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Influence of brown planthopper *Nilaparvava lugens* (Stal.) feeding on nutritional biochemistry of rice plant

K. Vanitha*, S. Suresh and K. Gunathilagaraj
***Tamil Nadu Agricultural University*, Coimbatore**

ABSTRACT

Among the four rice varieties selected, viz., TN1, Basmati370, ASD16 and Ptb33, total nitrogen, total phosphorus, chlorophyll a and b, reducing sugars, protein and free amino acid content was more in susceptible varieties compared to resistant varieties. Whereas, potassium was found significantly more in resistant variety Ptb33. BPH feeding caused considerable reduction of all the nutrients in all four varieties tested at seven days after infestation, where, the reduction was more in Basmati370 and TN1 which indicates their susceptibility compared to PTB33 and ASD16. Reduction in potassium content was very marginal, which was less than one per cent in Basmati 370, ASD 16 and Ptb33. There was up to 41.6 per cent reduction in total chlorophyll in Basmati 370 whereas, the reduction was only 12.48 per cent in Ptb33. However, upon BPH infestation increase in free amino acid content was observed in all four varieties.

Key words: *rice, biochemistry, brown planthopper, infestation*

Rice has been reported to be infested by a wide array of pests and among them, the brown planthopper (BPH) is one of the major pests causing frequent outbreaks (Park *et al*., 2007) and severe yield reductions. Host plant resistance is one of the most economical, effective and most practical methods of pest management. Nutritional biochemistry of a rice plant and its changes upon BPH infestation will give an idea of whether that plant is a susceptible host or not. Thus, the present investigation was taken up to study the influence of BPH feeding on nutritional biochemistry of four selected rice varieties with differential resistance.

MATERIALS AND METHODS

The analyses were carried out on Basmati 370, TN1, ASD16 and PTB33 to study the nutritional biochemistry of rice plants and to find out the influence of BPH infestation. Fifteen-day-old seedlings were transplanted in 10-cm diameter clay pots. The potted plants were covered with cylindrical Mylar ® cages (13×90 cm). After 30-days of transplanting, fourth or fifth-instar BPH nymphs were released at the rate of 10/plant. Biochemical analyses were carried out at seven days after infestation. The plants maintained without any BPH infestation served as control for each analysis. Eight replications were maintained for each test.

One gram of oven dried plant sample taken from both control and infested plants in each variety was analyzed for total nitrogen (Humphries, 1956), total phosphorus (Jackson, 1973) and total potassium (Jackson, 1973) content and the content was expressed as percentage. Chlorophyll content was estimated by using the method described by Witham *et al.* (1971) and expressed in mg g^{-1} fresh weight. One hundred mg of the leaves from both infested and control plants in each variety were taken for the analysis. Reducing sugars content in the basal stem region was estimated by using the method of Somogyi (1952) and expressed as mg g^{-1} fresh weight. Similarly, the protein content in the basal stem region was estimated by adopting the method of Lowry *et al.* (1951) and the total free amino acids by following the method of va Pin lee and Takahasi (1966) and expressed as mg g^{-1} of fresh sample.

The data obtained from the biochemical experiments were statistically analyzed in a completely randomized block design and different parameters observed in the experiments were subjected to LSD

by using the AGRES package which was used for comparing the means.

RESULTS AND DISCUSSION

Nutrients may play an important role in resistant mechanism in rice against BPH. The growth and development of rice plants are mainly affected by the function of nutrient up take particularly N, P and K in root systems and so pests feeding on them. Among the four varieties tested *viz*., TN1, ASD16, Basmati370 and PTB33, the susceptible varieties (Basmati370 and TN1) recorded more nitrogen (1.97 and 1.98 %) compared to the resistant variety, PTB33 (1.84 %) (Table 1). Thus these susceptible varieties have less effects of antibiosis on BPH, since survival of nymphs and adults, fecundity and egg hatchability were significantly increased with the increase of N content of plants as reported by Lu *et al*. (2005). Herbivores feeding on high N containing plants showed more survival, greater developmental rate and relative growth rate (Kaneshiro and Johnson, 1996), shorter developmental period (Xian *et al*., 2004) with bigger body sizes (Xian *et al*., 2007). Another important nutrient, *viz*., phosphorus is closely related to many physiological and biochemical processes in plants such as protein biosynthesis, cell division and growth. P is also important for photosynthesis in green plants. More phosphorus content was recorded in susceptible varieties compared to resistant varieties (Table 1). Potassium plays an essential role in plant growth because it activates over 60 enzymes and promotes protein synthesis. It was evident from this experiment that, potassium content was more in resistant variety, PTB33 (1.44 %) which is in agreement with Central Rice Research Institute (CRRI, 1984) report.

Studies on the influence of BPH infestation on the rice biochemistry revealed significant changes in the rice metabolites of the infested plants. Upon BPH infestation, a considerable reduction in N content was observed in all varieties and the decrease was more in Basmati370 (12.18%), followed by TN1 (8.99%) and ASD16 (9. 38%), whereas, in PTB33 only 4.36 per cent reduction was observed. The reduction in N was more compared to reduction in P and K. Removal of phloem sap containing sucrose and nitrogen compounds may be the cause for this reduction in N as reported by Chino *et al*. (1987). Further, Rubia- Sanchez *et al*. (1999) reported that reduction in leaf N content may be partly responsible for reduction in the photosynthetic rate and reduced growth of the main shoot is a possible major mechanism for BPH damage. Reduction was more in susceptible plants than in resistant plants. BPH feeding on rice plants caused decrease in the contents of N and photosynthetic products in the leaves and thus reduced the growth of main shoot and tillers (Sogawa *et al*., 1994; Watanabe and Kitagawa, 2000).

It was observed that K content was more in resistant variety PTB33, compared to other varieties unlike N and P. In this study, a slight reduction in P and K content was observed in plants upon BPH infestation. This can be explained by the findings of Lu *et al*. (2005) who reported that BPH infestation caused a reduction in the P and K up take of rice roots in varieties and the influence became more serious with the increase of BPH density and the prolongation of infestation duration. The per cent reduction of P was less and K was mush less upon BPH infestation compared to N content. There was up to 3.77 per cent reduction in P and 1.47 per cent reduction in K content was observed

Table 1. Changes in total nitrogen, total phosphorus and total potassium content in rice plant upon BPH infestation

Variety	Total nitrogen (%)*			Total phosphorus (%)*			Total potassium (%)*		
	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control
Basmati370	1.97 [a]	1.73 [c]	12.18	0.326 [a]	0.315 [a]	3.38	1.37 [b]	1.36 [b]	0.72
ASD16	1.93 [b]	1.74 [b]	9.83	0.313 [b]	0.306 [b]	2.39	1.38 [b]	1.37 [b]	0.72
TN1	1.98 [a]	1.8 [a]	8.99	0.298 [c]	0.288 [c]	3.77	1.36 [b]	1.34 [b]	1.47
PTB33	1.84 [c]	1.76 [b]	4.36	0.289 [d]	0.285 [c]	1.47	1.44 [a]	1.43 [a]	0.69
CD (5%)	0.044	0.013		0.009	0.005		0.031	0.022	
SEd	0.019	0.006		0.004	0.003		0.014	0.010	

* Mean of eight replications

Means followed by a common letter in a column are not significantly different at 5 % level

in TN1 upon BPH infestation, whereas, it was 1.47 per cent and only 0.69 per cent respectively in Basmati370 (Table 1). These results were in accordance with the findings of Reddy *et al*. (2002).

Chlorophyll content was high in susceptible variety TN1 followed by Basmati370 and ASD16 and it was low in PTB33. Total chlorophyll content was per cent 1.65 in TNI, whereas it was 1.50, 1.45 and 1.19 in Basmati, ASD16 and Ptb33 respectively (Table 2). This is in accordance with Umamaheswari (2001); Alagar, (2005) and Karthi (2007) who also reported higher chlorophyll content in BPH susceptible plants than resistant varieties. BPH infestation had greater influence on chlorophyll content and a maximum of 41.64 per cent, 36.6 per cent and 41.67 per cent reduction respectively in chlorophyll a, chlorophyll b and total chlorophyll content was recorded in Basmati370. However, PTB33 registered reduction of only 11.18 per cent, 15.12 per cent and 12.48 per cent in chlorophyll a, chlorophyll b and total chlorophyll content respectively (Table 2). Hence, it is manifested that, a marked reduction in chlorophyll a, chlorophyll b and total chlorophyll upon BPH infestation was noticed in all the four tested varieties. A dramatic decrease in chlorophyll content in rice plants upon BPH infestation was reported by Cagampang *et al*. (1974) and Kavitha (2008). Reduction in leaf nitrogen content caused by BPH feeding probably led to further reduction in leaf photosynthetic rate thus limiting the amount of assimilates produced and translocated to other tillers (Rubia-Sanchez *et al*., 1999).

It was observed that reducing sugar content was more in susceptible varieties than in resistant variety. Similarly, protein content in the basal stem of rice was also higher in susceptible plants compared to resistant varieties (Table 3). This is in line with the earlier findings which stated that soluble sugar content was high in susceptible varieties than in resistant varieties (CRRI, 1978). There was a less significant variation in the total free amino acids content among the four tested varieties where Ptb33 recorded low free amino acid content compared to other three varieties. This is in accordance with Nanda *et al.* (2000) who notified that the varieties which were resistant to BPH had low level of amino acids compared to susceptible varieties.

BPH infestation has greater influence on reducing sugar content. There was 30.07 per cent reduction in reducing sugar content in Basmati370, followed by 27.17 per cent in TN1. Similarly, a greater reduction in protein content was observed invariably in all the four varieties. The per cent reduction in protein content was higher in susceptible varieties when compared to resistant varieties. There was 26.81 per cent reduction in protein content in Basmati370, followed by 24.21 per cent in TN1 and 20.25 per cent in ASD16. In contrast, an increase in free amino acid content was observed in all four varieties upon BPH infestation and the increase was more in susceptible varieties compared to resistant variety PTB33 (Table 3). BPH feeding caused greater reduction in reducing sugar and protein content and the reduction was more in susceptible varieties than in resistant varieties. This is

Table 2. Changes in chlorophyll a, chlorophyll b and total chlorophyll content in rice basal stem portion upon BPH infestation

Variety	Chlorophyll a (mg g^{-1})*			Chlorophyll b (mg g^{-1})*			Total Chlorophyll (mg g^{-1})*		
	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control
Basmati370	1.22 ^{b}	0.71 ^{d}	41.64	0.32 ^{b}	0.21 ^{b}	36.6	1.50 ^{ab}	0.88 ^{d}	41.67
ASD16	1.17 ^{c}	0.78 ^{c}	33.14	0.31 ^{b}	0.22 ^{a}	28.72	1.45 ^{b}	0.93 ^{c}	35.71
TN1	1.32 ^{a}	0.83 ^{b}	37.28	0.39 ^{a}	0.24 ^{a}	37.61	1.65 ^{a}	1.01 ^{b}	38.46
PTB33	1.01 ^{d}	0.90 ^{a}	11.18	0.29 ^{c}	0.24 ^{a}	15.12	1.19 ^{b}	1.04 ^{a}	12.48
CD (5%)	0.024	0.035		0.013	0.014		0.039	0.023	
SEd	0.011	0.016		0.006	0.006		0.018	0.010	

* Mean of eight replications
Means followed by a common letter in a column are not significantly different at 5 % level

Table 3. Changes in reducing sugars, protein and free amino acid content in rice basal stem portion upon BPH infestation

Variety	Reducing sugars (mg g^{-1})*			Protein (mg g^{-1})*			Free amino acid (mg g^{-1})*		
	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control	Control	Infested	Per cent decrease over control
Basmati370	7.33 [a]	5.12 [c]	30.07	4.36 [a]	3.19 [d]	26.81	1.54 [a]	1.88 [a]	21.80
ASD16	6.63 [c]	5.26 [a]	20.67	4.08 [b]	3.25 [c]	20.25	1.52 [b]	1.84 [b]	20.82
TN1	6.86 [b]	4.99 [b]	27.17	4.43 [a]	3.36 [b]	24.21	1.54 [a]	1.85 [b]	19.84
PTB33	5.94 [d]	4.83 [b]	18.58	3.79 [c]	3.27 [a]	13.67	1.51 [b]	1.78 [c]	17.76
CD (5%)	0.017	0.013		0.089	0.039		0.021	0.047	
SEd	0.008	0.007		0.041	0.021		0.011	0.023	

* Mean of eight replications
Means followed by a common letter in a column are not significantly different at 5 % level

in accordance with the findings of Liu *et al*. (2008) and Wang *et al*. (2008) who reported that BPH feeding caused only slight reduction in protein and sucrose contents in resistant varieties and those infested plants also grow normally and maintain their photosynthetic activity.

Irrespective of their degree of resistance, only a little variation in free amino acid content was noticed among the four varieties, and similar observations were earlier reported by Saxena and Okech (1985). Upon BPH infestation, a dramatic increase in free amino acid content was noticed in all the four varieties tested and the increase was 21.8, 20.82, 19.84 and 17.76 per cent in Basmati370, ASD16, TN1 and Ptb33 respectively (Table 3). This is in support of Sogawa (1992) who revealed that the free amino acid content of chlorotic leaf blades was four times greater than that of healthy ones and chlorotic and brown leaves had 33 and 73 per cent less protein than did healthy leaves respectively. It is probable that as the stylet sheaths left by phloem-feeding insects in plant tissues could disrupt the phloem transport above the feeding site, consequently leading to temporary increase in local amino acids concentration (Bacheller and Romeao, 1992).

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