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Association study on yielding attributes and brown spot disease components in rice germplasm under aerobic condition

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Abstract
The study was executed with 150 genotypes of the rice along with three check varieties namely, Rajshree, Pankaj, and Rajendra Neelam for the eleven quantitative traits by using augmented randomized complete block design at Rice research farm of RPCAU, Pusa, Bihar, during *Kharif* season of 2019.These genotypes were screened under aerobic condition for assessment of interrelationship among various yield attributing parameters and brown spot disease components to assess eleven different traits. Association analysis discovered that the grain yield per plant had a significant positive association with test weight and significant high negative association with AUDPC. However, it was revealed that test weight exhibited negligible positive direct effect but the AUDPC exhibited highest negative direct effect on grain yield per plant. It was also reported that most of the traits were exhibiting moderate to high negative indirect effect on grain yield per plant via AUDPC suggesting that the negative selection for disease severity and AUDPC will reduce the damage to crop by the pathogen and consequently improve the yield.

Keywords: Association, yielding, disease, components, rice, aerobic

Introduction
Rice is the principal sustenance crop for large number of beings since first light of human progress, particularly in Asia and the West Indies. After maize and wheat, rice holds the position of third-most produced crop throughout the world (FAO, 2010). Rice is being cultivated in 114 nations of the world. In India, rice is grown under varied agro ecological environments extending from wet puddled soils of the deltas to scorched soil of Rajasthan in the west and from the coastal territories at the mean sea level to the sloping tracts of around 2200 m high in north. In Asia, lowland rice production utilizes about 45 per cent of the total fresh water. Based on the hydrological condition, soil status and water control the typical value of usage of water in low-lying rice cultivation is around 1,500-2,000 mm. Water is becoming scare for agriculture at present situation. It is envisioned that by the era of 2025, out of seventy five million hectare, the 15 million hectare of Asia's crop cultivation relying on the flooded irrigated system will prone to face the deprivation of water which will results in the certain extent of water deprivation condition in 15-20 million hectares of irrigated rice. Thus, one such forthcoming approach of rice cultivation is aerobic rice cultivation which reduces the water demand in rice production and increases the water use efficiency. Experiments on aerobic rice has shown that water requirement in aerobic rice were 50% lower (470-650mm) and water productivity were 64-88% higher than lowland rice (Suryavanshi *et al.*, 2013) [8]. In aerobic rice system, crop is established by direct seeding under non-puddled, non-flooded soil and field remain unsaturated throughout the season. In addition to coping with water scarcity this form of cultivation also reduces labor requirements and decreases greenhouse gas emissions. Aerobic rice cultivar is developed by combining the features of drought resistance of upland cultivar along with high yielding traits of lowland cultivar. In the aerobic cultivation the anticipated yields of rice are although to a certain extent lower than the yield attained through low- lying flood irrigated cultivation however, it can be promising option for the resource poor farmers who are entirely relying on the rainfall for crop production. Therefore aerobic cultivation of rice is slowly gaining momentum among farmers and research workers in order to achieve both higher productivity and efficient use of water.

Being a major field crop, it encounters a number of biotic and abiotic stresses *viz*., diseases, insect pest, weeds, salinity, drought etc. Despite evolution of series of newly developed rice cultigens and advancement of novel fungicidal formulations, diseases remains a potential threat that lowers the crop yield and associated profit derivation thereof. Annually, it causes reasonable to mammoth yield loss in rice and sometimes it may leads to eradication of the entire crop. The largely ignored yield limiting constraints in the rice is the brown spot whose etiological agent is *Bipolaris oryzae*. The testament of the great Bengal famine took place in the year of 1942, which has resulted in the devastating damage in the South Asian countries. It causes both quantitative as well as qualitative losses. It has documented in several surveys directed across all low-lying rice cultivation area of South Asian nations has found the losses in the yield ~ 50%. Although, the application of the chemicals for the management of this problem is available, but the management of this disease through the deployment of the varietal resistance is considered as efficacious, feasible and sustainable as well as budget-friendly approach. The crucial parameter which should be attained for the accomplishment of any cultivar widely depends on its high yielding capacity, although, it would be prudent enough if such cultivars also possess the potential to counterattack the damages due to imperative pest as well as the diseases. In order to enhance yielding attribute of aerobic rice information on correlation is viewed as of foremost significance in any crop improvement program since crop yield the complex quantitative attribute and is polygenetically controlled. Consequently, the selection premised on the crop yield alone is usually not efficacious. In such a situation enhancement in yield which is a prime objective of any breeding program is achieved through indirect selection based on its components and secondary characters are considered more efficient and reliable.

Material and Method

The present investigation was executed at the research farm, of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during the Kharif season of 2019. The experimental material used in this study include 150 rice genotypes along with the 3 check varieties named Rajshree, Pankaj and R. Neelam. Out of these three checks Rajshree was used as moderately resistant check and Neelam was used as resistant check while Pankaj was used as susceptible check. Eleven parameters *viz*., panicle length days to 50% flowering, plant height, disease intensity % (PDI), area under disease progress curve (AUDPC), days to maturity, number of panicles per plant, test weight, filled grains per panicle, number of tillers per plant, grain yield per plant. For the estimation of PDI and AUDPC, an epiphytotic condition for the brown spot was created by artificial inoculation by using the inoculum collected from Department of Plant Pathology, RPCAU, Pusa, Bihar after 65 days after sowing by using an aerosol sprayer. The PDI was estimated by carrying out the field scoring for three times during the entire cropping period, *i.e*. 20th October, 5th November, 20th November. Screening for brown spot resistance consists of visual scoring of affected plants following disease rating scale of Standard Evaluation System of Rice published by IRRI (2013). During scoring the tagged plants inside each plot was visually assessed for percent foliar affected area at fifteen days span. Disease intensity % (PDI) was calculated using the following formula:

$$\text{Disease intensity \%} = \frac{\text{Sum of all numerical ratings} \times 100}{\text{Number of plants observed } \times \text{Maximum rating}}$$

The percent disease intensity (PDI) was estimated by carrying out the field scoring for three times during the entire cropping period, *i.e.* 20th October 2019, 5th November 2019, 20th November 2019. Then the integration of PDI readings (disease severity) recorded from the rice variety estimated the values of AUDPC. AUDPC also summarizes the level of disease intensity along a period which is computed using the following formula as given by “Campbell and Madden (1990)”.

$$\text{AUDPC} = \sum_{i=1}^{n-1} (\text{Y}_{i+1} + \text{Y}_i)\ 0.5\ (\text{T}_{i+1} - \text{T}_i)$$

Where
Yi = PDI on ithdate
Ti = date of scoring of the disease
n = numbers of dates on which disease was scored.

Mean of the data recorded for all eleven quantitative traits was put through the statistical analysis.

Result and Discussion

Correlation analysis

Generally, the yielding ability of the crop is improved by practicing indirect selection via the other traits that are positively associated with the grain yield. Therefore, the acquaintance of the inter-relationship of the crop traits like grain yield with another trait is of utmost essence for the crop breeder to attain the desired level of genetic gain. Correlation is one such biometrical technique that provides information about the strength and direction of the association between the two traits. Therefore, the correlation at genotypic and phenotypic levels was calculated from the variance and covariance values for pairs of all the characters under study and has been presented in the Table 1

As the present investigation aimed with the view to ascertain the brown spot resistance cultivars, much emphasis was laid to apprehend the inter- relationship between the brown spot incidence parameters with grain yield and its components

The current investigation signposted that correlation at genotypic level existed of at higher magnitude than the correlation coefficients at the phenotypic level signifying association amidst the various traits might be existed due to strong inherent cause. The lower estimates of the phenotypic correlation co-efficient indicates that association was affected by the environment at the phenotypic level.

From the study, it was found that only test weight was showing significant positive association with grain yield per plant at genotypic and phenotypic level while a significant negative association was found between grain yield per plant and days to maturity, plant height, panicle length, filled grains per panicle. Comparable findings were likewise chronicled by Zahid *et al.* (2006) [9], Rashid *et al.* (2014) [6] for test weight suggesting that indirect selection via test weight might yield a fruitful result for the grain yield.

In this study, an endeavour was done to reveal the inter-relation between parameters used for brown spot assessment and various yield attributing traits. It was found that PDI and AUDPC exhibited a significantly high positive association with each other and with filled grains per panicle, plant height, and panicle length. The significant positive association between the plant height and panicle length with brown spot parameters might arise due to the increase in the surface area of the crop which predisposes the crop for more pathogen attack leading to incomplete grain filling. It was also found that significant high negative association with the grain yield per plant and number of panicles per plant as high PDI and AUDPC values will result in low yield indicating that grain infection affects seed development and may cause a loss in reproductive growth thereby increasing the susceptibility of the genotypes. Therefore, it could be concluded that the negative association of disease parameter with no of panicles per plant as well as yield per se will have bearing on the overall yield of the crop. Comparable findings were likewise chronicled by Koutroubas *et al*. (2009) [5], Chethana *et al.* (2018) [2], Elamawi *et al.* (2018) [3].

Table 1: Correlation co-efficient among the eleven traits of rice genotypes under aerobic condition

S. No.	Traits		DFF	DM	PH	PL	NTP	NPP	FGP	TW	GYP	PDI	AUDPC
			Genotypic Correlation Co-Efficient										
1.	DFF	Phenotypic Correlation Co-Efficient		0.9991**	0.0786	-0.1112*	-0.0543	-0.0049	0.1457**	-0.1045*	-0.0645	0.0016	0.0093
2.	DM		0.8652**		0.1303**	-0.0397	-0.0778	0.0029	0.1701**	-0.0862	-0.1002*	0.0580	0.0528
3.	PH		0.0779	0.1062*		0.6957**	-0.0731	-0.0893	0.2013**	0.0164	-0.3969**	0.4072**	0.4231**
4.	PL		-0.1085*	-0.0428	0.5895**		-0.0882	-0.0805	0.1009*	0.0736	-0.1657**	0.2023**	0.2086**
5.	NTP		-0.0549	-0.0748	-0.0680	-0.0773		0.6493**	0.0067	0.1073*	0.0479	-0.0902	-0.0915
6.	NPP		-0.0013	-0.0005	-0.0836	-0.0614	0.6269**		0.1036*	0.1473**	0.0382	-0.0959	-0.1113
7.	FGP		0.1331**	0.1458**	0.1927**	0.0926*	0.0086	0.1001*		-0.0514	-0.1083	0.1212	0.1243
8.	TW		-0.0991*	-0.0804	0.0163	0.0629	0.1051*	0.1423**	-0.0497		0.1961	-0.1970	-0.1813
9.	GYP		-0.0615	-0.0995	-0.3746	-0.1514	0.0470	0.0368	-0.1076	0.1893		-0.9192	-0.9357
10.	PDI		0.0016	0.0525	0.3922**	0.1820***	-0.0870	-0.0930*	0.1182*	-0.1937***	-0.9002		0.9760
11.	AUDPC		0.0054	0.0559	0.4078**	0.1865***	-0.0879	-0.1072*	0.1227**	-0.1785***	-0.9168	0.9641***	

Days to 50% flowering (DFF), Days to maturity (DM), Plant height (PH), Panicle length (PL), Number of tillers per plant (NTP), Number of panicles per plant (NPP), Filled grains per panicle (FGP), Test weight (g.) (TW), Grain yield per plant (g.) (GYP), Percent disease intensity (PDI) and Area under disease progress curve (AUDPC)

Path analysis

Path analysis is used to find out whether there is a spurious correlation within the independent variables. Hence, these correlations should be apportioned into direct and indirect effects in order to know the portion of total correlation, that is because of the effect of character alone known as “Direct effect” and the fraction that is due to the correlation of the character with the remaining characters, known as “Indirect effect”.

In the current examination, the phenotypic and genotypic correlations of grain yield per plant with rest of the quantitative parameters under study were segregated into their corresponding direct and indirect effects through path analysis. The results obtained has been formulated in Table 2.

Path analysis study in the current study revealed that not a single trait reported a high direct positive effect on grain yield per plant at the phenotypic level. Among all traits studied, days to 50% flowering followed by panicle length and test weight exhibited a maximum positive direct effect on the grain yield per plant at the genotypic level. Comparable findings were likewise chronicled by by Kole *et al.* (2010) [4], Babu *et al.* (2012) [1], Seyoum *et al.* (2012) [7].

The valuation of the true relationship amongst the yield attributes and AUDPC is crucial for understanding the reaction of genotypes towards brown spot disease incidence. Path analysis conducted in this investigation reported that the significant negative association AUDPC with grain yield per plant was due to the utmost negative direct effect of AUDPC. It is also found that most of the traits like plant height, panicle length, test weight and PDI exhibited moderate to high negative indirect effect via AUDPC on grain yield per plant. Comparable findings were likewise chronicled by Chethana *et al.* (2018) [2], Elamawi *et al.* (2018) [3].

Thus, it can be interpreted that the partitioning of the correlation values disclosed that most of the traits could not establish a true significant correlation with grain yield per plant which might arise due to very high negative indirect effects of the other traits through AUDPC on grain yield per plant. It can also be suggested that the negative selection for disease severity and AUDPC will reduce the damage to crop by the pathogen and consequently improve the yield.

Table 2: Path coefficient values for the traits of rice genotypes under aerobic condition

S. No.	Traits		DFF	DM	PH	PL	NTP	NPP	FGP	TW	PDI	AUDPC
1.	DFF	G	0.4328	0.4324	0.0340	-0.0481	-0.0235	-0.0021	0.0631	-0.0452	0.0007	0.0040
		P	-0.0554	-0.0480	-0.0043	0.0060	0.0030	0.0001	-0.0074	0.0055	-0.0001	-0.0003
2.	DM	G	-0.4780	-0.4784	-0.0623	0.0190	0.0372	-0.0014	-0.0814	0.0413	-0.0278	-0.0252
		P	0.0007	0.0008	0.0001	0.0000	-0.0001	0.0000	0.0001	-0.0001	0.0000	0.0000
3.	PH	G	-0.0037	-0.0062	-0.0472	-0.0329	0.0035	0.0042	-0.0095	-0.0008	-0.0192	-0.0200
		P	-0.0012	-0.0016	-0.0155	-0.0092	0.0011	0.0013	-0.0030	-0.0003	-0.0061	-0.0063
4.	PL	G	-0.0083	-0.0030	0.0519	0.0746	-0.0066	-0.0060	0.0075	0.0055	0.0151	0.0156
		P	-0.0017	-0.0007	0.0094	0.0160	-0.0012	-0.0010	0.0015	0.0010	0.0029	0.0030
5.	NTP	G	0.0006	0.0009	0.0008	0.0010	-0.0113	-0.0073	-0.0001	-0.0012	0.0010	0.0010

		P	-0.0001	-0.0001	-0.0001	-0.0002	0.0020	0.0012	0.0000	0.0002	-0.0002	-0.0002
6.	NPP	G	0.0003	-0.0002	0.0055	0.0049	-0.0398	-0.0613	-0.0064	-0.0090	0.0059	0.0068
		P	0.0001	0.0000	0.0056	0.0041	-0.0418	-0.0668	-0.0067	-0.0095	0.0062	0.0072
7.	FGP	G	0.0050	0.0058	0.0069	0.0035	0.0002	0.0036	0.0343	-0.0018	0.0042	0.0043
		P	0.0029	0.0032	0.0042	0.0020	0.0002	0.0022	0.0217	-0.0011	0.0026	0.0027
8.	Test wt	G	-0.0044	-0.0037	0.0007	0.0031	0.0045	0.0062	-0.0022	0.0424	-0.0084	-0.0077
		P	-0.0025	-0.0020	0.0004	0.0016	0.0026	0.0035	-0.0012	0.0248	-0.0048	-0.0044
9.	PDI	G	0.0001	0.0023	0.0160	0.0079	-0.0035	-0.0038	0.0048	-0.0077	0.0392	0.0383
		P	-0.0003	-0.0114	-0.0855	-0.0397	0.0190	0.0203	-0.0258	0.0422	-0.2179	-0.2101
10.	AUDPC	G	-0.0089	-0.0503	-0.4032	-0.1988	0.0871	0.1061	-0.1184	0.1727	-0.9300	-0.9529
		P	-0.0038	-0.0396	-0.2889	-0.1321	0.0623	0.0759	-0.0869	0.1265	-0.6829	-0.7084
11	GYP	G	-0.0645	-0.1002	-0.3969	-0.1657	0.0479	0.0382	-0.1083	0.1961	-0.9192	-0.9357
		P	-0.0615	-0.0995	-0.3746	-0.1514	0.0470	0.0368	-0.1076	0.1893	-0.9002	-0.9168
	Partial R^2	G	-0.0279	0.0479	0.0187	-0.0124	-0.0005	-0.0023	-0.0037	0.0083	-0.0361	0.8916
		P	0.0034	-0.0001	0.0058	-0.0024	0.0001	-0.0025	-0.0023	0.0047	0.1962	0.6494

Genotypic: R Square = 0.8837 Residual Effect = 0.3411
Phenotypic: R Square = 0.8523 Residual Effect = 0.3843

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