association with leaf area index, hulling recovery, milling recovery, L/B ratio, kernel linear elongation ratio, gel consistency at both genotypic and phenotypic levels.Test weight, showed significant positive association with kernel length, kernel breadth, kernel length after cooking, kernel breadth after cooking, volume expansion ratio, water uptake, alkali spreading value and exhibited significant negative association with hulling recovery, milling recovery, L/B ratio at both genotypic and phenotypic levels (Table 1 &2 . These results were in conformity with Bhadru *et al.,* (2012), Chaudharyand Motiramani (2003) and Garg *et al.,* (2010). At both genotypic and phenotypic levels leaf area index at maximum tillering stage showed significant positive association with milling recovery, head rice recovery, L/B ratio, kernel length after cooking and kernel linear elongation ratio and positive significant association with hulling recoveryat genotypic level only.

Hulling recovery exhibited significant positive association with milling recovery, L/B ratio and gel consistency. Milling recovery (%), recorded significant positive correlation with head rice recovery, L/B ratio, kernel linear elongation ratio at both genotypic and phenotypic levels and positive significant association with kernel length after cooking at genotypic level only.Head rice recovery manifested significant positive association with kernel length after cooking, kernel linear

Table 1: Phenotypic (r_p) correlations among grain yield, yield contributing and quality characters in rice (*Oryza sativa* L.)

Characters		DFF	DM	PH (cm)	TNT	EBT	PL (cm)	NGP	TW (g)	LAI	HP (%)	MP (%)	HRR (%)	KL (mm)	KB (mm)	L/B ratio	KLAC (mm)	KBAC (mm)	ER	VER	WU (ml)	GC (mm)	ASV	AC (%)	GYPP (g)
DFF	r_p	1	0.957**	0.333**	0.142	-0.263*	0.168	0.369**	-0.683**	0.107	0.244	0.214	0.227	-0.435**	-0.272*	-0.017	-0.318*	-0.397**	0.143	-0.372**	-0.099	0.11	-0.315*	0.069	-0.313*
DM	r_p		1	0.336**	0.148	-0.237	0.17	0.344**	-0.677**	0.146	0.231	0.193	0.228	-0.372**	-0.234	-0.019	-0.299*	-0.343**	0.125	-0.407**	-0.098	0.122	-0.319*	0.089	-0.294*
PH	r_p			1	0.378**	0.072	0.592**	0.239	-0.021	0.114	-0.005	-0.01	0.302*	-0.008	0.012	-0.053	0.233	-0.213	0.16	-0.033	0.440**	0.333**	0.031	0.442**	0.213
TNTP	r_p				1	0.236	0.165	0.478**	-0.236	0.392 **	0.146	0.146	0.264*	0.116	-0.229	0.400**	0.185	-0.303*	0.273*	-0.005	0.097	0.165	-0.013	0.18	0.304*
EBTP	r_p					1	0.161	0.206	0.187	0.411**	0.145	0.282*	0.568**	0.289*	0.157	0.018	0.512**	0.253	0.314*	0.233	0.205	0.388**	0.373**	-0.239	0.488**
PL	r_p						1	0.165	0.178	0.13	-0.093	0.008	0.222	0.277*	0.308*	-0.205	0.102	-0.129	-0.074	0.052	0.179	0.233	0.131	0.017	0.263*
NGPP	r_p							1	-0.531**	0.472**	0.487**	0.324*	0.228	-0.205	-0.695**	0.761**	0.085	-0.634**	0.568**	-0.032	-0.211	0.335**	-0.238	0.149	0.203
TW	r_p								1	-0.153	-0.466**	-0.274*	-0.154	0.528**	0.598**	-0.361**	0.529**	0.503**	-0.223	0.317*	0.343**	-0.069	0.635**	-0.061	0.411**
LAI	r_p									1	0.191	0.373 **	0.380**	0.212	-0.165	0.390**	0.376**	-0.108	0.350**	0.07	-0.335**	0.069	0.077	0.031	0.501**
HP	r_p										1	0.316 *	0.204	-0.378**	-0.506**	0.370**	-0.15	-0.367**	0.137	-0.107	-0.141	0.350**	-0.260*	0.021	-0.077
MP	r_p											1	0.548**	-0.011	-0.199	0.260 *	0.207	-0.376**	0.341**	0.137	-0.304*	-0.084	0.031	-0.269*	-0.046
HRR	r_p												1	0.08	0.069	-0.047	0.362**	-0.095	0.372**	0.096	0.061	0.332**	0.112	-0.176	0.101
KL	r_p													1	0.679**	-0.104	0.252	0.289*	-0.348**	-0.098	0.144	0.192	0.246	-0.128	0.420**
KB	r_p														1	-0.799**	0.073	0.612**	-0.562**	0.022	0.313*	0.023	0.338**	-0.221	0.116
L/B	r_p															1	0.117	-0.586**	0.476**	-0.074	-0.315*	0.09	-0.242	0.189	0.182
KLAC	r_p																1	0.07	0.550**	0.427**	0.193	0.022	0.673**	0.062	0.479**
KBAC	r_p																	1	-0.284*	0.095	0.245	-0.126	0.361**	-0.221	0.186
KLER	r_p																		1	0.377**	-0.124	-0.008	0.245	0.058	0.152
VER	r_p																			1	-0.055	-0.384**	0.266*	-0.193	0.173
WU	r_p																				1	0.239	0.351**	0.296*	0.134
GC	r_p																					1	0.004	0.185	0.197
ASV	r_p																						1	-0.003	0.369**
AC	r_p																							1	0.094
GYPP	r_p																								1

* Significant at 5% level ** Significant at 1% level r_p: genotypic level

DFF: Days to 50% Flowering; DM: Days to Maturity; PH: Plant Height (cm); TNTP: Total Number of Tillers per Plant; EBTP: Total number of Ear Bearing Tillers per Plant; PL: Panicle Length per plant (cm); NGPP: Number of Grains Per Panicle; TW: Test Weight (g); LAI: Leaf Area Index at maximum tillering stage; HP: Hulling percentage; ML: Milling percentage; HRR: Head Rice Recovery; KL: Kernel Length (mm); KB: Kernel Breadth (mm); L/B: Kernel L/B ratio; KLAC: Kernel Length After Cooking (mm); KBAC: Kernel Breadth After Cooking (mm); KLER: Kernel Linear Elongation Ratio; VER: Volume Expansion Ratio; WU: Water Uptake (ml); GC: Gel Consistency (mm); ASV: Alkali Spreading Value; AC: Amylose Content (%); GY: Grain Yield per plant (g).

Table 2: Genotypic (r_g) correlations among grain yield, yield contributing and quality characters in rice (*Oryza sativa* L.)

Characters		DFF	DM	PH (cm)	TNTP	EBTP	PL (cm)	NGP	TW (g)	LAI	HP (%)	MP (%)	HRR (%)	KL (mm)	KB (mm)	L/B ratio	KLAC (mm)	KBAC (mm)	ER	VER	WU (ml)	GC (mm)	ASV	AC (%)	GYPP (g)
DFF	r_g	1	0.983**	0.377**	0.270*	-0.260*	0.205	0.412**	-0.735**	0.129	0.334**	0.259*	0.238	-0.457**	-0.295*	-0.008	-0.338**	-0.458**	0.153	-0.476**	-0.125	0.108	-0.341**	0.13	-0.370**
DM	r_g		1	0.418**	0.255*	-0.277*	0.234	0.414**	-0.728**	0.158	0.300*	0.279*	0.254*	-0.410**	-0.281*	0.008	-0.353**	-0.468**	0.122	-0.540**	-0.109	0.131	-0.348**	0.14	-0.356**
PH	r_g			1	0.479**	0.061	0.663**	0.267*	-0.02	0.141	0.06	-0.078	0.388**	0.015	0.019	-0.048	0.257*	-0.332**	0.156	-0.078	0.488**	0.365**	0.028	0.504**	0.272*
TNTP	r_g				1	0.238	0.235	0.615**	-0.287*	0.481**	0.189	0.192	0.361**	0.121	-0.286*	0.490**	0.269*	-0.389**	0.425**	0.041	0.096	0.194	-0.013	0.152	0.527**
EBTP	r_g					1	0.141	0.218	0.235	0.461**	0.241	0.477**	0.737**	0.363**	0.201	0.023	0.611**	0.205	0.382**	0.354**	0.217	0.469**	0.459**	-0.3	0.657
PL	r_g						1	0.189	0.212	0.163	-0.031	0.138	0.211	0.346**	0.358**	-0.224	0.135	-0.215	-0.102	0.072	0.176	0.279*	0.156	0.049	0.425**
NGPP	r_g							1	-0.583**	0.500*	0.701**	0.491**	0.248	-0.219	-0.735**	0.811**	0.1	-0.841**	0.628**	-0.037	-0.244	0.343**	-0.252	0.189	0.238
TW	r_g								1	-0.159	-0.602**	-0.353**	-0.169	0.543**	0.623**	-0.383**	0.565**	0.621**	-0.224	0.382**	0.347**	-0.077	0.651**	-0.041	0.523**
LAI	r_g									1	0.254*	0.498**	0.412**	0.217	-0.168	0.402**	0.388**	-0.135	0.366**	0.091	-0.347**	0.075	0.077	0.02	0.671**
HP	r_g										1	0.318*	0.247	-0.508**	-0.632**	0.436**	-0.196	-0.627**	0.213	-0.078	-0.175	0.485**	-0.306*	0.066	-0.174
MP	r_g											1	0.714**	-0.005	-0.215	0.301*	0.312*	-0.445**	0.487**	0.243	-0.416**	-0.106	0.039	-0.498**	-0.097
HRR	r_g												1	0.085	0.074	-0.053	0.410**	-0.088	0.425**	0.134	0.058	0.350**	0.122	-0.258*	0.236
KL	r_g													1	0.690**	-0.117	0.264**	0.379**	-0.346**	-0.122	0.146	0.193	0.25	-0.144	0.591**
KB	r_g														1	-0.798**	0.072	0.718**	-0.595**	-0.035	0.325*	0.015	0.342**	-0.269*	0.195
L/B	r_g															1	0.13	-0.672**	0.525**	-0.018	-0.331**	0.102	-0.247	0.24	0.22
KLAC	r_g																1	0.095	0.536**	0.513**	0.22	0.025	0.693**	0.042	0.733**
KBAC	r_g																	1	-0.372**	0.08	0.335**	-0.153	0.468**	-0.301*	0.252*
KLER	r_g																		1	0.458**	-0.112	-0.008	0.256*	0.033	0.276*
VER	r_g																			1	-0.06	-0.471**	0.296*	-0.263*	0.252*
WU	r_g																				1	0.237	0.363**	0.371**	0.168
GC	r_g																					1	0.005	0.222	0.312*
ASV	r_g																						1	-0.014	0.510**
AC	r_g																							1	0.278*
GYPP	r_g																								1

* Significant at 5% level ** Significant at 1% level r_p: genotypic level

DFF: Days to 50% Flowering; DM: Days to Maturity; PH: Plant Height (cm); TNTP: Total Number of Tillers per Plant; EBTP: Total number of Ear Bearing Tillers per Plant; PL: Panicle Length per plant (cm); NGPP: Number of Grains Per Panicle; TW: Test Weight (g); LAI: Leaf Area Index at maximum tillering stage; HP: Hulling percentage; ML: Milling percentage; HRR: Head Rice Recovery; KL: Kernel Length (mm); KB: Kernel Breadth (mm); L/B: Kernel L/B ratio; KLAC: Kernel Length After Cooking (mm); KBAC: Kernel Breadth After Cooking (mm); KLER: Kernel Linear Elongation Ratio; VER: Volume Expansion Ratio; WU: Water Uptake (ml); GC: Gel Consistency (mm); ASV: Alkali Spreading Value; AC: Amylose Content (%); GY: Grain Yield per plant (g).

Table 3: Genotypic (G) direct and indirect effects of different traits on grain yield in rice (*Oryza sativa* L.)

Characters	DFF	DM	PH (cm)	TNT	EBT	PL (cm)	NGP	TW (g)	LAI	HP (%)	MP (%)	HRR (%)	KL (mm)	KB (mm)	L/B ratio	KLAC (mm)	KBAC (mm)	ER	VER	WU (ml)	GC (mm)	ASV	AC (%)	GYPP (g)
DFF	4.041	-0.342	0.588	0.005	-0.12	-0.58	0.487	-3.154	-0.247	1.228	-0.289	0.376	-9.191	7.592	0.135	0.925	-0.302	-0.021	-0.97	0.224	-0.315	-0.6	0.164	-0.370**
DM	4.1	-0.337	0.653	0.004	-0.13	-0.661	0.489	-3.123	-0.303	1.104	-0.311	0.401	-8.235	7.216	-0.14	0.967	-0.308	-0.017	-1.1	0.196	-0.382	-0.61	0.177	-0.356**
PH	1.523	-0.141	1.561	0.008	0.029	-1.874	0.315	-0.086	-0.271	0.222	0.087	0.613	0.302	-0.499	0.842	-0.704	-0.218	-0.021	-0.16	-0.874	-1.068	0.049	0.638	0.272*
TNT	1.092	-0.086	0.747	0.017	0.113	-0.664	0.726	-1.23	-0.921	0.695	-0.214	0.571	2.429	7.355	-8.564	-0.736	-0.256	-0.059	0.083	-0.172	-0.568	-0.02	0.192	0.527**
EBT	-1.05	0.093	0.096	0.004	0.475	-0.399	0.258	1.007	-0.883	0.886	-0.531	1.164	7.293	-5.163	-0.394	-1.671	0.135	-0.053	0.724	-0.389	-1.369	0.805	-0.38	0.657**
PL	0.829	-0.079	1.035	0.004	0.067	-2.827	0.223	0.908	-0.313	-0.115	-0.153	0.333	6.943	-9.195	3.909	-0.369	-0.142	0.014	0.147	-0.315	-0.814	0.273	0.063	0.425**
NGP	1.665	-0.139	0.416	0.011	0.104	-0.534	1.181	-2.501	-0.958	2.581	-0.547	0.391	-4.394	18.892	-14.171	-0.274	-0.554	-0.086	-0.08	0.437	-1.003	-0.44	0.238	0.238
TW	-2.97	0.245	-0.031	-0.01	0.111	-0.598	-0.69	4.292	0.305	-2.218	0.393	-0.267	10.918	-16.022	6.694	-1.547	0.409	0.031	0.78	-0.622	0.224	1.141	-0.052	0.523**
LAI	0.521	-0.053	0.221	0.008	0.219	-0.462	0.59	-0.682	-1.917	0.935	-0.555	0.651	4.362	4.319	-7.033	-1.063	-0.089	-0.05	0.186	0.622	-0.218	0.134	0.026	0.671**
HP	1.348	-0.101	0.094	0.003	0.114	0.089	0.828	-2.585	-0.486	3.684	-0.354	0.39	-10.207	16.26	-7.628	0.536	-0.413	-0.029	-0.16	0.313	-1.418	-0.54	0.083	-0.174
MP	1.046	-0.094	-0.121	0.003	0.226	-0.389	0.58	-1.513	-0.955	1.169	-1.115	1.128	-0.105	5.525	-5.262	-0.853	-0.293	-0.067	0.496	0.747	0.311	0.067	-0.63	-0.097
HRR	0.963	-0.086	0.606	0.006	0.35	-0.597	0.293	-0.725	-0.79	0.91	-0.796	1.579	1.701	-1.905	0.931	-1.122	-0.058	-0.058	0.273	-0.105	-1.022	0.214	-0.326	0.236
KL	-1.85	0.138	0.023	0.002	0.172	-0.977	-0.26	2.332	-0.416	-1.871	0.006	0.134	20.096	-17.749	2.053	-0.722	0.249	0.048	-0.25	-0.262	-0.565	0.437	-0.182	0.591**
KB	-1.19	0.095	0.03	-0.01	0.095	-1.011	-0.87	2.674	0.322	-2.329	0.239	0.117	13.869	-25.717	13.957	-0.197	0.472	0.082	-0.07	-0.583	-0.044	0.6	-0.34	0.195
L/B	-0.03	-0.003	-0.075	0.009	0.011	0.632	0.957	-1.644	-0.771	1.607	-0.336	-0.084	-2.36	20.532	-17.482	-0.356	-0.442	-0.072	-0.04	0.593	-0.299	-0.43	0.304	0.22
KLAC	-1.37	0.119	0.401	0.005	0.29	-0.381	0.118	2.427	-0.744	-0.722	-0.347	0.647	5.302	-1.848	-2.272	-2.737	0.063	-0.074	1.05	-0.394	-0.074	1.215	0.053	0.733**
KBAC	-1.85	0.158	-0.518	-0.01	0.097	0.608	-0.99	2.664	0.259	-2.311	0.496	-0.139	7.611	-18.457	11.741	-0.26	0.658	0.051	0.163	-0.601	0.447	0.82	-0.381	0.252*
ER	0.618	-0.041	0.243	0.007	0.181	0.287	0.742	-0.96	-0.701	0.786	-0.542	0.671	-6.946	15.31	-9.182	-1.466	-0.245	-0.138	0.936	0.201	0.022	0.449	0.042	0.276*
VER	-1.92	0.182	-0.122	0.001	0.168	-0.204	-0.04	1.638	-0.174	-0.287	-0.271	0.211	-2.452	0.91	0.322	-1.405	0.052	-0.063	2.045	0.107	1.375	0.519	-0.333	0.252*
WU	-0.51	0.037	0.761	0.002	0.103	-0.497	-0.29	1.489	0.665	-0.644	0.464	0.092	2.938	-8.365	5.784	-0.601	0.221	0.015	-0.12	-1.793	-0.692	0.636	0.469	0.168
GC	0.436	-0.044	0.57	0.003	0.223	-0.788	0.405	-0.329	-0.143	1.788	0.119	0.553	3.887	-0.388	-1.789	-0.069	-0.101	0.001	-0.96	-0.425	-2.921	0.008	0.28	0.312*
ASV	-1.38	0.117	0.043	0	0.218	-0.44	-0.3	2.794	-0.147	-1.127	-0.043	0.193	5.013	-8.806	4.318	-1.897	0.308	-0.035	0.605	-0.651	-0.013	1.753	-0.018	0.510**
AC	0.524	-0.047	0.787	0.003	-0.14	-0.14	0.223	-0.177	-0.039	0.243	0.555	-0.407	-2.886	6.905	-4.195	-0.115	-0.198	-0.005	-0.54	-0.665	-0.647	-0.02	1.265	0.278*

*Significant at 5% level ** Significant at 1% level Diagonal values indicate direct effects Residual effect at genotypic level = 0.2792

DFF: Days to 50% Flowering; DM: Days to Maturity; PH: Plant Height (cm); TNTP: Total Number of Tillers per Plant; EBTP: Total number of Ear Bearing Tillers per Plant; PL: Panicle Length per plant (cm); NGPP: Number of Grains Per Panicle; TW: Test Weight (g); LAI: Leaf Area Index at maximum tillering stage; HP: Hulling percentage; ML: Milling percentage; HRR: Head Rice Recovery; KL: Kernel Length (mm); KB: Kernel Breadth (mm); L/B: Kernel L/B ratio; KLAC: Kernel Length After Cooking (mm); KBAC: Kernel Breadth After Cooking (mm); KLER: Kernel Linear Elongation Ratio; VER: Volume Expansion Ratio; WU: Water Uptake (ml); GC: Gel Consistency (mm); ASV: Alkali Spreading Value; AC: Amylose Content (%); GY: Grain Yield per plant (g)

elongation ratio and gel consistency at both genotypic and phenotypic levels. Similar results were reported by Gangashetty *et al*., (2013), Basavaraja *et al.,* (2012), Datt *et al*., (2012), Ghaffar & Ghorbanal (2012) and Bhadru *et al.,* (2012). Kernel Length (mm) at both genotypic and phenotypic levels exhibited significant positive association with kernel breadth, kernel length after cooking, kernel breadth after cooking and grain yield per plant. Kernel breadth found positive significant correlation with kernel breadth after cooking, water uptake, alkali spreading value at both genotypic and phenotypic levels. Kernel Length/Breadth Ratio exhibited significant positive association with kernel linear elongation ratio at both genotypic and phenotypic levels.Simillar results were found with the results of Basavaraja *et al.,* (2012), Dat t*et al*., (2012) and Ghaffar & Ghorbanal (2012). Kernel length after cooking (mm) exhibited significant positive association with kernel linear elongation ratio, volume expansion ratio and alkali spreading value at both genotypic and phenotypic levels. Kernel breadth after cooking recorded significant positive association with alkali spreading value at both genotypic and phenotypic levels and showed positive significant association with grain yield per plant, water uptake and amylose content at genotypic level.

Kernel elongation ratio was found to have significant positive association with volume expansion ratio and alkali spreading value at both genotypic and phenotypic levels. It showed positive significant correlation with grain yield per plant at genotypic level.Volume expansion ratio had significant positive association with gel consistency, alkali spreading value at both genotypic and phenotypic levels and positive significant association with grain yield per plant and amylose content at genotypic level.Water Uptake (ml) correlations indicated that this trait had positive correlation with alkali spreading value and amylose content. Gel Consistency (mm) exhibited significant positive association with grain yield per plant at genotypic level. Alkali spreading value found to have significant positive association with grain yield per plant at both genotypic and phenotypic level. Amylose Content (%) recorded significant positive association with grain yield per plant at genotypic level only.These results are in accordance with Aditya and Anuradha (2013),Gangashetty *et al.,* (2013), Basavaraja *et al.,* (2012), Datt *et al*., (2012) and Ghaffar & Ghorbanal (2012).

The results of path analysis revealed that positive direct effects along with positive correlation plant height, total number of tillers per plant, number of ear bearing tillers per plant, number of grains per panicle, test weight, alkali spreading value and amylose content on grain yield per plant whereas days to maturity showed true relationship by establishing significant negative association and negative direct effect on grain yield per plant. (Table. 3).

CONCLUSION

Considering the nature and magnitude of character association and their direct and indirect effects, it can be inferred that simultaneous improvement of grain yield per plant is possible through manifestation of days to maturity, plant height, and total number of tillers per plant, test weight, alkali spreading value and amylose content.

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