Journal of Biopesticides, 3(2): 423 - 427 (2010) **423**

Organic source induced silica on leaf folder, stem borer and gall midge population and rice yield

P. Chandramani*, R. Rajendran[1], C. Muthiah and C. Chinniah

ABSTRACT

Experiments were carried out in field conditions to analyse the effect of induced resistance on certain major pests of rice ***viz.,*** leaf folder, stem borer and gall midge. The population of these insects were assessed at regular intervals on plants imposed with treatments including neem cake (NC),farm yard manure (FYM), Azospirillum (Azos), phosphobacterium (Phos), Silicate Solublising Bacteria (SSB) and lignite fly ash(LFA).The results revealed that the combination of FYM, three biofertilizers, lignite fly ash and neem cake applied in splits significantly reduced the incidence leaf folder (76.69%), stem borer (58.66) and gall midge (66.81%) as compared to NPK applied as inorganic form. The insect population was correlated with silica content and it was analysed in the leaf sheath and laminae of plants treated with organic sources of nutrients. As the age of the plant increased, silica content proportionately increased in the plants. There was significant difference in silica content on 45 and 60 DAT among treatments. The treatment *viz.*, application of three biofertilizers, lignite fly ash along with FYM and neem cake either as basal (7.8%) or in splits recorded high silica content (8.10 %) as compared to other treatments.It was found that the occurrence of these major insects was negatively correlated with silica content. Correlation values between silica and insects were -0.789 for leaf folder, -0.930 for stem borer and -0.958 for gall midge. The main cause for the death of insects due to fly ash application was wearing of mandibles and main feeding organs of insects which resulted in functionless mandibles so that the insects of paddy die without food. Further, the incidence of major insects was negatively correlated with yield. Application of organic sources of nutritions significantly increased the rice grain yield. The treatment with biofertilizers, lignite fly ash, FYM and neem cake in splits recorded significantly higher grain yield (5.49 t/ha) which was on a par with NPK applied plots (5.38 t/ha).and the per cent increase in yield over NPK was 2%.It is concluded that application of organic sources of nutrition reduced the incidence of leaf folder, stem borer and gall midge and increased the yield in rice.

Key words: Induced resistance, leaf folder, stem borer, gall midge, silica

INTRODUCTION

Rice is known as silicon accumulator (Takahashi *et al*. 1990; Jian Feng Ma *et al.*, 2006; Xue Qiang Zhao et al., 2010) and the plant benefits from Si nutrition (Yoshida, 1975 and Takahashi, 1995). It is required for the development of strong leaves, stems and roots. The formation of a thick silicated epidermal cell layer reduces the susceptibility of rice plants to 'insects' *viz.*, stem borers, plant hoppers and mite pests. According to Ishizuka (1964), the Si content of rice varies with plant age. Mature plants and older leaves have more Si than that in younger plants and leaves. In rice plants supply of Si also changed the total contents of carbohydrate, protein, phenol and these changes varied slightly with the stage of the crop and plant part (Ashoka Rani *et al*., 1997). Maxwell *et al*. (1972) and Panda *et al*. (1977) found that the infestations of rice stem borer were markedly reduced by adding silicon to soil.Tayabi and Azizi (1984) concluded that the application of silica at 1t/ha reduced the density of stem borer(*Scirpophaga incertulas)*. Subramanian and Gopalswamy (1991) reported that addition of silicate materials significantly reduced the incidence of *Cnaphalocrocis medinalis* and *Orseolia oryzae* in rice at tillering stage.

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. The current scenario of rice pests in the country causes severe yield reduction which 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).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 a 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.In the absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain insect pests.

Djamin and Pathak (1967) have found that the incisor region of the mandibles of stem borer larvae fed on rice plants with a high Si content were more damaged. When the effect of Si fertilization on Si content of plant and penetration time of yellow stem borer larvae in rice plants grown in nutrient solution was studied, the penetration time of first instar increased (IRRI, 1990). Hence silica content in rice plant was found to be negatively correlated with the incidence of stem borer, thrips, leaf folder and gall midge.

MATERIALS AND METHODS

Field experiments were conducted in RBD with three replications with plot size of 5x4 m^2 with 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* + phosphobacterium + silicate solubilizing bacteria (SSB) + NC ;T_6 – FYM + *Azospirillum* + phosphobacterium + 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 using the variety MDU 5.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.Leaf sheath and leaf laminae were collected from randomly selected ten plants for each treatment and utilized to analyse the silica content.Samples were taken at 30,45 and 60 DAT. The incidence of major pests *viz.*, gall midge, stem borer and leaffolder was recorded in 10 hills selected at random in each subplots at 15 days interval.

Quantification of Silica and yield

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 a volume of 250 ml in polythene volumetric flask. An aliquot of 2 ml was transferred into 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). At harvest, the grain yield was recorded in all the treatments.

Statistical analysis

Data collected in field experiments were statistically analysed using randomized block design.Square root transformation was followed for converting the population numbers. The treatment means were compared by Duncan's Multiple Range Test (DMRT) at p=0.05 for their significance (Gomez and Gomez, 1985).

RESULTS AND DISCUSSION

Leaffolder (*Cnaphalocrocis medinalis)* (Guenee)

The leaffolder damage was significant at p=0.05 level as per DMRT at 30 and 45 DAT. At 30 DAT, the best treatments were the combination of biofertilizers, lignite fly ash, FYM and neem cake in splits and neem cake as

Table 1. Influence of organics on the silica content (in %)

Treatments	30 DAT	45 DAT	60 DAT	75 DAT	Mean
NPK alone	4.00^a	4.10^b	4.30^b	4.40^b	4.20
FYM alone	4.10^a	4.80^b	4.50^b	4.90^b	4.58
FYM + NC	4.30^a	4.60^b	4.20^b	4.80^b	4.48
FYM + NC in splits	4.00^a	4.10^b	4.00^b	4.20^b	4.08
FYM + Azos + phos + SSB + NC	4.20^a	6.60^a	6.80^a	6.90^{ab}	6.13
FYM + Azos + phos + SSB + NC in splits	4.40^a	6.90^a	7.30^a	7.35^a	6.49
FYM + Azos + phos + SSB + LFA + NC	4.30^a	7.40^a	7.80^a	8.00^a	6.88
FYM + Azos + phos + SSB + LFA + NC in splits	4.60^a	7.90^a	8.10^a	8.8^a	7.35
Untreated check	4.00^a	3.50^b	4.60^b	4.5^b	4.15

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

Table 2. Influence of organic sources of nutritions on leaffolder damage, stem borer and gall midge in the field experiment

Treatments	Leaf folder damage (% Leaf damage)		stem borer incidence (% Dead heart/white ear)			gall midge incidence Silver shoot* (%)			Yield t/ha
	30 DAT	45 DAT	30 DAT	45 DAT	75 DAT	30 DAT	45 DAT	60 DAT	
NPK alone	7.38 (16.21)^{e}	11.23 (19.53)^{f}	3.58 (10.87)^{c}	12.31 (20.93)^{c}	3.10 (10.22)^{c}	2.35^{c}	11.11 (19.81)^{b}	9.27	5.38^{ab}
FYM alone	5.21 (12.94)^{d}	7.51 (16.54)^{e}	2.67 (9.35)^{b}	8.53 (17.10)^{b}	2.82 (9.51)^{c}	1.51^{b}	11.23 (20.01)^{b}	9.89	4.80^{f}
FYM + NC	3.84 (12.10)^{c}	5.62 (13.61)^{d}	2.01 (8.11)^{a}	7.91 (16.85)^{b}	2.07 (8.14)^{bc}	1.38^{b}	10.89 (19.51)^{b}	9.97	4.91^{e}
FYM + NC in splits	3.17 (11.36)^{c}	4.50 (12.63)^{c}	1.97 (7.82)^{a}	7.25 (16.23)^{b}	1.85 (7.77)^{b}	1.21^{ab}	10.92 (19.64)^{b}	9.94	5.10^{d}
FYM + Azos + phos + SSB + NC	2.35 (10.95)^{b}	4.17 (12.31)^{bc}	1.67 (7.43)^{a}	3.11 (9.82)^{a}	1.82 (7.71)^{b}	1.10^{ab}	8.21 (16.93)^{a}	9.81	5.22^{c}
FYM + Azos + phos + SSB + NC in splits	2.13 (10.54)^{ab}	3.82 (11.91)^{b}	1.62 (7.41)^{a}	2.98 (10.91)^{a}	1.69 (7.43)^{b}	1.07^{ab}	8.18 (16.67)^{a}	9.76	5.34^{b}
FYM + Azos + phos + SSB + LFA + NC	1.85 (9.81)^{a}	3.23 (11.45)^{b}	1.51 (7.35)^{a}	2.81 (9.84)^{a}	0.97 (5.21)^{a}	0.90^{a}	7.82 (17.21)^{a}	8.74	5.29^{bc}
FYM + Azos + phos + SSB + LFA	1.72 (9.54)^{a}	2.04 (9.41)^{a}	1.48 (7.21)^{a}	2.23 (8.87)^{a}	0.95 (5.13)^{a}	0.78^{a}	7.76 (17.13)^{a}	8.61	5.49^{a}
Untreated check	6.54 (14.61)^{d}	8.31 (16.84)^{e}	3.51 (11.12)^{c}	11.15 (11.84)^{c}	2.99 (9.59)^{c}	2.21^{c}	10.86 (19.47)^{b}	9.14NS	3.75^{g}
Correlation between insects and silica in rice	(45 DAT)	-0.789**		-0.930**	-0.956**				

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

Influence of organic sources of nutrition on insect pests and yield

T_1-NPK alone, T_2-FYM alone, T_3-FYM+NC, T_4- FYM+NC in splits, T_5- FYM+Azos+phos+SSB+ NC, T_6- FYM+Azos+phos+SSB+ NC in splits, T_7- FYM+Azos+phos+SSB+ LFC+NC, T_8- FYM+Azos+phos+SSB+LFA+ NC in splits, T_9-untreated checkSB-stem borer LF-leaf folder GM-gall midge, DH-dead heart

basal. The mean per cent leaffolder incidence recorded in these two treatments was 1.72 and 1.85 with the maximum per cent reduction of 76.69 and 74.93 over NPK respectively. At 45 DAT, the damage ranged from 2.04 to 11.23 per cent. The minimum damage with the maximum per cent reduction of 81.83 was observed in the treatment with biofertilisers, lignite fly ash, FYM and neem cake in splits (Table 1).

Stem borer (*Scirpophaga incertulas*) (Walker)

The damage due to stem borer was significant at p=0.05 level as per DMRT during all the plant ages observed. At 30 DAT, the treatments *viz.*, FYM + neem cake as basal and in splits, FYM + biofertilizers + neem cake as basal and in splits and FYM + biofertilizers + lignite fly ash + neem cake as basal and in splits were equally effective in reducing the per cent dead heart. The maximum per cent reduction over NPK in these treatments ranged from 43.85 to 58.66 as compared to 25.42 per cent in FYM alone. The per cent dead heart ranged from 2.23 to 12.31 at 45 DAT. The combination of biofertilizers, FYM and neem cake as basal and in splits and the combination of biofertilizers, lignite fly ash, FYM and neem cake as basal and in splits showed significantly less damage and were on a par with each other. The highest per cent reduction was 74.74 to 81.88 in these treatments, whereas at 75 DAT, the treatment with FYM, biofertilizers, lignite fly ash and neem cake as basal and in splits had least white ear damage of 0.97 and 0.95 respectively with the corresponding per cent reduction of 68.71 and 69.35 over NPK as inorganic form (Table 1).

Gall midge (*Orseolia oryza*)*e* (Wood-Mason)

The silver shoot incidence due to gall midge was significant at p = 0.05 level as per DMRT among treatments on 30 and 45 DAT. On 30 DAT, the combination of biofertilizers, lignite fly ash, FYM and neem cake as basal and in splits were equally effective with the highest per cent reduction of 61.7 and 66.81 respectively, whereas the other four combinations: biofertilizers, lignite fly ash, FYM and neem cake as basal and in splits and biofertilizers, FYM and neem cake as basal and in splits had the least silver shoot incidence of 7.82, 7.76, 8.21 and 8.18 per cent respectively at 45 DAT as compared to the maximum of 11.11 in NPK as inorganic form. However, at 60 DAT, the per cent damage recorded ranged from 8.74 to 9.97 among treatments (Table 1).

Silica

Silica content proportionately increased as the plant grew. There was significant difference at p=0.05 as per DMRT in silica content on 45 and 60 DAT among treatments. On 30 DAT, all treatments showed more or less the same silica content and the difference among treatment was not significant. It ranged from 4.00 to 4.60 per cent. At 45 DAT, silica content ranged from 3.50 to 7.90 per cent. The treatments *viz*., application of biofertilizers along with FYM and neem cake either as basal or in splits and application of biofertilizers, lignite fly ash along with FYM and neem cake either as basal or in splits recorded high silica content as compared to other treatments (Table 2). Similar result was also obtained on 60 DAT and 75 DAT. Correlation between the incidence of major insect pests and the silica content of rice treated with various organic sources of nutrition. showed negative correlation was statistically not significant at p = 0.05 as per DMRT. Correlation values between silica and insects were negatively significant: 0.789 for leaf folder, 0,930 for stem borer and 0.958 for gall midge (Table 2).

Impact of organic sources of nutritions on yield

Application of organic sources of nutritions significantly increased rice grain yield. The treatment with biofertilizers, lignite fly ash, FYM and neem cake in splits recorded significantly higher grain yield (5.49 t/ha) which was on a par with NPK applied plots (5.38 t/ha)at p=0.05as per DMRT followed by FYM, biofertilizers and neem cake in splits (5.34 t/ha). The per cent increase in yield over NPK was 2.00 in the treatment with FYM, biofertilizers, lignite fly ash and neem cake in splits (Table 2).

DISCUSSION

The incidence of leaf folder,stem borer and gall midge rice were noticed during 30 and 45 DAT ; 30,45 and 75 DAT ; 30,45 and 60 DAT respectively and hence the data were presented on the dates. The results revealed that a combination of FYM, three biofertilizers, lignite fly ash and neem cake applied in splits significantly reduced the incidence of leaf folder (76.69%), stem borer (58.66 %) and gall midge (66.81%) as compared to NPK applied as inorganic form. While adopting split application of neem cake, in addition to FYM, *Azospirillum*, phosphobacterium, SSB, lignite fly ash and neem cake applied in four splits were found to be effective in reducing the incidence of major insects throughout the periods of observation. As the plant grew older, silica content proportionately increased in plants as observed by Ishizuka (1964). There was a significant difference in silica content on 45, 60 and 75 DAT among treatments. The treatment *viz*., application of three biofertilizers, lignite fly ash along with FYM and neem cake either as basal (8.0%) or in splits recorded high silica content (8.80 %) on 75 DAT as compared to other treatments .This is in consonance with the findings of Vijayakumar and Narayanasamy (1995) who reported that the main cause for the death of insects due to fly ash application was wearing of mandibles and main feeding organs of insects which resulted in functionless mandibles so that the insects like leaffolder, grasshopper, stem borer and blue beetle of paddy die without food. Correlation values between silica and insects were -0.789 for leaf folder, -0.930 for stem borer and -0.958 for gall midge. Further, the incidence of stem borer, *Scirpophaga incertulas* ;leaffolder, *Cnaphalocrocis medinalis* and gall midge, *Orseolia oryzae* was negatively correlated with yield. Promoter or carrier-induced silicon transportation into rice in relation to yellow stem borer, *Scirpophaga incertulas* (Walker) and blast (*Pyricularia grisea*) disease resistance has been investigated by Voleti *et al.* (2008). They reported that simple amino acids, such as histidine, imidazole, glutamic acid, glycine and glutamine significantly enhanced the levels of $Si(OH)_4$ in the stem and 14–18% silicon transport into the leaf surface.

To summarise, the inorganic fertilizers provide large amount of nutrients in relatively short period of time resulting in luxuriant crop growth which led to heavy insect population. Organic manures work like slow release fertilizers thus providing balanced nutrition to plants and reducing the insect population. The combination of FYM, three biofertilizers, lignite fly ash and neem cake applied in splits significantly reduced the incidence of gall midge, stem borer and leaffolder with increased grain yield in rice as compared to NPK applied as inorganic form. Application of *Azospirillum* and phosphobacterium with FYM, SSB and lignite fly ash FYM increased the content of silica and potassium in plants which induced resistance in plants. In conclusion silicon is beneficial to plant growth and helps plants to overcome abiotic and biotic stresses by preventing lodging (falling over) and increasing resistance to pests and diseases, as well as other stresses.

REFERENCES

Ashoka Rani, Y., Narayanan, A., Saraswathi Devi, V. and Subbaramamma, P. 1997. The effect of silicon application on growth and yield of rice plants. *Annals of Plant Physiology,* **11**(2) : 123-128.

Djamin, A. and Pathak, M. D. 1967. Role of silica in resistance to Asiatic rice borer, *Chilo suppressalis* (Walker) in rice varieties. *Journal of Economic Entomology,* **60 :** 347 – 351.

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

International Rice Research Institute (IRRI). 1990. Programme report for 1989. Los Banos, Laguna, *Philippines.*

Ishizuka., Y. 1964. Nutrient uptake at different stages of growth. In : *The mineral nutrition of rice plant,* Symp.

IRRI, John Hopkins press, Baltimore, *Maryland*, 199 **P**.

Jian Feng Ma, Kazunori Tamai, Naoki Yamaji, Namiki Mitani, Saeko Konishi, Maki Katsuhara, Masaji Ishiguro, Yoshiko Murata and Masahiro Yano. 2006. A silicon transporter in rice. *Nature,* **440:** 688-691.

Maxwell, F. G., Jenkins, J. N. and Parroot, W. L. 1972. Resistance of plants to insects. *Advanced Agronomy,* **24** : 187-265.

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

Panda, N., Pradhan, B., Samalo, A. P. and Rao, P. S. P. 1977. Note on the relationship of some biochemical factors with resistance in rice varieties to yellow borer**.** *Indian J. Agric. Sci.,* **45** : 499-501.

Voleti, S. R., Padmakumari, A.P., Raju, V. S., Setty Mallikarjuna Babu and Subramania Ranganathan. 2008. Effect of silicon solubilizers on silica transportation, induced pest and disease resistance in rice (*Oryza sativa* L.). *Crop Protection,* **27** (10):1398-1402

Subramanian, S. and Gopalswamy, A. 1991. Effect of silica materials on incidence of rice pests. *Madras Agricultual Journal,* **78** (5 & 8): 213-215.

Takahashi, E. 1995. Uptake, mode and physiological function of silica. *Sci. Rice Plant,* **2**: 58-71.

Takahashi, E., Ma, J. F. and Miyake, Y. . 1990. The possibility of silicon as an essential element for higher plants. *Comments Agric. Food Chem., 2* : 99-122.

Tayabi, K. and P. Azizi. 1984. Influence of silica on rice yield and stem borer (*Chilo supremani*) in result) Iron in 1979-1980. *Pesticides, 18* : 20-22.

Vijayakumar, N. and Narayanasamy, P. 1995. Use of fly ash as a carrier in insecticide formulations. **In** : Fly ash in Agriculture (Narayanasamy, P. ed.) *Proceedings of National Seminar on use of lignite fly ash in agriculture,* Annamalai University, Annamalai Nagar, Tamil Nadu, 20-22 Dec.1995, 28 – 30 **PP**.

Xue Qiang Zhao, Namiki Mitani, Naoki Yamaji, Ren Fang Shen[1] and Jian Feng Ma. 2010. Involvement of silicon influx transporter OsNIP2;1 in selenite uptake in rice. *Plant Physiology Preview* (in press 10.1104/ 110.157867 **PP**)

Yoshida, S. 1975. The physiology of silicon in rice. *Technical bulletin No. 25.* Food and Fert. Tech. Centre Taipei, *Taiwan.*

P. Chandramani, R. Rajendran[1], C. Muthiah and C. Chinniah

Agricultural College and Research Institute,Madurai, Tamil Nadu, India, E-mail: deanagrimdu@tnau.ac.in

1.Agricultural College and Research Institute,Trichy, Tamil Nadu, India.

Received: February 9, 2010 Revised: April 5, 2010 Accepted: April 28, 2010