Hexapoda (*Insecta indica*) 51
Copyright © 2019 Entomology Academy of India. Chennai, India
Volume 29 Number 1&2 January-December 2022. pp. 51-57

Induction of resistance through foliar application of silicon and gibberellic acid against whitefly, *Bemisia tabaci* (Gennadius) infesting green gram

Ganapathy M[2], Chandramani P[2], Jayaraj J[2], Revathy N[2] and Balasubramaniam P[1]

1.Directorate of Natural Resource Management, TNAU, Coimbatore
2. Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Madurai – 625 104

ABSTRACT: Foliar application of silicic acid @ 0.1 and 0.2% and potassium silicate @ 0.5 and 1.0% with gibberellic acid @ 50 and 100 ppm were evaluated for white fly attacking green gram plant at farmers' holdings, Nattapatti, Madurai District, Tamil Nadu. The population density of *Bemisia tabaci* was observed at weekly interval during the growth season. Treatment with potassium silicate 1.0% @ 10 DAS & 20 DAS with gibberellic acid 100 ppm @ 30 DAS and 40 DAS significantly decreased the population of *B. tabaci* (3.70 whiteflies/top three leaves)as against the untreated check.(9.78 whiteflies/top three leaves)

Key words: Silicon, Gibberellic acid, Potassium silicate, Whitefly, *Bemisia tabaci*, Green gram

Introduction

Pulses occupy second place next to cereals and constitute an excellent supplement of protein in the human diet, thereby play a paramount role in combating the widespread malnutrition in the country. Among several pulses grown, mungbean or green gram, *Vigna radiata* L. Wilczek, is an economically important short duration grain legume crop.

Mungbean is grown in an area of 4.2 Million hectares with a total production of 2.01 Million tonnes, with an average productivity of 472 kg/ha (Anonymous, 2018). An improvement in the yield of

*Author for correspondence. Email: mmmganapathy517@gmail.com

mung bean is becoming difficult, mainly due to vulnerability to several insect pests which attack the plants from seedling to maturity. The insect pests reported on green gram include jassid, thrips, whitefly, galerucid beetle, pod borer, *Maruca vitrata* (Geyer), pod borer, *Helicoverpa armigera* (Hubner), stem fly and green bug, (Kumar *et al*., 2004; Nitharwal and Kumawat, 2013; Chaudhary *et al*., 2018). Among these insect pests, whitefly, *B. tabaci* causes considerable losses in the yield of green gram crop by sucking the sap from the ventral surface of leaves. Nymphs and adults of whitefly infest plants by suck the sap from new growth causing stunted growth, yellow mosaic and reduced yields. Plants become weak and susceptible to disease.

Use of synthetic chemical pesticides inappropriately to manage insect pests lead to the recurrence of insect pests, the elimination of natural enemies, development of resistance and pesticide residues in food and the ecosystems. The development of an eco-friendly strategy is critical to overcoming the challenges related with the usage of insecticides. Silicon use has been reported as a novel approach for the control of green gram insect pests.

The deposition of Si via 1% sodium silicate solution to wheat plants improved resistance to two aphids, *Metopolophium dirhodum* (Walk) and *Sitobion avenae* (Fabricius) (Hemiptera: Aphididae) (Gomes *et al*., 2015). In field studies, Si treated rice impaired feeding and suppressed insect population growth rates (Chandramani *et al*., 2010; Yang *et al*., 2017).

Foliar spray of calcium silicate at 5.0% was effective in facilitating the maximum deposition of silica content apart from increasing the activities of polyphenol oxidase (PPO) in groundnut leaves (Parthiban *et al*., 2019), while Si application to rapeseed (*Brassica napus* L.) plants showed increased resistance to insect herbivores (Teixeira *et al*., 2017; Nascimento *et al*., 2018). Boer *et al*. (2019) found that application of Si on maize seedlings increased the non-preference response by the aphid *R. maidis* (Fitch). In view of the above said, this study was taken up.

Materials & Methods

Field experiment was conducted at Nattapatti 9.97º N and 77.85º E , Madurai district to evaluate the effects of foliar application of silicon fertilizers on *B.tabaci* during *Rabi* 2022. The area is semiarid with a mean annual rainfall of 880 mm and 218 meters from above mean sea level, The experiment was laid out in a randomized block design with three replications and twelve treatments in a plot size of $20m^2$. The treatments comprised of T_1=Foliar spray of silicic acid @ 0.1%, T_2=Foliar spray of silicic acid @ 0.2%, T_3=Foliar spray of potassium silicate @ 0.5%, T_4=Foliar spray of potassium silicate @ 1.0%, T_5=T_1 + Gibberellic acid @ 50 ppm, T_6=T_2 + Gibberellic acid @ 100 ppm, T_7=T_3 + Gibberellic acid @ 50 ppm, T_8=T_4 + Gibberellic acid @ 100 ppm, T_9=Silicate Solubilizing Bacteria @ 2 kg ha^{-1}, T_{10}=Neem oil @ 2%, T_{11}=Chlorpyriphos 20% EC @ 1.5ml/l, and T_{12}=Untreated check. Foliar spray was done at 10, 20, 30 and 40 days after sowing (DAS) with a 10 l volume knapsack sprayer. Foliar application of silicic acid and potassium silicate was done at 10 DAS and 20 DAS and gibberellic acid at 30 DAS and 40 DAS. In all plots except the untreated control, silicon nutrients were foliar sprayed at their respective doses. The crop was raised as per standard agronomic practices. The population density of nymphs and adults of the whitefly, *Bemisia tabaci*, was assessed in three randomly selected leaves from the top, middle, and bottom of 5 randomly selected plants. The pretreatment population counts for the first spray were taken one day before the first spraying, and the post-treatment population counts were taken on third and ninth day of each spray from ten randomly selected plants each replication (Fleming and Retnakaran, 1985).The data collected were subjected to statistical analysis of variance by SPSS software and means were compared with Tukey's test at $P \leq 0.05$ (Tukey, 1977).

Results and Discussion

The data on the mean population of *B. tabaci* per five plants prior to the imposing of treatments ranged from 10.81 to 11.95/top three leaves. These observations were statistically non significant there by indicating the population of whitefly to be uniformly distributed in the experimental plot prior to impose of treatments.

After first spray (10 DAS), all the treatments were significantly effective in reducing whitefly population in comparison to untreated check. Foliar application of potassium silicate @ 1% + gibberellic acid @ 100 ppm was found to be significantly superior among all the treatments (6.16 whiteflies/top three leaves) followed by potassium silicate @ 0.5% + gibberellic acid @ 50 ppm (6.82 whiteflies/top three leaves) and the untreated check (14.60 whiteflies/top three leaves).

After second spray (20 DAS), foliar application of potassium silicate @ 1% + gibberellic acid @ 100 ppm (3.79 whiteflies/top three leaves) and potassium silicate @ 0.5% + gibberellic acid @ 50 ppm (3.68 whiteflies/top three leaves) were found to be on par with each other. The population recorded in the untreated check was 10.88 whiteflies/top three leaves.

In case of third spray (30 DAS), all the treatments were significantly effective in reducing whitefly population in comparison to untreated check. The treatment with potassium silicate @ 0.5% + gibberellic acid @ 50 ppm was found to be most effective and significantly superior over all other treatments by recording the lowest mean population (2.40whiteflies/top three leaves). The next best treatment was foliar application of potassium silicate @ 1% + gibberellic acid @ 100 ppm with mean population of 1.77 whiteflies/top three leaves. On fourth spray, the same trend was observed among different treatments.

The data on overall efficacy of various treatments on *B. tabaci* is presented in Table 1. The mean population ranged from 3.70 to 6.90 whiteflies/top three leaves among treatments against the untreated check (9.78 whiteflies/top three leaves). The treatment, potassium silicate @ 1% + gibberellic acid @ 100 ppm had registered lowest mean population of 3.70 whiteflies/top three leaves followed by potassium silicate @ 0.5% + gibberellic acid @ 50 ppm (3.90 whiteflies/top three leaves). Regarding per cent reduction over control, it was observed that foliar application of potassium silicate @ 1% + gibberellic acid @ 100 ppm recorded 53.16%, followed by potassium silicate @ 0.5% + gibberellic acid @ 50 ppm (50.63%).

Table 1. Efficacy of different sources of silicon against whitefly, *Bemisia tabaci* on green gram

Treatments	PTC	No. of whitefly/ top three leaves*												Cumulative mean	Per cent reduction over control
		I Spray (10 Days After Sowing)			II Spray (20 Days After Sowing)			III Spray (30 Days After Sowing)			IV spray (40 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 - Silicic acid @ 0.1%	11.52 (3.39)	10.13 (3.18)^{gh}	9.92 (3.15)^{f}	10.02 (3.17)^{f}	8.54 (2.46)^{i}	5.39 (2.32)^{h}	6.96 (2.64)^{f}	6.06 (2.46)^{h}	4.77 (2.18)^{h}	4.76 (2.18)^{h}	4.61 (2.14)^{h}	4.53 (2.13)^{h}	4.39 (2.10)^{h}	6.52 (2.55)^{h}	17.50
T_2 - Silicic acid @ 0.2%	11.01 (3.32)	9.92 (3.15)^{fg}	9.07 (3.01)^{e}	9.49 (3.08)^{e}	7.88 (2.36)^{h}	4.95 (2.22)^{g}	6.42 (2.53)^{e}	5.59 (2.36)^{g}	4.35 (2.08)^{g}	4.36 (2.09)^{g}	4.22 (2.05)^{g}	4.07 (2.02)^{g}	3.95 (1.99)^{g}	6.06 (2.46)^{g}	23.28
T_3 - Potassium silicate @ 0.5%	10.81 (3.29)	9.31 (3.05)^{ef}	8.29 (2.88)^{d}	8.80 (2.97)^{d}	7.23 (2.26)^{fg}	4.51 (2.12)^{f}	5.87 (2.42)^{d}	5.12 (2.26)^{f}	3.92 (1.98)^{f}	3.97 (1.99)^{f}	3.81 (1.95)^{f}	3.61 (1.90)^{f}	3.52 (1.88)^{f}	5.53 (2.35)^{e}	29.99
T_4 - Potassium silicate @ 1.0%	10.96 (3.31)	8.94 (2.99)^{de}	7.77 (2.79)^{d}	8.35 (2.89)^{d}	6.97 (2.16)^{e}	4.07 (2.02)^{e}	5.52 (2.35)^{c}	4.65 (2.16)^{e}	3.50 (1.87)^{e}	3.68 (1.92)^{e}	3.54 (1.88)^{e}	3.15 (1.77)^{e}	3.08 (1.76)^{e}	5.17 (2.27)^{d}	34.56
T_5 - T_1 + Gibberellic acid @ 50 ppm	11.27 (3.36)	8.49 (2.91)^{cd}	6.99 (2.64)^{c}	7.74 (2.78)^{c}	5.92 (2.04)^{d}	3.63 (1.91)^{d}	4.77 (2.18)^{b}	4.18 (2.04)^{d}	3.08 (1.75)^{d}	3.18 (1.78)^{c}	3.03 (1.74)^{d}	2.69 (1.64)^{d}	2.64 (1.63)^{d}	4.60 (2.15)^{cd}	41.73
T_6 - T_2 + Gibberellic acid @ 100 ppm	10.97 (3.31)	7.87 (2.81)^{bc}	6.96 (2.64)^{c}	7.41 (2.72)^{c}	6.07 (1.93))^{c}	3.19 (1.79)^{c}	4.63 (2.15)^{b}	3.71 (1.93)^{c}	2.65 (1.63)^{c}	3.01 (1.74)^{bc}	2.85 (1.69)^{c}	2.23 (1.49)^{c}	2.21 (1.49)^{c}	4.35 (2.09)^{c}	44.97
T_7 - T_3 + Gibberellic acid @ 50 ppm	11.95 (3.46)	7.38 (2.72)^{ab}	6.25 (2.50)^{b}	6.82 (2.61)^{b}	4.61 (1.80)^{b}	2.75 (1.66)^{b}	3.68 (1.92)^{a}	3.24 (1.80)^{a}	2.23 (1.49)^{a}	2.40 (1.55)^{a}	2.24 (1.50)^{b}	1.77 (1.33)^{b}	1.77 (1.33)^{b}	3.90 (1.97)^{b}	50.63
T_8 - T_4 + Gibberellic acid @ 100 ppm	10.98 (3.31)	6.89 (2.62)^{a}	5.44 (2.33)^{a}	6.16 (2.48)^{a}	5.26 (1.66)^{a}	2.31 (1.52)^{a}	3.79 (1.95)^{a}	2.77 (1.66)^{b}	2.73 (1.65)^{b}	2.83 (1.68)^{b}	2.67 (1.63)^{a}	1.31 (1.14)^{a}	1.34 (1.16)^{a}	3.70 (1.92)^{a}	53.16
T_9 - Silicate Solubilizing Bacteria @ 2 kg/ha	11.87 (3.44)	10.78 (3.28)^{h}	9.66 (3.11)^{ef}	10.22 (3.20)^{f}	9.19 (2.55)^{j}	5.83 (2.41)^{h}	7.51 (2.74)^{g}	6.48 (2.55)^{i}	5.19 (2.28)^{i}	5.15 (2.27)^{i}	4.99 (2.22)^{i}	4.99 (2.23)^{i}	4.83 (2.20)^{i}	6.90 (2.63)^{i}	12.60
T_{10} - Neem oil @ 2%	11.33 (3.37)	9.31 (3.05)^{ef}	8.29 (2.88)^{d}	8.80 (2.97)^{d}	7.61 (2.31)^{gh}	4.64 (2.15)^{fg}	6.13 (2.48)^{d}	5.33 (2.31)^{f}	4.18 (2.04)^{f}	4.21 (2.05)^{g}	4.05 (2.01)^{f}	3.97 (1.99)^{f}	3.83 (1.96)^{f}	5.75 (2.40)^{f}	27.28
T_{11} - Chlorpyriphos 20% EC @ 1.5ml/l	11.14 (3.34)	8.77 (2.96)^{de}	7.81 (2.79)^{d}	8.29 (2.88)^{d}	6.57 (2.19)^{ef}	4.27 (2.07)^{ef}	5.42 (2.33)^{c}	4.81 (2.19)^{e}	3.23 (1.80)^{e}	3.44 (1.85)^{d}	3.06 (1.81)^{e}	2.36 (1.54)^{e}	2.44 (1.56)^{e}	4.88 (2.21)^{cd}	38.26
T_{12} - Untreated check	11.61 (3.45)	14.19 (3.77)^{j}	15.02 (3.88)^{g}	14.60 (3.82)^{g}	12.46 (2.89)^{k}	9.31 (3.05)^{j}	10.88 (3.30)^{h}	8.36 (2.89)^{j}	7.31 (2.70)^{j}	7.12 (2.67)^{j}	6.96 (2.63)^{j}	6.78 (2.60)^{j}	6.55 (2.56)^{j}	9.78 (3.13)^{j}	0.00
SEd	NS	0.36	0.31	0.24	0.23	0.27	0.15	0.23	0.14	0.14	0.11	0.20	0.10	0.10	-
P(≤0.05)		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

Figures in parentheses are square root transformed values

PTC - Pre Treatment Count

DAS - Days After Spray

P - Statistically Significant

NS - Non Significant

SEd - Standard Error

**Highly Significant

Tukey's test was followed

The present study is in corroboration with the finding of Correa *et al.* (2005) who reported that foliar application of 1 % calcium silicate + 0.005 % of activator acibenzolar-S-methyl caused significant reduction in oviposition by *Bemisia tabaci* in cucumber. Moraes*et al.* (2005) observed that sodium silicate applied at 1 percent in liquid form to either soil or foliage successfully managed the phloem-feeding arthropods. The foliar and soil application of calcium silicate as a source of silicon increased the mortality of whitefly (Meena*et al.,* 2014).

Callis-Duehl*et al.* (2017) evaluated that application of potassium silicate solution (30 ml of 2 mM), reduced number of *Bemisia tabaci* on cucumber leaves whereas the number of whiteflies on untreated cucumber leaves was higher (44.5%). This finding revealed that a *B. tabaci* population has less preference to silicon treated plants.

Ramirez-Godoy *et al.* (2018) showed that application of silicon in the form of potassium silicate (2 ml/L) significantly reduced the oviposition rate of *Diaphorina citri* up to 60 percent in Tahiti lime. Nikpay and Laane (2020) reported that four spray application of silicic acid was more effective than other treatments on sugarcane mite damage. Alyousuf *et al.* (2022) demonstrated that in tomato, the foliar spray of silicic acid (0.8%) decreased the population of whitefly and tomato leaf miner in the greenhouse. Application of silicon dioxide and potassium silicate at the concentrations of 200 and 400 ppm on cotton plants significantly lowered the ovipositional preferences and prolonged the duration of all the life stages of *B. tabaci* compared to the untreated plants when applied through foliar application (Abbasi *et al*., 2022).

Conclusion

The foliar application of silicon and gibberellic acid was found to be best option to manage white fly *Bemisia tabaci* in green gram**.** In organic farming, the use of silicon products is widely accepted, and it may be very well integrated with other ecofriendly pest manangement practices to get good yield and insecticide residue free crop.

References

Abbasi, A., Sufyan, M., Arif, M.J., and Sahi, S.T. 2022. Effect of silicon on oviposition preference and biology of *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) feeding on *Gossypium hirsutum* (Linnaeus). *International Journal of Pest Management* 68(2): 124-134.

Alyousuf,A., Hamid, D., Desher, M.A., Nikpay,A.,and Laane. H.M. 2022. Effect of silicic acid formulation (Silicon 0.8%) on two major insect pests of tomato under greenhouse conditions. *Silicon* Pp: 1-7.

Anonymous. 2018. DES Ministry of Agriculture & FW (DAS & FW), GOI IV Adv. Est, 2017-2018.

Boer, C. A., Sampaio, M. V. and Pereira, H. S. (2019). Silicon-mediated and constitutive resistance to Rhopalosiphum maidis (Hemiptera: Aphididae) in corn hybrids. Bulletin of Entomological Research, 109, 356-364. https://doi.org/10.1017/S0007485318000585

Callis-Duehl, K.L., McAuslane, H.J., Duehl A.J., and Levey.D.J . 2017. The effects of silica fertilizer as an anti-herbivore defense in cucumber. *Journal of Horticultural Research*25(1): 89-98.

Crop Production Guide 2021. Tamil Nadu Agricultural University, Coimbatore and Department of Agriculture, Government of Tamil Nadu, India Pp: 246-275.

Chandramani, P., Rajendran, R., Muthiah, C., and Chinniah, C. 2010. Organic source induced silica on leaf folder, stem borer and gall midge population and rice yield. *Journal of Biopesticide*3(2):423.

Chaudhary, D.M., Chaudharyand, M.M., Chaudhary, F. 2018. Evaluation of newer insecticidal formulation against sucking pests and effect on yield of soybean (*Glycine max* L.). *International Journal of Current Microbiology and Applied Science* 7(8):3834-3840.

Correa, R.S., Moraes, J.C., Auadand, A.M., Carvalho, G.A.2005. Silicon and acibenzolar-S-methyl as resistance inducers in cucumber, against the whitefly *Bemisia tabaci* (Gennadius)(Hemiptera: Aleyrodidae) biotype B. *Neotropical Entomology*34: 429-433.

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

Gomes, F.B., de Moraes, J.C., dos Santos, C.D., and Goussain, M.M. 2015. Resistance induction in wheat plants by silicon and aphids. *Scientific Agriculture* 62(6):547–551

Kumar, R.,Razvi S.M.S., and Ali, S. 2004. Seasonal and varietal variation in the population of whitefly (*Bemisia tabaci* Genn.) and incidence of yellow mosaic virus in urd and mungbean. *Indian Journal of Entomology* 66(2):155-158.

Meena, V., Dotaniya, M., Coumar, V., Rajendiran, S., Kundu, S., and Subba Rao, A. 2014. A case for silicon fertilization to improve crop yields in tropical soils. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences* 84(3): 505-518.

Moraes, J.C., Goussain, M.M., Carvalho, G.A., and Costa, R.R. 2005. Feeding non-preference of the corn leaf aphid *Rhopalosiphum maidis* (Fitch, 1856) (Hemiptera: Aphididae) to corn plants (*Zea mays* L.) treated with silicon. *Ciência e Agrotecnologia*29:761-766.

Nascimento, A.M., Assis, F.A., Moraes, J.C., Souza, B.H.S. 2018. Silicon application promotes rice growth and negatively affects development of *Spodoptera frugiperda* (J. E. Smith). *Journal of Applied Entomology* 142:241– 249. https://doi.org/10.1111/jen.12461

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, *Stethorusgilvifrons*(Col.: Coccinellidae) on two sugarcane commercial varieties. *Persian Journal of Acarology* 9(1):57-66.

Nitharwal, M., Kumawat, K.C., and Choudhary, M. 2013. Population dynamics of insect pests of Green gram, Vigna radiata in semi-arid region of Rajasthan. *Journal of Insect Science*. 26(1):90-92.

Parthiban, P., Chinniah, C., Murali Baskaran, R.K., Kalyanasundaram, M.,Suresh, K., and Karthick, S. 2019. Biochemical alternation and silicon accumulation in groundnut (*Arachishypogaea* L.) in response to root and foliar application of two sources of silicon. *Phosphorus, Sulfur and Silicon and the Related Elements*194:917–921. https://doi.org/10.1080/10426507.2019. 1576679

Ramírez-Godoy,A., del Pilar,V.H.M., Beltrán N.J.N ., and Díaz.H.R., 2018. Effect of potassium silicate application on populations of Asian Citrus Psyllid in Tahiti lime, *Hort Technology*28(5): 684–691.

Teixeira, N.C., Valim, J.O.S., and Campos, W.G. 2017. Silicon-mediated resistance against specialist insects in sap-sucking and leaf-chewing guilds in the Si non-accumulator collard. *Entomologia Experimentalis Et Applicata* 165: 94-108.

Tukey, J.W. 1977.Exploratory data analysis2: 131-160.

Yang, L., Han, Y.,Li, P., Wen L., and Hou, M. 2017. Silicon amendments to rice plants impairs sucking behaviours and population growth in the phloem feeder *Nilaparvata lugens* (Hemiptera: Delphacidae). *Scientific Reports* 7:1101. https://doi.org/10.1038/s41598-017-01060-4.