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Research Note

Cause and effect analysis for yield and grain quality traits in rice (*Oryza sativa* L.)

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Abstract

Character association studies with six field biometrics and nine grain quality traits recorded from 60 rice genotypes revealed that single plant yield was significantly correlated with number of filled grains per panicle (r = 0.516), and positively correlated with days to 50% flowering (r = 0.144), plant height (r = 0.129) and panicle length (r = 0.134). Kernel length is positively correlated with gel consistency (r = 0.006). Amylose content has positive correlation with gelatinization temperature (r = 0.215) and gel consistency (r = 0.014). Head rice recovery manifested good relationship with kernel breadth (r = 0.074) and milling (r = 0.466). Path coefficient analysis manifested that the traits number of filled grains/panicle (0.912), number of panicles/plant (0.582), and 1000-grain weight (0.404) had high positive direct effects on grain yield per plant and also kernel length (0.690) and milling percentage (0.577) had high direct effect on head rice recovery. Hence, these traits were regarded as significant attributes in devising selection criteria for attaining yield objectives.

Keywords

Correlation, Path Analysis, Quality, Rice, Yield

The Paddy production in the World accounts for 756.7 million tonnes from the cultivated area of 161.1 million hectare during 2016 – 17. In 2017, India contributed 22% of the World production of paddy from 27% of the total paddy cultivated area with the annual production of 43.49 million tonnes (FAO, 2017). To feed the growing population from the present scenario of shrinking resources, we need varieties or hybrids which grow better under adverse conditions with high yield potential. The lifestyles of the consumer are being progressively enhanced, people's want for premium quality rice is also constantly on the increase. Hence, improving rice grain quality along with good yield potential has been a major concern in rice breeding programs to meet the consumer preference and market demand. (Devi *et al.*, 2015)

Selection based on grain yield is obviously misleading as it is evident that component traits influence much on the complex trait, grain yield besides G X E interaction. Hence, understanding about the association between yield and its causative characters is needed for a proficient selection approach for the plant breeders to develop an efficient variety. Path coefficient analysis delivers facts about the influence of each causative character to yield directly as well as indirectly and also permits breeders to categorize the genetic features in agreement with their contribution. (Devi *et al.*, 2017). The present study was undertaken to bunch up certain effective information on the cause and effect of genetic attributes to yield and grain quality in a set of 60 rice genotypes. The field trial was conducted at Tamil Nadu Rice Research Institute, Aduthurai during Kharif 2017 with 60 rice genotypes. The details of the genotypes are furnished in Table 1.

The seeds were sown by adopting dry seeding in raised nursery bed. Twenty five days old seedlings of each genotype were transplanted in three rows by adopting a spacing of 20 x 10 cm at the rate of 15 plants per row in a Completely Randomized Block Design with three replications. Appropriate agronomic practices were followed to raise a good crop. A random sample of five plants in the middle row of a plot was tagged and recorded biometrical traits *viz.*, plant height (cm), number of panicles/plant, panicle length (cm), number of filled grains per panicle, 1000-grain weight (g), single plant yield (g). Days to 50% flowering was computed on plot basis. The grain quality characters *viz*, hulling percentage, milling percentage, head rice recovery, kernel length (mm), kernel width (mm), L/B ratio, gel consistency, gelatinization temperature and amylose content were recorded in the seeds which are harvested at proper harvest maturity and dried uniformly up to 12 – 13% moisture content. The seed was dehuskedin MacGill Rice Sheller and polished in

MacGill Rice Polisher and data on head rice recovery was noted. Length and breadth of ten polished kernels were measured with the help of graph paper. The value was averaged and recorded in millimeter.

Gel Consistency test was conducted by the method described by Cagampang*et al.* (1973). Gelatinization temperature was determined as described by Little *et al.* (1958). Amylose content was determined by simplified calorimetric method as described by Sowbhagya and Bhatacharya (1971). The treatment mean values for all the characters were subjected to compute the analysis of variance on the basis of model proposed by Panse and Sukhatme (1978). The path and correlation coefficient analysis was done following the method of Dewey and Lu (1958). In this study, significance in ANOVA for both biometrical and quality traits indicates the presence of considerable genetic variation among the experimental material. (Table 2 & Table 3).

Genotypic Correlation coefficient analysis among the quantitative characters between single plant yield and other component traits were computed (Table 4). Single plant yield had strong positive association with number of filled grains per panicle (r = 0.516) and positively correlated with days to 50% flowering (r = 0.144), plant height (r = 0.129) and panicle length (r = 0.134). Similar findings were reported by Lakshmi *et al.* (2014), Ratna*et al.* (2015), Jan *et al.* (2017) and Rathod*et al.* (2017).

However, the traits *viz.*, number of panicles/plant (r = -0.039) and 1000 grain weight (r = -0.115) are found to show negative correlation with single plant yield. This attribute may be due to the compensation with length of the panicle and grain size on a single plant. The results are in accordance with the reports of Rai*et al.* (2014) and Jan *et al.* (2017) for number of panicles/plant and Naseem*et al.* (2014) for 1000 grain weight but found contrary with the results of Rashid *et al.* (2013).

It is also evidenced in the study that number of panicles/plant showed strong negative association with panicle length (r = -0.547), number of filled grains/panicle (r = -0.459) and 1000 grain weight (r = -0.412). Thus proving the above inference of compensation mechanism in the plants among the traits *viz.*, number of panicles/plant, panicle length, 1000 grain weight and filling percentage. The results are in accordance with the report of Lakshmi *et al.* (2014) and found contrary with the results of Rathod*et al.* (2017) for the association of number of panicles/plant with other traits. There existed positive association between panicle length and 1000 grain weight (0.402). The results are in accordance with the report of Rai*et al.* (2014) and found contrary with the results of Rashid *et al.* (2013) for the association of panicle length.

Correlation coefficient analysis among grain quality characters between head rice recovery and other physical traits of the grain were presented (Table 5). Head rice recovery exhibited strong positive correlation with hulling percentage (r = 0.173), milling percentage (r = 0.466) and kernel breadth (r = 0.074) and similarly, kernel length and kernel length/breadth ratio showed negative correlation with head rice recovery and milling percentage. This indicates that medium and medium slender and short bold grains may give high grain recovery during milling rather than long or long slender type. Though long or long slender grain type may facilitate for larger sink size for getting high yield, selection need to be focused for medium grain length for good recovery percentage. The result is in accordance with the findings of Devi *et al.* (2017) and Edukondalu*et al.* (2017).

In the present study, kernel length showed significant positive correlation with kernel length/breadth ratio (r = 0.820) and gelatinization temperature (r = 0.309) and positive association with gel consistency (r = 0.006) and amylose content (r = 0.037). This result is in accordance with the findings of Devi *et al.* (2017) and contrary to the findings of Rawte*et al.* (2017). Similarly kernel length/breadth ratio and gel consistency (r = 0.001) are positively correlated and gel consistency exhibited negative association with kernel breadth (r = -0.006). This infers that long kernels may end with soft gel consistency striking an indirect selection of long kernels for soft gel consistency which is in accordance with the findings of Rawte*et al.* (2017).

Amylose content had shown positive correlation with gel consistency (r = 0.014), gelatinization temperature (r = 0.215), kernel length (r = 0.037) and kernel breadth (r = 0.137). The gelatinization temperature association with amylose is greater than other traits implying that high amylose containing genotypes require high cooking time or temperature. This result is found similar with the findings of Rawte*et al.* (2017).

Taking grain yield as effect and other quantitative characters as causes, genotypic correlation coefficients were divided with the help of path coefficient analysis to unravel the direct and indirect effect of traits contributing towards grain yield (Table 6). From the path analysis, it was revealed that number of filled grains/panicle (0.912), number of panicles/plant (0.582), 1000-grain weight (0.404) and days to 50% flowering (0.151) had positive direct effects on grain yield per plant. Similar results were obtained by Kishore *et al.* (2015), Ratna*et al.* (2015) and Jan *et al.* (2017) for days to 50% flowering, Naseem*et al.* (2014) and Kishore *et al.* (2015) for number of panicles/plant, Kishore *et al.* (2015) and Ratna*et al.* (2015) for number of filled grains/panicle and Ratna*et al.* (2015), Kishore *et al.* (2015) and Jan *et al.* (2017) for 1000-grain weight.

Considering head rice recovery as effect and the quality characters as causes, path analysis revealed that milling percentage (0.577) and amylose content (0.251) had direct effect on head rice recovery (Table 7). Thus, enhancement of genotypes with long kernel and milling percentage that are having high direct effects might help in obtaining high head rice recovery. However, indirect effect of kernel length/breadth ratio through kernel length and breadth, indirect effect of hulling and milling percentage through kernel length/breadth ratio and, indirect effect of gelatinization temperature through kernel length had been observed.

The genetic structure of grain yield is derived from the net effect produced by various yield constituents working with one another. Based on the cause and effect analysis, it may be concluded that the grain filling percentage with good panicle length are the key causative traits to obtain high yield. Similarly long kernels for soft gel consistency, medium sized grain for good head rice recovery are the traits for indirect selection at field level. The amylose content may serve as an indicator for breeding varieties with good gel consistency and cultures with moderate cooking time.

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Table 1. Genetic materials taken for study

ADT 36	APO	EC 815128	JGL 11118	PUSA BASMATI 1	TPS 5
ADT 37	ASD 16	EC 815131	JGL 17004	PUSA BASMATI 1121	VANAPRABA
ADT 41	ASD 18	EC 815136	MDU 6	PMK (R) 3	VANDANA
ADT 42	ASD 19	EC 815138	MTU 1121	PUSA SUGANDH - 2	WAYRAREM
ADT 43	ASD 20	EC 815140	PUSA 1509	PUSA SUGANDH - 3	WGL 14377
ADT 45	BHAVANI	GOVIND	PUSA 1592	PUSA SUGANDH - 5	JAYA
ADT 47	CO 47	HEERA	PUSA 1612	RASI	GEB 24
ADT (R) 48	CO 51	IMPROVED PUSA BASMATI 1	PUSA 44	RNR 15048	MDU 5
ANJALI	DRR DHAN 43	INTAN	PUSA 677	SAHBHAGIDHAN	AD 07073
ANNA (R) 4	EC 815108	IR 64	PUSA 834	TKM 11	AD 09219

Table 2. Analysis of Variance (ANOVA) for yield traits in rice

Source of Variation	df	Days to 50% flowering	Plant Height	Number of panicles/plant	Panicle Length	Number of filled grains/ panicle	1000 grain weight	Single Plant Yield
Replication	2	16.03	342.32	22.2	2.24	573.52	0.98	15.08
Genotypes	59	396.68**	677.72**	8.17**	14.31**	6193.08**	44.94**	185.84**
Error	122	6	150.7	4.87	2.03	24.27	0.24	2.45

** Significant at 1% level

Table 3. Analysis of Variance (ANOVA) for quality traits in rice

Source of Variation	df	Kernel length	Kernel breadth	L/B ratio	Hulling %	Milling %	Head Rice Recovery	Gel consistency	Gelatinization Temperature	Amylose content
Replication	2	2.6	0.2	0.0001	171.22	113.8	77.86	126.47	0.45	11.51
Genotypes	59	5.61**	0.33**	1.73**	91.39**	146.52**	163.41**	4200.94**	6.97**	81.00**
Error	122	0.004	0.0002	0.00002	0.2	0.15	0.12	0.88	0.002	0.03

** Significant at 1% level

Table 4. Genotypic correlation coefficient for yield traits in rice

Character	Days to 50% flowering	Plant Height	Number of panicles/ plant	Panicle Length	Number of filled grains/ panicle	1000 grain weight	Single Plant Yield
Days to 50% flowering	1.000	0.382**	-0.044	0.128	0.040	0.057	0.144
Plant Height		1.000	-0.518**	0.644**	0.327*	0.174	0.129
Number of panicles/plant			1.000	-0.547**	-0.459**	-0.412**	-0.039
Panicle length				1.000	0.225	0.402**	0.134
Number of filled grains/panicle					1.000	-0.348**	0.516**
1000 grain weight						1.000	-0.115
Single Plant Yield							1.000

**** -** Significant at 1% level
* - Significant at 5% level

Table 5. Genotypic correlation coefficient for quality traits in rice

Character	Kernel length	Kernel breadth	L/B ratio	Hulling %	Milling %	Gel consistency	Gelatinization Temperature	Amylose Content	Head Rice Recovery
Kernel length	1.000	-0.171	0.820**	-0.418**	-0.337**	0.006	0.309**	0.037	-0.178
Kernel breadth		1.000	-0.693**	-0.029	0.055	-0.006	0.026	0.137	0.074
L/B ratio			1.000	-0.297*	-0.298*	0.001	0.223	-0.044	-0.195
Hulling %				1.000	0.437**	0.174	-0.073	0.049	0.173
Milling %					1.000	-0.034	0.062	-0.029	0.466**
Gel Consistency						1.000	-0.268*	0.014	0.021
Gelatinization Temperature							1.000	0.215	-0.077
Amylose Content								1.000	0.128
Head Rice Recovery									1.000

**** -** Significant at 1% level
* - Significant at 5% level

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Table 6. Direct and indirect effects of yield components on single plant yield in rice

Character	Days to 50% flowering	Plant Height	Number of panicles/ plant	Panicle Length	Number of filled grains/ panicle	1000 grain weight
Days to 50% flowering	**0.151**	0.042	-0.026	0.015	0.037	0.023
Plant Height	0.044	**-0.143**	-0.302	0.064	0.298	0.070
Number of panicles/plant	-0.005	0.023	**0.582**	-0.054	-0.419	-0.167
Panicle length	0.015	-0.029	-0.318	**0.099**	0.205	0.162
Number of filled grains/panicle	0.021	0.148	-0.267	0.112	**0.912**	-0.199
1000 grain weight	0.007	0.014	-0.240	0.040	-0.318	**0.404**
Single Plant Yield	0.144	0.129	-0.039	0.134	0.516	-0.115

Table 7. Direct and indirect effects of quality traits on head rice recovery in rice

Character	Kernel length	Kernel breadth	L/B ratio	Hulling %	Milling %	Gel consistency	Gelatinization Temperature	Amylose Content
Kernel length	**0.690**	0.090	0.216	0.030	-0.164	0.076	-0.042	0.007
Kernel breadth	-0.118	**-0.525**	0.667	0.002	0.027	0.000	0.008	0.027
L/B ratio	0.566	0.363	**-0.963**	0.021	-0.145	0.000	0.034	-0.008
Hulling %	-0.289	0.015	0.286	**-0.072**	0.213	0.004	0.010	0.009
Milling %	-0.232	-0.029	0.286	-0.032	**0.577**	-0.018	0.038	-0.016
Gel Consistency	0.004	0.036	-0.001	-0.013	-0.016	**0.004**	0.036	0.003
Gelatinization Temperature	0.214	-0.014	-0.215	0.005	0.030	-0.001	**-0.187**	0.038
Amylose Content	0.026	-0.072	0.042	0.013	-0.014	0.003	-0.029	**0.251**
Head Rice Recovery	-0.178	0.074	-0.195	0.173	0.466	0.021	-0.077	0.128

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Fig. 1. Path Diagram for Single Plant Yield

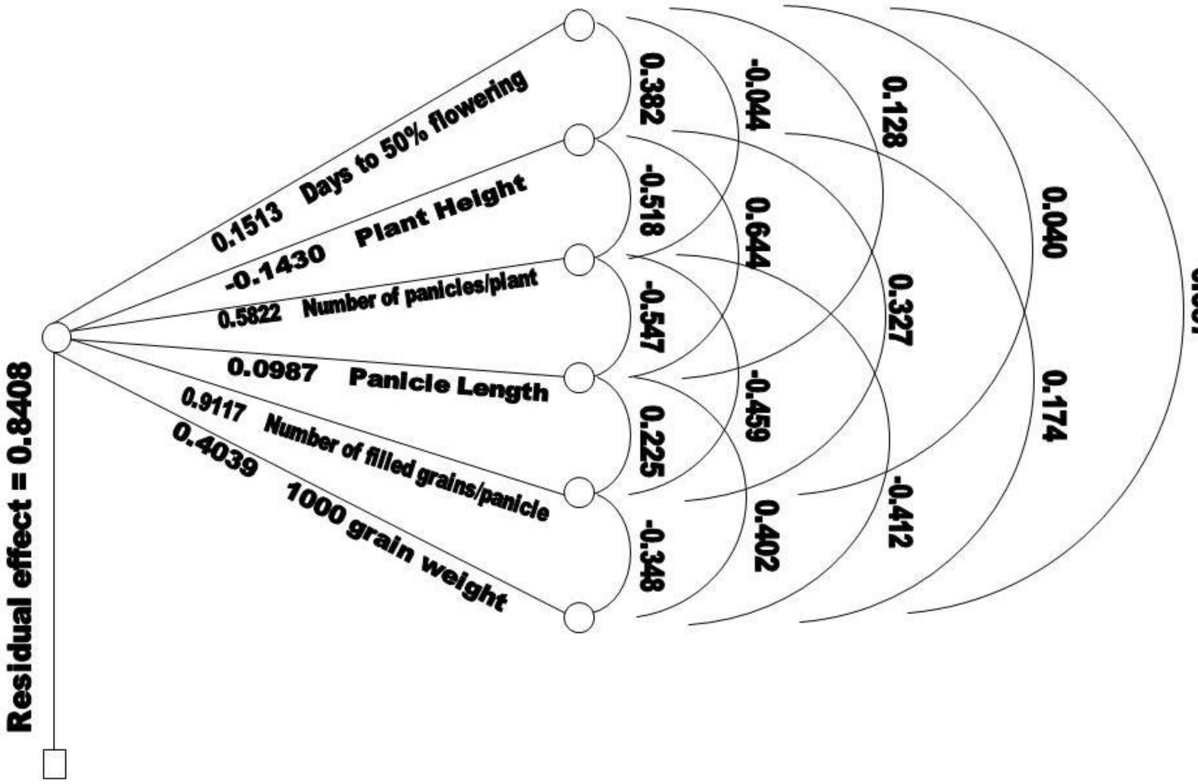

Fig. 2. Path Diagram for Head Rice Recovery