www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(4): 1026-1029

www.thepharmajournal.com
Received: 04-02-2022
Accepted: 06-03-2022

S Panda
Ph.D. Research Scholar,
Department of Entomology,
N. M. College of Agriculture,
Navsari Agricultural University,
Gujarat, India

Raghunandan H
Department of Entomology,
Odisha University of Agriculture
and Technology, Bhubaneswar,
Odisha, India

Corresponding Author
S Panda
Ph.D. Research Scholar,
Department of Entomology,
N. M. College of Agriculture,
Navsari Agricultural University,
Gujarat, India

Plant response to combined action of silicon amendment and insecticidal toxicity against rice plant hopper

S Panda and Raghunandan H

Abstract
Plant hopper causes substantial losses to both dry and wet season rice in India necessitating increased dependency on chemical pesticides contributing to environmental pollution. It is hypothesized that application of silicon can enhance the level of efficacy of insecticides by inducing resistance in the crop against these sucking pests and minimize the use of harmful pesticides. A field trial was carried out in Odisha University of Agriculture and Technology during *rabi*' 2017 to evaluate the performance of combined action of insecticides and diatomaceous earth, an organic source of silicon, applied at 300 kg ha^{-1} as basal one day before transplanting in comparison to the silicate fertilizer alone as standard check and untreated control. The experiment could establish the resistance inducing ability of diatomaceous earth and its compatibility with dinotefuran and acephate in arresting the hopper build up to 4.37 to 7.60 $hill^{-1}$ compared to 22.47 $hill^{-1}$ in rice. Spraying of acephate alone failed miserably in controlling this pest with a maximum incidence of 19.60 $hill^{-1}$ but showed synergistic action when combined with the silicate fertilizer reducing the hopper population to 2.00 $hill^{-1}$ as against 2.57 and 34.33 $hill^{-1}$ in standard check and untreated control respectively thus, exhibiting the importance of combined action of exogenous application of silicon and acephate in reducing hopper severity in rice.

Keywords: Diatomaceous earth, insecticides, plant hoppers, rice, silicon

1. Introduction
Rice [*Oryza sativa* L.], one of the important cereal crops, is the staple food for over half the world's people and accounts for second largest cereal production after maize with over 740 million tonnes. India alone produces 159 million tonnes of paddy and contributes 20 per cent of the total rice consumed throughout the world (FAO, 2016) [4]. However, the productivity is one of the lowest (36.95 q ha^{-1}), which is mainly attributed to various biotic stress of which insect pests are severe constraints. Rice in India is ravaged by an array of insect pests amongst which, brown plant hopper (BPH), *Nilaparvata lugens* (Stal) and white backed plant hopper (WBPH), *Sogatella furcifera* (Horvath) have been reported to cause substantial loss to the crop. Both nymph and adult hoppers cause plant damage through massive desapping leading to yellowing of leaves and ultimate drying under severe infestation producing hopper burn symptoms. In order to tackle these pests farmers mostly rely on use of chemical insecticides, which results in severe harmful consequences including environmental pollution and human health hazards. Hence, to have a long term solution and wider applicability, integrated pest management (IPM) involving eco-friendly tactics such as use of safer pesticides coupled with crop management should be developed (Hao *et al.* 2008) [7] as an alternative strategy.
Dinotefuran, a new molecule belonging to third generation neo-necotinoid group and buprofezin, a chitin inhibitor are widely used by the farmers for controlling plant hoppers in rice. Earlier reports suggest that buprofezin and dinotefuran are effective against plant hoppers with low risks to environment including human beings (Krishnaiah *et al*. 1996) [9] and predators (Ghosh *et al*. 2014) [5] in rice ecosystem respectively. Now, their combination product has been developed, with the prime objective of providing greater efficacy and longer suppression of hoppers infesting rice.
Silicon (Si) on the other hand is a functional element and reported to have a role in inducing resistance against insect pests in rice (Panda *et al*. 1975) [11]. Rice being a good Si-accumulator (Yamamoto *et al*. 2012) [18] actively stimulates defense mechanisms, enhancing host resistance to a wide range of abiotic and biotic stresses (Ma and Yamaji, 2006) [10]. This experiment was therefore conducted to study the combined effect of exogenous application of silicon along with

insecticides for effective suppression of plant hoppers in rice.

2. Materials and Methods

The field trial was laid out in a randomized complete block design with three replications during *rabi*' 2017. Twenty - one - day old seedlings (*cv*. TN1) were transplanted in 20 m^2 plots at 15 cm x 20 cm spacing following local recommended practices. Treatments comprised spraying of dinotefuran 20 SG, buprofezin 25 SC, (dinotefuran + buprofezin) 58 WG and acephate 75 SP at 200 800, 320 and 667 g or ml/ha respectively alone and in combination with soil basal application of diatomaceous earth (DAE) at 300 kg/ha. DAE an organic source of silicon containing sea diatoms having 63.7 % SiO_2, which was found promising as a soil ameliorating agent against various stresses (Rojht *et al*. 2010) has been used in this experiment and crop response to various treatments against plant hoppers was compared with Si supplements through DAE alone and untreated check (water spray). DAE was soil incorporated during final puddling, a day prior to transplanting, whereas test insecticides were sprayed by knapsack sprayer using 500 liters of water ha^{-1} at 30 and 52 days after transplanting (DAT). population assessment of hoppers was done at one day before and 3, 7, 14, and 21 days after (DAS) each spraying through visual counting of nymph and adult on ten randomly selected hills in each plot leaving two border rows from all sides. Plot wise grain yield was recorded leaving border rows and hectare yield was computed. Data were then subjected to statistical analysis and test of significance was done through ANOVA following Gomez and Gomez (1984) [6] for proper interpretation.

3. Results and Discussion

Hopper population (mixed BPH and WBPH), as influenced by various treatments at different growth stages of plant have been presented in Table 1. Treatment variation was non-significant at early vegetative stage, one day before and three days after the first scheduled 30 DAT spraying. Thereafter, the population started slowly building up from 7 DAS onwards with an incidence of 3.97 hoppers $hill^{-1}$ in untreated check but with a significantly lower pest load in all treatments except acephate. Ten days after however, this molecule coupled with Si amendment could effectively restrict the hoppers to1.2 $hill^{-1}$ as against 3.53 in control. Rest of the treatments including DAE alone could keep the hopper population under check effectively. Role of DAE is supported by earlier report of Salim and Saxena (1992) [13] suggesting silicon application in rice decreased the food intake, growth longevity, fecundity and population growth of white backed plant hopper, *Sogatella furcifera.* Chandramani *et al*. (2009) [2] further opined that presence of high silica content in plant enhanced phenol and tannin content in stem and leaf and thus, was effective against BPH in rice. Two weeks after first spraying, dinotefuran and buprofezin and their combination product with or without silicon amendment showed superior performance with 2.2 - 5.31 hoppers $hill^{-1}$ compared to 12.8 $hill^{-1}$ in control. At the peak activity of hoppers (21 DAT) silicon amended plots receiving dinotefuran, buprofezin and acephate were found highly promising with a population record of 8.73-17.17 $hill^{-1}$ as against 25.53 hoppers $hill^{-1}$ in control. The silicate fertilizer alone on the other hand exhibited its resistance inducing ability against these hoppers registering 11.44 hoppers $hill^{-1}$ which, remained on par with above insecticide added treatments. This enhanced plant defense against planthoppers due to exogenous application of Si in rice has earlier been reported (Yang *et al*. 2014, He *et al.* 2015, Wu *et al*. 2017, Yang *et al*. 2017 a, b) [21, 8, 17, 19, 20]. With special reference to BPH, Sujatha *et al*. (1987) [16] reported that the silicon content of rice plants can positively promote the resistance under field situation. As per Yoshihara *et al*. (1979) [22] the soluble silicic acid found in resistant rice varieties is the major factor inhibiting the population growth of BPH. It is presumed that poor population growth of BPH on Si amended plants may be because of reduced fecundity and nymphal survival rate as reported by He *et al.* (2015) [8].

High population build up necessitated second spraying at 52 DAT revealing the cumulative impact of insecticidal sprays in various treatments in the subsequent observations. Three days after second spray (55 DAT), the impact of basal application of DAE continued to exhibit its ability to restrict hopper incidence. This organic product alone could arrest the pest and the efficacy remained on par with those of combined action of DAE and dinotefuran or acephate registering 4.37 to 7.6 hoppers $hill^{-1}$ compared to 22.47 hoppers $hill^{-1}$ in untreated check. Enhanced toxicity of dinotefuran, buprofezin, acephate and combination product due to DAE amendment was distinctly observed at seven days after second spraying with a record of 3.1 – 6.0 hoppers $hill^{-1}$ as against 32.23 hoppers $hill^{-1}$ in control. On the other hand, acephate alone, that miserably failed (15.67 $hill^{-1}$) to restrict the hoppers, displayed its synergistic action with DAE in containing the pest build up (3.2 $hill^{-1}$). The trend was maintained at 10 days after second spray, with a corresponding population of 19.6 and 2.0 $hill^{-1}$ respectively as against 34.33 hoppers $hill^{-1}$ in control and 2.57 $hill^{-1}$ in plots with DAE alone. However, acephate as an effective insecticide against BPH has earlier been reported by Bhavani and Rao (2005) [1].

Subsequent observations showed the supremacy of dinotefuran spray either alone or in combination with DAE with 0.6 – 3.83 hoppers $hill^{-1}$. The enhanced efficacy of acephate sprays in silicon amended plots restricting the hoppers population by fifty percent over acephate alone was observed even at the crop maturity (Table 1). The trend was also clearly evident from mean data highlighting the role of DAE alone and in combination with insecticides. As explained earlier this may be because of the fact that plants with higher silicon content in their tissues had a higher level of resistance to rice pests (Savant *et al*. 1997) [14]. According to Panda *et al*. (1975) [11] the larvae of rice yellow stem borer, brown plant hopper and leaf roller were unable to attack rice plants which became resistant because of high Si content in the stems, which support the present finding. The insect midgut epithelium plays an important role in food digestion and is an important cite for insecticide detoxification (Smagghe and Tirrym, 2001) [15]. It is presumed that Si could damage the ultrastructure of the midgut epithelium through the separation of epithelial layer from the basement membrane as observed in larvae of leaf miner of tomato (Dos Santos *et al*. 2015) [3]. This negatively affects the growth and development of insect and prevents insects from developing resistance to insecticides producing its additive effect with that of Si. Impact of different treatments on grain yield was also clearly evident with a greater contribution from DAE as soil ameliorating agent and its resistance inducing capability against plant hoppers with a record of 3.0 – 8.5 q ha^{-1} incremental yields over corresponding insecticide alone, the highest being in combination with acephate.

Table 1: Effect of insecticides and DAE on the incidence of plant hoppers in rice during *rabi,* 2017

Treatment details		Mixed population of BPH and WBPH (numbers hill^{-1})												
		First spray						Second spray						
Treatments	**Dose**	**1 DBS**	**3 DAS**	**7 DAS**	**10 DAS**	**14 DAS**	**21 DAS**	**3 DAS**	**7 DAS**	**10 DAS**	**14 DAS**	**21 DAS**	**Mean**	**Grain yield (q/ha)**
T_1: (Dinotefuran + Buprofezin) 58 WDG	320g/ha	1.10 (1.24)	0.13 (0.79)	1.70 (1.48)	2.05 (1.58)	5.30 (2.40)	17.87 (4.26)	14.60 (3.86)	7.13 (2.75)	2.73 (1.78)	4.47 (2.22)	6.73 (2.68)	6.27	38.33
T_2: Dinotefuran 20 SG	200g/ha	1.20 (1.30)	0.00 (0.71)	0.20 (0.84)	2.37 (1.69)	4.37 (2.20)	19.47 (4.46)	9.63 (3.18)	3.53 (2.00)	1.13 (1.27)	0.73 (1.11)	0.60 (1.04)	4.20	39.00
T_3: Buprofezin 25 SC	800ml/ha	0.80 (1.14)	0.20 (0.83)	1.53 (1.40)	0.87 (1.17)	2.20 (1.63)	21.73 (4.70)	17.60 (4.23)	12.87 (3.59)	8.73 (3.02)	11.60 (3.46)	16.20 (4.07)	9.35	36.60
T_4: Acephate 75 SP	667g/ha	0.97 (1.20)	0.33 (0.88)	3.57 (1.99)	3.03 (1.87)	11.70 (3.46)	22.00 (4.73)	11.93 (3.48)	15.67 (3.98)	19.60 (4.46)	18.57 (4.35)	22.03 (4.73)	12.84	33.63
T_5: (Dinotefuron + Buprofezin) 58 WDG + DAE	320g/ha + 300kg/ha	1.47 (1.38)	0.07 (0.75)	0.16 (0.81)	1.50 (1.40)	5.27 (2.40)	25.33 (5.07)	10.10 (3.24)	3.10 (1.88)	1.43 (1.38)	5.98 (2.53)	9.97 (3.23)	6.29	41.90
T_6: Dinotefuran 20 SG +DAE	200g/ha + 300kg/ha	2.27 (1.64)	0.13 (0.79)	0.13 (0.79)	0.40 (0.92)	8.75 (3.02)	8.73 (3.02)	4.37 (2.19)	3.17 (1.89)	3.40 (1.97)	3.83 (2.06	3.63 (2.02)	3.65	45.00
T_7: Buprofezin 25 SC + DAE	800ml/ha + 300kg/ha	1.20 (1.28)	0.20 (0.83)	0.47 (0.98)	0.60 (1.02)	5.30 (2.40)	17.17 (4.18)	10.60 (3.29)	5.97 (2.54)	5.53 (2.44)	10.70 (3.33)	14.97 (3.92)	7.15	40.10
T_8: Acephate 75 SP + DAE	667g/ha + 300kg/ha	1.13 (1.24)	0.13 (0.79)	2.10 (1.60)	1.20 (1.30)	7.37 (2.79)	8.20 (2.93)	5.60 (2.46)	3.12 (1.89)	2.00 (1.58)	9.30 (3.12)	11.33 (3.41)	5.05	42.10
T_9: Diatomaceous earth (DAE)	300kg/ha	0.63 (1.02)	0.47 (0.97)	1.73 (1.46)	1.20 (1.30)	4.47 (2.21)	11.40 (3.41)	7.60 (2.84)	6.00 (2.54)	2.57 (1.74)	8.15 (2.92)	11.20 (3.39)	5.48	36.83
T_{10}: Untreated check	-	1.23 (1.31)	0.80 (1.13)	3.97 (1.88)	3.53 (2.00)	12.80 (3.64)	25.53 (5.10)	22.47 (4.77)	32.23 (5.69)	34.33 (5.90)	41.00 (6.43)	34.50 (5.88)	21.12	30.53
SE(m) ±		0.137	0.089	0.231	0.107	0.204	0.262	0.236	0.270	0.137	0.218	0.253		1.232
CD (P ≤ 05)		NS	NS	0.69	0.32	0.60	0.78	0.70	0.80	0.41	0.65	0.75		3.66
Figures in parantheses are the transformed √(x+0.5) values					DBS: day before spraying				DAS: days after spraying					

4. Conclusion

The experiment could establish the promising effect of DAE at 300 kg ha^{-1}as an organic source of silicon in inducing resistance in rice plant against the plant hoppers and its compatibility with insecticides like dinotefuran and combination product of dinotefuran+buprofezin for providing additive effects and with acephate for a synergistic effect in arresting the hopper build-up in rice ecosystem. Thus, exogenous application of diatomaceous earth can very well be recommended to farmers as an eco-holistic approach for effective integration into the pest management system in rice particularly in hopper endemic pockets.

5. Acknowledgement

Authors acknowledge the help rendered by Dr. S. Pattanaik, Former Professor and Head, Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar for providing DAE for the field experiment.

6. References

1. Bhavani B, Rao PRM. Bioefficacy of certain insecticides against rice Planthoppers vis-à-vis natural enemies under irrigated field conditions. Indian Journal of Plant Protection. 2005;33(1):64-67.
2. Chandramani P, Rajendran R, Sivasubramanian P, Muthiah C. Management of hoppers in rice through host nutrition. Journal of Biopesticides. 2009;2(1):99-106.
3. Dos Santos MC, Resende JAM, de Sá VGM, Zanúncio JC, Serrão JE. Effect of silicon on the morphology of the midgut and mandible of tomato leafminer *Tuta absoluta* (Lepidoptera: Gelechiidae) larvae. Invertebrate Survival Journal. 2015;12:158-165.
4. FAO. Crop production statistics, FAOSTAT. (www.fao.org/faostat/en#data/QC), 2016.
5. Ghosh A, Samanta A, Chatterjee ML. Dinotefuran: A third generation neonicotinoid insecticide for management of rice brown planthopper. African Journal of Agricultural Research. 2014;9(8):750-754.
6. Gomez KA, Gomez AA. Statistical procedure for agricultural research, John Wiley and Sons, New York, 1994, 680-686.
7. Hao LX, Han YQ, Hou ML, Liao XL. Resistance of Japonica rice varieties in Liaohe Valley to *Chilo suppressalis* and its underlying mechanisms. Acta Ecologica Sinica. 2008;28:5987-5993.
8. He WQ, Yang M, Li ZH, Qiu JL, Liu F, Qu XS. High levels of silicon provided as a nutrient in hydroponic culture enhances rice plant resistance to brown planthopper. Crop Protection. 2015;67:20-25.
9. Krishnaiah NV, Reddy AA, Ramprasad AS. Studies on buprofezin and synthetic pyrethroids against hoppers in rice. Indian Journal of Plant Protection. 1996;24(1/2):53-60.
10. Ma JF, Yamaji N. Silicon uptake and accumulation in higher plants. Trends in Plant Sciences. 2006;11:392-397.
11. Panda N, Pradhan B, Samalo AP, Rao PSP. Note on the relationship of some biochemical factors with resistance in rice varieties to yellow rice borers. Indian Journal of Agricultural Sciences. 1975;45:14-16.
12. Rojht H, Horvat A, Athanassiou CG, Vayias BJ, Tomanovic Z, Trdan S. Impact of geochemical composition of diatomaceous earth on its insecticidal activity against adults of *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). Journal of Pest Science. 2010;83:429-436.
13. Salim M, Saxena RC. Iron, silica, aluminium stress and varietal resistance effects on white backed plant hopper. Crop Science. 1992;32:212-219.

14. Savant NK, Snyder GH, Datnoff LE. Silicon management and sustainable rice production. Advances in Agronomy. 1997;58:151-199.
15. Smagghe G, Tirrym L. Insect midgut as a site for insecticide detoxification and resistance. In: Biochemical Sites of insecticide action and resistance; Ishaaya, Ed. Springer Berlin, Germany, 2001, 293-321.
16. Sujatha G, Reddy GPV, Murthy MMK. Effect of certain biochemical factors on expression of resistance of rice varieties to brown plant hopper (*Nilaparvata lugens* Stal). Journal of Research. 1987;15:124-128.
17. Wu X, Yu Y, Baerson SR, Song Y, Liang G, Ding C, *et al*. Interactions between nitrogen and silicon in rice and their effects on resistance toward the Brown Planthopper *Nilaparvata lugens.* Frontier Plant Science. 2017;8:28.
18. Yamamoto T, Nakamura A, Iwai H, Ishii T, Ma JF. Effect of silicon deficiency on secondary cell wall synthesis in rice leaf. Journal of Plant Research. 2012;125:771-779.
19. Yang L, Han Y, Li P, Wen L, Hou M. Silicon amendment to rice plants impairs sucking behaviors and population growth in the phloem feeder *Nilaparvata lugens* (Hemiptera: Delphacidae). Scientific Reports. 2017a;7:1101.
20. Yang L, Han Y, Li P, Li F, Ali S, Hou M. Silicon amendment is involved in the induction of plant defense responses to a phloem feeder. Science Reporter. 2017b;7(1):4232.
21. Yang GQ, Zhu ZF, Hu WF, Ge LQ, Wu JC. Effects of foliar spraying of silicon and phosphorus on rice (*Oryza sativa*) plants and their resistance to the white backed planthopper, *Sogatella furcifera* (Hemiptera: Delphacidae). Acta Entomologica Sinica. 2014;57:927-934.
22. Yoshihara T, Sogawa K, Pathak MD, Juliano BO, Sakamura S. Soluble silicic acid as a sucking inhibitory substance in rice against the brown plant hopper (Homoptera: Delphacidae). Entomologia Experimentalis Applicata. 1979;26:314-322.