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Influence of calcium silicate application on the population of *Aproaerema modicella* Deventer (Lepidoptera: Gelechiidae) on groundnut

P. Parthiban*, C. Chinniah, R. K. Murali Baskaran[1], N. Muthukrishnan[2], D. S. Rajavel[3] and K. S. Karthick

Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai 625 104, Tamil Nadu, India; [1]ICAR-National Institute of Biotic Stress Management, Baronda, Raipur 493 225, Chhattisgarh, India; [2]Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India; [3]Regional Research Station, Tamil Nadu Agricultural University, Virudhunagar 626 107, Tamil Nadu, India. Email: parthitnau@gmail.com

ABSTRACT: Field experiments with foliar application of calcium silicate @ 2.0, 3.5 and 5.0 per cent, soil drenching of calcium silicate @ 10.0, 15.0 and 20.0 per cent and combination of foliar and soil drenching (@ 2.0% + 20.0%, 3.5% + 15.0% and 5.0% + 10.0%) were evaluated on 20 days old groundnut plant and compared with an untreated check. Application of calcium silicate *via* foliage and soil simultaneously @ 5 and 10 per cent on 20 days after dibbling of groundnut was effective to reduce the population of leaf miner and their leaflet damage, recording mean population of 5.25 nos. of larvae/10 plants and 16.46 per cent leaflet damage, respectively, while it was 12.25 nos. of larvae/10 plants and 27.95 per cent leaflet damage in untreated control. Reduction in population of leaf miner in groundnut might be due to silica induced plant defensive enzymes, however, the moderate reduction in population of leaf miner pest in groundnut can be well explained due to the high accumulation of silica in groundnut plants. © 2018 Association for Advancement of Entomology

KEY WORDS: Calcium silicate, groundnut leaf miner, management, silica

INTRODUCTION

Groundnut ranks first among oilseeds with high oil recovery (40%). Around 40 to 50 per cent of the pod output is used for oil production and the rest being used as seed and feed. Groundnut is a good source of niacin. In India, about 115 insect pest species have been recorded to cause damage to groundnut at various growth stages of the crop and also in the storage. Among these only 10 insects *viz*., leaf miner, white grub, leaf hopper, thrips, aphids, tobacco caterpillar, gram caterpillar, red hairy caterpillar, stem borer and termite, found to cause considerable yield loss. Silicon forms 27.8 per cent of the earth's crust next to oxygen (46.1%) (Haynes, 2014; Keeping *et al*., 2014; Pinto *et al*., 2014; Vasanthi *et al*., 2014). Silicon is concentrated at level equivalent to those of macro nutrients (Kamenidou *et al*., 2009). Plants absorb silicon in the form of monosilisic acid Si $(OH)_4$ which gets accumulated in cell walls as silica gel (Rodrigues and Datnoff, 2005). Accumulation rates of silicon in different plants may vary between 1 to 10 per cent of plant dry weight (Epstein, 1994) and

* Author for correspondence

monocots store more silicon than dicots (Rodrigues *et al*., 2001). It is often several times higher than the rate of accumulation of other essential macro nutrients such as nitrogen, phosphorus and potassium (Nakata *et al*., 2008). The minimum amount of silicon needed to withstand the abiotic and biotic stresses in various plants is 3 to 5 per cent (Datnoff *et al*., 1997). Accumulated silicon in rice plants enhances resistance against insects and diseases, increases erectness of leaves resulting in increased photosynthesis, improves water usage, and decreases toxicity due to heavy metals and cuticular transpiration (Nakata *et al*., 2008). Besides, the positive effects which have been mentioned for silicon, its presence in plant tissue at high concentrations does not cause any toxicity or damage to the plant (Ma *et al*., 2006).

MATERIALS AND METHODS

Field experiments were conducted during April 2015 – July 2015 and January 2016 – April 2016 in an area of 25 cents in average weather condition of 30 ± 2^0C and 79 ± 5 % RH at farmers' holdings, Azhagarkovil, Madurai District, Tamil Nadu, India. The experiment was carried out in a randomized block design and each treatment was replicated thrice. Groundnut (cv. VRI 2) seeds were sown in the field at a spacing of 30 x 10 cm. All the standard package of practices recommended for the crops were followed except plant protection measures. Various treatments including foliar application of calcium silicate @ 2.0, 3.5 and 5.0 per cent, soil drenching of calcium silicate @ 10.0, 15.0 and 20.0 per cent and application of calcium silicate *via* foliage and soil were done separately on 20 days old groundnut seedlings. The population of leaf miner, *Aproaerema modicella* Deventer (number of larvae/10 plants) were recorded at ten days interval, starting from 20 days after sowing on ten plants selected at random/replication. The per cent reduction over untreated control for each treatment was calculated for further analysis.

Data on population of leaf miner and leaflet damage were subject to square root and arcsine transformation before subjecting to two way ANOVA using IRRISTAT software version 6.5. The difference between the means of various treatments was compared with LSD test at 5% significance level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Population of leaf miner: With reference to the incidence of *A. modicella*, T_9 recorded significantly the lowest mean population of 5.25 larvae/10 plants with per cent reduction of 57.14 per cent, compared to untreated control (5.25 larvae/10 plants) (Table 1) which was significantly superior to the remaining treatments, followed by T_8, which registered the mean population (5.63 larvae/10 plants; 54.04%) and T_3 (5.83 larvae/10 plants; 52.41%) which were on par statistically with reference to *A. modicella*, followed by T_7 (6.17 larvae/10 plants; 49.63%), T_2 (6.17 larvae/10 plants; 49.63%), T_1 (6.96 larvae/ 10 plants; 43.18%), T_6 (7.00 larvae/10 plants; 42.86%), T_5 (7.46 larvae/10 plants; 39.10%) and T_4 (7.75 larvae/10 plants; 36.73%), and control was recorded the 12.25 larvae/10 plants. On 20 DAS, no significant difference was noticed between treatments on the incidence of leaf miner, while on 30 DAS, the lowest mean population was recorded in T_9 (3.67 larvae/10 plants), followed by T_3 (4.00 larvae/10 plants), T_8 (4.33 larvae/10 plants), T_2 (4.33 larvae/10 plants), T_7 (4.67 larvae/10 plants), T_1 (4.67 larvae/10 plants), T_6 (5.00 larvae/10 plants), T_5 (5.00 larvae/10 plants) and T_4 (5.33 larvae/10 plants) which were significantly different from each other with reference to *A. modicella*. Similar trend was noticed on 40, 50, 60, 70 and 80 DAS in various treatments.

Leaflet damage: Among different treatments tried for the management of *A. modicella* in groundnut, T_9 recorded the lowest mean leaflet damage of 16.46 per cent, followed by T_8 (17.03%) and T_3 (17.50%) which were on par statistically (Table 2), followed by T_2 (18.13%), T_7 (18.15%), T_1 (19.31%), T_6 (19.34%), T_5 (20.01%) and T_4 (20.83%), while control plot recorded 27.95 per cent leaflet damage by *A. modicella*. There was no significant difference between treatments on 20 DAS. Same trend was noticed on 30, 40, 50, 60, 70, 80 and 90 DAS also in various treatments.

Numerous studies have proven that silicon application could increase the pest resistance of

Table 1. Population of *Aproaerema modicella* Deventer in groundnut ecosystem as influenced by silica nutrition (Pooled analysis)

	Treatments	Population of *A. modicella* (No. of larvae / 10 plants)**									% reduction over untreated control
		20 DAS***	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	Mean	
T_1	Foliar spray of calcium silicate @ 2.0 %	2.33 (1.53)	4.67 $(2.16)^{bcd}$	7.67 $(2.77)^{cd}$	11.00 $(3.32)^{de}$	9.00 $(3.00)^{cd}$	8.00 $(2.83)^{cd}$	7.67 $(2.77)^{cd}$	5.33 $(2.31)^{c}$	6.96 $(2.64)^{cd}$	43.18
T_2	Foliar spray of calcium silicate @ 3.5 %	2.00 (1.41)	4.33 $(2.08)^{abc}$	7.00 $(2.65)^{bc}$	10.33 $(3.21)^{cd}$	8.33 $(2.89)^{abc}$	7.33 $(2.71)^{bc}$	5.67 $(2.38)^{b}$	4.33 $(2.08)^{b}$	6.17 $(2.48)^{bc}$	49.63
T_3	Foliar spray of calcium silicate @ 5.0 %	2.33 (1.53)	4.00 $(2.00)^{ab}$	6.33 $(2.52)^{ab}$	9.00 $(3.00)^{ab}$	8.33 $(2.89)^{abc}$	7.00 $(2.65)^{b}$	5.67 $(2.38)^{b}$	4.00 $(2.00)^{ab}$	5.83 $(2.41)^{ab}$	52.41
T_4	Drenching of calcium silicate @ 10.0 %	1.67 (1.29)	5.33 $(2.31)^{de}$	8.67 $(2.94)^{e}$	12.00 $(3.46)^{f}$	10.33 $(3.21)^{e}$	9.00 $(3.00)^{e}$	8.00 $(2.83)^{d}$	7.00 $(2.65)^{d}$	7.75 $(2.78)^{d}$	36.73
T_5	Drenching of calcium silicate @ 15.0 %	2.00 (1.41)	5.00 $(2.24)^{cde}$	8.33 $(2.89)^{de}$	11.67 $(3.42)^{ef}$	10.00 $(3.16)^{e}$	9.00 $(3.00)^{e}$	7.33 $(2.71)^{cd}$	6.33 $(2.52)^{d}$	7.46 $(2.73)^{d}$	39.10
T_6	Drenching of calcium silicate @ 20.0 %	2.33 (1.53)	5.00 $(2.24)^{cde}$	8.00 $(2.83)^{de}$	10.67 $(3.27)^{d}$	9.33 $(3.05)^{d}$	8.33 $(2.89)^{de}$	7.00 $(2.65)^{c}$	5.33 $(2.31)^{c}$	7.00 $(2.65)^{cd}$	42.86
T_7	T_1 + Drenching of calcium silicate @ 20.0 %	2.00 (1.41)	4.67 $(2.16)^{bcd}$	6.67 $(2.58)^{ab}$	9.67 $(3.11)^{bc}$	8.67 $(2.94)^{bcd}$	7.33 $(2.71)^{bc}$	6.00 $(2.45)^{b}$	4.33 $(2.08)^{b}$	6.17 $(2.48)^{bc}$	49.63
T_8	T_2 + Drenching of calcium silicate @ 15.0 %	1.67 (1.29)	4.33 $(2.08)^{abc}$	6.33 $(2.52)^{ab}$	9.00 $(3.00)^{ab}$	8.00 $(2.83)^{ab}$	6.67 $(2.58)^{ab}$	5.33 $(2.31)^{ab}$	3.67 $(1.92)^{ab}$	5.63 $(2.37)^{ab}$	54.04
T_9	T_3 + Drenching of calcium silicate @ 10.0 %	2.33 (1.53)	3.67 $(1.92)^{a}$	6.00 $(2.45)^{a}$	8.33 $(2.89)^{a}$	7.67 $(2.77)^{a}$	6.00 $(2.45)^{a}$	4.67 $(2.16)^{a}$	3.33 $(1.82)^{a}$	5.25 $(2.29)^{a}$	57.14
T_{10}	Untreated control	1.67 (1.29)	5.67 $(2.38)^{e}$	9.67 $(3.11)^{f}$	13.00 $(3.61)^{g}$	15.33 $(3.92)^{g}$	18.33 $(4.28)^{f}$	18.00 $(4.24)^{e}$	16.33 $(4.04)^{e}$	12.25 $(3.50)^{e}$	—
	SEd	NS*	0.0964	0.0765	0.0643	0.0686	0.0740	0.0819	0.0952	0.0805	—
	CD (P=0.05)	NS	0.2026	0.1608	0.1351	0.1440	0.1555	0.1720	0.2000	0.1691	—

*NS: Non significant; ** Mean of three replications ***DAS: Days after sowing Figures in parentheses are square root transformed values
In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05)

Table 2. Per cent leaflet damage by *A. modicella* in groundnut ecosystem as influenced by silica nutrition (Pooled analysis)

	Treatments	% leaflet damage**									% reduction over untreated control
		20 DAS***	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	Mean	
T_1	Foliar spray of calcium silicate @ 2.0 %	15.43 (23.13)	15.79 (23.41)^{bcd}	19.04 (25.87)^{c}	25.04 (30.03)^{de}	24.61 (29.74)^{d}	20.21 (26.71)^{e}	18.72 (25.64)^{e}	15.62 (23.28)^{d}	19.31 (26.09)^{d}	30.91
T_2	Foliar spray of calcium silicate @ 3.5 %	15.11 (22.87)	15.24 (22.98)^{abc}	18.13 (25.20)^{ab}	23.12 (28.74)^{c}	23.05 (28.69)^{c}	19.16 (25.96)^{d}	16.01 (23.59)^{c}	15.24 (22.98)^{d}	18.13 (25.20)^{c}	35.13
T_3	Foliar spray of calcium silicate @ 5.0 %	15.69 (23.33)	15.16 (22.91)^{ab}	17.96 (25.07)^{a}	22.14 (28.07)^{b}	21.19 (27.41)^{b}	17.84 (24.98)^{bc}	15.73 (23.37)^{bc}	14.31 (22.23)^{bc}	17.50 (24.73)^{bc}	37.13
T_4	Drenching of calcium silicate @ 10.0 %	14.86 (22.67)	16.67 (24.10)^{ef}	20.02 (26.58)^{d}	27.14 (31.40)^{f}	26.23 (30.81)^{e}	23.12 (28.74)^{g}	20.34 (26.81)^{f}	18.26 (25.30)^{f}	20.83 (27.15)^{e}	25.47
T_5	Drenching of calcium silicate @ 15.0 %	15.19 (22.94)	16.26 (23.78)^{def}	19.59 (26.27)^{cd}	25.87 (30.37)^{e}	25.12 (30.08)^{d}	21.46 (27.60)^{f}	19.46 (26.18)^{ef}	17.14 (24.46)^{e}	20.01 (26.57)^{de}	28.41
T_6	Drenching of calcium silicate @ 20.0 %	15.54 (23.22)	16.04 (23.61)^{cde}	18.95 (25.80)^{bc}	24.95 (29.97)^{d}	24.65 (29.77)^{d}	20.34 (26.81)^{e}	18.65 (25.58)^{e}	15.56 (23.23)^{d}	19.34 (26.09)^{d}	30.81
T_7	T_1 + Drenching of calcium silicate @ 20.0 %	15.09 (22.86)	15.65 (23.30)^{abcd}	18.02 (25.12)^{a}	22.47 (28.30)^{bc}	23.16 (28.77)^{c}	18.65 (25.58)^{cd}	17.21 (24.51)^{d}	14.96 (22.75)^{cd}	18.15 (25.21)^{c}	35.06
T_8	T_2 + Drenching of calcium silicate @ 15.0 %	14.96 (22.75)	15.22 (22.96)^{abc}	17.62 (24.82)^{a}	22.11 (28.05)^{b}	20.32 (26.79)^{a}	17.06 (24.39)^{b}	15.12 (22.88)^{ab}	13.85 (21.85)^{ab}	17.03 (24.37)^{ab}	39.07
T_9	T_3 + Drenching of calcium silicate @ 10.0 %	15.66 (23.31)	14.84 (22.66)^{a}	17.46 (24.70)^{a}	20.06 (26.61)^{a}	19.64 (26.31)^{a}	16.23 (23.76)^{a}	14.64 (22.49)^{a}	13.12 (21.23)^{a}	16.46 (23.93)^{a}	41.11
T_{10}	Untreated control	14.92 (22.72)	17.13 (22.45)^{f}	21.36 (27.53)^{e}	29.63 (32.98)^{g}	34.05 (35.70)^{f}	37.19 (37.58)^{h}	36.21 (37.00)^{g}	33.14 (35.15)^{g}	27.95 (31.92)^{f}	—
	SEd	NS*	0.3217	0.3007	0.2761	0.2777	0.2962	0.3093	0.3235	0.3005	—
	CD (P=0.05)	NS	0.6760	0.6318	0.5801	0.5834	0.6222	0.6498	0.6796	0.6313	

*NS: Non significant; **Mean of three replications ***DAS: Days after sowing Figures in parentheses are arcsine transformed values
In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05)

many plant species (Datnoff *et al*., 1997). Silica fertilizer could be an environmental friendly alternative to control crop pests. The mechanisms of Si-induced resistance of plants to pests result from its association with cell wall components. The induced resistance of plants to insects is a potential strategy in the integrated pest management aiming the reduction of deleterious effects of chemical compounds. Among the various treatments, foliar spray of calcium silicate @ 5.0% + drenching of calcium silicate @ 10.0% treatment (T_9) was the best in reducing the population of leaf miner and their leaflet damage, recording mean population of 5.25 nos. of larvae/10 plants and 16.46 per cent leaflet damage, respectively, while it was 12.25 nos. of larvae/10 plants and 27.95 per cent leaflet damage in untreated control.

The outcome of the present study modify the usage with the findings of Tayabi and Azizi (1984) concluded that the application of silica @ 1 tonne / ha reduced the incidence of stem borer, *Scirpophaga incertulas* in rice. Mandras (1991) pointed out that the harder epidermal cells on stems and leaf sheaths in response to silica addition delayed larval penetration. The present study modify with the report of Ranganathan *et al*. (2006) who showed that addition of silicon led to reduction of damage due to yellow stem borer (*Scirpophaga incertulas*) which could be attributed to the reduced preference as well as digestibility of the host leaves and straw by the insect owing to the presence of higher silica content. Voleti *et al*. (2008) who also suggested that the application of silica to rice, stem borer damage was significantly reduced and enhanced the solubilization of silica by 3 to 5 fold as indicated by the augmented silica acid present in stem of the rice plant and that of silica in rice leaves.

Anderson and Sosa (2001) who also stated that the application of various sources of Si including bagasse furnace ash, silica slag, potash and calcium silicate have also reduced infestation and crop damage by sugarcane stem borers *viz*., *Scirpophaga excerptalis* and *Diatraea saccharalis*. This is again in line with the findings of Camargo *et al*. (2010) who reported that silicate-induced Si accumulation in sugarcane resulted in partial control of the sugarcane borer *D. saccharalis*.

Coors (1987) demonstrated that high levels of silica in leaves of beetroot decreased the digestibility of *Spodoptera eridania* apart from increased consumption rate. Goussain *et al*. (2002) proved that *Spodoptera frugiperda* (Smith) larvae displayed increased mortality, cannibalism and mandibular wear after feeding on corn plants applied with Si. Massey *et al*. (2006) also too proved that provision of Si increased abrasiveness of the leaves of four or five grass species studied, while changing the relative palatability of the grasses, deterring feeding, reducing the growth rates and feeding efficiency of two generalist insect, *Spodoptera exempta* and *Schistocerca gregaria*. Parrella *et al*. (2007) proved a signiûcant reduction in leaf miner emergence in chrysanthemum plants treated (root dipping) with potassium silicate @ 200 ppm. Almeida *et al*. (2009) stated that application of calcium silicate reduces the *Frankliniella schultzei* Trybon incidence on tomato. Similarly, Hou and Han (2010) reported silica amendment that reduces the *Chilo suppressalis* incidence (Walker) in rice. Shalaby (2011) reported magnesium and sodium silicate also suppressed cotton leaf worm, *Spodoptera littoralis* Boisd damage on sugar beet. Han *et al*. (2015) who confirmed that the silicon amendment, @ 0.16 and 0.32 g Si/kg soil, enhanced the resistance level of a susceptible rice variety against rice leaf folder. It is concluded that application of calcium silicate *via* foliage and soil @ 5 and 10%, respectively on 20 days after dibbling of groundnut, though reduced the population of *A. modicella* in groundnut.

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