Principal Component Analysis of Brown Planthopper Resistance Mechanisms in the Recombinant Inbred Lines of Cross Basmati 370/ASD16 in Rice

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Abstract

A set of recombinant inbred lines (RILs) of cross Basmati370/ASD16 was tested for brown planthopper (BPH) resistance using resistance mechanisms viz.*, antixenosis, antibiosis and tolerance. Correlation analysis among the phenotypic parameters associated with resistance to BPH revealed significant differences among several parameters. Principal component analysis (PCA) carried out on 182 variables (RILs of Basmati370/ASD16 cross) across 11 resistance parameters provided the Eigen values of 184.37, 0.61 and 0.42 with the proportions of 0.991, 0.003 and 0.002 for PCA1, PCA2 and PCA3 respectively. PCA analysis carried out on 11 variables (parameters used to assess BPH resistance) across 182 RILs provided the Eigen values of 2.8674, 2.0499 and 1.5194 with the proportions of 0.261, 0.186 and 0.138 for PCA1, PCA2 and PCA3, respectively. Among the parameters tested, FPLI, PDWLI, nymphal settling preference and winged female percentage were contributing more for resistance than other parameters.*

Keywords: Rice, RILs, phenotypic screening, principal component analysis

Introduction

Though insect pest complex of rice has undergone a drastic change during last three decades following green revolution, still planthopper population has been attaining serious proportions leading to pest outbreak and crop failure in many parts of the world and also in India (Anonymous, 2008). The main methods used to control BPH to apply chemical insecticides and/or develop and grow resistant varieties in an integrated pest management strategy. However, misuse of some chemical pesticides has often resulted in resurgence of BPH. Therefore, the most economic and efficient method for controlling the BPH is exploiting the natural resistance to infestation. Understanding the mechanisms of resistance is a prerequisite for developing durable resistant varieties. In this context a set of one hundred and eighty two recombinant inbred lines (RILs) of cross Basmati370/ ASD16 was tested along with their parents and checks (TN1-susceptible check and PTB33- resistant check) for BPH resistance involving all three resistance mechanisms *viz.*, antixenosis, antibiosis and tolerance. principal component analysis (PCA) is a powerful tool that reduces the data dimension by extracting important features of the data. Hence, in the present investigation, PCA was carried out to find out resilient mechanisms contributing towards BPH resistance using RILs of Basmati370/ASD16.

Materials and methods

A set of 182 recombinant inbred lines (RILs) developed from Basmati370 / ASD16 cross was subjected for phenotypic screening for BPH resistance along with parents *viz.*, Basmati370 and ASD16 and checks *viz.*, PTB33 and TN1 during 2007-2008. A total of eleven resistance parameters *viz.*, nymphal developmental period (NDP) (Pongprasert and Weerapat, 1979), nymphal survival (NS) (Heinrichs *et al.*, 1985), growth index (GI) (Panda and Heinrichs, 1983), male percentage (MP), female percentage (FP), winged male percentage (WM), winged female percentage (WF), population build up (PB) and nymphal settling preference (NSP) after 72 hours by following Heinrichs *et al.*, (1985), functional plant loss index (FPLI) and plant dry weight loss index (PDWLI) (Panda and Heinrichs, 1983) were considered for phenotypic screening for resistance. All the parameters were assessed using standard procedures.

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The mean of all resistance parameters tested was used for correlation analysis and PCA. Analysis was carried out on data using the Minitab Statistical Software Version 13 for all the variables (Minitab Inc., 1983).

Results and discussion

Correlation analysis among the phenotypic parameters associated with resistance to BPH revealed significant differences between several parameters. Highly significant positive correlation between survival and growth index (0.90) and a significant negative correlation between developmental period and growth index (-0.59) were observed as anticipated. Developmental period showed a significant positive correlation with male population (0.16) and negative correlation with female population (-0.16) revealing the antibiosis component of resistance *i.e*., prolongation of developmental period results in more male than female population (Table 1).

A positive correlation of population build up with survival and a negative correlation with developmental period were noticed as expected. Besides, the population build up was positively correlated with female population and negatively correlated with per cent winged forms. This indicated that higher nymphal survival coupled with shorter developmental period and brachypterous female population supported higher population build up in the susceptible RILs. The total population build up was low on the resistant RILs and this might be due to reduced fecundity, feeding rate, survival and prolonged nymphal developmental period as reported by Gao and Bei (1992). Besides, Cook *et al*. (1987) reported that in moderately resistant varieties weight gain of the BPH insects was significantly lower and thus that would definitely influence the fecundity or viability of developing adults and hence F_1 population generation.

Similarly, there was a significant positive correlation with the developmental period and the macropterous forms of both male (0.392) and female (0.429), which also represents antibiosis component of resistance. The F1 population was negatively correlated with developmental period and positively correlated with Growth index. Highly significant positive correlation between tolerance parameters *viz*., FPLI and PDWLI was observed as anticipated. There was a positive correlation (0.075) between F_1 and FPLI but it was not significant. On the contrary, a significant negative correlation (-0.156) was observed between F_1 and PDWLI (Table 1).

In the present study, FPLI of different RILs showed significant variations and this parameter was not significantly correlated with antixenosis and antibiosis parameters. This is in accordance with the findings of Horber (1980) and Ho *et al*. (1982) who suggested that moderately resistant and highly tolerant varieties may need not exhibit properties of non-preference and antibiosis to great extent and, on the other hand, highly non-preferred and highly antibiotic cultivars may not possess tolerance. PDWLI was positively correlated with F_1 and FPLI. The plants with higher plant dry weight loss had high FPLI, which showed their susceptibility. Some accessions exhibited very low FPLI as well as PD loss and thus found to be tolerant to BPH attack. According to Rubia-sanchez *et al*. (2003), reduction in root dry weight due to BPH feeding was more

Table 1. Correlation analysis of different components of resistance traits in RILs against BPH

	NS	NDP	GI	MP	FP	WM	WF	PB	NSP (72 h)	FPLI
NDP	-0.19**									
GI	0.90**	-0.59**								
MP	0.03	0.15**	-0.04							
FP	-0.03	-0.15**	0.04	1.00						
WM	0.11	0.39**	-0.25 **	-0.07	0.07					
WF	-0.05	0.43**	-0.22 **	0.08	-0.08	0.37**				
PB	0.34**	-0.28**	0.40 **	-0.10	0.10	-0.07	-0.09			
NSP(72 h)	-0.14*	0.002	-0.12	-0.05	0.05	-0.06	-0.04	-0.17**		
FPLI	0.06	-0.09	0.09	-0.04	0.04	-0.02	-0.08	0.07	-0.04	
PDWLI	0.09	0.11	0.03	-0.13	0.13	-0.002	0.12	-0.17**	0.12	0.42**

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

Where, NS = Nymphal survival; NDP = Nymphal developmental period; GI = Growth index; MP = Male percentage; FP = Female percentage; WM = Winged male percentage; WF = Winged female percentage; PB = Population build up; NSP = Nymphal settling preference; FPLI = Functional plant loss index; PDWLI = Plant dry weight loss index in susceptible varieties compared to resistant varieties. Several genotypes having high level of tolerance to BPH were recorded with low FPLI and PDWLI (Panda and Heinrichs, 1983; Li *et al*., 1991; Cohen *et al*., 1997).

PCA carried out on 182 variables (RILs of Basmati370/ ASD16 cross) across 11 resistance parameters provided the Eigen values of 184.37, 0.61, 0.42 and 0.28 with the proportions of 0.991, 0.003, 0.002 and 0.002 for PCA1, PCA2, PCA3 and PCA4, respectively. Eigen values greater than 1.0 were observed fro PCA1 and PCA2. All the variables were distributed over the PC space indicating their distinctness (Table 2 and Fig 1).

The PCA carried out in the present study positioned the parents and RILs for their level of resistance. The occurrence of RILs with extremes of level of resistance beyond the parental levels indicated the transgressive variation for BPH resistance (Fig. 1).

PCA analysis carried out on 11 variables (parameters used to assess BPH resistance) across 182 RILs provided the Eigen values of 2.8674, 2.0499, 1.5194 and 1.3902 with

Table 2. Eigen analysis of the correlation matrix based on PCA on means of 12 variables of resistance on 182 RILs with parents and checks

Item	PCA1	PCA2	PCA3	PCA4
Eigen value	184.37	0.61	0.42	0.28
Proportion	0.991	0.003	0.002	0.002
Cumulative	0.991	0.995	0.997	0.998

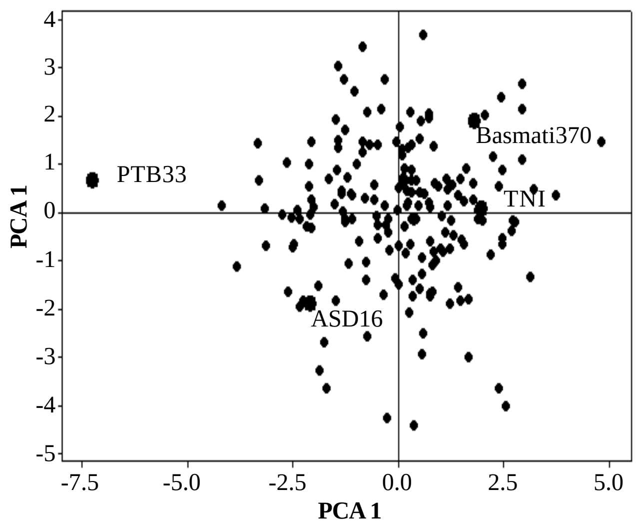

Figure 1. Principal component analysis: Score plot of PCA1 and PCA2 of 182 RILs, parents and checks across resistance parameters observed

Table 3. Eigen analysis of the correlation matrix based on PCA on 11 variables (parameters of BPH resistance) across 182 RILs

Item	PCA1	PCA2	PCA3	PCA4
Eigen value	2.8674	2.0499	1.5194	1.3902
Proportion	0.261	0.186	0.138	0.126
Cumulative	0.261	0.447	0.585	0.712

the proportions of 0.261, 0.186, 0.138 and 0.126 for PCA1, PCA2, PCA3 and PCA4 respectively. The Eigen value for PCA1 was greater than PCA2, PCA3 and PCA4 with a contribution of just 26.1 per cent to the total variance. Component loadings of all the variables on the first two components were not strong and significant (Tables 3 and 4). The underlying topographical gradient between variables projected into a PC space by using PCA scores of first and second axes are shown in score plots and loading plots (Figs 1 and 2). Among the resistance parameters tested, tolerance parameters (FPLI, PDWLI), NSP and winged female percentage were found to contribute to high for BPH resistance compared to other parameters (Fig 2).

Table 4. Component loadings based on PCA on 11 variables (parameters of BPH resistance) across 182 RILs

Parameters	PCA1	PCA2	PCA3	PCA4
NSP	-0.008	0.136	0.205	-0.432
NS	0.399	-0.208	-0.370	0.178
NDP	-0.454	0.004	-0.253	0.126
GI	0.521	-0.169	-0.198	0.100
MP	-0.166	-0.653	-0.012	-0.153
FP	0.166	0.653	0.012	0.153
WM	-0.286	0.133	-0.298	0.352
WF	-0.322	0.001	-0.437	0.209
PB	0.327	-0.053	-0.089	0.336
3FPLI	0.121	0.073	-0.437	-0.426
PDWLI	0.022	0.175	-0.489	-0.497

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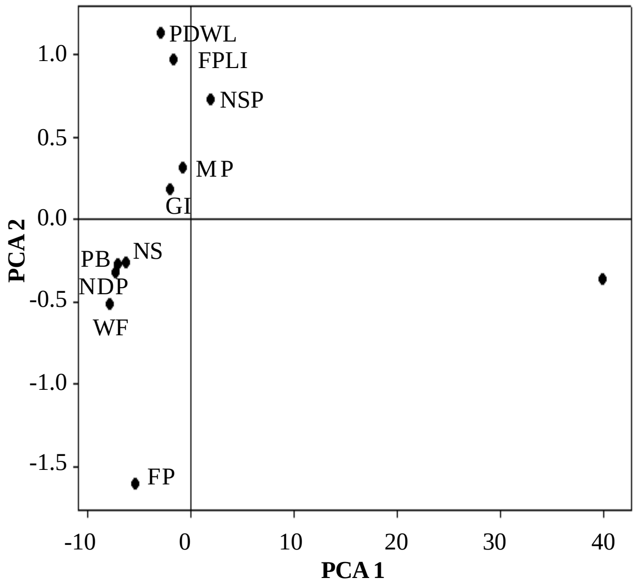

Figure 2. Principal component analysis: Score plot of PCA1 and PCA2 of 11 parameters across 182 RILs, parents and checks

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