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Original scientific paper

CHARACTER ASSOCIATION AND PATH ANALYSIS IN BACTERIAL BLIGHT RESISTANCE GENES PYRAMIDED SEGREGATING POPULATIONS OF RICE (*Oryza sativa* L.)

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An exploratory research work was conducted to study the character association and their direct and indirect effects on grain yield in three bacterial blight resistance genes introgressed segregating populations (F_2) in rice. Data for yield and five other traits which were component of yield were recorded in 449 F_2 individuals in all three crosses. Thousand grain weight was highly correlated with single plant yield in (r=0.95**, p<0.01) CB 174 R × IRBB 60> (r=0.48**, p<0.01) CB 87 R × IRBB 60> (r=0.44**, p<0.01) TNAU CMS 2B × IRBB 60. Thousand grain weight was exhibited important yield determining component for CB 174 R × IRBB 60 (0.92) and CB 87 R × IRBB 60 (0.45), and panicle length for (0.39) TNAU CMS 2B × IRBB 60 by direct effect. The genetic information derived from our study could be useful to select potential segregating individual among the F_2 population for future rice breeding program.

Key words: early generation, correlation coefficient, direct and indirect effects, yield components

INTRODUCTION

Rice is the most important staple food crop in the world. To meet the demands of rice consumption, 121.2 million tons of rice will be estimated by the year 2030, 129.6 million tons by 2040 and 137.3 million tons by 2050 (CRRI ANNUAL REPORT, 2012-13). It's well known to the scientific community, F_2 generation derived from cross between two diverse inbred lines which provides complete and informative population for genetic analysis, theoretically (ALLARD, 1956). Among the segregating generations F_2 generation is most crucial, where selection has to be done more critically. For improvement of any breeding programme, genetic variability is

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indispensable for that. Greater spectrum of genetic variability in segregating population mainly depends upon the relative importance of genetic variability encountered among the genotypes used for hybridization programme and its offer better option for selection. Path coefficient analysis has been used successfully in Agriculture, breeders could select the traits which is responsible for crop yield (DEWEY and LU, 1959) and it permits partitioning the correlation coefficient into two components like direct effect of predictor variable upon its response variable and indirect effect of predictor variable on response variable through another predictor variable (DEWEY and LU, 1959). MORALES (1986) considered as number of grains per panicle and thousand grain weight could be important criteria for increasing crop yield. REUBEN and KATULI (1989) found that number of grains per panicle was yield determining component in rice breeding. An investigation was framed to study the nature of these associations in gene introgressed segregating population in rice.

MATERIALS AND METHODS

Experimental materials were comprised of three F_2 populations evolved by crossing CB 87 R, TNAU CMS 2B and CB 174 R used as female (recurrent) parents and IRBB 60 used as male (donor) parent. CB 174 R is the restorer line of released rice hybrid CORH 4 (COMS 23A / CB 174 R) in TNAU, a medium slender grain type, which matures in 135 days. Similarly, TNAUCMS 2B and CB 87 R are the maintainer and restorer line of released rice hybrid CORH 3 (TNAU CMS 2B / CB 87 R) in TNAU, which has features of non-sticky and non-aromatic and short duration nature. IRBB 60 is the donor for bacterial blight resistant, carrying the genes of *Xa21, xa13, and xa5* on chromosome 11, 8 and 5 respectively. An F_2 individual of each population was evaluated during rainy season of 2012 (Table 1). The present study was conducted at Department of Rice, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The area is located at latitude 11º 00´ N and longitude of 77 º 00´ and an elevation of 427.00 meters above mean sea level. Recommended package of practices was followed to maintain the healthy crop.

Table 1. Crosses, number of individuals in the bacterial blight resistance gene introgressed segregating populations.

S.No.	Cross	No. of individuals
1.	CB87 R × IRBB60	289
2.	TNAUCMS 2B × IRBB60	50
3.	CB174 R × IRBB60	110

Data collection

Data was collected on single plant basis at the time of harvest on plant height (cm, from the ground level to the tip of the primary panicle of selected plants at the time of maturity), number of productive tillers (no, panicle bearing tillers counted), panicle length (cm, length of the panicle on the main axis measured at the grain maturity stage), number of grains (no, dry threshed grain per plant used to count by seed counter), thousand grain weight (g, weight of the dry threshed 1000 grain per plant) and single plant yield (g, weight of the dry threshed grain per plant).

Data analysis

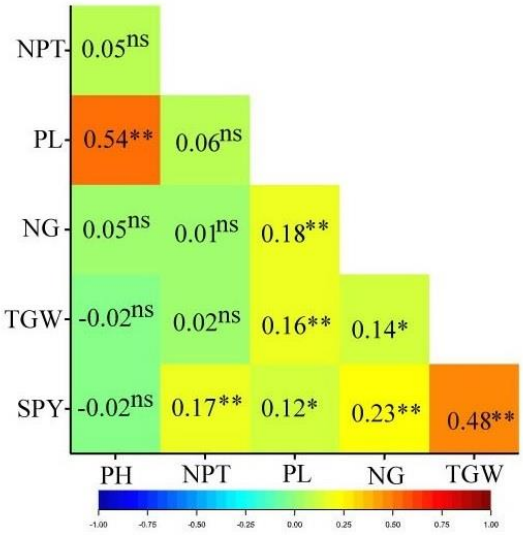
Phenotypic data of each F_2 individuals were used for statistical analysis. Correlation analysis was done using statistical package GENSTAT release 14.1 (PAYNE *et al*., 2011). The partitioning of correlation coefficient into direct and indirect effect estimates were calculated using the methods of DEWEY and LU, (1959) and this was carried out using SAS v 9.4 (SAS INSTITUTE INC., 2015).

RESULTS AND DISCUSSION

Wider variability, low to high heritability and genetic advance as percent of mean, skewness and kurtosis was found among these crosses for all the traits were reported earlier by PONNAIAH GOVINTHARAJ *et al*. (2016 and 2017).

Correlation coefficients for CB 87 R × IRBB 60

Correlation coefficient was significant among all the characters except between plant height with number of productive tillers and number of grains were positively non-significant, while it was negatively non-significant for thousand grain weight and single plant yield and whereas, number of productive tillers were positively non-significant for panicle length, number of grains and thousand grain weight (Figure 1).



*,** significant at P<0.05 and P<0.01, respectively

Figure 1. Correlation among yield and yield contributing traits for the cross of CB 87 R × IRBB 60.

Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

Single plant yield showed significant and positive association with number of productive tillers (r=0.17**, p<0.01), panicle length (r=0.12**, p<0.01), number of grains (r=0.23**, p<0.01), thousand grain weight (r=0.48**, p<0.01) and while it was negatively non-significant (r=-0.02^{ns}) for plant height. Similar findings were reported earlier by ZAHID *et al*.

(2006) and AKHTAR *et al*. (2011) for these traits. This finding was concluded that simultaneous improvement of both the trait is possible. Plant height was negatively non-significant with rice yield which was indicated that taller plant would reduce the grain yield due to higher rate of photosynthesis at vegetative stage rather than reproductive stage and susceptible to lodging (ZAHID *et al*., 2006; AKHTAR *et al*., 2011). Plant height was highly correlated with panicle length (r=0.54**, p<0.01). Generally, taller plants possessed well exserted panicle due to accumulation favourable alleles present for internode elongation which is supported by YOSHIDA (1981) that expansive growth of internodes starts at around panicle initiation (SADEGHI, 2011; BABU *et al*., 2012).

Path coefficients for CB 87 R × IRBB 60

In the present study, most of the studied characters exhibited positive direct effect except plant height (Table 2). Among these, thousand grain weight showed highest direct effect (0.45) followed by (0.16) for number of grains and number of productive tillers. This finding agreed with the study of RAM, (1992) for these components. Negative direct effect of plant height on rice yield suggested that dwarf plant height could be produced more yield than taller one (AKHTAR *et al*., 2011). In case of indirect effect, thousand grain weight showed positive with panicle length (0.07) and number of grains (0.06). Thousand grain weight was showed important yield determining component in this CB 87 R × IRBB 60. The residual effect of present study was 0.72 indicating that 28% of the variability in single plant yield was contributed by characters studied in path analysis. The residual effect of single plant yield influenced by sampling errors along with failure of perfect correlation between panicle length and thousand grain weight in this (CB 87 R × IRBB 60) cross combination.

Table 2. Direct and indirect effect of path coefficient matrix for yield and yield contributing traits of CB 87 R × IRBB 60.

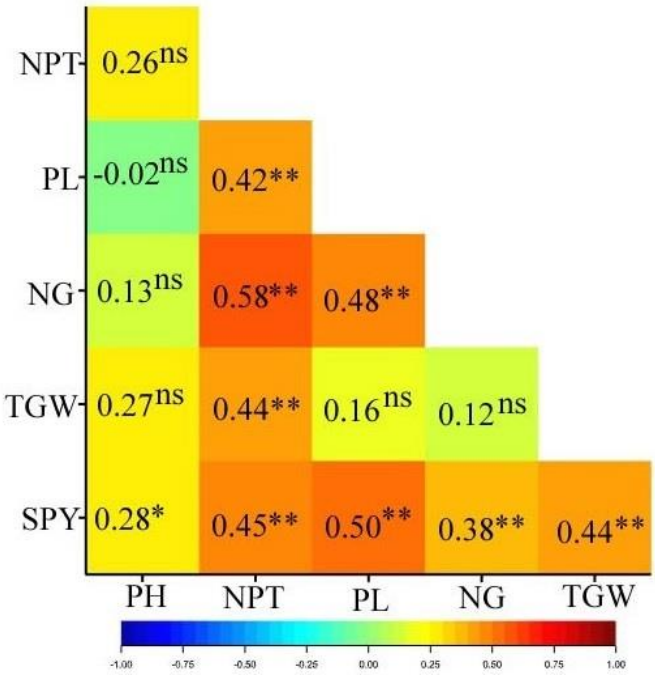
Characters	PH	NPT	PL	NG	TGW	SPY
PH	-0.05	0.01	0.02	0.01	-0.01	-0.02^{ns}
NPT	0.00	0.16	0.00	0.00	0.01	0.17**
PL	-0.02	0.01	0.03	0.03	0.07	0.12*
NG	0.00	0.00	0.01	0.16	0.06	0.23**
TGW	0.00	0.00	0.01	0.02	0.45	0.48**

Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

Correlation coefficients for TNAU CMS 2B × IRBB 60

Significant correlation was found among all the studied characters except plant height with number of productive tillers, panicle length, number of grains and thousand grain weight, whereas between thousand grain weight with panicle length and number of grains (Figure 2). The traits like plant height (0.28*, p<0.05), number of productive tillers (0.45**, p<0.01), panicle length (r=0.50**, p<0.01), number of grains (r=0.38**, p<0.01) and thousand grain weight (r=0.44**, p<0.01) were significantly and positively associated with single plant yield. This finding was supported by KENNEDY and RANGASAMY, (1998) for thousand grain weight; ERADASAPPA *et al*. (2007) and KARTHIKA GUNASEKARAN *et al*. (2017) for plant height; KRISHNA *et al*. (2008) for number of productive tillers; SANKAR *et al*. (2006) for panicle length. Number of

productive tillers highly correlated with panicle length (0.42**, p<0.01), Number of grains (r=0.58**, p<0.01), thousand grain weight (0.44**, p<0.01). The reason for this association may be higher number productive tillers leads to produce higher panicles, number of grains per panicle, obviously we get higher grain weight.



*,** significant at P<0.05 and P<0.01, respectively

Figure 2. Correlation among yield and yield contributing traits for the cross of TNAU CMS 2B × IRBB 60.

Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

Path coefficients for TNAU CMS 2B × IRBB 60

Positive direct effect was found for all the characters (Table 3). From this study, panicle length (0.39) was showed highest direct effect followed by thousand grain weight (0.29). Similar result was reported by KARAD and POL, (2008) for panicle length. In case of, indirect effect was found for number of productive tillers (0.13). Panicle length was showed negatively indirect effect on grain yield. In this combination (TNAU CMS 2B × IRBB 60), panicle length was played major yield determining component. The estimated residual effect was 0.57 indicating that 43% of the variability in single plant yield was contributed by characters studied in path analysis. Residual effect from the current study of single plant yield influenced by sampling errors along with failure of perfect correlation between panicle length and thousand grain weight.

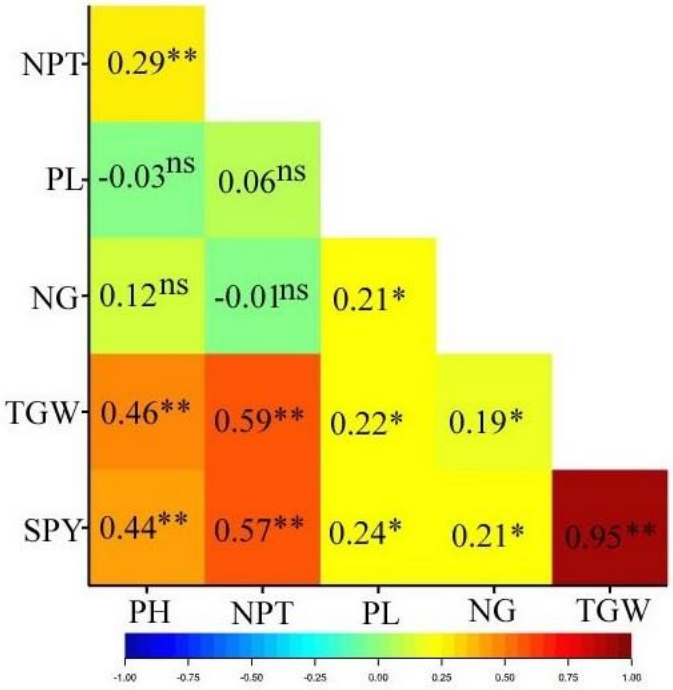
Table 3. Direct and indirect effect of path coefficient matrix for yield and yield contributing traits of TNAU CMS 2B × IRBB 60.

Characters	PH	NPT	PL	NG	TGW	SPY
PH	0.18	0.02	-0.01	0.01	0.08	0.28*
NPT	0.05	0.06	0.16	0.05	0.13	0.45**
PL	0.00	0.02	0.39	0.04	0.05	0.50**
NG	0.02	0.03	0.19	0.09	0.04	0.37**
TGW	0.05	0.03	0.06	0.01	0.29	0.44**

Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

Correlation coefficients for CB 174 R × IRBB 60

Plant height was positively and negatively non-significant association with number of grains and panicle length (Figure 3).



*,** significant at P<0.05 and P<0.01, respectively

Figure 3. Correlation among yield and yield contributing traits for the cross of CB 174 R × IRBB 60.
Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

Whereas number of productive tillers showed positively and negatively non-significant with panicle length and number of grains, respectively. All pairs of variables, viz. plant height (r=0.44**, p<0.01), number of productive tillers (r=0.57**, p<0.01), panicle length (r=0.24*, p<0.05), number of grains (r=0.21*, p<0.05) and thousand grain weight (r=0.95**, p<0.01) were positively significant association with grain yield. This finding was supported with BABU *et al*. (2012); HASAN *et al*. (2013); REDDY *et al*. (2013); VANISREE *et al*. (2013) for plant height; MINNIE *et al*. (2013) for panicle length; BASAVARAJA *et al*. (2013) for number of productive tillers. Plant height is a complex character in rice and it was controlled by several genetic factors (CHEEMA *et al*., 1987). Reduced plant height could leads to increase the resistance to lodging and reduce substantial yield losses associated with this trait (ABBASI *et al*., 1995). Positive association between any of the two traits insisted that simultaneous improvement of both the traits is possible without compromising the selection of any of the trait. Our finding was concluded that plants having long panicles could have the high number of filled grains which was obviously increasing the rice yield (ISLAM *et al*., 2016).

Path coefficients for CB 174 R × IRBB 60

In the present study, all of studied characters exhibited positive direct effect (Table 4). Among these, thousand grain weight (0.92) showed highest direct effect followed by (0.03) for number of grains and panicle length. The obtained results in this study were in agreement with the findings of AKHTAR *et al*. (2011) and KARTHIKA GUNASEKARAN *et al*. (2017) for thousand grain weight; PANWAR (2006) for number of grains; PANWAR and MASHIAT, (2007) and CHAKRABORTI *et al*. (2009) for number of productive tillers. In case of indirect effect, thousand grain weight showed positively high with number of productive tillers (0.54) and plant height (0.42). Among the studied characters thousand grain weight was showed important for yield determining component. The residual effect was 0.10 indicating that 90% of the variability in single plant yield was contributed by characters studied in path analysis. Obtained residual effect from this study of single plant yield influenced by sampling errors along with failure of perfect correlation between panicle length and thousand grain weight.

Table 4. Direct and indirect effect of path coefficient matrix for yield and yield contributing traits of CB 174 R × IRBB 60.

Characters	PH	NPT	PL	NG	TGW	SPY
PH	0.01	0.01	0.00	0.00	0.42	0.44**
NPT	0.00	0.02	0.00	0.00	0.54	0.57**
PL	0.00	0.00	0.03	0.01	0.20	0.24*
NG	0.00	0.00	0.01	0.03	0.18	0.21*
TGW	0.00	0.01	0.01	0.01	0.92	0.95**

Note: PH: Plant height (cm), NPT: Number of productive tillers, PL: Panicle length (cm), NG: Number of grains per panicle, TGW: Thousand grain weight (g), SPY: Single plant yield (g).

CONCLUSIONS

Genetic improvement of polygenic/quantitative traits can be attained from understanding the magnitude and amount of genetic variability available from the genetic material. Our experimental results were summarized that thousand-grain weight showed positively significant

correlation and highest direct effect on rice grain yield found in all three early generation crosses and this could be selection criteria.

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POVEZANOST SVOJSTAVA I *PATH* ANALIZE U GENIMA ZA OTPORNOST NA BAKTERIOZNU PLAMENJAČU PIRAMIDALNO SEGREGIRAJUĆIH POPULACIJA PIRINČA (*Oryza sativa* L.)

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IZVOD

Istraživanja su sprovedena da bi se ispitala povezanost svojstava i njihovih direktnih i indirektnih uticaja na prinos zrna u tri gena odgovorna za rezistentnost/otpornost na bakterioznu plamenjaču segregirajuće populacije (F_2) pirinča. Podaci za prinos i pet drugih svojstava komponenti prinosa su registrovani kod 449 F_2 pojedinačnih biljaka u sva tri ukrštanja. Korelacija između mase 1000 zrna i prinosa pojedinačnih biljaka bila je visoka u (r=0.95**, p<0.01) CB 174 R × IRBB 60> (r=0.48**, p<0.01) CB 87 R × IRBB 60> (r=0.44**, p<0.01) TNAU CMS 2B × IRBB 60. Ovo svojstvo se pokazalo kao važna komponenta za utvrđivanje prinosa kod CB 174 R × IRBB 60 (0.92) i CB 87 R × IRBB 60 (0.45), i za utvrđivanje dužine cvasti za (0.39) TNAU CMS 2B × IRBB 60 direktnim uticajem/efektom. Genetičke informacije do kojih se došlo u ovom ispitivanju mogu biti korisne za odabir potencijalnih pojedinačnih biljaka u okviru F_2 populacije za buduće programe oplemenjivanja pirinča.

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