



Studies of genetic correlation and path coefficient analysis between resistance to brown spot disease and yield related traits in rice (*Oryza sativa* L.)

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ARTICLE INFO

Received : 24 December 2021

Revised : 27 March 2022

Accepted : 04 April 2022

Available online: 21 August 2022

Key Words:

AUDPC

Brown spot

Cochliobolus miyabeanus

Correlation studies

Path analysis

Resistance

Rice

ABSTRACT

Brown spot disease in rice is caused by *Cochliobolus miyabeanus* (Anamorph: *Bipolaris oryzae* (Breda de Haan) Shoemaker, 1959 (Synonyms: *Helminthosporium oryzae*). It causes significant losses by affecting both economic yield and grain quality. Though, it is a minor disease in most of the parts of the world but the historical famines like Krishna Godaveri Delta famine and Bengal famines and huge crop losses in a number of incidences as in Guyana and Nigeria renders it as a potential threat to rice crop and adverted the requirement of efficient, sustainable and economical strategies to cope with the pathogen. In this context, availability of resistant sources against the pathogen is a noteworthy alternative for disease management. Realising the importance of resistant sources, the present research investigation was undertaken to study association between resistance to brown spot disease and yield attributing traits in rice via correlation studies and path analysis to identify high yielding resistant lines for brown spot disease in rice. In this study disease resistance expressed in terms of AUDPC showed negative correlation with yield and yield attributing traits and direct negative effect on yield. Thus, AUDPC can be utilised as a selection parameter for developing improved cultivars with higher grain yield and lower susceptibility towards the brown spot pathogen.

Introduction

Rice (*Oryza sativa* L.) is the most preferred staple food crop of more than half of the global population (Li *et al.*, 2014). It supplies 20-80% of dietary energy and 12-17% of dietary proteins for Asians. It is a semi-aquatic annual grass native to tropical Asia. In India it has the largest area under cultivation and highest production among grain

crop. In India approximately 43.19 million hectares area is under the cultivation of rice from which 115.63 million tons of grain is produced with average productivity of 26.77 Q/ha (3rd Adv. Est. 2018-19, Annual Report, DAC&FW). A well-managed crop with adequate irrigation, nutrient and crop health management yield average 2-3 t/ha.

However, its yield potential is adversely affected by diseases, insect-pest and weeds. Among these, fungal diseases especially brown spot is a potential threat to rice crop with respect to its production and productivity. The disease is caused by *Cochliobolus miyabeanus* (Ito and Kuribayashi, 1927) (Synonyms: *Helminthosporium oryzae*). The pathogen infects the coleoptiles (causing blighting), leaves (forming oval, dark brown to purplish-brown spots ultimately killing the leaf) and even the seeds which are badly damaged at the flowering to milk stages than at the soft dough or mature stages (Ou, 1985). The disease is of great importance on ground of economic significance and have a historical context as well in form of two major epidemics in India, the first in 1918–19 in the Krishna Godavari delta and the second, the Great Bengal Famine during 1942 (Ghose *et al.*, 1960). These epidemics were a results of heavy crop loss upto 90 % (Ghose *et al.*, 1960; Sunder *et al.*, 2005) in associated area due to large scale devastation by the pathogen in absence of suitable management practises. Among a number of alternatives, use of resistant sources against the pathogen is considered to be the most sustainable and economical method of disease management. However, it is often reported that the field resistance in commercial varieties of a crop is not durable and liable for breakdown on account of fast evolving pathogen like *Cochliobolus miyabeanus*. To cope with this, it is imperative that the resistant sources should be diverse and should be strategically employed to prevent the speedy spread of pathogen or to trap it in limited cropped area. In this regard, the available germplasm resources should be screened against the pathogen and evaluated for higher yield characteristics to identify high yielding resistance genotypes. Further, on ground of being a polygenic trait, yielding potential of a genotype is highly influenced by environmental factors (Khatab *et al.*, 2016). The component traits also have direct and indirect effect via other traits on the final yield. These effects could be identified and estimated following association studies involving correlation and path analysis (Jaiswal *et al.*, 2019). Path analysis is employed to disentangle the direct and indirect influences of component traits on grain yield and also quantifies the inter relationship among the various component traits. The inferences

derived based on the results of association studies provides an obvious understanding in selection of component trait to be used for direct and /or indirect selection, if required. Keeping these in view, the present investigation is carried out with the objective of studying the associations between resistance to brown spot disease and yield attributing characters in rice.

Material and Methods

The present research was carried out at Rice Research Farm, Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar on 300 genotypes of rice along with three check varieties namely Rasi (resistant check), IR-64 (moderately resistant check) and Pankaj (susceptible check) in augmented design during *kharif* season 2019 and *kharif* season 2020. The experimental plot was subdivided into 12 blocks with replicated checks and unreplicated test genotypes. The entries were raised in nursery and transplanted in the main field 30 days after sowing at a spacing of 20cm x15cm. All the recommended package of practices were followed along with necessary prophylactic plant protection measures to raise a good crop. The fungal suspension was used for spraying the crop for artificial inoculation in controlled conditions while in the field the susceptible check was used as infector row. Moreover, the experimental location is a hotspot for brown spot infection. Disease scoring was done visually on 10 individual plants following Standard Evaluation System for Rice (SES), IRRI, 2013 for brown spot at grain filling stage. Data on yield and yield attributing traits were recorded and subjected to statistical analysis using OPSTAT 2020 for studying the association between disease resistance and yield. The correlation coefficients between variables under study was calculated following Johnson *et al.* (1955) and the Path coefficient analysis was carried out following Wright (1921) and Dewey and Lu (1959).

Results and Discussion

Correlation Analysis

Association between two or more traits in terms of degree and direction can be defined by correlation. Table 1 represents the genotypic (above diagonal)

and phenotypic (below diagonal) correlation among different traits under study. AUDPC showed significant and positive phenotypic and genotypic correlation with days to 50% flowering (0.93 & 0.80), days to physiological maturity (0.96 & 0.83) and plant height (0.87 & 0.65) while significant but negative correlation with panicle length (-0.95 & -0.80) number of effective tillers per plant (-0.67 & -0.51), number of grains per panicle (-0.73 & -0.57), test weight (-0.89 & -0.73) and yield (-0.48 & -0.37) (Fig. 1).

Path analysis

Phenotypic Path Matrix

In phenotypic path matrix (table 2) highest direct positive effect on grain yield was shown by number of grains per panicle (0.59) followed by number of

effective tillers per plant (0.45; similar to Singh *et al.*, 2018) and test weight (0.36) while the highest direct negative effect was shown by days to physiological maturity (-0.36) followed by AUDPC (-0.13), panicle length (-0.09) and plant height (-0.013; similar to Kumar *et al.*, 2018). The highest positive indirect effect was shown by number of grains per panicle (similar to Prakash *et al.*, 2018) via test weight (0.42) while the lowest positive indirect effect was shown by days to 50 % flowering via number of effective tillers per plant (0.02). Further, the highest negative indirect effect on grain yield was shown by days to physiological maturity via days to 50 % flowering (-0.35) while the lowest negative indirect effect was shown by plant height via number of effective tillers per plant (-0.004).

Table 1: Estimates of Genotypic and Phenotypic Correlation co-efficient between yield and its related trait

Traits	Days to fifty per cent flowering	Days to physiological maturity	Plant height (cm)	Panicle length (cm)	Effective tillers per plant	Grains per panicle	Test weight (g)	AUDPC	Grain yield per plant (g)
Days to fifty per cent flowering	1.00	0.99***	0.92***	0.88***	-0.52***	-0.59***	-0.85***	0.93***	-0.31**
Days to physiological maturity	0.99***	1.00	0.92***	0.91***	-0.57***	-0.65***	-0.88***	0.96***	-0.37**
Plant height (cm)	0.80 ***	0.80***	1.00	0.83***	-0.47***	-0.48***	-0.76***	0.87***	-0.22**
Panicle length (cm)	0.78***	0.82***	0.71***	1.00	0.62***	-0.68***	-0.83***	-0.95***	0.43***
Effective tillers per plant	-0.43***	-0.46***	-0.34**	0.52***	1.00	0.85***	0.80***	-0.67***	0.90***
Grains per panicle	-0.52***	-0.57***	-0.40***	-0.57***	0.65***	1.00	0.88***	-0.73***	0.92***
Test weight (g)	-0.72***	-0.75***	-0.57***	-0.71***	0.60***	0.70***	1.00	-0.89***	0.72***
AUDPC	0.80***	0.83***	0.65***	-0.80***	-0.51***	-0.57***	-0.73***	1.00	-
Grain yield per plant (g)	-0.27**	-0.32**	-0.19**	0.37**	0.79***	0.83***	0.65***	-0.37**	1.00

*Significant at 5%, **1% and ***0.1 % probability levels. Phenotypic correlation above diagonal; Genotypic correlation below diagonal

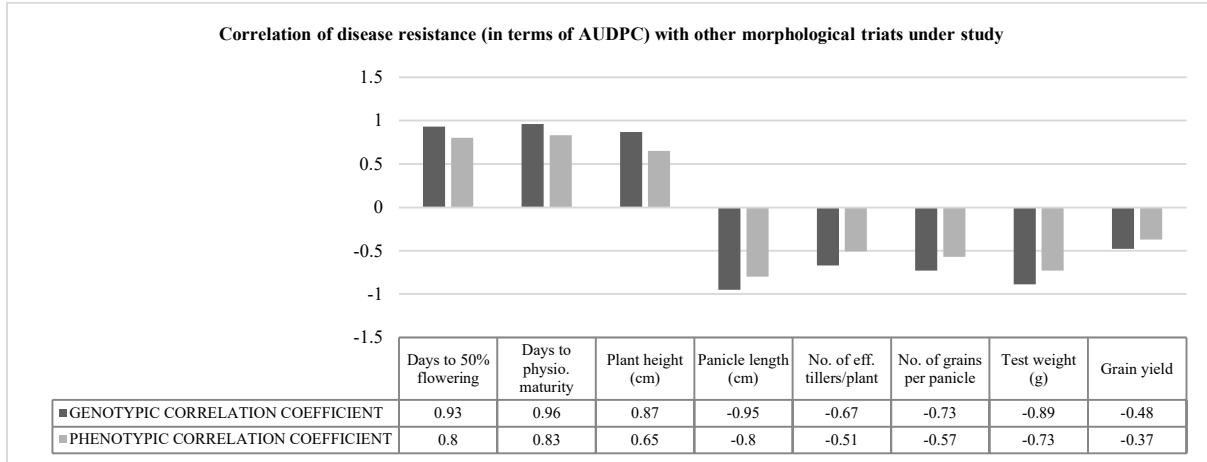


Figure 1: Correlation of disease resistance (in terms of AUDPC) with other morphological traits under study.

Table 2: Estimates of Phenotypic(P) and Genotypic (G)matrix of direct and indirect effects on grain yield per plant

Traits		Days to fifty per cent flowering	Days to physiological maturity	Plant height (cm)	Panicle length (cm)	Effective tillers per plant	Grains per panicle	Test weight (g)	AUDPC	Correlation with Grain yield per plant (g)
Days to fifty per cent flowering	P	0.05	0.05	0.04	0.04	0.02	0.03	0.04	0.04	-0.27
	G	4.10	4.08	3.78	3.61	2.15	2.44	3.47	3.84	-0.31
Days to physiological maturity	P	-0.35	-0.36	-0.28	-0.29	-0.16	-0.20	-0.27	-0.29	-0.32
	G	-5.74	-5.76	-5.31	-5.24	-3.27	-3.76	-5.07	-5.52	-0.37
Plant height (cm)	P	-0.01	-0.01	-	-0.01	-0.004	-0.005	-	-0.008	-0.19
	G	-0.19	-0.19	-0.21	-0.17	-0.10	-0.10	-0.16	-0.18	-0.22
Panicle length (cm)	P	-0.07	-0.08	-0.07	-0.09	-0.05	-0.05	-0.07	-0.07	0.37
	G	-0.16	-0.17	-0.15	-0.18	-0.11	-0.12	-0.15	-0.17	0.43
Effective tillers per plant	P	0.19	0.20	0.15	0.23	0.45	0.29	0.27	0.23	0.79
	G	0.10	0.11	0.09	0.12	0.19	0.16	0.15	0.13	0.90
Grains per panicle	P	0.30	0.34	0.24	0.34	0.38	0.59	0.42	0.34	0.83
	G	0.62	0.67	0.49	0.70	0.88	1.04	0.91	0.75	0.92
Test weight (g)	P	0.26	0.27	0.21	0.26	0.22	0.25	0.36	0.26	0.65
	G	0.49	0.51	0.44	0.48	0.46	0.51	0.57	0.51	0.72
AUDPC	P	-0.10	-0.11	-0.08	-0.10	-0.07	-0.07	-0.09	-0.13	-0.37
	G	-0.39	-0.40	-0.36	-0.39	-0.28	-0.30	-0.37	-0.41	-0.48

Bold diagonal values indicates the direct effect; $R^2 (P) = 0.8989$ RESIDUAL EFFECT = 0.3179; $R^2 (G) = 1.0061$ RESIDUAL EFFECT = 0.0781

Genotypic Path Matrix

Genotypic path matrix (table 2) showed highest direct positive effect was shown by days to 50% flowering (4.10; similar to Ratna *et al.*, 2015) followed by number of grains per panicle (1.04), test weight (0.57) and number of effective tillers per plant (0.19) while days to physiological maturity (-5.76), AUDPC (-0.41), plant height (-0.21) and panicle length (-0.18) showed direct negative effect. Bhadru *et al.*, (2011) and Chandra *et al.*, (2009) reported positive direct effect of days to 50% flowering and Eidi kohnaki *et al.*, (2013) and Kiani and Nematzadeh (2012) found the positive direct effect and significant positive correlation coefficient between productive tillers/plant and grain yield/plant which also supported the present finding. Thus, number of grains per panicle and test weight were identified as major contributors toward yield enhancement and can be used as the major selection indices for identifying high yielding resistant lines. The highest positive indirect effect on yield (similar to Jaiswal *et al.*, 2019) was shown by days to 50% flowering via days to physiological maturity (4.08) while the lowest positive indirect effect on yield was shown by number of effective tillers per plant via plant height (0.09). The highest indirect negative effect was shown by days to physiological maturity via days to 50 % flowering (-5.74) while the lowest indirect negative effect was shown by panicle length via number of effective tillers per plant (-0.11).

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Conclusion

In this study, disease resistance expressed in terms of AUDPC showed negative correlation with yield and yield attributing traits. Further it showed direct negative effect on yield. It also showed indirect negative effect on yield via other traits under study. This is evident from the fact that a genotype that is less affected by pathogen has lower value of AUDPC and is expected to show better growth and development at all the critical stages of plant growth thus, exhibit higher yield. So, a negative correlation is obtained between AUDPC and yield and yield attributing traits. Thus, AUDPC could be used as a selection parameter of developing improved cultivars with higher grain yield and lower susceptibility towards the brown spot pathogen. The salient findings of this study establish a negative association between AUDPC and yield. Hence, a line with lower AUDPC value would be expected to be resistant to the pathogen and have higher yield.

Acknowledgement

We duly acknowledge ICAR for financial support. We also extend our sincere gratitude to Dr. Rajesh Ranjan, Assistant Professor, Dept. of Plant Pathology for his valuable guidance and generous help in the disease screening.

Conflict of interest

The authors declare that they have no conflict of interest.

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