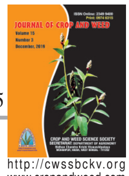
Journal of Crop and Weed, 18(2): 307-311 (2022)

ISSN- O : 2349 9400 ; P : 0974 6315



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Silicate fertilizer induced resistance to rice yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae)

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Received : 29.04.2022 ; Revised : 03.06.2022 ; Accepted : 13.06.2022

DOI: https://doi.org/10.22271/09746315.2022.v18.i2.1606

ABSTRACT

Exogenous silicon through the basal field application of diatomaceous earth at 50, 100, 200, 300, 400 and 500 kg ha^{-1} exhibited a promising result in enhancing plant resistance to rice stem borer. A maximum of 69.8 and 67.2 % decline in borer damage were recorded at vegetative and reproductive stages, respectively with 300 kg ha^{-1} dose as against 43 and 76 % decline in standard check, calcium silicate at 2000 kg ha^{-1}.This enhanced resistance was primarily attributed to a higher silicon deposit of 13 g kg^{-1} dry plant sample compared to 4.3 g kg^{-1} in untreated check resulting in 52 % gain in yield. At higher doses, however, the product showed breaking down of resistance against the borers.

Keywords: Diatomaceous earth, rice, silicon, stem borer, *Scirpophaga incertulas*

Rice, *Oryza sativa* L. is a good silicon (Si) accumulator (Takahashi *et al*.,1990; Ma *et al*., 2006; Zhao *et al*., 2010) and this element benefits the plant immensely. Thick silicate epidermal layer formed due to this beneficial element provides resistance to various insect pests (Kvedaras and Keeping, 2007). Yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is the most serious pest prevailing in all the rice growing regions of Asia and South-east Asia (Khan *et al.,* 1991). Freshly emerged larvae feed on leaf epidermal layer for a short period before boring. Thereafter, they bore into the paddy stem through the leaf sheath resulting in dead heart (DH) and white ear head (WE) during vegetative and reproductive stages, respectively resulting in 40-60% loss in grain yield (Jayaraj and Muthukrishnan, 2013). Chemical insecticides are generally less effective because of short exposure time of the larvae prior to their entry into the stem(Sheng *et al*., 2003). Moreover, chemical control is considered as expensive, labor consuming and leads to environmental pollution including toxicity to the non - target species (Tanaka *et al.,*2000). Hence, integrated pest management involving eco-friendly components like inherent resistance and crop management is suggested as an alternative strategy to get a long-term solution (Hao *et al*., 2008). One of the crop management tactics is through the amendment of silicate fertilizers (Alvarez and Datnoff, 2001; Ma *et al*., 2001), which was undertaken in the present investigation with the hypothesis that the Si amendment will enhance the rice plant defense response to yellow stem borer attack.

A replicated field trial was conducted in randomized block design during *rabi* 2016 to test the efficacy of diatomaceous earth (DAE) at different doses against YSB in rice. DAE is an organic source of silicon, commercially marketed by Agripower Australia Pvt. Ltd., and contains sea diatoms having 63.7 % SiO_2. The product was tested at 50, 100, 200, 300, 400, 500 kg ha^{-1} and performance was compared with those of standard check, calcium silicate ($CaSiO_3$) at 2000 kg ha^{-1} and control. DAE was soil incorporated as basal application during the final puddling, one day before transplanting. Three weeks old rice (Var. TN1) seedlings were transplanted in 20 m^2 plots at 20 cm row to row and 15 cm plant to plant spacing. The crop was then raised following recommended practices except plant protection measures.

Stem borer damage was assessed at both vegetative and reproductive stages from ten randomly selected hills leaving two border rows from the sides of each plot. At thirty and fifty days after transplanting (DAT) observations on dead heart (DH) were recorded by counting the total and the infested tillers whereas, white ear head (WE) symptom was recorded just before harvesting by counting the number of total panicle bearing tillers and the infested tillers, from which the per cent damage was computed. Spiders and mirid bug population (numbers hill^{-1}) was recorded at pre-harvest to ascertain the effect of the test product on natural enemies of insect pests. Prior to harvesting, plant samples were collected for Si estimation. The grain yield was recorded from each plot excluding two border rows and yield per hectare was computed. Plant samples were used to estimate the silicon content following the Molybdenum-blue colorimetric method (Hallmark *et al*., 1982).

The plant response to the basal application of DAE at different doses in restricting the stem borer damage

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was evident from Table 1. In the early tillering stage (30 DAT) borer damage varied significantly with a record of 5.16-17.28 % DH, minimum being in plots receiving 300 kg DAE ha^{-1} as against 20.83 % in untreated check. This was followed by 100, 200 and 500 kg doses with a corresponding damage of 9.47,10.10 and 10.12 % DH. Calcium silicate, the standard check, on the other hand could restrict the borer damage up to13.26 % DH, which was at par with that of 400 kg dose of DAE. Low dose of DAE failed to give adequate protection (17.28 % DH) and was the least effective treatment at this stage.

At the active tillering stage (50 DAT), the lowest (5.74-7.77 % DH)YSB damage was observed in 300 to 400 kg ha^{-1} treatments followed by the standard check, $CaSiO_3$with 11.11% DH as compared to 22.07 % in untreated control. All other test doses remained poor performers with 20.73-24.71% DH. Mean borer damage revealed better performance of DAE at 300 and 400 kg ha^{-1} with an average damage of 6.47 to 9.75 % DH accounting to 59.54 – 69.83 % decline over control compared to 43.17% decline in standard check (Table 1). Earlier report of Fallah *et al.* (2011) corroborates the present finding. According to them 10-20 % reduced borer damage was recorded in plants supplemented with silicate fertilizer, because of silica deposition in shoot, leaf and panicle. Hou & Han (2010) on the other hand reported lesser success on larval penetration into silica treated plants, thus making the neonates vulnerable to be preyed upon by their natural enemies. Antibiosis mechanism of resistance conferred by Si on YSB has also been reported by Panda and Khush (1995).

The residual effect of Si amendment at the fag end of the crop was good enough to restrict the borer damage. The lowest WE incidence of 3.46 and 4.5 % with a corresponding decline of 76 and 67 % over control was recorded from plots receiving $CaSiO_3$ and DAE at 300 kg ha^{-1}dose compared to 14.45 % WE in control (Table 1) signifying the practical utility of this natural source of silicate fertilizer in rice. Higher doses of DAE (400 and 500 kg ha^{-1}) with a damage of 8.23-10 % WE though proved efficacious in declining borer damage by 30-43 %, remained inferior to 300 kg dose that resulted in 68.85 % reduction as against 76.05 % reduced damage by inorganic calcium silicate. Damage during heading stage is more crucial from the yield point of view (Krishnaiah and Verma, 2012) attributing a loss of 27.6-71.7 % compared to 11.2-40.1% losses at the vegetative stage. Poor performance of DAE at higher doses in arresting borer damage at both vegetative and heading stage may be attributed to breaking down of resistance to YSB at higher doses. Such breaking down of resistance in rice to YSB by higher doses of DAE, $CaSiO_3$ and rice hull ash has also been reported earlier by Mishra (2018). Further the finding has been substantiated by Kanew *et al*. (2006) who observed a maximal effect of enhanced resistance to stem borer (*Chilo suppressalis*) by an addition of silicon at 20 g kg^{-1} of soil.The increased damage on plants receiving higher doses of Si amendments indicates that plant is not able to derive optimal benefit from additional dose of Si supplements for resisting the YSB damage. Similar observations with rice leaf folder have earlier been reported by Han *et al*. (2015).

Pre-harvest observation revealed the existence of the spider complex comprising *Lycosa* sp., *Tetragnatha* sp*., Oxyopes* sp. and *Argeopes* sp.of which, the former was the predominant one. The population of spiders varied from 1.03 – 1.17 hill^{-1} in different treatments as against 1.25 hill^{-1} in control. Since spiders can feed on wide range of insects, their population reduction in treated plots might not be attributed to the resistance induced by Si on YSB, rather it could be due to poor insect pest load existing in the treated plots. Earlier studies also showed that application of silicon had no effect on natural enemies (Reynolds *et al*., 2009).

The Mirid bug, *Cyrtorhinus lividipennis* is basically a predator of plant and leaf hoppers infesting rice. Therefore, their population appeared in a hopper density dependent manner. At pre harvest, peak activity was recorded with a population of 0.71- 1.05 hill^{-1} as against 1.08 hill^{-1} in control. The variation was presumed to be due to change in hopper density in different treatments. The finding is supported by an earlier report of Reynolds *et al*. (2009) who suggested that silicon may increase the production of herbivore induced plant volatiles, which play an important role in attracting predators and parasites.

Silicon content estimated from field samples of rice plants revealed a marked variation amongst the treatments. The maximum accumulation of this beneficial nutrient was observed from plants receiving DAE at 300 and 400 kg ha^{-1} with a record of 13.01 and 14.84 g kg^{-1} dry weight, respectively whereas the same was 4.3 g kg^{-1} in untreated check. Further increase in dose to 500 kg ha^{-1} adversely affected Si accumulation (7.08 g kg^{-1}) and remained on par with that of standard check (9.12 g kg^{-1}). Such higher Si accumulation at 300-400 kg ha^{-1} doses explain the reason for their greater effectiveness in arresting the borer damage (Fig. 1) as observed earlier by Marwat and Baloch (1985) who detected more damage to mandibles of larvae feeding on plants having higher silicon content, thus, facing difficulty in penetration.

Silicon amendment at various doses resulted in distinct variation in grain yield with a minimum of 20% gain over control. Maximum yield (38.9 q ha^{-1}) was obtained from plots receiving 300 kg dose accounting

Table 1: Stem borer damage in rice as influenced by various doses of diatomaceous earth during *rabi*, 2016

Treatments	Dose (kg ha^{-1})	Stem borer damage in *rabi* rice: Vegetative stage (% DH) 30 DAT	50 DAT	Mean	% decrease over control	Reproductive stage (%WE) Pre-harvest	% decrease over control	Natural enemies (nos./hill) Spiders Pre-harvest	Mirid bug Pre-harvest	Si content (g kg^{-1} dry wt.)	Grain yield (q ha^{-1})	% increase over control
T_1: Diatomaceous earth	50	17.28 (4.21)	20.73 (4.6)	19.01	11.37	6.32 (2.60)	56.26	1.17 (1.29)	1.03 (1.24)	4.13 (2.15)	30.9	20.70
T_2: Diatomaceous earth	100	9.47 (3.15)	23.91 (4.94)	16.69	22.19	5.81 (2.47)	59.79	1.03 (1.24)	0.96 (1.21)	5.40 (2.42)	31.3	22.27
T_3: Diatomaceous earth	200	10.10 (3.25)	24.71 (5.02)	17.41	18.83	5.88 (2.51)	59.30	1.13 (1.27)	1.05 (1.24)	5.01 (2.34)	33.2	29.69
T_4: Diatomaceous earth	300	5.16 (2.35)	7.77 (2.86)	6.47	69.83	4.74 (2.33)	67.19	1.13 (1.27)	1.00 (1.22)	13.01 (3.66)	38.9	51.95
T_5: Diatomaceous earth	400	13.75 (3.77)	5.74 (2.48)	9.75	54.54	8.23 (2.95)	43.04	1.07 (1.25)	0.90 (1.18)	14.84 (3.91)	34.5	34.76
T_6: Diatomaceous earth	500	10.12 (3.25)	21.87 (4.72)	16.00	25.40	10.00 (3.23)	30.79	1.03 (1.24)	0.71 (1.10)	7.08 (2.83)	33.5	30.86
T_7: Calcium silicate	2000	13.26 (3.70)	11.11 (3.40)	12.19	43.17	3.46 (1.89)	76.05	1.03 (1.23)	1.05 (1.22)	9.12 (3.10)	36.8	43.75
T_8: Untreated check	-	20.83 (4.61)	22.07 (4.84)	21.45	-	14.45 (3.85)	-	1.25 (1.32)	1.08 (1.26)	4.30 (2.20)	25.6	-
S. E. m (±)		**0.11**	**0.13**			**0.19**		**0.04**	**0.02**	**0.14**	**2.28**	
C. D. $_{0.05}$		**0.33**	**0.39**			**0.55**		**0.10**	**0.07**	**0.40**	**6.58**	

Figures inside the parentheses are the transformed. $\sqrt{(x+0.5)}$ values

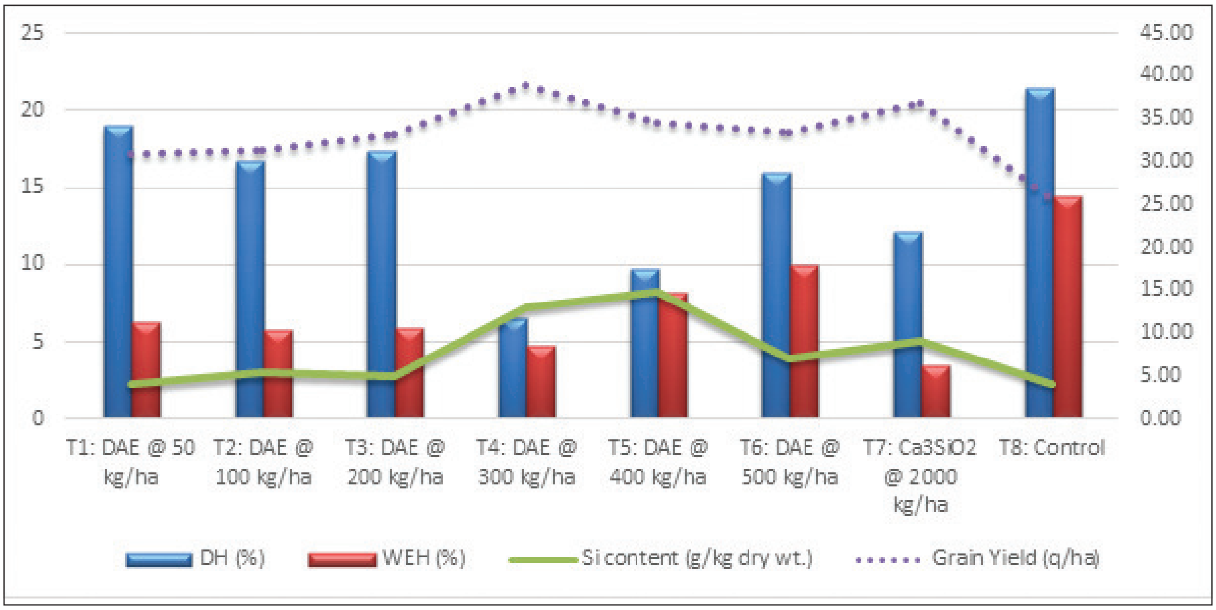

Fig.1: Relation of stem borer damage (DH and WE) with silicon content in plant samples as influenced by various doses of DAE

for about 52 % gain over control compared to 36.8 q ha^{-1} (43.75 % gain) in standard check and 25.6 q ha^{-1} in untreated check. Rest of the treatments yielded at par with each other with a record of 30.9 -34.5 q ha^{-1} exhibiting the benefit of this silicate fertilizer as a soil ameliorating agent besides inducing resistance against YSB in rice. According to Takahashi and Miyake (1982) supplementation of silicon enhanced photo assimilation, further promoting transport of carbon towards rice panicles that contributed towards greater yield. Our finding on the correlation of Si and yield (Fig. 1) have been substantiated with the findings of Ma and Yamaji (2006) who observed that rice plant gains benefit due to higher silicon accumulation in its tissues promoting healthy growth, consistent production and protection from major insect pests like stem borer.

CONCLUSION

The investigation thus, demonstrated the effectiveness of DAE at various doses in inducing resistance to YSB in rice plants. Considering the overall performance of test doses at vegetative and reproductive stages, field application of DAE at 300 kg ha^{-1} was found optimum against YSB. It not only showed greater efficacy, in restricting the borer damage throughout the crop stages but also resulted higher yield. The finding is of great practical utility from farmers' point of view suggesting use of DAE at the rate of 300 kg ha^{-1} in rice as basal soil application in a holistic approach to manage yellow stem borer as well as to enhance the yield.

ACKNOWLEDGEMENT

Authors acknowledge the help rendered by Dr. S.Pattanaik, Former Professor and Head, Department of Soil Science and Agricultural Chemistry, O.U.A.T.f or providing DAE for the trial and helping in laboratory estimation of silicon.

REFERENCES

Alvarez, J. and L.E. Datnoff, 2001. The economic potential of silicon for integrated management and sustainable rice production. *Crop Protec.*,**20**:43-48.

Fallah, A., Osko, T., Khosravi, V., Mohammadian, M. and Rosttami, M. 2011. Reduction of chemical pesticides by using silicate fertilizer in paddy fields. In:*Proceedings of 5th International Conference on Silicon in Agriculture*. Beijing, China, 13-18 September. p 46.

Hallmark, C.T., Wilding, L.P. and Smeck, N.E.1982. "Silicon" Methods of soil analysis.Part-2. Chemical and Microbilogical Properties (methods of soilan2): 263-273.

Hou, M. and Han, Y.Q. 2010. Silicon mediated rice plant resistance to the rice stem borer *Chilo suppressalis*: effects of silicon treatment, rice varietal resistance and larval stage. In:*Proceedings of the 5th International Conference on Silicon in Agriculture*. Beijing, China,13-18 September. pp 62-63.

Han,Y.Q., Lei. W., Wen, L. and Hou, M. 2015. Silicon mediated resistance in a susceptible rice variety to the rice leaffolder, *Cnaphalocrocis medinalis* Guenee (Lepidoptera:Pyralidae). *PLoS ONE,***10**(4).

Hao, L.X., Han. Y.Q., Hou, M.L. and Liao, X.L. 2008. Resistance of Japonica rice varieties in Liaohe Valley to *Chilo suppressalis* and its underlying mechanisms. *Acta Ecologoca Sinica,* **28**:5987-5993.

Jayaraj, J. and Muthukrishnan, N. 2013. Controlling yellow stem borer in rice, The Hindu, Agriculture Research and Technology, 19 September, pp 22.

Kanew, S.R., Choi, H., Kim, J.Y., Vigneswaren, S. and Shim, W.G. 2006. Removal of arsenic (III) from ground water using low-cost industrial by-products – blast furnace slag. *Water Quality Res. J.*, **41**: 130-139.

Khan, Z.R., Ltsinger, J.A., Barrion, A.T., Villanueva, F.F.D., Fernandez, N.J., Taylo, L.D. 1991. World bibliography of rice stem borers. International Rice Research Institute, Manila. ISBN 971-22-0015-9, p 415.

Krishnaiah, K. and Varma, N.R.G. 2012. Status paper on changing insect pest scenario in the rice ecosystem, a national perspective, Directorate of Rice Research, Rajendranagar, Hyderabad, pp 2-8.

Ma, J.F., Tamai, K., Yamaji, N., Mitani, N., Konishi, S., Katsuhara, M., Ishiguro, M., Murata, Y. and Yano, M. 2006. A silicon transporter in rice. *Nature*,**440**: 688-691.

Ma, J.F. and Yamaji, N. 2006. Silicon uptake and accumulation in higher plants. *Trends Pl. Sci.,* **11**(8):392-397.

Ma, J.F., Miyake, Y. and Takahashi, E. 2001. Silicon as a beneficial element for crop plants.pp.17-30. *In*: L.E. Datnoff, G.H.Snyder, and G.H. Kornodorfer (eds), *Silicon in Agriculture*. Elsevier. Amsterdam, The Netharlands.

Marwat, N.K. and Baloch, U.K. 1985. Varietal resistance in rice to *Tryporyza* species of stem borers and its association with plant moisture, total ashes and silica contents *Pak. J. Agric. Res.*, **6**: 278-281.

Mishra, I.O.P. 2018. Silicon-induced resistance to stem borers and leaf folder in rice (*Oryza sativa* L.) Ph.D. Thesis submitted to Odisha University of Agriculture and Technology, Odisha, India.

Panda, N. and Khush, G. 1995. Host plant resistance to insects, CAB International, Wallingford, United Kingdom. p. 431.

Reynolds, O.L., Keeping, M.G. and Meyer, J.H. 2009. Silicon –augmented resistance of plants to herbivorous insects: a review. *Annals.Appl.Biol.*, **155** : 171-186.

Sheng, C.F., Wang, H.T. and Sheng S.Y. 2003. Pest status and loss assessment of crop damage caused by the rice borers, *Chilo suppressalis* and *Tryporyza incertulas* in China. *China Bull. Entomo.,* **40** : 289-294.

Takahashi, E. and Miyake, Y. 1982. The effect of silicon on the growth of cucumber plant. In*: Proceedings of 9th International Plant Nutrition Collog*, Warwick University, United Kingdom, pp 669.

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.

Tanaka, K., Endo, S. and Kazano, H. 2000.Toxicity of insecticides to predators of rice planthoppers: Spiders, the mirid bug and dryinid wasp. *Appl. Entomol. Zool*., **35**:177-187.

Zhao, X.Q., Mitani, N.,Yamaji, N., Shen, R.F. and Ma, J.F. 2010. Involvement of silicon influx transporter OsNIP2;1 in selenite uptake in rice. *Pl.Physiol. Preview,***10**:1104.