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STUDIES ON TRAIT ASSSOCIATION AND PATH ANALYSIS FOR PROTEIN AND YIELD RELATED TRAITS IN F_2 POPULATION OF RICE (*Oryza sativa* L.)

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ABSTRACT

The present experiment was carried out in rice using F_2 segregating populations of two cross combinations *viz.*, RNR 15048 x JAK 686 and RNR 15048 x JAK 685. Correlation analysis revealed negative and significant correlation of protein content with number of filled grains per panicle, test weight, single plant yield and kernel length and positive non-significant association with panicle length, number of productive tillers per plant and L/B ratio in cross I and positive non-significant association with days to 50% flowering, plant height, number of productive tillers per plant, number of filled grains per panicle, kernel breadth and amylose content and negative association with panicle length, test weight, single plant yield, kernel length and L/B ratio in cross II. Path analysis revealed that L/B ratio exerted highest positive direct effect on the protein content followed by kernel breadth, number of productive tillers per plant and panicle length in cross-I and number of productive tillers per plant, plant height, amylose content, test weight and kernel length exerted highest positive direct effect on the protein content in cross –II.

KEYWORDS: Correlation, path analysis and grain protein content

Rice (*Oryza sativa* L.) is one of the primary cereals and the most widely consumed staple food for more than half of the world's population, as well as one of the major protein sources in Asian countries. Food with nutritional value is always desired for human health. The world population is expected to reach nine billion by 2050, so there will be an increasing demand for varieties with desirable quality and nutritionally enriched in the future. This principal staple food contains a reduced quantity of many essential micro and macro elements such as vitamins, minerals, some phytochemicals, essential amino acids and fatty acids, which are indispensable to human health (Das *et al.*, 2020).

Rice grain protein is the second most abundant component of milled rice grain and has been studied extensively in the context of its important role as a nutrient. The net protein utilization from rice grains is highest among the cereal grains, despite rice having the lowest protein content (Juliano, 1992). With the improvement of people's living standards, rice consumers are paying much attention to good grain quality. Quality of rice is an important character to determine the economic value in the export market and consumer acceptance. Rice grain is composed of approximately 80-85% starch, 4-10% protein, 1% lipid and 10% moisture. Rice grain protein consists of two categories, functional protein (10%) and seed storage protein (SSP, 90%). The SSP in rice can be classified into four fractions: albumin, globulin, prolamin and glutelin according to differences in solubility (Chen *et al.*, 2018). Among them, glutelin is the most abundant one, which comprises about 60-80% of the total SSPs. The nutritional value of rice glutelin is superior to other rice storage proteins due its higher lysine content and greater digestibility by the humans. As a result, any significant change in glutelin content will definitely affect grain nutrition quality (Yang *et al.*, 2019). Protein content affects grain appearance, processing quality and eating quality of rice. In view of this, the present study was carried out to determine the character association and path coefficients analysis of protein and yield related traits by using F_2 segregating populations of two cross combinations.

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MATERIAL AND METHODS

The experiment was conducted at Agricultural Research Institute, Rice Research Centre, PJTSAU, Rajendranagar, Hyderabad during *rabi* 2021-22 to study character association and path analysis of the crosses (RNR 15048 x JAK 686) and (RNR 15048 x JAK 685). Two cross combinations are represented as cross I and cross II. 'Telangana sona' is the popular variety of Telangana having low glycemic index, excellent grain cooking quality and moderate protein content. However, JAK 686 and JAK 685 are having high grain protein content. The F_2 seeds of two cross combinations were sown in nursery. Twenty seven days old seedlings were transplanted as single seedling per hill in the main field with a spacing of 20 × 15 cm and all the recommended package practices were followed during crop growth period. Observations were recorded for 12 traits *viz.,* days to 50% flowering, plant height, panicle length, number of productive tillers per plant, number of filled grains per panicle, test weight, grain yield per plant, kernel length, kernel breadth, L/B ratio, amylose content and grain protein content in 150 selected plants in each cross combinations. Data recorded was further subjected to statistical analysis. Correlation and path coefficient statistical analysis were done using the DOS-based Excel program, TNAUSTAT-Statistical package (Manivannan, 2014).

RESULTS AND DISCUSSION

Correlation analysis provides information about relationship among the various characters and determines the component characters, on which selection can be based for genetic improvement in the grain yield. Positive correlation between desirable traits is favourable as it helps in simultaneous improvement of both the characters. On the other hand, negative correlation will hinder the simultaneous expression of both characters with high values.

In the present investigation, correlations were studied among protein, yield and its related traits in F_2 population of two cross combinations (RNR 15048 x JAK 686 and RNR 15048 x JAK 685). The findings of the correlations among yield, yield contributing traits and grain quality traits are provided in Table 1 and 2.

The results of correlation analysis revealed that positive and significant association of days to 50% flowering with number of filled grains per panicle (0.213) and negative significant association with plant height (-0.407), number of productive tillers per plant (-0.163), single plant yield (-0.209) in cross I and negative significant association with plant height (-0.731), number of filled grains per panicle (-0.177), test weight (-0.239), single plant yield (-0.250), kernel length (-0.554) and L/B ratio (-0.363) in cross II. The results are in accordance with the findings of Shet *et al.* (2012), Devi *et al.* (2019), Bhuvaneswari *et al.* (2018) for single plant yield and Selvaraj *et al.* (2011) for number of productive tillers per plant. It was observed that plant height exhibited significant and positive correlation with panicle length (0.329) and number of productive tillers per plant (0.171) in cross I. The results were in agreement with the findings of Ratna *et al.* (2015) for panicle length. Plant height had positive and significant association with panicle length (0.243), number of filled grains per plant (0.208), test weight (0.234), single plant yield (0.191) kernel length (0.524) and L/B ratio (0.342) in cross II. Similar results were reported by Hajiaqatabar *et al.* (2016) for single plant yield. Panicle length showed negative and significant association with test weight (-0.188) in cross I and positive significant association with L/B ratio (0.197) and negative significant association with kernel breadth (-0.194) in cross II. Positive and significant association of number of productive tillers per plant with single plant yield (0.198) and negative significant association with number of filled grains per panicle (-0.182) in cross I. Similar results were registered by Bhuvaneswari *et al.* (2018), Laxuman *et al.* (2011), Pradeep *et al.* (2018), Kalaiselvan *et al.* (2019), Singh *et al.* (2020), Swapnil *et al.* (2020) for single plant yield. Number of productive tillers per plant had positive significant association with test weight (0.273), single plant yield (0.492) and negative significant association with number of filled grains per panicle (-0.286) in cross II. Number of filled grains per panicle exhibited positive and significant association with single plant yield (0.489) kernel length (0.259) and L/B ratio (0.179) and negative significant association with protein content (0.194) in cross I. The results are in accordance with the findings of Pradeep *et al.* (2018), Kalaiselvan *et al.* (2019) Ratna *et al.* (2015), Sala *et al.* (2015), Singh *et al.* (2020), Swapnil *et al.* (2020) for single plant yield. Positive significant association of number of filled grains per panicle with single plant yield (0.240) and L/B ratio (0.245) and negative significant association with kernel breadth

Table 1. Correlation Coefficient in F_2 Population of Cross-I (RNR 15048 × JAK 686) for yield and its contributing characters with grain protein content in rice

Traits	DFF	PH	PL	PT	GPP	TW	SPY	KL	KB	L/B	AC	PC
DFF	1.000	-0.407**	0.042	-0.163*	0.213**	-0.115	-0.209*	0.068	0.058	0.008	-0.039	-0.041
PH		1.000	0.329**	0.171*	0.025	-0.112	0.158	-0.010	0.007	0.006	0.067	-0.029
PL			1.000	0.070	-0.107	-0.188*	-0.151	-0.156	-0.049	-0.055	0.022	0.073
PT				1.000	-0.182*	0.024	0.198*	-0.002	-0.094	0.076	-0.016	0.113
GPP					1.000	0.098	0.489**	0.259**	0.004	0.179*	0.065	-0.194*
TW						1.000	0.488**	0.257**	0.176*	0.006	0.108	-0.184*
SPY							1.000	0.283**	-0.006	0.188*	0.037	-0.208*
KL								1.000	0.068	0.590**	0.107	-0.192*
KB									1.000	-0.745**	0.083	-0.155
L/B										1.000	-0.017	0.010
AC											1.000	-0.107
PC												1.000

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

DFF- Days to 50% flowering, PH- Plant height, PL-Panicle length, PT-Number of productive tillers per plant, GPP-Number of grains per panicle, TW- 1000 grain weight, SPY- Single plant yield, KL- Kernel length, KB- Kernel breadth, L/B- Kernel L/B ratio, AC- Amylose content, PC- Protein content.

Table 2. Correlation Coefficient in F_2 Population of Cross-II (RNR 15048 × JAK 685) for yield and its contributing characters with grain protein content in rice

Traits	DFF	PH	PL	PT	GPP	TW	SPY	KL	KB	L/B	AC	PC
DFF	1.000	-0.731**	-0.117	-0.012	-0.177*	-0.239**	-0.250**	-0.554**	0.016	-0.363**	-0.051	0.048
PH		1.000	0.243**	-0.051	0.208*	0.234**	0.191*	0.524**	-0.005	0.342**	0.021	0.049
PL			1.000	-0.139	0.149	0.131	0.016	0.045	-0.194*	0.197*	-0.089	-0.002
PT				1.000	-0.286**	0.273**	0.492**	0.001	0.049	-0.034	0.050	0.031
GPP					1.000	-0.075	0.240**	0.042	-0.235**	0.245**	0.133	0.140
TW						1.000	0.390**	0.281**	0.042	0.150	-0.024	-0.054
SPY							1.000	0.103	0.077	-0.033	0.156	-0.130
KL								1.000	0.283**	0.404**	0.016	-0.078
KB									1.000	-0.750**	0.030	0.010
L/B										1.000	-0.024	-0.051
AC											1.000	0.093
PC												1.000

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

DFF- Days to 50% flowering, PH- Plant height, PL-Panicle length, PT-Number of productive tillers per plant, GPP-Number of grains per panicle, TW- 1000 grain weight, SPY- Single plant yield, KL- Kernel length, KB- Kernel breadth, L/B- Kernel L/B ratio, AC- Amylose content, PC- Protein content.

(-0.235) in cross II. Positive and significant association of test weight with single plant yield (0.488), kernel length (0.257) and kernel breadth (0.176) and negative significant association with protein content (-0.184) in cross I. The results were in agreement with the findings of Bhuvaneswari *et al.* (2018), Sala *et al*. (2015), Kumar *et al*. (2018), Singh *et al*. (2020) for single plant yield. Positive and significant association of test weight with single plant yield (0.390) and kernel length (0.281) in cross II. Single plant yield showed positive and significant association with kernel length (0.283) and L/B ratio (0.188) and negative significant association with grain protein content (-0.208) in cross I. Similar results were registered by Ekka *et al*. (2011) for kernel length and Dhakal *et al*. (2017) for protein content. Single plant yield had positive association with kernel length, kernel breadth and amylose content and negative association with L/B ratio and protein content in cross II. Kernel length exhibited positive and significant association with L/B ratio (0.590) and negative significant association with protein content (-0.192) in cross I and positive significant association with kernel breadth (0.283) and L/B ratio (0.404) in cross II. Kernel breadth showed negative and significant association with L/B ratio (-0.745) in cross I and cross II. L/B ratio exhibited negative correlation with amylose content in cross I. Amylose content showed negative association with grain protein content in cross I.

Correlation analysis revealed negative and significant correlation of protein content with number of filled grains per panicle (-0.194), test weight (-0.184), single plant yield (-0.208) and kernel length (-0.192) and positive association with panicle length, number of productive tillers per plant and L/B ratio in cross I and positive association with days to 50% flowering, plant height, number of productive tillers per plant, number of filled grains per panicle, kernel breadth and amylose content and negative association with panicle length, test weight, single plant yield, kernel length and L/B ratio in cross II.

Correlation gives only the relation between two variables, whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921) for better interpretation of cause and effect relationship. Hence, this objective was undertaken in the present investigation.

Based on the data recorded in the F_2 population in the present investigation, the correlations coefficients were estimated to determine direct and indirect effects at phenotypic level taking protein content as the dependent character. The results of path coefficient analysis for yield, related traits and quality traits are presented in Table 3 and 4.

Days to 50% flowering exerted negative direct effect (-0.075) on protein content and positive indirect effects on protein content through plant height, panicle length, test weight, single plant yield, kernel breadth, L/B ratio and amylose content and it had negative indirect effects through number of productive tillers per plant, number of filled grains per panicle, kernel length on protein content in cross I and days to 50% flowering exerted positive direct effect (0.086) on protein content in cross II. Plant height exhibited negative direct effect (-0.076) on protein content and indirect positive influence of this trait on protein content was observed through days to 50% flowering, panicle length, number of productive tillers per plant, test weight, kernel length, kernel breadth and L/B ratio and indirect negative effects on protein content through number of filled grains per panicle, single plant yield and amylose content in cross I and plant height exhibited positive direct effect (0.215) on protein content in cross II. Panicle length had positive and direct effect (0.032) on protein content and positive indirect influence of this trait on protein content was observed through number of productive tillers per plant, number of filled grains per panicle, test weight, single plant yield, kernel length and indirect negative effects on protein content through days to 50% flowering, plant height, kernel breadth, L/B ratio and amylose content in cross I and panicle length had negative direct effect (-0.009) on protein content in cross II.

Number of productive tillers per plant exerted positive direct effect (0.123) on protein content and indirect positive effects on protein content through panicle length, number of filled grains per panicle, L/B ratio, amylose content and protein content and indirect negative effects through plant height, test weight, single plant yield, kernel length and kernel breadth in cross I and number of productive tillers per plant had positive and direct effect (0.324) on protein content in cross II. Number of filled grains per panicle had negative direct effect (-0.045) on protein content and indirect positive influence of this trait on protein content was observed through kernel breadth and L/B ratio and indirect

Table 3. Phenotypic path coefficient analysis showing direct and indirect effects of yield related traits with grain protein content in F_2 Population of Cross-I (RNR 15048 × JAK 686)

Traits	DFF	PH	PL	PT	GPP	TW	SPY	KL	KB	L/B	AC	PC
DFF	**-0.075**	0.031	0.001	-0.020	-0.009	0.006	0.032	-0.023	0.011	0.003	0.002	-0.041
PH	0.030	**-0.076**	0.010	0.021	-0.001	0.006	-0.024	0.003	0.001	0.002	-0.004	-0.029
PL	-0.003	-0.025	**0.032**	0.008	0.004	0.010	0.023	0.054	-0.009	-0.021	-0.001	0.073
PT	0.012	-0.013	0.002	**0.123**	0.008	-0.001	-0.030	-0.001	-0.017	0.029	0.001	0.113
GPP	-0.016	-0.001	-0.003	-0.022	**-0.045**	-0.005	-0.074	-0.089	0.008	0.069	-0.004	-0.194
TW	0.008	0.008	-0.006	0.003	-0.004	**-0.056**	-0.074	-0.089	0.033	0.002	-0.006	-0.184
SPY	0.015	-0.012	-0.004	0.024	-0.022	-0.027	**-0.152**	-0.098	-0.001	0.072	-0.002	-0.208
KL	-0.005	0.008	-0.005	0.001	-0.011	-0.014	-0.043	**-0.346**	0.012	0.226	-0.006	-0.192
KB	-0.004	-0.006	-0.001	-0.011	-0.002	-0.010	0.001	-0.023	**0.187**	-0.286	-0.005	-0.155
L/B	-0.006	-0.005	-0.001	0.009	-0.008	-0.001	-0.028	-0.204	-0.139	**0.384**	0.001	0.010
AC	0.002	-0.005	0.007	-0.002	-0.003	-0.006	-0.005	-0.037	0.015	-0.006	**-0.060**	-0.107

Bold values are direct effects

DFF- Days to 50% flowering, PH- Plant height, PL-Panicle length, PT-Number of productive tillers per plant, GPP-Number of grains per panicle, TW- 1000 grain weight, SPY- Single plant yield, KL- Kernel length, KB- Kernel breadth, L/B- Kernel L/B ratio, AC- Amylose content, PC- Protein content.

Table 4. Phenotypic path coefficient analysis showing direct and indirect effects of yield related traits with grain protein content in F_2 Population of Cross-II (RNR 15048 × JAK 685)

Traits	DFF	PH	PL	PT	GPP	TW	SPY	KL	KB	L/B	AC	PC
DFF	**0.086**	-0.157	0.001	-0.004	-0.060	-0.016	0.108	0.040	0.001	0.567	-0.005	0.048
PH	-0.063	**0.215**	-0.002	-0.016	0.071	0.016	-0.082	-0.037	-0.001	-0.053	0.002	0.049
PL	-0.010	0.052	**-0.009**	-0.045	0.051	0.009	-0.007	-0.003	-0.007	-0.030	-0.008	-0.002
PT	-0.001	-0.011	0.001	**0.324**	-0.098	0.018	-0.213	-0.001	0.002	0.005	0.004	0.031
GPP	-0.015	0.045	-0.001	-0.093	**-0.343**	-0.005	-0.104	-0.003	-0.009	-0.038	0.013	-0.140
TW	-0.020	0.050	-0.001	0.088	-0.025	**0.068**	-0.169	-0.020	0.002	-0.023	-0.002	-0.054
SPY	-0.021	0.041	-0.001	0.160	0.082	0.026	**-0.432**	-0.007	0.003	0.005	0.015	-0.130
KL	-0.048	0.112	-0.004	0.005	0.014	0.019	-0.044	**-0.072**	0.001	-0.063	0.001	-0.078
KB	0.001	-0.001	0.001	0.161	-0.080	0.002	-0.033	-0.020	**0.003**	0.116	0.003	0.010
L/B	-0.031	0.073	-0.001	-0.011	0.084	0.010	0.014	-0.002	-0.002	**-0.155**	-0.002	-0.051
AC	-0.004	0.004	0.008	0.016	0.045	-0.001	-0.067	-0.001	0.001	0.003	**0.097**	0.093

Bold values are direct effects

DFF- Days to 50% flowering, PH- Plant height, PL-Panicle length, PT-Number of productive tillers per plant, GPP-Number of grains per panicle, TW- 1000 grain weight, SPY- Single plant yield, KL- Kernel length, KB- Kernel breadth, L/B- Kernel L/B ratio, AC- Amylose content, PC- Protein content.

negative effects on protein content through days to 50% flowering, plant height, panicle length, number of productive tillers per plant, test weight, single plant yield, kernel length and amylose content in cross I and number of filled grains per panicle had positive and direct effects (0.343) on protein content in cross II. Test weight exerted negative direct (-0.056) effects on protein content and indirect positive effects through days to 50% flowering, plant height, number of productive tillers per plant, number of productive tillers per plant, kernel breadth and L/B ratio on protein content and negative indirect effects on protein content through panicle length, number of filled grains per panicle, single plant yield, kernel length and amylose content in cross I and test weight showed positive and direct effect (0.068) on grain protein content in cross II. Single plant yield exhibited negative direct effects (-0.152) on protein content and indirect positive effects of this trait on protein content through days to 50% flowering, number of productive tillers per plant and L/B ratio and indirect negative effects was observed on protein content through plant height, panicle length, number of filled grains per panicle, test weight, kernel length, kernel breadth and amylose content in cross I and single plant yield had negative and direct effects (-0.432) on protein content in cross II.

Kernel length had negative direct effect (-0.346) on protein content and indirect positive effects were recorded on protein content through plant height, number of productive tillers per plant, kernel breadth and L/B ratio and indirect negative effects were observed through days to 50% flowering, panicle length, number of filled grains per panicle, test weight, single plant yield and amylose content in cross I and kernel length exerted negative and direct effects (-0.072) on protein content in cross II. Kernel breadth exhibited positive direct effect (0.187) on protein content and positive indirect influence of this trait through single plant yield and negative indirect effect through days to 50% flowering, plant height, panicle length, number of productive tillers per plant, number of filled grains per panicle, test weight, kernel length, L/B ratio and amylose content in cross I and kernel breadth exhibited positive and direct effects (0.003) on protein content in cross II. Kernel L/B ratio showed positive and direct effect (0.384) on protein content and positive indirect effects through number of productive tillers per plant and amylose content and negative indirect effects through days to 50% flowering, plant height, panicle length, number of filled grains per panicle, test weight, single plant yield, kernel length and kernel breadth in cross I and kernel L/B ratio had negative and direct effect (-0.155) on protein content in cross II. Amylose content exhibited negative direct effect (-0.060) on protein content and positive indirect effect through days to 50% flowering, panicle length, kernel breadth and negative indirect effect through plant height, number of productive tillers per plant, number of filled grains per panicle, test weight, single plant yield, kernel length and L/B ratio on protein content in cross I and amylose content had positive and direct effect (0.097) on protein content in cross II. Positive direct effects on protein content were observed for panicle length, number of productive tillers per plant, kernel breadth and L/B ratio in cross I and days to 50% flowering, plant height, number of productive tillers per plant, test weight, kernel breadth and amylose content in cross II.

The findings of the present investigation revealed that L/B ratio exerted highest positive direct effect on the protein content followed by kernel breadth, number of productive tillers per plant and panicle length in cross-I and number of productive tillers per plant, plant height, amylose content, test weight and kernel length exerted highest positive direct effect on the protein content in cross –II.

CONCLUSION

It was concluded that critical analysis of both correlation and path analysis indicated that L/B ratio, kernel breadth, kernel length, amylose content were determined as most important traits as both the correlation coefficients as well the direct effects were high with protein content.

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