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P Parthiban
Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

C Chinniah
Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

RKM Baskaran
ICAR-National Institute of Biotic Stress Management, Baronda, Raipur, Chhattisgarh, India

DS Rajavel
Department of Entomology, Regional Research Station, Tamil Nadu Agricultural University, Virudhunagar, Tamil Nadu, India

M Kalyanasundaram
Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

K Suresh
Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

Correspondence
P Parthiban
Department of Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

Influence of Silica nutrition on the population of natural enemies of groundnut (*Arachis hypogaea* L.)

P Parthiban, C Chinniah, RKM Baskaran, DS Rajavel, M Kalyanasundaram and K Suresh

Abstract
Foliar application of calcium silicate @ 2.0, 3.5 and 5.0%, soil drenching of calcium silicate @ 10.0, 15.0 and 20.0% and a combination of foliar and soil drenching @ 2.0% + 20.0%, 3.5% + 15.0% and 5.0% + 10.0% were evaluated on 20 day old groundnut plant (Cv. VRI 2) and compared with untreated check during April 2015 – July 2015 with a weather condition of 30 ± 2^{0}C and 79 ± 5% RH at farmers' holdings, Azhagarkovil, Madurai District, Tamil Nadu, India. Application of calcium silicate @ 2.0, 3.5 and 5.0%, soil drenching of calcium silicate @ 10.0, 15.0 and 20.0% and combination of foliar and soil drenching @ 2.0% + 20.0%, 3.5% + 15.0% and 5.0% + 10.0% on 20 days after dibbling of groundnut was on the activity and diversity of natural enemies viz., coccinellids (*Cheilomenes sexmaculatus* (L.) and *Coccinella transversalis* Fabricius), spiders (*Oxyopes salticus* Hentz) and *Chrysoperla zastrowi sillemi* (Esben-Peterson) in groundnut ecosystem, all treatments including untreated control recorded equal population of natural enemies and also per cent field recovery of *Trichogramma chilonis* Ishii and *T. japonicum* were almost equal.

Keywords: Calcium silicate, Groundnut, Natural enemies, Safe

Introduction
Silicon forms 27.8 per cent of the earth's crust next to oxygen (46.1%) [1]. Silicon is concentrated at level equivalent to those of macro nutrients [2]. Plants absorb silicon in the form of monosilisic acid Si $(OH)_4$ which gets accumulated in cell walls as silica gel [3]. Accumulation rates of silicon in different plants may vary between 1 to 10 per cent of plant dry weight [4] and monocots store more silicon than dicots [5]. It is often several times higher than the rate of accumulation of other essential macro nutrients such as nitrogen, phosphorus and potassium [6].

Silicon can improve the host plant defense through the third trophic level, enhancing the attraction of natural enemies, with the consequent biological control by the induction of plant resistance likely through different volatile compounds produced by insect attacked plants. Population of mirids, spiders and *Paederus* sp. was slightly changed when more silica nutrition was given [7].

Messina and Sorenson [8] observed greater effectiveness of the predator *Chrysoperla plorabunda* (Fitch) on resistant wheat plants, where low populations of the aphid *Diuraphis noxia* (Mordvilko) were found, Also the development and longevity of *Aphidius colemani* (Viereck) was not affected when the insect developed on aphids reared on plants treated with silicon, thus showing its compatibility with biological control. Moraes *et al.* [9] found Si fertilization of wheat had no tri-trophic effect on the biological life parameters of two beneficial arthropods *Chrysoperla externa* (Hagen) and *A. colemani* when fed with diet of greenbug, *Schizaphis graminum* (Rondani) which in turn was feeding on Silicon treated wheat. Hence the present field experiment was conducted during April 2015 – July 2015 under unprotected condition of farmer's holding.

2. Materials and Methods
Field experiment was conducted during April 2015 – July 2015 in an area of 25 cents in a weather condition of 30 ± 2^{0}C 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%, soil drenching of calcium silicate @ 10.0, 15.0 and 20.0% and application of calcium silicate *via* foliage and soil were imparted separately on 20 days old groundnut seedlings.

Population of coccinellids, spiders and green lacewings (numbers/10 plants) were recorded at ten day interval, starting from 30 and 40 days after sowing on ten plants selected at random in each replication.

The *Corcyra* egg cards were placed and per cent field recovery of *Trichogramma chilonis Ishii* and *T. japonicum* Ashmead was recorded at 15 days interval, commencing from 45th day after sowing in each intercropping and pure crop system, replication wise.

2.1 Statistical analysis: Field experiment was conducted in a Randomized Block Design. Data on population of leaf hopper, aphids and thrips were subject to square root 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.

3. Results and Discussion

Observation on the activity and diversity of natural enemies viz., coccinellids (*Cheilomenes sexmaculatus* (L.) and *Coccinella transversalis* Fabricius), spiders (*Oxyopes salticus* Hentz) and *Chrysoperla zastrowi sillemi* (Esben-Peterson) in groundnut ecosystem, imposed with various sources silica nutrition, corroborated that all treatments including untreated control recorded equal population of natural enemies and the mean population ranged from 6.06 to 6.78 nos./10 plants for coccinellids, 2.78 to 3.17 nos./10 plants for spider population, whereas the *C. zastrowi sillemi* population ranged from 3.40 to 3.73 nos./10 plants (Table 1, 2 & 3).

With regard to per cent recovery of egg parasitoids, there was no significant difference among the treatments during 45, 60 and 75 DAS and the mean percentage ranged from 7.09 to 7.64 per cent of field recovery of egg parasitoid (Table 4).

In the present study, the population of natural enemies *viz*., coccinellids, spiders and *Chrysoperla zastrowi sillemi* in groundnut ecosystem, imposed by with various sources of silica nutrition, corroborated that all treatments including an untreated control recorded equal population of natural enemies and the mean population ranged from 6.06 to 6.78 nos./10 plants for coccinellids, 2.78 to 3.17 nos./10 plants for spiders, 3.40 to 3.73 nos./10 plants for *C. zastrowi sillemi.* With regard to per cent recovery of egg parasitoids, there was no significant difference among the treatments and the mean percentage ranged from 7.09 to 7.64 per cent of field recovery of egg parasitoid. This is in agreement with the findings of Slansky and Rodriguez (1987) [7] who suggested that the population of mirids, spiders and rove beetles were not significantly changed when applying more silica nutrition. Schmutter [10] observed that organic nutrition was safer to wolf spider, *Lycosa psuedoannulata* Boes in field condition.

Similarly, Katti *et al*. [11] recorded no activity of parasitoids on yellow stem borer and 11.8 and 8 to 10 per cent parasitism on gall midge and leaf folder with lower population of predatory spiders (0-5/25 hills) and mirid bugs (0-3/25 hills) in schedule based protected rice. Whereas Moraes *et al.* [12] found that Si application on wheat crop had no tri-trophic effect on the biological parameters of two beneficial arthropods *Chrysoperla externa* (Hagen) and *Aphidius colemani* (Viereck) fed with green bug *Schizaphis graminum* (Rondani) which in turn was fed with Si-treated wheat.

Reynolds *et al*. [13] and Pinto *et al.* [14] reported that silica enhances the natural enemies on cucumber crop. It is concluded that the application of calcium silicate *via* spraying and soil application at the rate of 5 and 10%, respectively on 20 day after dibbling of groundnut, though safe the population of natural enemies in groundnut moderately which can be enhanced by including calcium silicate as one of the components in IPM, besides for easy adoption by the farmers as calcium silicate is readily available in the market.

Table 1: Diversity of natural enemies (Coccinellids) in the groundnut ecosystem as influenced by silica nutrition (Field experiment II) (Season: Summer 2015)

Treatments		Population of Coccinellids (Nos. / 10 plants)**						Mean
		30 DAS***	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	
T_1	Foliar spray of calcium silicate @ 2.0%	2.67 (1.63)	4.00 (2.00)	6.33 (2.52)	8.67 (2.94)	9.00 (3.00)	8.67 (2.94)	6.56 (2.56)
T_2	Foliar spray of calcium silicate @ 3.5%	2.33 (1.53)	3.67 (1.92)	6.00 (2.45)	8.33 (2.89)	8.67 (2.94)	8.00 (2.83)	6.17 (2.48)
T_3	Foliar spray of calcium silicate @ 5.0%	2.33 (1.53)	3.67 (1.92)	6.00 (2.45)	7.67 (2.77)	8.67 (2.94)	8.00 (2.83)	6.06 (2.46)
T_4	Drenching of calcium silicate @ 10.0%	3.33 (1.82)	4.33 (2.08)	6.33 (2.52)	8.33 (2.89)	9.00 (3.00)	8.67 (2.94)	6.67 (2.58)
T_5	Drenching of calcium silicate @ 15.0%	3.00 (1.73)	4.33 (2.08)	6.00 (2.45)	8.00 (2.83)	9.33 (3.05)	9.00 (3.00)	6.61 (2.57)
T_6	Drenching of calcium silicate @ 20.0%	3.00 (1.73)	4.00 (2.00)	6.00 (2.45)	8.00 (2.83)	9.67 (3.11)	9.00 (3.00)	6.61 (2.57)
T_7	T_1 + Drenching of calcium silicate @ 20.0%	2.67 (1.63)	3.67 (1.92)	5.67 (2.38)	8.33 (2.89)	9.00 (3.00)	8.67 (2.94)	6.34 (2.52)
T_8	T_2 + Drenching of calcium silicate @ 15.0%	2.33 (1.53)	3.33 (1.82)	6.33 (2.52)	8.00 (2.83)	9.67 (3.11)	8.33 (2.89)	6.33 (2.52)
T_9	T_3 + Drenching of calcium silicate @ 10.0%	2.33 (1.53)	3.33 (1.82)	6.00 (2.45)	8.00 (2.83)	9.33 (3.05)	8.00 (2.83)	6.17 (2.48)
T_{10}	Untreated control	3.33 (1.82)	4.67 (2.16)	6.33 (2.52)	8.33 (2.89)	9.33 (3.05)	8.67 (2.94)	6.78 (2.60)
SEd		NS	NS	NS	NS	NS	NS	NS
CD (P=0.05)		NS	NS	NS	NS	NS	NS	NS

*NS: Non significant

**Each value is the mean of three replications

***DAS: Days after sowing

Figures in parentheses are square root transformed values

Table 2: Diversity of natural enemies (Spiders) in the groundnut ecosystem as influenced by silica nutrition (Field experiment II) (Season: Summer 2015)

Treatments		Population of Spiders (Nos. / 10 plants)**						Mean
		30 DAS***	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	
T_1	Foliar spray of calcium silicate @ 2.0%	1.67 (1.29)	2.00 (1.41)	3.33 (1.82)	4.00 (2.00)	3.33 (1.82)	3.33 (1.82)	2.94 (1.71)
T_2	Foliar spray of calcium silicate @ 3.5%	1.33 (1.15)	2.00 (1.41)	3.33 (1.82)	3.67 (1.92)	3.67 (1.92)	3.00 (1.73)	2.83 (1.68)
T_3	Foliar spray of calcium silicate @ 5.0%	1.33 (1.15)	2.33 (1.53)	3.00 (1.73)	3.67 (1.92)	4.00 (2.00)	3.00 (1.73)	2.89 (1.70)
T_4	Drenching of calcium silicate @ 10.0%	2.00 (1.41)	2.33 (1.53)	3.67 (1.92)	3.33 (1.82)	3.67 (1.92)	3.67 (1.92)	3.11 (1.76)
T_5	Drenching of calcium silicate @ 15.0%	2.00 (1.41)	2.00 (1.41)	3.67 (1.92)	4.00 (2.00)	3.33 (1.82)	3.33 (1.82)	3.06 (1.75)
T_6	Drenching of calcium silicate @ 20.0%	1.67 (1.29)	2.33 (1.53)	3.33 (1.82)	3.33 (1.82)	3.67 (1.92)	3.00 (1.73)	2.89 (1.70)
T_7	T_1 + Drenching of calcium silicate @ 20.0%	1.67 (1.29)	2.00 (1.41)	3.00 (1.73)	4.33 (2.08)	3.33 (1.82)	3.33 (1.82)	2.94 (1.71)
T_8	T_2 + Drenching of calcium silicate @ 15.0%	1.67 (1.29)	2.00 (1.41)	3.67 (1.92)	3.67 (1.92)	3.33 (1.82)	3.00 (1.82)	2.89 (1.70)
T_9	T_3 + Drenching of calcium silicate @ 10.0%	1.33 (1.15)	1.67 (1.29)	3.33 (1.82)	3.33 (1.82)	4.00 (2.00)	3.00 (1.82)	2.78 (1.67)
T_{10}	Untreated control	2.00 (1.41)	2.33 (1.53)	3.33 (1.82)	3.67 (1.92)	3.67 (1.92)	4.00 (2.00)	3.17 (1.78)
SEd		NS*	NS	NS	NS	NS	NS	NS
CD (P=0.05)		NS	NS	NS	NS	NS	NS	NS

*NS: Non significant
**Each value is the mean of three replications
***DAS: Days after sowing
Figures in parentheses are square root transformed values

Table 3: Diversity of natural enemies (*Chrysoperla zastrowi sillemi* Esben-Peterson) in the groundnut ecosystem as influenced by silica nutrition (Field experiment II) (Season: Summer 2015)

Treatments		Population of *C. zastrowi sillemi* (Nos. / 10 plants)**					Mean
		40 DAS**	50 DAS	60 DAS	70 DAS	80 DAS	
T_1	Foliar spray of calcium silicate @ 2.0%	2.00 (1.41)	2.33 (1.53)	3.67 (1.92)	5.00 (2.24)	4.67 (2.16)	3.53 (1.88)
T_2	Foliar spray of calcium silicate @ 3.5%	1.67 (1.29)	2.67 (1.63)	3.67 (1.92)	4.67 (2.16)	4.33 (2.08)	3.40 (1.84)
T_3	Foliar spray of calcium silicate @ 5.0%	1.67 (1.29)	2.33 (1.53)	4.00 (2.00)	5.00 (2.24)	4.67 (2.16)	3.53 (1.88)
T_4	Drenching of calcium silicate @ 10.0%	2.33 (1.53)	2.00 (1.41)	4.33 (2.08)	4.00 (2.00)	5.33 (2.31)	3.60 (1.90)
T_5	Drenching of calcium silicate @ 15.0%	2.33 (1.53)	2.33 (1.53)	3.67 (1.92)	5.33 (2.31)	4.33 (2.08)	3.60 (1.90)
T_6	Drenching of calcium silicate @ 20.0%	2.00 (1.41)	2.67 (1.63)	3.67 (1.92)	4.67 (2.16)	4.33 (2.08)	3.47 (1.86)
T_7	T_1 + Drenching of calcium silicate @ 20.0%	1.67 (1.29)	2.67 (1.63)	4.00 (2.00)	4.33 (2.08)	4.67 (2.16)	3.47 (1.86)
T_8	T_2 + Drenching of calcium silicate @ 15.0%	2.33 (1.53)	2.33 (1.53)	3.67 (1.92)	4.33 (2.08)	5.00 (2.24)	3.53 (1.88)
T_9	T_3 + Drenching of calcium silicate @ 10.0%	1.67 (1.29)	2.33 (1.53)	4.33 (2.08)	5.00 (2.24)	4.33 (2.08)	3.53 (1.88)
T_{10}	Untreated control	2.00(1.41)	2.67 (1.63)	4.00 (2.00)	4.67 (2.16)	5.33 (2.31)	3.73 (1.93)
SEd		NS*	NS	NS	NS	NS	NS
CD (P=0.05)		NS	NS	NS	NS	NS	NS

*NS: Non significant
**Each value is the mean of three replications
***DAS: Days after sowing
Figures in parentheses are square root transformed values

Table 4: Per cent field recovery of egg parasitoids (*Trichogramma chilonis* Ishii and *T. japonicum* Ashmead) in the groundnut ecosystem as influenced by silica nutrition (Field experiment II) (Season: Summer 2015)

Treatments		% field recovery**			Mean
		45 DAS***	60 DAS	75 DAS	
T_1	Foliar spray of calcium silicate @ 2.0%	4.12 (11.69)	8.24 (16.67)	9.36 (17.81)	7.24 (23.26)
T_2	Foliar spray of calcium silicate @ 3.5%	3.96 (11.46)	8.56 (17.01)	10.06 (18.49)	7.53 (23.52)
T_3	Foliar spray of calcium silicate @ 5.0%	3.92 (11.40)	8.13 (16.56)	9.22 (17.67)	7.09 (23.13)
T_4	Drenching of calcium silicate @ 10.0%	4.57 (12.34)	7.96 (16.38)	10.18 (18.60)	7.57 (23.55)
T_5	Drenching of calcium silicate @ 15.0%	4.32 (11.99)	8.86 (17.31)	9.75 (18.19)	7.64 (23.61)
T_6	Drenching of calcium silicate @ 20.0%	4.14 (11.73)	8.46 (16.91)	9.20 (17.65)	7.27 (23.29)
T_7	T_1 + Drenching of calcium silicate @ 20.0%	4.04 (11.57)	8.28 (16.72)	9.86 (18.30)	7.39 (23.39)
T_8	T_2 + Drenching of calcium silicate @ 15.0%	3.92 (11.40)	7.95 (16.37)	9.74 (18.18)	7.20 (23.23)
T_9	T_3 + Drenching of calcium silicate @ 10.0%	4.01 (11.54)	8.72 (17.17)	10.03 (18.46)	7.59 (23.57)
T_{10}	Untreated control	4.86(12.73)	7.94 (16.36)	9.25 (17.70)	7.35 (23.36)
SEd		NS*	NS	NS	NS
CD (P=0.05)		NS	NS	NS	NS

*NS: Non significant
**Each value is the mean of three replications
***DAS: Days after sowing
Figures in parentheses are arcsine transformed values

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