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Genetics of association among yield and blast resistance traits in rice (*Oryza sativa*)

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ABSTRACT

Blast disease caused by the fungus *Pyricularia oryzae* is one of the serious threats to world's most important staple food crop, rice (*Oryza sativa* L.). The improvement of blast resistance is one of the priority areas in breeding. Knowledge about association of yield traits with resistance parameters should be of paramount importance prior to development of a high yielding resistant variety. The present study was designed to understand the association of different traits in the segregating generations (F_3 and BC_2F_1) developed from a high yielding rice variety ADT 43 and a blast resistant Near Isogenic Line (NIL), viz. CT13432-3R. The associations among traits related to yield and blast resistance were investigated. The correlation and path analysis have shown that characters like lesion type, potential disease incidence, lesion number and infested leaf area has significant positive correlation and high positive direct effect with leaf blast susceptibility. Therefore it was concluded that selecting genotypes with lower lesion number, high seedling vigour and short compact panicles with less exertion are preferable to reduce leaf blast disease incidence. Single plant yield was positively correlated with plant height, number of productive tillers, panicle length and filled grains per panicle. The highest genotypic association to grain yield was contributed by number of productive tillers. Selection of genotypes for these traits will ultimately result in increased yield.

Key words: Blast, Correlation, *Oryza sativa*, Path analysis, *Pyricularia oryzae*, Yield

Rice (*Oryza sativa* L.) is the most important staple food crops in the world, which feeds one third of the global population. Blast disease caused by the fungus *Pyricularia oryzae* is a serious threat to rice production worldwide and can result in 5-50% of yield loss. This may even extend up to 100% damages on infestation under favourable conditions. The most practical and economical approach to control blast is the use of resistant varieties. Hence, breeding for blast resistance is a major objective in rice improvement programs. While improving popular adapted varieties for blast resistance, there is a chance of reduction in the potential yield due to some undesirable association between resistance contributing traits with grain yield. Improvement of varieties for resistance without sacrificing its actual yield potential requires an apparent knowledge on interrelationship of resistance and yield contributing traits. Identification of the characters, which are closely related and contributing to yield, becomes highly essential. Because, grain yield is a complex character and is very difficult to improve by direct selection. In this context, correlation is an important tool to measure the direction and strength of relationship of different characters with grain yield. Correlation provides information about yield components and this helps in the selection of superior genotypes from genetically diverse population. The interpretations from correlation studies become more evident when correlations are partitioned into the components of direct, indirect as well as residual effects through path analysis in order to determine the relative magnitude of various attributes contributing to yield (Jayasudha and Sharma 2010). Path coefficient analysis makes selection of complex traits like yield and resistance more effective by partitioning total correlation into direct and indirect effect (Priya and Joel 2009).

Several studies were conducted in varieties, hybrids and segregating generations to understand the association of yield related traits in rice. Agahi *et al.* (2007) investigated 16 yield related traits under correlation and path analysis in 25 rice varieties and found that grain yield can be improved by selecting lines with higher number of productive tillers and grains per panicle. Laxuman *et al.* (2011) analysed 188 back-crossed inbred lines (BILs) from Swarna × NERICA-L-20 of rice to study the rice grain yield and its component traits by correlation and path coefficients analysis. Selvaraj *et al.* (2011) analysed correlation and path coefficient of

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grain yield traits among blast resistant genotypes of rice. Similarly, Haider *et al.* (2012) also followed the genotypic and phenotypic correlation among morphological traits and contribution of these traits to the rice yield under drought stress.

During the last decade, the genetics of blast resistance has been extensively studied. Introgression of blast resistance genes has been practiced and new varieties have also been emerged from such breeding programs (Rahman *et al.* 2011). Even though, there are a number of reports available in rice on correlation and path coefficient analysis of yield traits. But, genetic studies on association between resistance and yield traits are lacking in rice. Therefore, the present study was aimed to determine the correlations between yield and resistance traits in the segregating generation of an advanced population from the cross of blast resistant and susceptible genotypes as well as to quantify the coefficient of variation of these traits. This study also compares the deviation of association in traits in selfed and back crossed progenies from a cross when resistance and yield traits are improved simultaneously.

MATERIALS AND METHODS

The experimental materials initially consisted of a three gene pyramided CO 39 Near Isogenic Lines CT13432-3R as the resistant donor and a popular south Indian rice variety ADT 43 as the blast susceptible parent for the improvement. The present study work was conducted at Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. In this study, crosses between susceptible and resistant parents were made and the advanced generations up to F3, BC4F1 and BC3F2 were obtained by selfing and back crossing. Segregating generations were evaluated both in normal and epiphytotic conditions. The observations on various traits related to yield and blast resistance were recorded from the field experiments on parents and introgressed lines following Standard Evaluation System (SES, IRRI, 2002). Phenotypic data were recorded for the following traits, viz. plant height (PH), number of tillers (NT), productive tillers (PRT), leaf length (LL), leaf width (LW), panicle length (PL), days to first flowering (DFF), days to maturity (DM), filled grains per panicle (FGP), total grains per panicle (TGP), spikelet fertility (SPF), spikelet sterility (SPS), 100 grain weight (100GW), single plant yield (SPY), leaf blast (LB), lesion number(LN), lesion type (LT), infested leaf area (ILA), percentage potential disease incidence (PDI%), seedling vigour (VIG) and resistance (RES). These abbreviations are used in the Tables. The phenotypic data taken in the population of 210 F_3 lines and 97 BC_2F_1 lines were utilized for correlation studies and interpretation of trait association.

Correlation coefficient analysis was done by using Karl Pearson's (1895) measure of simple correlation coefficient between the characters. The path coefficient analysis was done following formula given by Wright (1921,1934) to describe the influence of several independent characters (or causes) on a dependent character (or effect) by partitioning the individual correlation coefficients between a dependent and a specific independent character. The direct and indirect effects were classified based on the scale given by Lenka and Mishra (1973).

RESULTS AND DISCUSSION

Correlation and path analyses are the important tools for deriving information regarding association of characters. Correlation study estimates the mutual relationship between various characters. It helps in determining the component characters on which selection can be made for improvement in yield and resistance. The F_3 and BC_2F_1 generations of resistant and susceptible parents were screened at epiphytotic conditions. Data from these generations were utilized for the analysis as the yield and resistance contributing traits were recorded in these generations simultaneously. The estimated correlation coefficients among various component traits of yield and blast resistance under normal and epiphytotic condition are presented in Table 1 and 2. The Pearson's correlation coefficients among 19 traits in the F_3 generation are presented in Table 1. Characters like lesion number (0.89), potential disease incidence (1.00), infected leaf area (0.84) and lesion type (0.88) had significant positive correlation with leaf blast at 1% level of significance. On the other hand, spikelet fertility (-0.14) had negative correlation with total grains per panicle. In the present study, single plant yield was significantly positively correlated with plant height (0.48), number of productive tillers (0.32), panicle length (0.37), leaf width (0.43), filled grains per panicle (0.30) and total grains per panicle (0.30). But, no significant correlation was shown by single plant yield with any of the resistance contributing traits.

In the BC_2F_1 population; leaf blast (0.82), lesion type (0.78), potential disease incidence (0.82), lesion number (0.81), seedling vigour (0.98), panicle length (0.18) and infected leaf area (0.83) showed high positive correlation at 1% level of significance with blast resistance score. Where, lowest value 1 scores for high resistance and 9 indicates the highly susceptible. So, these traits are positively contributing for the disease incidence (Table 2). Single plant yield was positively correlated with filled grains per panicle (0.21). Plant height was recorded high and positive correlation with number of productive tillers (0.35), number of tillers (0.39), leaf length (0.21), panicle length (0.22) and total grains per panicle (0.17). Satheesh Kumar and Saravanan (2012) observed highly significant and positive genotypic correlation with number of productive tillers per plant, filled grains per panicle and total number of grains. In this generation, panicle length had significant and positive correlation with resistance contributing traits, viz. leaf blast (0.13), lesion type (0.13), infested leaf area (0.16), resistance (0.18) and potential disease incidence percentage (0.13). Single plant yield was positively correlated with filled grains per panicle. Therefore it can be concluded that selecting genotypes with lower lesion number, lowest lesion type, high seedling vigour and short compact panicles with less exertion are preferable to reduce leaf blast. Improvement

Table 1 Estimates of Karl Pearson's correlation coefficients among different component traits in F_3 generation

F_3=210	PH	NT	PRT	LL	LW	PL	DFF	DM	FGP	TGP	SPF	SPS	100GW	SPY	LN	ILA	PDI%	LB	LT
PH	1.00																		
NT	0.21**	1.00																	
PRT	0.31**	0.76**	1.00																
LL	0.38**	0.05	0.09	1.00															
LW	0.51**	0.07	0.20**	0.48**	1.00														
PL	0.62**	0.08	0.18*	0.52**	0.42**	1.00													
DFF	0.06	0.02	-0.05	0.02	0.03	0.04	1.00												
DM	0.06	0.02	-0.05	0.02	0.03	0.04	1.00**	1.00											
FGP	0.17*	0.03	0.17*	0.23**	0.22**	0.17*	0.11	0.11	1.00										
TGP	0.18**	0.05	0.15*	0.25**	0.23**	0.19*	0.13	0.13	0.96**	1.00									
SPF	-0.1	-0.11	0.02	-0.09	-0.07	-0.08	-0.07	-0.07	0.08	-0.19*	1.00								
SPS	0.1	0.12	-0.01	0.1	0.07	0.08	0.06	0.06	-0.09	0.18*	-0.99**	1.00							
100GW	-0.04	-0.05	-0.11	-0.03	-0.13	-0.15	-0.03	-0.03	-0.07	-0.1	0.14*	-0.13	1.00						
SPY	0.48**	0.11	0.32**	0.19**	0.43**	0.37**	0	0	0.30**	0.30**	-0.03	0.03	-0.07	1.00					
LN	-0.04	0.01	-0.01	0	-0.04	0	-0.02	-0.02	-0.03	-0.05	0.08	-0.09	0.03	-0.1	1.00				
ILA	-0.07	0.06	0.04	-0.05	-0.05	-0.05	0.03	0.03	0.01	-0.02	0.1	-0.11	0.05	-0.07	0.86**	1.00			
PDI%	-0.05	0.04	0.01	-0.03	-0.01	-0.01	0.03	0.03	0.02	-0.01	0.11	-0.12	0.02	-0.12	0.89**	0.84**	1.00		
LB	-0.05	0.04	0.01	-0.03	-0.01	-0.01	0.03	0.03	0.02	-0.01	0.11	-0.12	0.02	-0.12	0.89**	0.84**	1.00**	1.00	
LT	-0.03	0.04	0.01	-0.03	-0.01	0.02	0.05	0.05	0.04	-0.01	0.14*	-0.16*	0.02	-0.12	0.87**	0.84**	0.88**	0.88**	1.00

*Significant at 5% level of probability. ** Significant at 1% level of probability. Plant height (PH) in cm, number of tillers (NT), number of productive tillers (PRT), leaf length (LL) in cm, leaf width (LW) in mm, panicle length (PL) in cm, days to first flowering (DFF), days to maturity(DM), filled grains per panicle (FGP), total grains per panicle (TGP), spikelet fertility (SPF), spikelet sterility (SPS), 100 grain weight (100GW), single plant yield (SPY), lesion number(LN), infested leaf area (ILA), potential disease incidence percentage (PDI%), leaf blast (LB) and lesion type (LT).

Table 2 Estimates of Karl Pearson's correlation coefficients among different component traits in BC_2F_1 generation

BC_2F_1=97	PH	NT	PRT	LL	PL	LB	PDI%	LN	LT	ILA	RES	VIG	FGP	TGP	SPF	SPS	100GW	SPY
PH	1.00																	
NT	0.39**	1.00																
PRT	0.35**	0.97**	1.00															
LL	0.21*	0.26**	0.25**	1.00														
PL	0.22*	0.04	0.01	0.25	1.00													
LB	-0.08	-0.14	-0.16	0.03	0.13	1.00												
PDI%	-0.08	-0.14	-0.16	0.03	0.13	1.00**	1.00											
LN	0.03	0.02	-0.02	0.07	0.09	0.83**	0.83**	1.00										
LT	0.01	-0.07	-0.07	0.13	0.13	0.83**	0.83**	0.82**	1.00									
ILA	-0.01	-0.06	-0.09	0.07	0.16	0.95**	0.95**	0.88**	0.89**	1.00								
RES	-0.08	-0.06	-0.09	0.02	0.18	0.82**	0.82**	0.81**	0.78**	0.83**	1.00							
VIG	-0.04	-0.07	-0.1	0.08	0.16	0.95**	0.95**	0.90**	0.88**	0.98**	0.87**	1.00						
FGP	0.15	-0.01	-0.03	0.12	0.13	0.14	0.14	0.07	0.04	0.08	0.05	0.09	1.00					
TGP	0.17	0	-0.02	0.17	0.14	0.13	0.13	0.06	0.04	0.06	0.05	0.08	0.98**	1.00				
SPF	0	0.01	0.01	-0.23**	-0.03	0.02	0.02	-0.01	-0.01	0.05	-0.03	0.01	0.18	-0.02	1.00			
SPS	0.03	0.01	0.01	0.26**	0.03	-0.01	-0.01	0.01	0.02	-0.04	0.02	-0.01	-0.16	0.05	-0.99**	1.00		
100GW	-0.08	0.02	0.01	0.11	0.18	0.09	0.09	0.07	0	0.09	-0.03	0.07	0.02	0	0.1	-0.1	1.00	
SPY	-0.01	0.13	0.11	0.06	-0.03	-0.09	-0.09	-0.14	-0.1	-0.12	-0.11	-0.12	0.21*	0.19	0.12	-0.12	0.06	1.00

*Significant at 5% level of probability. **Significant at 1% level of probability. Plant height (PH) in cm, number of tillers (NT), number of productive tillers (PRT), leaf length (LL) in cm, panicle length (PL) in cm, leaf blast (LB), potential disease incidence percentage (PDI%), lesion number(LN), lesion type (LT), infested leaf area (ILA), resistance (RES), seedling vigour (VIG), filled grains per panicle (FGP), total grains per panicle (TGP), spikelet fertility (SPF), spikelet sterility (SPS), 100 grain weight (100GW) and single plant yield (SPY).

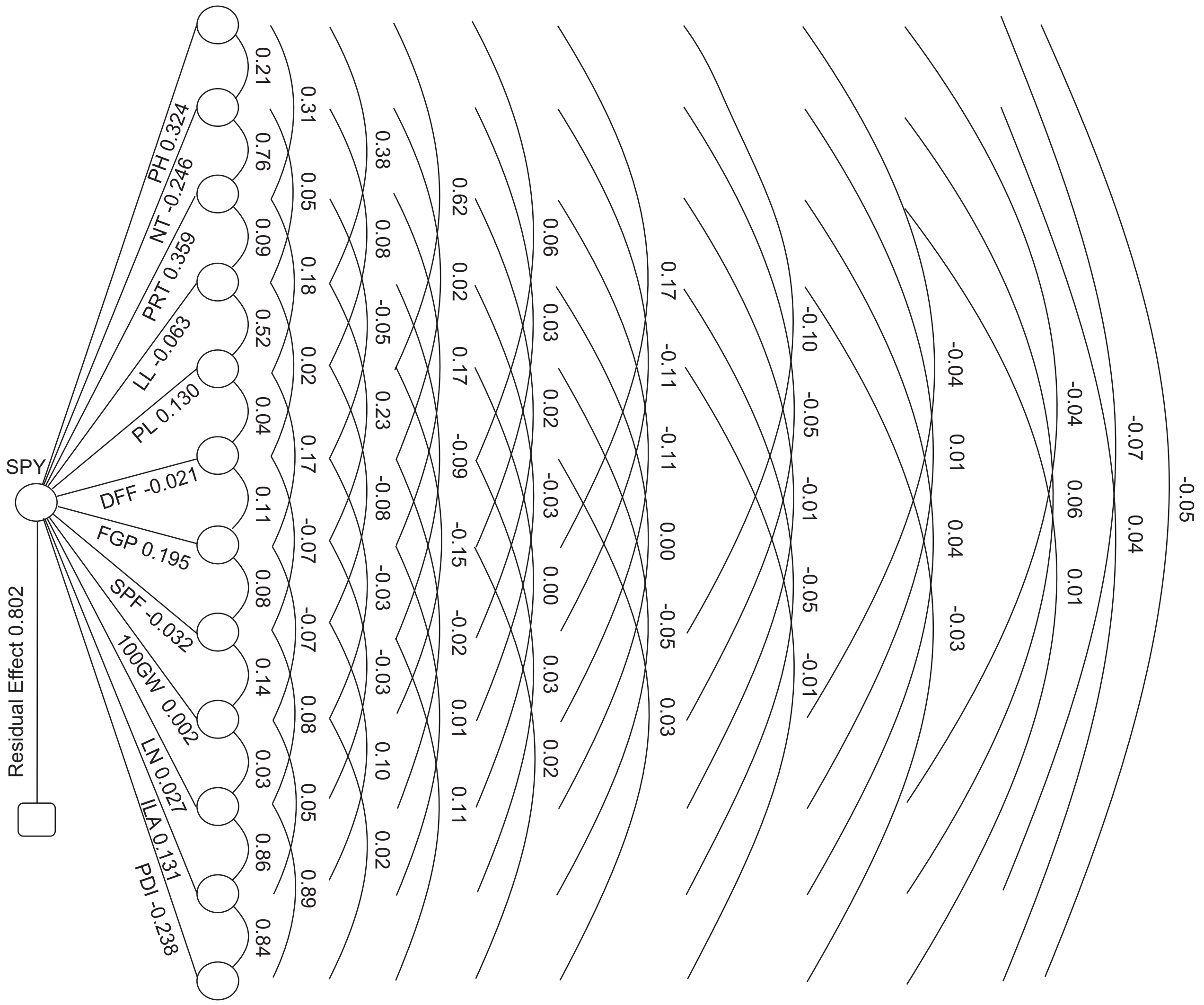

Fig 1 Phenotypic path diagram for dependent variable single plant yield (SPY)

of single plant yield requires selection of genotypes with more number of productive tillers, enhanced plant height, lengthier panicle and more filled grains. This was also in confirmation with the findings of Anbanandan *et al.* (2009), Sabesan *et al.* (2009) and Selvaraj *et al.* (2011).

Correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Path coefficient analysis was worked out to determine the true component of grain yield. Phenotypic path diagram representing the estimates of direct and indirect effect of the component characters on single plant yield are presented in Fig 1. Among F_3 segregating population, the high positive direct effect on single plant yield was contributed by number of productive tillers (0.359) and plant height (0.324) followed by filled grains per panicle (0.195), panicle length (0.130), infected leaf area (0.131), lesion number (0.027) and 100 grain weight (0.002). The potential disease incidence (-0.238), number of tillers (-0.246), spikelet fertility (-0.032) and days to 50 per cent flowering (-0.021) showed direct effect on yield in a negative direction (Fig 1). Considering potential disease incidence as dependent variable, path coefficients were worked out and the matrix is given in the Fig 2. Lesion number (0.6557) and infected leaf area (0.2623) had high positive direct effect on potential disease incidence. Single plant yield (-0.0689), leaf length (-0.0285), 100 grain weight (-0.0103) and number of tillers (-0.0051) had very low but negative association with potential disease incidence (Fig 2.). It was found that highest genotypic correlation coefficient in positive direction was contributed by number of tillers, number of productive tillers, filled grains per panicle, 100 grain weight and panicle length. Hence, direct selection for these traits is suggested for getting yield improvement. Similar results were also reported by Gawai *et al.* (2006) and Jayasudha and Sharma (2010) for number of tillers per plant and filled grains per panicle. Previous reports on correlation and path coefficient analysis on grain yield and yield components of rice cultivars (Cyprien and Kumar 2011, Akthar *et al.* 2011, Abarshar *et al.* 2011, Chakraborty *et al.* 2010, Chandra *et al.* 2009, Girish *et al.* 2006, Surek and Basar 2003, Ekka *et al.* 2011) are in agreement with our results.

Knowledge of correlation between yield and its contributing characters are basic and foremost endeavor in

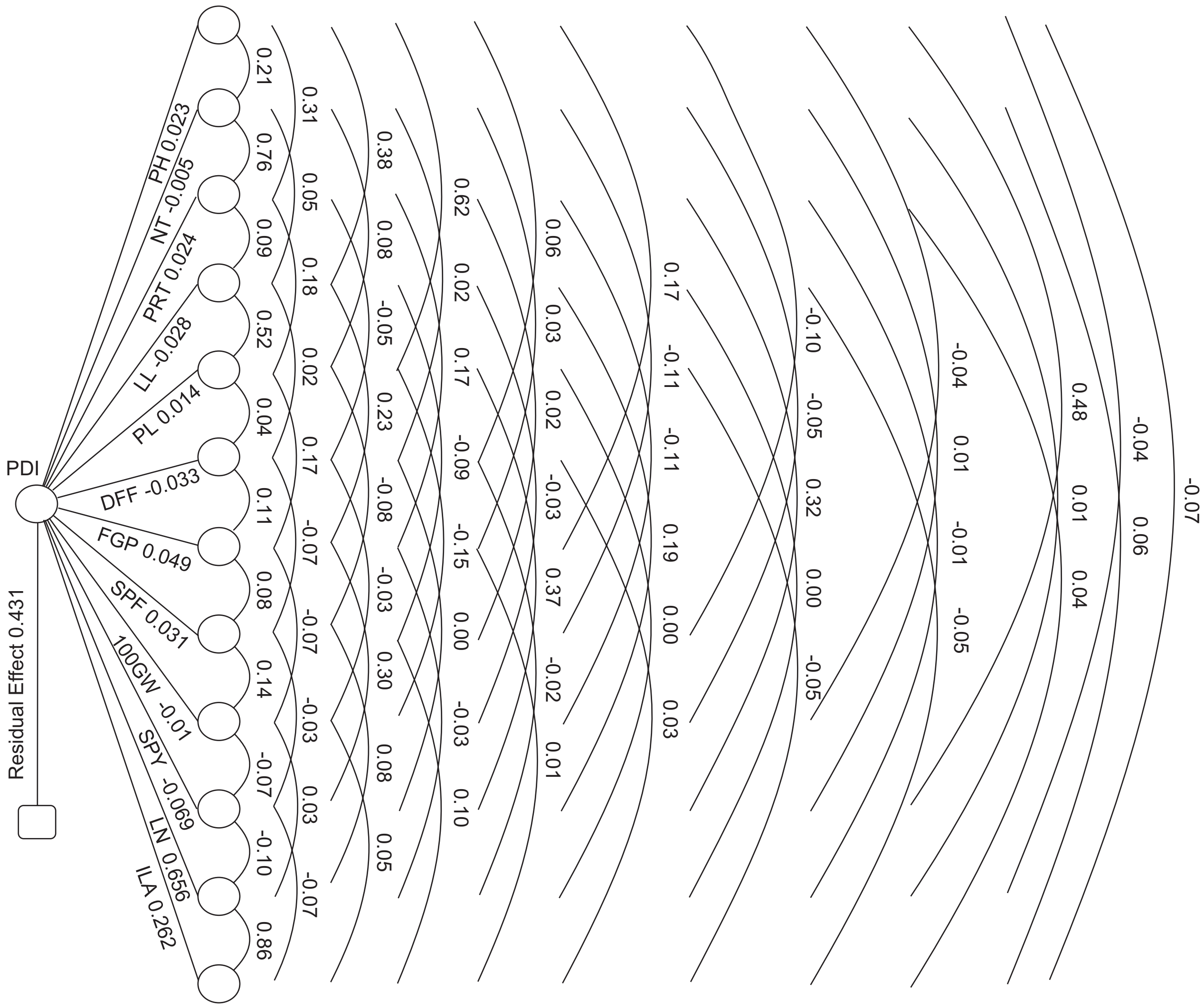

Fig 2 Phenotypic path diagram for dependent variable potential disease incidence percentage (PDI %)

plant selection. These are necessary for a sound breeding programme. Study was also conducted to understand the association of resistance contributing traits by considering the potential disease incidence as the dependent character. Lesion number and infested leaf area had high positive direct effect on potential disease incidence. Single plant yield, number of tillers, 100 grain weight and leaf length had very low but negative association with potential disease incidence. Direct selection of plants on these traits in negative direction will result in reduction of potential disease incidence percentage. Other traits exhibited only negligible direct and indirect effect on the disease incidence. Residual effect of path analysis was high. The component characters used here contribute only a low per cent of variability and it shows influence of external factors like environment in the yield. It was found that the contributing traits to blast disease resistance are not having any significant association with yield and related traits. The association analysis of present study indicates that successful improvement of a susceptible variety is possible by simultaneous direct selection of component traits for yield and resistance parameters, viz. number of productive tillers, panicle length, filled grains per panicle, potential disease incidence, lesion number and infested leaf area.

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