Management of hoppers in rice through host nutrition – A novel approach

P.Chandramani, R.Rajendran, P.Sivasubramanian and C.Muthiah

ABSTRACT

Experiments were carried in pot culture and field to analyse the effect of induced resistance on hopper pests of rice.The biological traits *viz*.,oviposition period ,adult emergence, growth index, adult longevity were studied based on standard procedures on plants imposed with treatments including neem cake, FYM , *Azospirillum*, phosphobacterium , silicate solublising bacteria and lignite fly ash. The combination of FYM, three biofertilizers, lignite fly ash and neem cake applied in splits significantly reduced the incidence GLH (59.13%),WBPH (63.12%) and BPH(74.545%) as compared to NPK applied as inorganic form. There has been a significant difference existed among treatments in oviposition period of BPH and WBPH and it ranged from 5.67 to 8.70 and 5.10 to 7.00 days respectively. The nymphal period was lengthened in the treatments *viz*., FYM, biofertilizers and neem cake as basal and in splits and FYM, biofertilizers, lignite fly ash and neem cake as basal and in splits and it was 15.01, 15.23, 15.87 and 15.92 days respectively as against 11.74 days in NPK applied plants. Longevity of BPH and WBPH varied from 5.00 to 7.15 and 3.70 to 6.15 days respectively.The presence of higher phenol (3.5 and 2.85 mg/g in stem and leaf), tannin (5.65 and 4.50 mg/g in stem and leaf) and silica (6.20 and 6.46 mg/g in stem and leaf) in the effective treatments imparted induced resistance through antibiosis mechanism to rice pests which was evidently proved in the biological traits tested.

Key words: Rice hoppers, induced resistance, biological traits, biochemicals

INTRODUCTION

The current scenario of rice pests in the country cause severe yield reduction includes brown planthopper (BPH), *Nilaparvata lugens* (Stal.); White backed planthopper (WBPH), *Sogatella furcifera* (Horvath); Green leafhopper (GLH), *Nephotettix virescens* (Distant); stem borer, *Scirpophaga incertulas* (Walker); leaffolder, *Cnaphalocrocis medinalis* (Guenee) and gall midge, *Orseolia oryzae* (Wood-Mason). In India losses incurred by different insect pests of rice are reported to the tune of 15,120 million rupees which in turn works out to 18.60 per cent of total losses (Lal, 1996).

Over reliance on highly toxic, hazardous pesticides has created higher magnitude of environmental pollution leading to imbalance in natural ecosystem. Development of resistance in insects becomes major problem due to indiscriminate use of pesticides. Hence, the use of less toxic compounds of natural plant origin, host resistance, bioagent, adoption of cultural practices and inclusion of non rice crops in cropping system are given priority as important components for implementation of IPM programme.

Organic manures work like slow release fertilizers thus providing balanced nutrition to plant and reduces the insect population. In FYM treated plots, increased levels of leucoanthocyanins, catechins flovanolglycosides and phenol carboxylic acids were reported and these are responsible for resistance to many pests. Kajimura *et al*. (1995) recorded less population of BPH and WBPH in organically farmed field than in the non organically farmed field.

Lignite fly ash is particularly effective against rice pests *viz*. leaffolder, yellow hairy caterpillar and a number of plant sap suckers (Kanojia *et al*., 2001). It is known that certain rice genotypes are more efficient accumulators of Si, thus making them more resistant (Winslow, 1992) Narayanasamy (1995) stated that the silica content of fly ash has got translocated to the plant system which increases the layers of sclerenchymatous cells especially in culms and leaves which in turn induces resistance in the rice plant to the problems of BPH, GLH and other sucking insects.

Plant resistance is a most economic and desirable method for the management of pests. In the absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain insect

Table1. Impact of organic sources of nutritions on oviposition period and longevity (in days) of BPH and WBPH

Treatments	Oviposition period		Longevity	
	BPH	WBPH	BPH	WBPH
NPK alone	8.70[d]	7.00[b]	7.15[b]	6.15[b]
FYM alone	7.25[c]	6.27[b]	6.97[b]	5.5[b]
FYM + NC	7.10[c]	5.32[a]	6.85[b]	5.50[b]
FYM + NC in splits	7.00[c]	5.28[a]	6.83[b]	5.27[b]
FYM + Azos + phos + SSB + NC	6.15[b]	5.31[a]	5.58[a]	4.25[a]
FYM + Azos + phos + SSB + NC in splits	6.10[b]	5.30[a]	5.42[a]	4.10[a]
FYM + Azos + phos + SSB + LFA + NC	5.75[a]	5.15[a]	5.21[a]	3.75[a]
FYM + Azos + phos + SSB + LFA + NC in splits	5.67[a]	5.10[a]	5.00[a]	3.70[a]
Untreated check	8.65[d]	6.78[b]	7.07[b]	6.00[b]

In a column mean followed by same letter are not significantly different at P = 0.05 as per DMRT.

pests.Induced resistance is defined as an enhancement of plant's defensive capacity against a broad spectrum of pests and pathogens that is acquired after appropriate stimulation.Hence this investigation was undertaken to study the induced resistance and its impact on major pests of rice.

MATERIALS AND METHODS

Field and pot culture experiments were carried out to assess the influence of organic sources of nutrients on hopper pests of rice.

Field Experiments

Field Experiment was conducted at Agricultural College and Research Institute, Madurai using the variety MDU 5 having nine treatments [T_1 – NPK alone (100: 50: 50 kg NPK / ha); T_2 – FYM alone (12.5 t / ha); T_3 – FYM + neem cake (NC) (250 Kg/ha); T_4 – FYM + NC in splits (125 Kg/ ha as basal, 125 Kg/ha in 3 equal splits); T_5 – FYM+ *Azospirillum* + Phospho bacterium + silicate solubilizing bacteria (SSB) + NC; T_6 – FYM + *Azospirillum* + phospho bacterium + SSB + NC in splits; T_7 – FYM + *Azospirillum* + Phosphobacterium + SSB + lignite fly ash + NC; T_8 - FYM + *Azospirillum* + Phosphobacterium + SSB + lignite fly ash +NC in splits and T_9 - Untreated check]. All the agronomic practices were followed uniformly in all the plots with plot size of 5 x 4 m^2 and spacing of 15 x 10 cm.The design adopted was RBD with three replications.The incidence hopper pests was observed at regular intervals in each treatment in randomly selected 10 tillers.

Neem cake was applied in four splits, first as basal and subsequent splits at 20 days interval. Lignite fly ash was applied in three splits, first as basal and subsequent splits at monthly interval. At harvest, the grain yield was recorded in all the treatments

The biofertilisers *viz.*, *Azospirillum* , phosphobacterium and silicate solubilizing bacteria were purchased from the Biofertiliser Lab maintained by Agricultural College, Madurai. FYM and neem cake were purchased from fertilizer shop, Madurai. Lignite fly ash was purchased from Neyveli Lignite Corporation, Neyveli.The nutrient content in *Azospirillum*, phosphobacterium, silicate solubilizing bacteria, FYM, neem cake and lignite fly ash were also analysed in the Soil Science Laboratory of Agricultural College, Madurai before the experiments.

Nutrient Status of organic sources used in the present investigation

Organic sources	N(%)	P(%)	K(%)	silicon(%)
Farm Yard Manure	0.50	0.25	0.45	-
Neem cake	5.20	1.10	1.5	-
Lignite fly ash	traces	traces	1.08	27.35

Pot culture experiments

Twenty five days old MDU 5 seedlings were transplanted separately into a microplots of size 0.5 x 0.5 x 0.4 m. The treatments were imposed basally. Four hills were maintained uniformly in each microplot. The experiment was carried out in completely randomized block design with three replications.The treated plants were utilized to study the biological traits of leaf and planthoppers.The following biological traits were studied

Oviposition period

A pair (male and female) of BPH and WBPH was introduced separately into the glass tubes (24 x 4 cm)

Table 2. Influence of organics on nymphal duration, adult emergence and growth index of BPH

Treatments	Nymphal duration (in days)	BPH Adult emergence (in %)	Growth index
NPK alone	11.74(3.38)^{b}	83.10(65.73)^{i}	7.08(2.67)^{e}
FYM alone	12.63(3.51)^{b}	80.50(63.80)^{hg}	6.37(2.51)^{e}
FYM + NC	13.16(3.68)^{b}	72.63(58.46)^{f}	5.52(2.35)^{d}
FYM + NC in splits	13.85(3.71)^{b}	61.57(51.69)^{e}	4.45(2.10)^{c}
FYM + Azos + phos + SSB + NC	15.01(3.88)^{a}	55.30(48.04)^{d}	3.68(1.90)^{b}
FYM + Azos + phos + SSB + NC in splits	15.23(3.91)^{a}	50.71(45.41)^{c}	3.33(1.82)^{b}
FYM + Azos + phos + SSB + LFA + NC	15.87(3.99)^{a}	46.61(43.06)^{a}	2.94(1.70)^{a}
FYM + Azos + phos + SSB + LFA + NC in splits	15.92(4.01)^{a}	41.13(39.89)^{b}	2.58(1.61)^{a}
Untreated check	12.12(3.48)^{b}	80.13(63.53)^{g}	6.61(2.56)^{e}

Values in parentheses are square root transformations; In a column mean followed by same letter are not significantly different at P = 0.05 as per DMRT.

containing rice culm with 15 cm long pieces collected from various treatments. The rice culm was replaced daily by a healthy one until the egg deposition by adult ceased or the adult died. The rice culm exposed in each treatment was examined daily for deposition of eggs and the time taken for the oviposition was worked out (Heinrichs and Rapusas, 1983).

Development of nymphs

Twenty days old plants exposed with various treatments were confined with a mylar film cage (60 x 20 cm). Five first instar nymphs were then released into each cage. Nymphs were allowed to reach the adult stage and the adult emergence was recorded daily. The total number of adults emerging from each treatment was determined and per cent adult emergence was calculated as

$$\text{Adult emergence (\%)} = \frac{\text{Number of adults that emerged}}{\text{Number of nymphs infested}} \times 100$$

The mean developmental period (first instar nymphs to adult) of BPH and WBPH on each treatment was calculated and the mean growth index was computed as follows (Pablo, 1977).

$$\text{Growth index} = \frac{\text{Adult emergence (in \%)}}{\text{Mean developmental period (in days)}}$$

Adult longevity and adult weight

To evaluate the adult longevity, an experiment was set up as similar that of determination of oviposition period. A newly emerged male and female adults were introduced into each treatment and the adults survival were observed daily until death and days to mortality were recorded (Rodriguez – Rivera, 1972). The adults of BPH, GLH and WBPH developed under various treatments were weighed separately in groups of ten after anesthetizing them with chloroform.

Biochemical analyses

All the biochemical components were estimated from leaf sheath and leaf blade separately in three replications.

Total phenols

One gram of the sample was ground in 10-20 ml of 80 per cent ethanol. The homogenate was centrifuged at 10,000 rpm for 20 minutes and the supernatant was collected. The residue was re extracted and the supernatant pooled. The supernatant was evaporated to dryness. The residue dissolved in 5 ml of distilled water. Aliquots of 0.2 to 2.0 ml was pipetted out into test tubes and volume made up in each tube to 2.0 ml with water. To each tube 5.0 ml of 20% Na_2CO_3 was added and the contents were allowed to stand for 10 minutes. One ml of folin – ciocalteau reagent was added to all the tubes. After 30 minutes, the absorbance was measured at 660 nm. A standard curve was prepared using different concentrations of catechol. With the standard curve, the concentration of total phenol present in various treated samples was calculated (Malick and Singh, 1980).

Table 3. Influence of organic sources of nutritions on insect weight (in mg)

Treatments	Insect weight		
	GLH	WBPH	BPH
NPK alone	1.38[b]	0.96[c]	1.27[d]
FYM alone	1.20[b]	0.82[b]	1.20[d]
FYM + NC	1.18[b]	0.79[b]	1.00[c]
FYM + NC in splits	0.99[ab]	0.76[b]	0.98[bc]
FYM + Azos + phos + SSB + NC	0.92[a]	0.70[a]	0.85[b]
FYM + Azos + phos + SSB + NC in splits	0.91[a]	0.70[a]	0.83[b]
FYM + Azos + phos + SSB + LFA + NC	0.96[a]	0.68[a]	0.72[a]
FYM + Azos + phos + SSB + LFA + NC in splits	0.89[a]	0.62[a]	0.69[a]
Untreated check	1.30[b]	0.91[c]	1.25[d]

In a column mean followed by same letter are not significantly different at P = 0.05 as per DMRT

Tannin

One gram of sample was ground using distilled water and taken in 250 ml conical flask, 75 ml of distilled water was added and boiled for 30 minutes. The solution was centrifuged at 2000 rpm for 20 minutes and the supernatant was collected in a 100 ml volumetric flask and the volume was made upto 100 ml with distilled water. 1.0 ml of sample extract was taken and transferred to 100 ml volumetric flask containing 75 ml of distilled water. 5.0 ml of Folin Denis reagent and 10 ml of sodium carbonate solution were added and the volume was made up to 100 ml. After 30 minutes the mixture was shaken well and the absorbance was measured at 700 nm. Standard curve was drawn using different concentrations of tannic acid. Using the standard curve, the tannin content of treated samples was calculated (Bwins, 1971).

Total sugars

One gram of the sample was hydrolysed by keeping it in a water bath for three hours with 5 ml of 2.5 N HCl. Using solid sodium carbonate the sample was neutralised and the volume made up to 100 ml. The sample was centrifuged and the supernatant used for analysis. Aliquots of 0.5 and 1.0 ml were taken from the sample and the volume was made upto one ml using distilled water in all the tubes. Four ml of anthrone reagent was added to all the test tubes and the tubes were kept in boiling water bath for eight minutes. Tubes were cooled immediately and the green colour read at 630 nm. A standard curve was prepared using different concentrations of glucose. The amount of soluble sugars present in the sample was calculated using the standard graph. (Mahadevan and Sridhar, 1986)

Total free aminoacids

One gram of the sample was ground well with a pestle and mortar in 10 ml of 80 per cent ethanol. The homogenate was centrifuged and the supernatant was used for estimation. From the working standard solution containing 100 mg of leucine per ml, pipette out 0.2, 0.4, 0.6, 0.8 and 1.0 ml into a series of test tubes and 0.1 ml of the sample extract. One ml of ninhydrin was added and the volume was made upto two ml in all the tubes. The tubes were kept in the boiling water bath for 20 minutes. Five ml of the diluent solvent (equal volume of water and *n – propanol*) was added, mixed well and allowed to stand for 15 minutes. The intensity of the purple colour was read at 570 nm. The concentration of total free aminoacids in the sample was calculated using the standard curve and expressed as per cent equivalent of leucine (Moore and Stein, 1984)

Silica

Oven dried sample of 0.5 g plant material was digested with triple acid and the digest was added with excess of sodium carbonate to dissolve the silica. The resultant solution was made up to the volume of 250 ml in polythene volumetric flask. An aliquot of 2 ml was transferred in to 50ml polythene standard flask and the intensity of blue colour was read at 660 nm in a spectrophotometer using sodium meta silicate as standard as per the procedure outlined by Nayar *et al.* (1975).

Statistical analysis

Data collected in various field and pot culture experiments were statistically analysed using randomized and completely randomized block designs respectively. Square root transformation was followed for converting the population numbers. The treatment means were compared by Duncan's Multiple Range Test (DMRT) for their significance (Gomez and Gomez, 1985).

RESULTS AND DISCUSSION

Oviposition period

There has been a significant difference existed among treatments in oviposition period of BPH and WBPH and it ranged from 5.67 to 8.70 and 5.10 to 7.00 days respectively. The maximum oviposition period of 8.70 and 7.15 days was recorded in NPK applied plants for BPH and WBPH

Table 4. Influence of organic sources on GLH, WBPH and BPH population (No./tiller) and per cent reduction over NPK (PR) after 30, 45 and 60 days after transplanting.

Treat-ments	GLH						WBPH						BPH					
	30		45		60		30		45		60		30		45		60	
	GLH	PR	GLH	PR	GLH	PR	WBPH	PR	WBPH	PR	WBPH	PR	BPH	PR	BPH	PR	BPH	PR
NPK alone	1.35 (1.15)^{f}	--	3.23 (1.78)^{g}	--	2.38 (1.55)^{d}	--	1.71 (1.27)^{g}	--	3.01 (1.71)^{f}	--	2.30 (1.50)^{f}	--	2.41 (1.54)^{g}	--	3.81 (1.94)^{d}	--	3.23 (1.78)^{g}	-
FYM alone	1.15 (1.06)^{b}	14.81	2.51 (1.57)^{d}	22.29	1.85 (1.35)^{d}	22.27	1.60 (1.24)^{g}	6.43	2.51 (1.59)^{g}	16.61	2.21 (1.47)^{f}	3.91	1.82 (1.33)^{bc}	24.48	2.50 (1.56)^{f}	34.38	2.17 (1.45)^{d}	32.82
FYM + NC	1.03 (1.01)^{b}	23.10	1.87 (1.35)^{e}	42.11	1.25 (1.13)^{ed}	47.48	1.10 (1.03)^{b}	35.67	2.23 (1.47)^{d}	25.91	1.87 (1.34)^{bc}	18.70	1.31 (1.12)^{b}	45.64	1.87 (1.35)^{b}	50.92	1.58 (1.22)^{f}	51.08
FYM + NC in splits	0.87 (0.92)^{ab}	35.56	1.65 (1.25)^{bc}	48.92	1.11 (1.06)^{e}	53.36	1.00 (0.97)^{ab}	41.52	2.15 (1.45)^{d}	28.57	1.63 (1.25)^{b}	29.13	1.25 (1.10)^{b}	48.13	1.51 (1.22)^{b}	60.37	1.45 (1.20)^{f}	55.11
FYM + Azos + phos + SSB + NC	0.83 (0.90)^{ab}	38.52	1.58 (1.22)^{b}	51.08	1.07 (1.02)^{e}	55.04	0.94 (0.95)^{a}	45.03	1.85 (1.34)^{e}	38.54	1.55 (1.23)^{b}	29.57	1.21 (1.10)^{b}	49.79	1.31 (1.13)^{ab}	65.62	1.13 (1.05)^{b}	65.02
FYM + Azos + phos + SSB + NC in splits	0.77 (0.86)^{a}	42.96	1.47 (1.20)^{b}	54.49	0.98 (0.98)^{e}	58.82	0.91 (0.93)^{a}	46.78	1.33 (1.13)^{b}	55.81	1.48 (1.21)^{ab}	32.61	1.03 (1.01)^{b}	57.26	1.10 (1.03)^{e}	71.13	0.85 (0.91)^{a}	73.68
FYM + Azos + phos + SSB + LFA + NC	0.72 (0.83)^{a}	46.67	1.35 (1.13)^{a}	58.20	0.76 (0.85)^{b}	68.07	0.91 (0.92)^{a}	46.78	1.29 (1.11)^{b}	57.14	1.31 (1.13)^{a}	35.65	1.00 (1.00)^{b}	58.51	1.23 (1.10)^{a}	69.72	0.93 (0.95)^{ab}	71.21
FYM + Azos + phos + SSB + LFA + NC in splits	0.61 (0.75)^{a}	54.81	1.32 (1.11)^{a}	59.13	0.57 (0.73)^{a}	76.05	0.87 (0.90)^{a}	49.12	1.11 (1.03)^{a}	63.12	2.21 (1.48)^{e}	43.04	0.66 (0.81)^{a}	72.61	0.97 (0.98)^{a}	74.54	0.66 (0.81)^{a}	79.57
Untreated check	1.24 (1.10)^{c}	--	3.11 (1.77)^{g}	--	2.30 (1.53)^{d}	--	1.65 (1.23)^{g}	--	2.87 (1.68)^{f}	--		--	2.33 (1.51)^{g}	--	3.56 (1.87)^{d}	--	3.15 (1.79)^{g}	-

Values in parentheses are square root transformations; In a column mean followed by same letter are not significantly different at 5 % by DMRT

Table 5. Influence or organics on biochemical constituents in field condition after 30 and 60 days after treatments DAT

Treatments	Phenol (mg/g)			Tannin (mg/g)			Total sugars (mg/g)			Total free amino acids (mg/g)			Silica content (%)		
	30	60	Mean	30	60	Mean	30	60	Mean	30	60	Mean	30	60	Mean
T_8 Stem	3.3	3.7	3.50	5.6	5.7	5.65	4.7	5.0	4.85	1.2	2.4	1.80	4.60	7.80	6.20
Leaf	2.7	3.0	2.85	4.2	4.8	4.50	5.1	5.6	5.35	1.2	2.6	1.90	4.82	8.10	6.46
T_1 Stem	2.1	1.9	2.00	3.3	3.7	3.50	6.2	6.8	6.50	1.5	3.2	2.35	4.00	4.28	4.14
Leaf	1.4	1.6	1.50	3.1	3.4	3.25	8.4	9.1	8.75	1.6	3.6	2.60	4.21	4.30	4.26
T_9 Stem	1.1	0.9	1.00	2.0	1.7	1.85	5.4	5.7	5.55	1.5	3.2	2.35	4.00	4.58	4.29
Leaf	1.0	0.9	0.95	1.8	1.5	1.65	8.1	8.9	8.50	1.5	3.5	2.50	4.24	4.60	4.42

respectively as against a minimum period noticed in plants treated with FYM, biofertilizers, lignite fly ash and neem cake as basal and in splits. Whereas, the treatments with FYM, neem cake either in splits or basal, biofertilizers and lignite fly ash were on par with each other in registering minimum oviposition period for WBPH.

Longevity

Longevity of BPH and WBPH adults showed significant difference among treatments. Longevity of BPH and WBPH varied from 5.00 to 7.15 and 3.70 to 6.15 days respectively. The longevity of BPH and WBPH was more in NPK applied plants and in untreated check. The treatment with FYM, bio fertilizers with or without lignite fly ash along with neem cake as basal and in splits reduced the longevity of BPH adults. The same trend was noticed in case of longevity of WBPH also (Table1).

Nymphal duration

The nymphal duration and adult emergence were significantly influenced by the application of organic sources of nutrition. The nymphal period was lengthened in the treatments *viz*., FYM, biofertilizers and neem cake as basal and in splits and FYM, biofertilizers, lignite fly ash and neem cake as basal and in splits. The nymphal duration was 15.01, 15.23, 15.87 and 15.92 days respectively as against 11.74 days in NPK applied plants (Table 2) .

Adult Emergence

The per cent adult emergence was minimum in the combination of FYM, biofertilizers, lignite fly ash and neem cake as basal (46.61%) followed by same combination of treatment but neem cake in splits (41.13%). The maximum per cent adult emergence (83.10%) was recorded in NPK applied plants. Accordingly growth index of BPH was less in the treatment with FYM, biofertilisers, lignite fly ash and neem cake as basal as well in splits and it was 2.94 and 2.58 days respectively as against 7.08 days in NPK applied plants (Table 2).

Weight of adult hoppers

The differences in adult weight of GLH, BPH and WBPH were significant among treatments. The weight reduction of these three hoppers was much pronounced in the treatments with biofertilizers either with or without lignite fly ash along with FYM and neem cake in splits and basal. The adult weight was maximum in NPK applied plants followed by untreated check (Table 3).

The decreased insect size, reduced adult longevity and oviposition period were observed in the the treatment with FYM, bio fertilizers with or without lignite fly ash along with neem cake as basal and in splits exhibiting a high level of antibiosis. These antibiosis mechanism obtained by the effective treatment was in agreement with Painter (1951); Khan and Saxena (1985). Growth index was meagre with the corresponding prolonged developmental period in the best treatments. These observations are in confirmity with the findings of Dash and Senapathi (1995). Population increase reflects the degree of insect establishment which is considered as an important criterian for assessing the level of resistance in rice (Heinrichs and Rapusas, 1983).

Organic sources of nutrition on the incidence of hoppers

GLH

The population of GLH varied significantly among treatments during the plant stages observed. The GLH population ranged from 0.61 to 1.35, 1.32 to 3.23 and 0.57 to 2.38 per tiller at 30, 45 and 60 DAT respectively. At 45 DAT, the FYM, biofertilizers, lignite fly ash and neem cake applied as basal or in splits were consistently effective in reducing the incidence of GLH with the population reduction of 58.20 and 59.13 per cent (Table4).

WBPH

The population level of WBPH differed significantly among treatments at 30 and 45 DAT. The population ranged from 0.87 to 1.71, 1.11 to 3.01 and 1.31 to 2.30 per tiller respectively on 30, 45 and 60 DAT .The combination of biofertilizers, lignite fly ash, FYM and neem cake in splits was significantly superior over other treatments where the mean population recorded was 1.11 and 1.31 per tiller with the highest per cent reduction of 63.12 and 43.04 at 45 and 60 DAT, respectively over NPK (Table 4).

BPH

Significant differences have been existed in BPH population at 30 and 45 DAT. The mean population level varied from 0.66 to 2.41 and 0.97 to 3.81 per tiller at 30 and 45 DAT respectively. The minimum population was found in the combination of biofertilizers, lignite fly ash, FYM and neem cake in splits (T_8) on 30 DAT. Whereas on 45 DAT, the treatments *viz*., FYM, biofertilizers, lignite fly ash and neem cake as basal and FYM, biofertilizers and neem cake in splits were also equally effective as that of T_8. The maximum per cent reduction of 72.61 and 74.54 over NPK was recorded in the treatment T_8 on 30 and 45 DAT, respectively (Table 4).

Total phenol, tannin, silica, total sugars and free aminoacids

Through field evaluation, total phenol content tannin, silica, total sugars and total free aminoacids were estimated in the leaf and stem collected from treated plants of the promising treatment in comparision with NPK as inorganic form and untreated check.The results revealed that the plant samples collected from plots treated with FYM, biofertilizers, lignite fly ash and neem cake applied in splits showed higher content of total phenol (3.5 and 2.85 mg/g in stem and leaf), tannin (5.65 and 4.50 mg/g in stem and leaf), silica (6.20 and 6.46 mg/g in stem and leaf) and minimum level of total sugars and total free aminoacids and thereby exhibited high level of induced resistance (Table 5).

Correlation between hoppers and biochemical factors

The presence of high phenol content is significantly negatively correlated with the incidence of GLH (r = -0.929) and BPH(r = -0.701). Similarly, the presence of high silica content is negatively correlated with the incidence of GLH (r = -0.786), WBPH (r = -0. 0.931) and BPH (r = - 0.790). The presence of high tannin content is negatively correlated with the incidence of GLH (r = -0.829) and BPH(r= -0.638).Where as the presence of high total sugar content is positively correlated with the incidence of WBPH (r = -0.604) and BPH (r = -0.493) (Table 6).

Table 6. Correlation between insects and biochemical factors in rice (45 DAT)

Insects	Correlation co-efficient (r)			
	Biochemical factors			
	Phenol	Silica	Tannin	Total sugars
GLH	-0.929**	-0.786**	-0.829**	0.396^{NS}
WBPH	-0.245^{NS}	-0.931**	-0.457^{NS}	0.604*
BPH	-0.701**	-0.790**	-0.638**	0.493*

* - Significant at 5 per cent level; ** - Significant at 1 per cent level; NS – Non significant

This reduction in population of plant and leafhoppers might be due to their inhibition in feeding and ovipositional deterrency exhibited in the treated plants. This is in line with the findings of Athisamy (1994) who reported that *Azospirillum* at higher doses in combination with organic manure decreased the feeding rate of BPH and adversely affected its growth and development. Anuradha (1989) also reported that the plants treated with *Azospirillum* combined with FYM increased the contents of total phenol and silica in rice which might have checked the planthopper population. This was again in consonance with the earlier findings of Kajimura *et al*. (1995). They recorded less population of BPH and WBPH in organically farmed field than in the non organically farmed field. In the present study, it is also evident that addition of lignite fly ash led to translocation of silica to the plant system especially in culms and leaves imparting induced resistance in plants.

The biochemical constituents of plants imposed with various organic sources of nutrition tested revealed that total phenol,silica and tannin were high in the promising treatment while the total sugars and total free aminoacids were low during the period of experimentation.The presence of total phenol,silica and tannin in the effective treatment imparted induced resistance through antibiosis mechanism to rice pests in terms of poor growth index in

BPH, shortening of longevity and oviposition period of WBPH and BPH and reduced weight of GLH,WBPH and BPH.

REFERENCES

Bwins, R.E. 1971. Methods for estimation of tannin in grain sorghum and other food stuffs. *Agronomy Journal*, **63** : 511-512.

Dash, A.N. and Senapathi, B. 1995. Efficacy of neem derivatives as rice seedling root dip against green leafhopper, *Nephotettix virescens* (Distant) under green house conditions. *Journal of Entomological Research*, **19:** 33-38.

Gomez, K.A. and Gomez, A.A. 1985. *Statistical procedures for Agricultural Research*, John wiley and Sons, New York.

Heinrichs, E.A. and Rapusas, H.R. 1983. Levels of resistance to the white backed planthopper, *Sogatella furcifera* (Homoptera : Delphacidae) in rice varieties with different resistance genes. *Environmental Entomology*, **12:** 1793-1797.

Khan, Z.R. and Saxena, R.C. 1985. Behavioural and physiological responses of *Sogatella furcifera* (Homoptera : Delphacidae) to selected resistant and susceptible rice cultivars. *Journal of Economic Entomology*, **78**: 1280-1286.

Kajimura, T., Fujisaki, K. and Nakasuji, F. 1995. Effect of organic rice farming on leafhoppers and planthoppers and amino acid content in rice phloem sap and survival of planthoppers. *Applied Entomological Zoology*, **30:** 17-22.

Kanojia, R.K., Kanawjia, S.K. and Srivastava, P.C. 2001. Utilization of fly ash in agriculture: a potential soil amendment for increasing crop yields. *Indian Farming*, **51**(3): 29.

Lal, O.P. 1996. *Recent Advances in Entomology*, (Lal, O.P. ed.) Apl. Publication, New Delhi. 392 **P.**

Mahadevan, A. and Sridhar, R. 1986. *Methods in Physiological Plant Pathology*, Sivakami Publications, Madras.

Malick, C.P. and Singh, M.B. 1980. In : *Plant Enzymology and Histo Enzymology*, Kalyani Publishers. New Delhi. 286 **P.**

Moore, S. and Stein, W.H. 1984. In: *Methods in Enzymology* (Colowick, S.P and N. Kaplan eds.). Academic press, New York. 468. **P.**

Narayanasamy, P.1995. Development and use of fly ash pesticides in agriculture. pp 1-4. In : fly ash in agriculture (Narayanasamy, P.ed.) *Proceedings of National Seminar on use Lignite Fly ash in Agricul ture*, Annamalai University, Annamalai Nagar, Tamil Nadu. 20-22 December. 1995.

Nayar, P.K., Misra, A.K. and Patnaik, S. 1975. Rapid micro determination of silicon in rice plant. *Plant and Soil*, **42** : 491 – 494.

Pablo, S.J. 1977. Resistance to white backed plant hopper *Sogatella furcifera* (Horvath) in rice varieties. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi, India.

Painter, R.H. 1951. *Insects resistance in crop plants.* The Macmillan Co., New York. 520.**P.**

Rodriguez-Rivera, R. 1972. Resistance to the whitebacked planthopper, *Sogatella furcifera* (Horvath) in rice varieties. M.Sc. Thesis, University of the Philippines, Los Banos, Philippines, 69 **P.**

Winslow, M.D. 1992. Silicon, disease resistance and yield of rice genotypes under upland cultural conditions. *Crop Science*, **32:** 1208 - 1213.

P. Chandramani*, R. Rajendran, P. Sivasubramanian and C. Muthiah

Agricultural College and Research Institute, TNAU, Madurai-625104, Tamil Nadu, India.

*Communication author E-mail : chandramani10@yahoo.co.in