Biological Forum – An International Journal 15(9): 180-183(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Biochar as Silicon Inducer and its Effects on Bhendi Mite, *Tetranychus cinnabarinus* (Boisduval)

***A. Nithish Kumar*[1]*, P. Chandramani*[2]**, R. Nalini*[3]*, M. Ananthan*[4] *and P. Kannan*[5]**

[1]*Research Scholar, Department of Agricultural Entomology, AC and RI, Madurai (Tamil Nadu), India.*
[2]*Professor, Department of Agricultural Entomology, AC and RI, Madurai (Tamil Nadu), India.*
[3]*Professor and Head, Department of Agricultural Entomology, AC and RI, Madurai (Tamil Nadu), India.*
[4]*Professor, Department of Horticulture, AC and RI, Madurai (Tamil Nadu), India.*
[5]*Associate Professor, Department of Soils and Environment, AC and RI, Madurai (Tamil Nadu), India.*

(Corresponding author: P. Chandramani)*
(Received: 24 June 2023; Revised: 20 July 2023; Accepted: 22 August 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: The use of biochar as organic amendments in order to curtail the pest resurgence and environmental pollution. A field experiment was conducted at Melur village, Madurai district to assess the effectiveness of biochar against the damage caused by *Tetranychus cinnabarinus* (Boisduval) on okra plants. Treatments involving varying levels of biochar and Rice Husk Ash (RHA) as basal application were supplemented with alternating foliar sprays of 1.0% potassium silicate and 1.0% azadirachtin. The population density of *T. cinnabarinus* was monitored weekly throughout the crop season. The results of the field experiment revealed that seed treatment of biochar @ 100g/kg of seed + basal application of biochar @75 kg/ha along with foliar spray of 1.0% potassium silicate at 30 and 60 DAS and 1.0% azadirachtin at 45 and 75 DAS (T_9) led to a significant reduction in the population of mite. The next best treatments were seed treatment with biochar @ 100g/kg + basal application of RHA @ 75kg/ha along with spraying of potassium silicate and azadirachtin (T_{10}) and standard check, basal application of neem cake 250 kg/ha + Imidacloprid @ 100 ml/ha. The per cent reduction observed was 51.92 % in the treatment T_9 over the control where as it was 47.49 % and 46.13 % in T_{11} and T_{10} respectively.

Keywords: Biochar, rice husk ash, potassium silicate, basal application, *Tetranychus.*

INTRODUCTION

Bhendi scientifically referred as *Abelmoschus esculentus* L. (Moench) and commonly recognized as okra extensively cultivated in tropical and subtropical regions across the world (Maurya *et al.*, 2022). Among vegetables, bhendi is one of the most stable crops grown well throughout the season. It occupies fifth position among vegetables, with an area of 5.50 lakh hectares under vegetables in our country with a production of 6.87 lakh metric tonnes (Indiastat 2022). Insect pests pose a significant constraint in the successful growth of okra, with as many as 72 different insect species recorded (Srinivasa and Rajendran 2003). Most destructive insect pests recorded from sowing upto harvest on bhendi are spotted bollworm, *Earias vittella* (Fabricius), whiteflies, *Bemisia tabaci* (Gennadius), fruit borer, *Helicoverpa armigera* (Hubn.), leafhopper, *Amrasca devastans* (Ishida), aphid, *Aphis gossypii* (Glover), red spider mite, *Tetranychus cinnabarinus* (Boisduval) (Mane *et al.*, 2010). Aphids and leafhoppers are important pests in the early stage of the crop which desap the plants, make them weak and reduce the yield. Failure to control them in the initial stages was reported to cause a yield loss to the tune of 54.04% (Chaudhary and Dadeech 1989). The red spider mite, *T. cinnabarinus* has assumed the status of major pest and caused 17.46% yield loss in okra (Jaydeb *et al.*, 1996).

Various pests control methods are practiced to reduce the incidence of pest damages. Among them chemical control plays front line defense in controlling pest attack. Using alternative methods, such as organic sources like biochar, can be a beneficial approach to mitigate the losses associated with pesticide resistance and resurgence to insect pests. Enhancing plant resistance can play a significant role in pest management. Biochar application significantly enhances insect pest resistance in plants with yield increase. Silicon deposition in the plant may reinforce plant insect resistance by providing a mechanical barrier against insect pests. Silicon plays an important role in plant defense against biotic and abiotic stresses (Cooke and Leishman 2016). Higher Si content in a host plant not only increase physical resistance but also chemical defense triggered by herbivores. Silicon enhances the attraction of natural predators to plants infested by pests, thereby augmenting biological control mechanisms. Xiao *et al.* (2014) investigated the Si transformation and dissolution in rice straw-derived biochar and pointed out that biochar could be an effective Si fertilizer for soil.

The effect of biochar induces the systemic resistance against suppression of symptoms caused by the broad mite in pepper (Elad *et al.*, 2010). One of the possible solutions to overcome intensive application of insecticides in bhendi is to use alternatives such as natural amendments like biochar which create no risk to human and the surrounding environment. Keeping this view, the present study was conducted.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* season of 2023 at Perumalpatti village, Melur block, Madurai district situated between latitude 10.02°N and longitude 78.35°E. This region has semi- arid climate zone with an average annual rainfall of 880mm and elevation of 220 meters above mean sea level.

The experiment was done in Randomised Block Design with three replications and twelve treatments combination with plot size of 20m^2. The treatments comprised of T_1 - seed treatment of biochar @100g/kg of seeds, T_2 -T_1+Azadirachtin 1%, T_3 – Basal application of biochar@ 300kg/ha, T_4 – Basal application of biochar @ 150kg/ha, T_5 – Basal application of biochar @ 75kg/ha, T_6 – Basal application of Rice Husk Ash (RHA) @300 kg/ha, T_7 - Basal application of RHA @150 kg/ha, T_8 - Basal application of RHA @75 kg/ha, T_9 - T_1+T_5, T_{10} - T_1+T_8, T_{11} – Neem cake 250kg/ha + imidacloprid @ 100 ml/ha and T_{12} - Untreated check. Foliar spray was done at 30, 45, 60 and 75 DAS which were applied by a 10 litre capacity knapsack sprayer. Foliar application of potassium silicate was done at 30th and 60th DAS and Azadirachtin was done at 45th and 75th DAS. Wherever basal application of biochar and rice husk ash was done, Silicate Solubilizing Bacteria (SSB) was incorporated at the rate of 2kg/ha.

All the Agricultural techniques advised as per the crop production guide were employed for the cultivation of bhendi (CPG, 2020). The mite population density was evaluated by examining three leaves each from the top, middle and bottom of 10 randomly selected plants. Pre-treatment population counts were recorded a day prior to the initial spraying while post treatment counts were recorded on third and ninth days after each spray from a randomly selected plants of each replicate (Fleming and Retnakaran 1985). The collected data were subjected to statistical ANOVA by SPSS software and means were compared with tukey's test at $P \leq 0.05$ (Tukey, 1977).

RESULTS AND DISCUSSION

The results revealed that all treatments were effective over the untreated check in reducing mite infestation (Table 1). After first spray (30 DAS), seed treatment of biochar @ 100g/kg of seed + basal application of biochar @ 75 kg/ha + foliar spray of potassium silicate @ 1% (T_9) recorded minimum mite population (7.05/ cm^2 leaf) followed by standard check i.e. basal application of neem cake 250 kg/ha +imidacloprid @100 ml/ha (T_{10}) (8.24/cm^2 leaf) as against untreated check (12.70 insects/ cm^2 leaf).

Similarly, after second spray (45 DAS), seed treatment of biochar @ 100g/kg of seed + basal application of biochar @ 75 kg/ha + foliar spray of azadirachtin @ 1% (T_9) recorded minimum mite population (9.35 insects/ cm^2 leaf) followed by seed treatment of biochar @ 100 g/kg of seed + basal application of rice husk ash @ 75 kg/ha + foliar spray of azadirachtin @ 1% and (T_{10}) (10.02 insects/ cm^2 leaf) as against untreated check (17.84 insects/ cm^2 leaf).

After the third spray (60 DAS), seed treatment of biochar @ 100g/kg of seed + basal application of biochar @ 75 kg/ha + foliar spray of azadirachtin @ 1% (T_9) recorded minimum mite population (17.09 insects/ cm^2 leaf) followed by seed treatment of biochar @ 100g/kg of seed + basal application of RHA @ 75 kg/ha + foliar spray of potassium silicate @ 1% (T_{10}) (18.44 insects/cm^2 leaf) which was on par with basal application of neem cake @ 250 kg/ha + imidacloprid @ 100ml/ ha (T_{11}) (18.48 insects/cm^2 leaf). In the untreated check the mean mite population recorded was (30.91insects/cm^2 leaf).

On fourth spray (75 DAS), the same trend was observed among different treatments. Hence, in the present study on comparing cumulative mean, the population of mite was significantly less in T_9 (10.18 insects/ cm^2 leaf) followed by T_{11} (11.12 insects/ cm^2 leaf) and T_{10} (11.41 insects/cm^2 leaf) as against 21.18 insects/ cm^2 leaf in the untreated check. The percent reduction observed in T_9, T_{11} and T_{10} was 51.92, 47.49 and 46.13 respectively over control.

The present finding is in confirmation with the findings of Nikpay and Laane (2020) who reported that four spray application of silicic acid was more effective than other treatment on mite damage. Similar studies were carried out by Ismail *et al.* (2022) suggested that incorporating silicon into integrated pest management programs for controlling two spider mites in strawberries could serve as plant defense inducer, exhibiting a negative correlation with the density of the two spotted spider mite population. Further Ganapathy *et al.* (2022) observed that foliar application of potassium silicate resulted in substantial reduction in the population density of leaf hoppers. Thakur and Sood (2022) also reported that azadirachtin was the most effective in controlling mite population and increasing fruit yield in cucumber. The present work is in concurrence with the findings of Panda *et al.* (2022) who reported that the application of diatomaceous earth rich in exogenous silica led to an augmentation of plant defenses against the rice stem borer.

Table 1: Efficacy of different sources of silica against mite, *Tetranychus cinnabarinus* of bhendi.

Treatments	No. of mites/ cm^2 leaf*													Cumulative mean	Per cent reduction over control
	PTC	I Spray-Potassium silicate1% (30 Days After Sowing)			II Spray - Azadirachtin 1% (45 Days After Sowing)			III Spray- Potassium silicate 1% (60 Days After Sowing)			IV spray -Azadirachtin 1% (75 Days After Sowing)				
		3 DAS	9 DAS	Mean	3 DAS	9 DAS	Mean	3 DAS	9 DAS	Mean	3 DAS	9 DAS	Mean		
T_1-Seed Treatment of biochar @ 100g/kg	15.98 (4.00)	11.58 (3.40)^{g}	8.83 (2.97)^{f}	10.21 (3.19)^{f}	14.26 (3.78)^{f}	9.48 (3.08)^{cd}	11.87 (3.45)^{d}	25.22 (5.02)^{f}	24.52 (4.95)^{g}	24.87 (4.99)^{f}	23.32 (4.83)^{gh}	22.55 (4.75)^{g}	22.93 (4.79)^{g}	16.04 (4.01)^{e}	24.24
T_2 -T_1+Azadirachtin 1%	15.86 (3.98)	10.84 (3.29)^{f}	8.43 (2.90)^{e}	9.63 (3.10)^{e}	14.95 (3.87)^{g}	13.07 (3.62)^{f}	14.01 (3.74)^{f}	27.33 (5.23)^{g}	23.12 (4.81)^{f}	25.23 (5.02)^{f}	21.92 (4.68)^{f}	21.15 (4.60)^{f}	21.54 (4.64)^{f}	16.20 (4.02)^{e}	23.52
T_3 – Basal application biochar@ 300kg/ha	16.35 (4.04)	9.63 (3.10)^{d}	7.55 (2.75)^{d}	8.59 (2.93)^{d}	13.35 (3.65)^{e}	12.08 (3.48)^{e}	12.72 (3.57)^{e}	23.78 (4.88)^{d}	16.68 (4.08)^{cd}	20.23 (4.50)^{c}	15.48 (3.93)^{cd}	14.71 (3.83)^{c}	15.10 (3.88)^{c}	12.75 (3.57)^{c}	39.79
T_4-Basal application biochar @ 150kg/ha	15.87 (3.98)	12.58 (3.55)^{h}	10.18 (3.19)^{g}	11.38 (3.37)^{h}	15.64 (3.95)^{h}	13.99 (3.74)^{g}	14.81 (3.85)^{g}	27.87 (5.28)^{g}	19.21 (4.38)^{e}	23.54 (4.85)^{e}	18.01 (4.24)^{e}	17.24 (4.15)^{e}	17.63 (4.20)^{e}	15.47 (3.93)^{d}	26.94
T_5 – Basal application biochar @ 75kg/ha	16.14 (4.02)	13.59 (3.69)^{j}	10.87 (3.30)^{h}	12.23 (3.50)^{j}	16.49 (4.06)^{i}	15.31 (3.91)^{h}	15.90 (3.99)^{h}	28.85 (5.37)^{h}	25.45 (5.04)^{h}	27.15 (5.21)^{g}	24.25 (4.92)^{hi}	23.48 (4.85)^{h}	23.86 (4.88)^{h}	18.38 (4.29)^{g}	13.22
T_6 – Basal application Rice husk ash (RHA) @ 300 kg/ha	16.21 (4.03)	10.10 (3.18)^{e}	6.89 (2.62)^{bc}	8.50 (2.91)^{d}	12.90 (3.59)^{d}	10.41 (3.23)^{d}	11.66 (3.41)^{d}	24.47 (4.95)^{e}	17.32 (4.16)^{d}	20.90 (4.57)^{d}	16.12 (4.02)^{d}	15.35 (3.92)^{d}	15.74 (3.97)^{d}	12.79 (3.58)^{c}	39.60
T_7 - Basal application RHA @ 150 kg/ha	15.89 (3.99)	11.83 (3.44)^{g}	9.19 (3.03)^{f}	10.51 (3.24)^{g}	15.34 (3.92)^{gh}	13.63 (3.69)^{fg}	14.48 (3.81)^{g}	29.61 (5.44)^{i}	24.00 (4.90)^{g}	26.81 (5.18)^{g}	22.80 (4.78)^{fg}	22.03 (4.69)^{g}	22.42 (4.73)^{g}	17.15 (4.14)^{f}	19.02
T_8 - Basal application of RHA @ 75 kg/ha	16.25 (4.03)	13.17 (3.63)^{i}	10.56 (3.25)^{h}	11.87 (3.44)^{j}	16.09 (4.01)^{i}	15.55 (3.94)^{h}	15.82 (3.98)^{h}	30.58 (5.53)^{j}	26.99 (5.19)^{i}	28.78 (5.36)^{h}	24.91 (4.99)^{i}	24.57 (4.96)^{i}	24.74 (4.97)^{i}	18.90 (4.35)^{h}	10.76
T_9 - T_1+T_5	15.98 (4.00)	8.03 (2.83)^{a}	6.08 (2.46)^{a}	7.05 (2.66)^{a}	11.33 (3.37)^{a}	7.38 (2.72)^{a}	9.35 (3.06)^{a}	19.72 (4.44)^{a}	14.45 (3.80)^{a}	17.09 (4.13)^{a}	13.25 (3.64)^{a}	12.48 (3.53)^{a}	12.87 (3.59)^{a}	10.18 (3.19)^{a}	51.92
T_{10} - T_1+T_8	16.14 (4.02)	9.30 (3.05)^{d}	7.17 (2.68)^{c}	8.24 (2.87)^{d}	12.08 (3.48)^{i}	7.95 (2.82)^{ab}	10.02 (3.16)^{b}	20.73 (4.55)^{b}	16.15 (4.02)^{c}	18.44 (4.29)^{b}	14.95 (3.87)^{c}	14.18 (3.76)^{c}	14.57 (3.82)^{c}	11.41 (3.38)^{b}	46.13
T_{11} –Neem cake @ 250kg/ha + Imidacloprid @100 ml/ha	15.74 (3.97)	8.62 (2.94)^{b}	6.66 (2.58)^{b}	7.64 (2.76)^{b}	12.47 (3.53)^{c}	8.49 (2.91)^{b}	10.48 (3.24)^{c}	21.86 (4.68)^{c}	15.09 (3.88)^{b}	18.48 (4.30)^{b}	13.89 (3.73)^{b}	13.12 (3.62)^{b}	13.51 (3.68)^{b}	11.12 (3.33)^{b}	47.49
T_{12} - Untreated check	16.23 (4.03)	14.05 (3.75)^{k}	11.34 (3.37)^{i}	12.70 (3.56)^{k}	17.49 (4.18)^{j}	18.19 (4.27)^{i}	17.84 (4.22)^{i}	31.49 (5.61)^{k}	30.33 (5.51)^{j}	30.91 (5.56)^{i}	28.75 (5.36)^{j}	29.02 (5.39)^{j}	28.88 (5.37)^{j}	21.18 (4.60)^{i}	
SEd	NS	0.10	0.14	0.08	0.17	0.42	0.31	0.31	0.32	0.23	0.38	0.34	0.32	0.15	
P		0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	

* Mean of three replications
PTC - Pre Treatment Count
SE - Standard Error
Figures in parentheses are square root transformed values
DAS - Days After Spray
**Highly Significant
P - Statistically Significant
Tukeys test
NS - Non Significant

CONCLUSIONS

Employing basal application of biochar and rice husk ash along with potassium silicate and azadirachtin significantly reduce the population density of mite in bhendi. In the context of organic farming, the incorporation of silicon sources such as biochar could be contemplated as a future consideration for sustainable eco-friendly approaches and mitigating pests under field conditions.

FUTURE SCOPE

Overuse of synthetic insecticide causes environmental pollution. In order to overcome this we are in the need of using organic source, which enhance the silica uptake through biochar mediated resistance for promoting sustainable and ecofriendly approaches.

Author contribution. ANK performed the analysis by collecting the data and wrote the paper. PC helped in conceive the data and designed the analysis. RN, MA, PK performed the manuscript drafting.

Ethical Approval. This article does not contain any other studies, human and animal participants which is denoted by any other authors.

Acknowledgement. I acknowledge my chairperson, all the members for their suggestion to conduct the experiment during my research work and farmer for providing field for experiment. We sincerely thank the Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai.

Conflict of Interest. None.

REFERENCES

Chaudhary, H. R. and Dadheech, L. N. (1989). Incidence of insects attacking okra and the avoidable losses caused by them. *Annals of Arid Zone*, *28*(3-4), 305-307.

Cooke, J. and Leishman, M. R. (2016). Consistent alleviation of abiotic stress with silicon addition: a meta-analysis. *Functional Ecology*, *30*(8), 1340-1357.

CPG (2020). Crop Production Guide. Tamil Nadu Agricultural University, Coimbatore and Department of Agriculture, Government of Tamil Nadu, India. pp: 69-72.

Elad, Y., David, D. R., Harel, Y. M., Borenshtein, M., Kalifa, H. B., Silber, A. and Graber, E. R. (2010). Induction of systemic resistance in plants by biochar, a soil-applied carbon sequestering agent. *Phytopathology*, *100*(9), 913-921.

Fleming, R. and Retnakaran, A. (1985). Evaluating single treatment data using Abbott's formula with reference to insecticides. *Journal of Economic Entomology*, *78*(6), 1179-1181.

Ganapathy, M., Chandramani, P., Jayaraj, J., Revathy, N. and Balasubramaniam, P. (2022). Silicon and gibberellic acid as resistance inducers in green gram against leaf hopper *Empoasca kerri* (Pruthi). *Indian Journal of Ecology*, *49*(5), 1770-1772.

India stat 2022. Ministry of Statistics and Programme Implementation: https://www.indiastat.com/data/agriculture/ladys-finger-okra/data-year/2022

Ismail, M. S., Abdallah, A. M., and Aboghalia, A. H. (2022). Silicon as a plant defense inducer against the two-spotted spider mite *Tetranychus urticae* (Trombidiformes: Tetranychidae) invasion on strawberry. *International Journal of Pest Management*, 1-10.

Jaydeb, G., Mukherjee, A. B. and Sarkar, P. K. (1996). Assessment of loss of bhendi against red spider mite. *Environment and Ecology*, *14*(2), 480-481.

Mane, S. A., Waghmare, U. M. and Yadav, G. A. (2010). Bio-Efficacy and economics of some newer insecticides against fruit borer (*Earias vitella* Fabricius) of okra. *Pestology*, *34*(5), 101-104.

Maurya, B. K., Neetu, Dwivedi, S. V., Singh, D. P., Maurya, S. K. (2022). Combining Ability Studies for Growth, Yield and its Related Traits in Okra [*Abelmoschus esculentus* (L.) Moench. *Biological Forum – An International Journal*, *14*(3), 62-69.

Nikpay, A. and Laane, H. M. (2020). Foliar amendment of silicic acid on population of yellow mite, *Oligonychus sacchari* (Acari: Tetranychidae) and its predatory beetle, *Stethorus gilvifrons* (Col.: Coccinellidae) on two sugarcane commercial varieties. *Persian J. Acarol*, *9*(1), 57-66.

Panda, S., Raghunandan, H. and Mishra, I. O. P. (2022). Silicate fertilizer induced resistance to rice yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae). *Journal of Crop and Weed*, *18*(2), 307-311.

Srinivasa, R., and Rajendran, R. (2003). Joint action potential of neem with other plant extracts against the leaf hopper *Amrasca devastance* (Distant) on okra. *Pest Management and Economic Zoology*, *10*(1), 131-136.

Thakur, S. and Sood, A. K. (2022). Foliar application of natural products reduces population of two-spotted spider mite, *Tetranychus urticae* Koch on parthenocarpic cucumber (*Cucumis sativus* L.) under protected environment. *Crop Protection*, *160*, 106036.

Tukey, J. W. (1977). *Exploratory data analysis* (Vol. 2, pp. 131-160).

Xiao, X., Chen, B. and Zhu, L. (2014). Transformation, morphology, and dissolution of silicon and carbon in rice straw-derived biochars under different pyrolytic temperatures. *Environmental science and technology*, *48*(6), 3411-3419.

How to cite this article: A. Nithish Kumar, P. Chandramani, R. Nalini, M. Ananthan and P. Kannan (2023). Biochar as Silicon Inducer and its Effects on Bhendi Mite, *Tetranychus cinnabarinus* (Boisduval). *Biological Forum – An International Journal*, *15*(9): 180-183.