

Study of Potassium Silicate Spraying in Coffee Plants to Control *Oligonychus ilicis* (McGregor) (Acari: Tetranychidae)

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Abstract

The southern red mite, *Oligonychus ilicis* (McGregor) (Acari: Tetranychidae) can cause a significant reduction in the photosynthesis potential and the growth of new coffee plants (*Coffea* spp., Rubiaceae). Studies suggest that the leaf spraying of silicon (Si) leads to increase plants resistance in order to reduce infestations of insect pests such as herbivores, borers, sucking insects and mites. The objective of this study was to evaluate the effect of leaf spraying of potassium silicate (K_2SiO_3) to control the southern red mite in coffee plants. Experiments were conducted in coffee plants (*Coffea arabica* L.), grown in a greenhouse, by means of completely randomized design with six treatments: Dose 0 (control), 2, 4, 6, 8 and 10 liters of silicate potassium ha^{-1} and five replications. Plants treated with potassium silicate, regardless of the applied dose, had a lower *O. ilicis* infestation compared to the control, not allowing the population increase, thus a smaller damage in coffee leaves. The silicon content in leaves was higher in plants treated with the highest dose of potassium silicate. It was observed that there was induction of defense molecules such as tannins and lignin in plants sprayed with potassium silicate. It was concluded that the potassium silicate applied in leaf spraying had positive effect on reducing *O. ilicis* attack in coffee plants, even being a dicot. Therefore, the applications of potassium silicate by leaf spraying can be used in programs of integrated management of the southern red mite in coffee, with a view to sustainable management and environmental protection.

Keywords

Induced Resistance, Agricultural Acarology, Silicon, Integrated Pest Management, Potassium Metasilicate

1. Introduction

The southern red mite, *Oligonychus ilicis* (McGregor) (Acari: Tetranychidae), is an important pest of the coffee plantations (*Coffea* spp., Rubiaceae) in all producing regions of Brazil. This mite lives in the upper surface of the leaves and pierce the cells of the epidermis and mesophyll for their feeding and absorbs part of the cellular content that overflows [1]. As a consequence, the leaves lose their natural brightness, become tanned, with a reduction of up to 50% in the potential of photosynthesis [2] and delayed growth of new plants [3], resulting in damage to the development of plants and in coffee production [4] [2]. The continued use of chemical acaricides to control the *O. ilicis* mite population may result in resistant specimens among the mite population, as well as the possibility of causing resistance in other pests of coffee and affecting human health due to high amounts of toxic waste [1] [5] [6] [7].

Studies suggest that the application of silicon (Si) leads to increase resistance of plants in order to prevent the development of pests and diseases and thus enable a more sustainable agriculture [8]. And has been shown to reduce infestations of insect pests such as herbivores, borers, sucking insects, and mites [9] [10] [11].

Positive effects on the use of Si are evident in the reduction of feeding time of the aphid *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) in wheat (*Triticum aestivum* L., Poaceae) [12], protection of cucumber plant (*Cucumis sativa* L., Cucurbitaceae), eggplant (*Solanum melongena* L., Solanaceae), common bean (*Phaseolus vulgaris* L., Fabaceae) and corn (*Zea mays* L., Poaceae) against the two-spotted spider mite, *Tetranychus urticae* Koch (Tetranychidae) [13] and reduced the palatability of sunflower leaves (*Helianthus annuus* L., Asteraceae) to the attack of caterpillar *Chlosyne lacinia saundersii* Doubleday (Lepidoptera: Nymphalidae) [14].

The silicon implementation efficiency can also be observed in the third trophic level, as shown in experiment Y-tube olfactometer; cucumber plants (*C. sativus*) treated with potassium silicate and infested with *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) were more attractive to the predator *Dicranolaius bellulus* (Guérin-Méneville) (Coleoptera: Melyridae) compared with infested plants with *H. armigera* and without potassium silicate application. Results suggest that Si applied to plants with subsequent pest infestation increases the plants' attractiveness to natural enemies; an effect that was reflected in elevated biological control in the field [15].

Although, there is a great diversity of studies that prove the importance of silicon as a beneficial element to the diverse cultures, and as inducing agent of resistance to pests, few studies are found in the literature involving the application of silicon in the coffee plantations (*Coffea* spp.) and the effect on pest mites of this agroecosystem. Therefore, experiments were conducted with the objective of evaluating the attack of *O. ilicis* on coffee plants treated with potassium silicate (K_2SiO_3), applied by leaf spraying, for a more sustainable management of the pest and environmental protection.

2. Material and Methods

The experiment was carried out in laboratory and greenhouse at the experimental station of *Empresa de Pesquisa Agropecuária de Minas Gerais - EPAMIG Sul*, in Lavras, Minas Gerais, Brazil.

2.1. Lab Rearing of the *Oligonychus ilicis*

Adults of *O. ilicis* were collected in coffee plantations (*Coffea arabica* L.) free of agrochemicals, in the municipality of Lavras, state of Minas Gerais, Brazil, and taken to the laboratory of acarology of the EPAMIG Sul/EcoCentro, in Lavras, and reared under controlled temperature conditions at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $70\% \pm 10\%$ of relative humidity and 14 hours of photophase.

The mites were reared in detached leaves of coffee placed on a sponge with 1 cm thickness occupying the entire bottom of an uncapped Petri dish (15 cm diameter) constantly moistened with distilled water. A strip of hydrophilic cotton was placed around the leaf and in contact with the wet sponge to maintain its turgescence and serve as a physical barrier to prevent the mites from escaping [16] [17].

2.2. Test of the Topical plus Residual Effect of Si on Coffee Leaves after Leaf Spraying

Were used 30 coffee plants of the Yellow Catucaí cultivar (*C. arabica*) with approximately 80 - 100 cm of height, planted in pots with 20 liters' capacity.

Forty adult females of *O. ilicis*, from the laboratory rearing, were transferred with the aid of a thin brush for each of the 30 coffee plants.

The treatments analyzed consisted of potassium silicate (K_2SiO_3) as a silicon source (Si 12.2% - 171 g/liter; K_2O 12.5% - 175 g/liter), from UNA-PROSIL® (*Usina Nova América Indústria e Comércio*, Paracambi, Rio de Janeiro, Brazil). The doses 2, 4, 6, 8 and 10 liters of potassium silicate ha^{-1} were tested, applied by leaf spraying mean, and a control (dose 0) was sprayed with water alone. The experimental design was completely randomized with six treatments and five replicates.

Two applications of potassium silicate with an interval of 15 days were carried out over the mites on the leaves infested with the pest mites. For the spraying, a manual sprayer of constant pressure was used and then the plants were kept inside a greenhouse.

From 3 and 7 days of the first application and 7 and 15 days from the second application one leaf was removed from each plant and taken to the laboratory, where the numbers of eggs, young stages (larvae and nymphs) and alive adults of the mite *O. ilicis* were counted under a binocular stereoscopic microscope with an increase of up to 40x.

2.3. Test of the Residual Effect of Si on Coffee Leaves after Leaf Spraying

The methodology of this experiment was similar to that used in the experiment

of the topical plus residual effect of Si on leaves, differing in infestation by mites, which was carried out at 24 hours and at 15 days after the application of potassium silicate, with the transfer of 40 females of *O. ilicis*, from the rearing laboratory, for each coffee plant, and one application of potassium silicate was carried out before infestation of the leaves with the mites. Evaluations were performed from 7, 15 and 21 days of the infestation, in the same manner as in the former experiment.

2.4. Determination of Silicon Content on Coffee Leaves after Leaf Spraying

The end of experiment, the plants leaves of the treatments were collected and submitted to an analysis of the Si leaf concentration in the Laboratory of Fertilizer Technology (LAFER) of the Federal University of Uberlândia, MG, Brazil (UFU), using the methodology of Korndörfer, Pereira and Camargo [8].

2.5. Evaluation Coffee Leaf Damage by *Oligonychus ilicis*

The leaf damage of the mite *O. ilicis*, reddish brown marks on the upper surface of the coffee leaves, was evaluated by means of damage index (ID) according to Smith-Meyer [18], and notes from 0 to 5 are assigned, with some modifications: 0 = absence of damage; 1 = up to 20% of the leaf area with damage; 2 = 21% - 40% of leaf area with damage; 3 = 41% - 60% of leaf area with damage; 4 = 61% - 80% of leaf area with damage and 5 = more than 80% of leaf area with damage.

2.6. Determination of the Tannin and Lignin Contents in Coffee Leaves after Leaf Spraying

Ten leaves of coffee plants were detached from each pots (replication) of the control and of the treatment 6 (dose 10 liters of potassium silicate/ha, highest dose analyzed) and dried in a drying oven at 60°C; after being crushed in Willy TE-648 mill with 30 meshes sieve.

The samples were sent to the Laboratory of Vegetable Products of the Department of Food Science of the Federal University of Lavras - UFPA, Lavras, MG, Brazil, for the determination of tannins and lignin. For tannin contents the leaf extract was obtained according to the methodology of Deshpande, Cheryan and Salunke [19] and determination was performed by the Folin-Ciocalteu colorimetric method, according to AOAC [20]. The lignin content was determined by Van Soest method [21].

2.7. Statistical Analysis

The obtained data from the number of mites in the leaves were submitted to the normality test of Shapiro-Wilk and presented normality and homogeneity for all evaluated parameters. The values obtained were submitted to analysis of variance and the means number were compared by the Tukey test ($P \leq 0.05$) [22]. Greenhouse leaf damage indexes were analyzed using the Kruskal-Wallis test and the means number of treatments were compared with Dunn's test ($p =$

0.05). For the experiment of tannin and lignin the contents were used the Student's t test.

3. Results

3.1. Topical plus Residual Effects of Si in Coffee Leaves after the Leaf Spraying

The results show that the number of *O. ilicis* mites, in the immature and adult phases, no significant difference was observed between potassium silicate and control doses in the first two weeks after the first application of the product (Table 1). After 7 days of the second Si application, it was observed that all treatments with silicate presented a reduction in infestation of *O. ilicis* in relation to the control, and the dose of 10 liters/ha of silicate (treatment 6) presented the lowest number of alive *O. ilicis*. After 15 days of the second Si application, the control and treatment 2 (2 liters of silicate/ha) presented a higher number of alive mites than the other treatments (Table 1).

The number of eggs placed by *O. ilicis* was affected by the different doses of potassium silicate only after 7 days of the first application, where the control and treatment 3 (4 liters/ha) presented higher number of eggs in relation to the other treatments, in the following evaluations no differences were observed between the analyzed doses (Table 2).

A regression analysis showed that 15 days after the second application of potassium silicate, the higher dose of the applied product show the lower the number of mites (adults, larvae and alive nymphs) (Figure 1) and eggs found in coffee leaves (Figure 2).

3.2. Residual Effect of Si in Coffee Leaves after the Leaf Spraying

The potassium silicate residue resulting from leaf spraying, at all doses analyzed, significantly reduced the infestation of mites in immature and adult phases, compared to the control that showed a high *O. ilicis* infestation (Table 3).

Table 1. Number (mean \pm SE) of alive mites (adults, larvae and nymphs) of *Oligonychus ilicis*, per coffee leaf, as a function of the topical plus residual effect of potassium silicate, after 3 and 7 days of the first application, and 7 and 15 days after the second application.

Treatments Liters of potassium silicate/ha	Number of alive mites per coffee leaf*			
	At 3 days after the 1 st application	At 7 days after the 1 st application	At 7 days after the 2 nd application	At 15 days after the 2 nd application
1. Control	29.20 \pm 20.61 a	11.40 \pm 10.55 a	60.20 \pm 19.60 a	49.40 \pm 42.55 a
2. 2 liters	23.00 \pm 24.09 a	0.80 \pm 01.79 a	10.00 \pm 08.00 b	17.80 \pm 20.62 ab
3. 4 liters	2.40 \pm 01.14 a	7.20 \pm 05.67 a	37.60 \pm 24.70 ab	05.60 \pm 06.06 b
4. 6 liters	2.80 \pm 02.59 a	1.00 \pm 00.70 a	12.20 \pm 09.81 b	07.60 \pm 03.91 b
5. 8 liters	8.00 \pm 07.97 a	5.80 \pm 08.01 a	23.00 \pm 26.57 b	07.80 \pm 05.58 b
6. 10 liters	3.20 \pm 04.15 a	0.60 \pm 00.55 a	05.00 \pm 05.19 b	02.60 \pm 02.60 b

*Means followed by the same letter in the column do not differ by Tukey's test ($P \leq 0.05$).

Table 2. Number (mean \pm SE) of *Oligonychus ilicis* eggs per coffee leaf, as a function of the topical plus residual effect of potassium silicate, 3 and 7 days after the first application, and 7 and 15 days after the second application.

Treatments Liters of potassium silicate/ha	Number of eggs per coffee leaf*			
	At 3 days after 1 st application	At 7 days after the 1 st application	At 7 days after the 2 nd application	At 15 days after the 2 nd application
1. Control	55.60 \pm 39.83 a	101.00 \pm 19.026 a	75.80 \pm 71.00 a	29.00 \pm 17.17 a
2. 2 liters	47.00 \pm 45.22 a	16.00 \pm 25.05 b	40.00 \pm 58.03 a	40.60 \pm 23.49 a
3. 4 liters	17.40 \pm 20.58 a	65.80 \pm 40.41 ab	45.40 \pm 24.60 a	45.20 \pm 44.61 a
4. 6 liters	16.20 \pm 15.10 a	18.40 \pm 11.15 b	29.80 \pm 12.25 a	29.20 \pm 28.70 a
5. 8 liters	52.00 \pm 51.69 a	25.20 \pm 32.57 b	30.80 \pm 29.82 a	29.80 \pm 12.95 a
6. 10 liters	28.60 \pm 34.38 a	18.20 \pm 11.76 b	26.80 \pm 22.87 a	23.20 \pm 21.79 a

*Means followed by the same letter in the column do not differ by Tukey's test ($P \leq 0.05$).

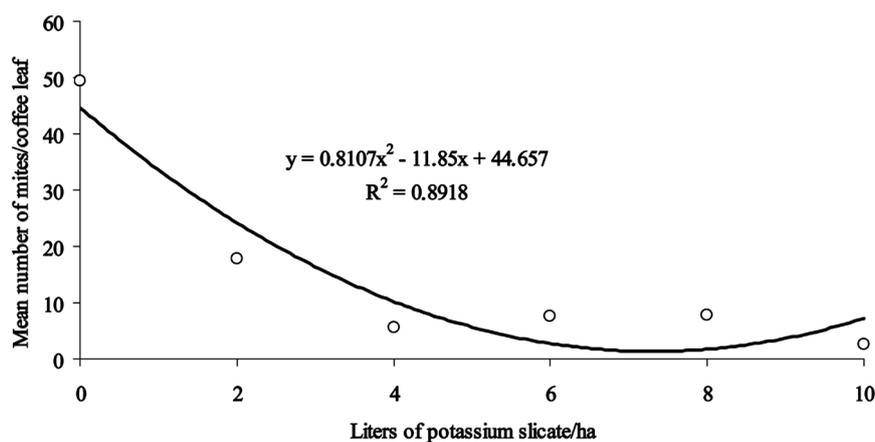


Figure 1. Mean number of *Oligonychus ilicis* mites (adults, larvae and alive nymphs) per coffee leaf, as a function of the topical plus residual effect, at 15 days after the second application, according to the different doses of applied potassium silicate (Markers = observed number; Line = estimated number) (Lab temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $70\% \pm 10\%$ RH and 14 h of photophase).

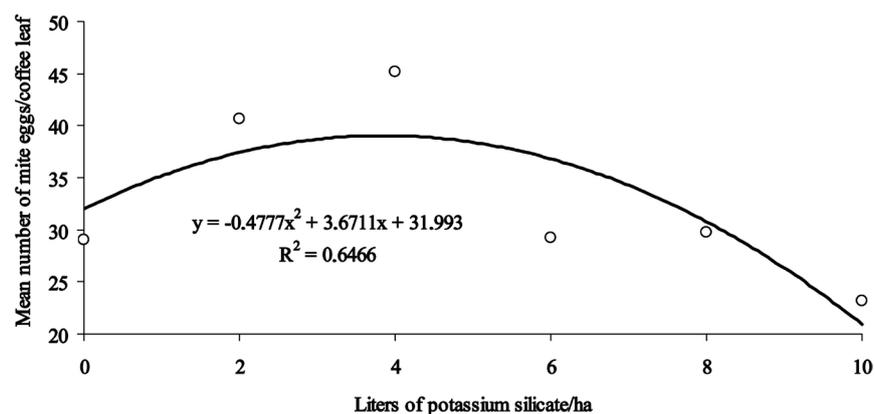


Figure 2. Mean number of *Oligonychus ilicis* eggs per coffee leaf, as a function of the topical plus residual effect, at 15 days after the second application, according to the different doses of applied potassium silicate (Markers = observed number; Line = estimated number) (Lab temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $70\% \pm 10\%$ RH and 14 h of photophase).

Table 3. Number (mean \pm SE) of alive mites (adults, larvae and nymphs) of *Oligonychus ilicis*, per coffee leaf, as a function of the residual effect of potassium silicate, after 3, 7 and 21 days after the leaf spraying.

Treatments Liters of potassium silicate/ha	Number of alive mites per coffee leaf*		
	At 3 days after the application	At 7 days after the application	At 21 days after the application
1. Control	19.60 \pm 09.26 a	44.60 \pm 13.01 a	50.00 \pm 00.00 a
2. 2 liters	10.80 \pm 10.98 ab	08.80 \pm 14.17 b	06.80 \pm 01.09 b
3. 4 liters	04.60 \pm 10.28 b	09.00 \pm 13.47 b	02.00 \pm 00.00 cd
4. 6 liters	00.40 \pm 00.89 b	07.00 \pm 06.70 b	00.20 \pm 00.45 d
5. 8 liters	02.20 \pm 04.92 b	03.80 \pm 06.94 b	03.40 \pm 02.07 cd
6. 10 liters	00.00 \pm 00.00 b	02.80 \pm 01.79 b	00.00 \pm 00.00 d

*Means followed by the same letter in the column do not differ by Tukey's test ($P \leq 0.05$).

Table 4. Number (mean \pm SE) of *Oligonychus ilicis* eggs per coffee leaf, as a function of the residual effect of potassium silicate, after 3, 7 and 21 days after the leaf spraying.

Treatments Liters of potassium silicate/ha	Number of eggs per coffee leaf*		
	At 3 days after the application	At 7 days after the application	At 21 days after the application
1. Control	101.60 \pm 64.88 a	45.20 \pm 1.64 a	50.80 \pm 1.30 a
2. 2 liters	021.80 \pm 13.10 b	09.80 \pm 9.40 b	02.00 \pm 0.71 b
3. 4 liters	001.00 \pm 02.24 b	02.80 \pm 4.38 b	01.00 \pm 0.00 bc
4. 6 liters	000.60 \pm 01.34 b	04.00 \pm 5.48 b	00.00 \pm 0.00 c
5. 8 liters	002.80 \pm 04.38 b	05.20 \pm 5.97 b	01.00 \pm 0.00 bc
6. 10 liters	000.00 \pm 13.10 b	00.00 \pm 0.00 b	00.00 \pm 0.00 c

*Means followed by the same letter in the column do not differ by Tukey's test ($P \leq 0.05$).

In all evaluations the number of the pest mite eggs, was highest in the control (without application of potassium silicate - dose 0) compared to the other doses analyzed (**Table 4**).

3.3. Si Content in Coffee Leaves after the Leaf Spraying

All treatments had higher Si content in the leaves compared to the control, and the doses of 10 and 8 liters/ha of potassium silicate presented 18.4, 15 times more Si than the control, or 80% and 70% more Si, respectively (**Figure 3**).

3.4. Index of Coffee Leaf Damage by the Mite *Oligonychus ilicis* in Greenhouse

The results showed that the higher the dose, the lower was the damage caused by the southern red mite in the coffee leaves (reddish brown marks on the upper surface of the coffee leaves), a parameter measured by the damage index (score from 0 to 5). The control had the highest leaf area damage index (4.8) and

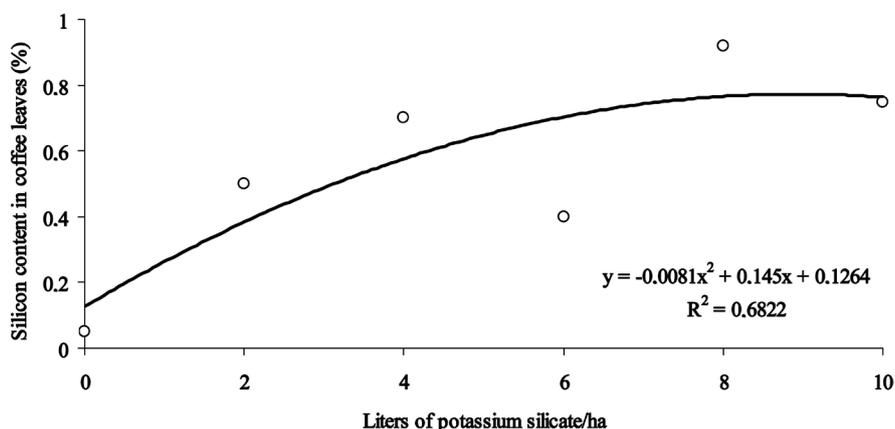


Figure 3. Silicon content (%) in coffee leaves submitted to different concentrations of potassium silicate.

Table 5. Damage caused by *Oligonychus ilicis* on coffee leaf as a function of the potassium silicate dose applied and measured by the damage index (ID \pm SE).

Treatments Liters of potassium silicate/ha	Damage index (ID \pm SE)*
1. Control	4.8 \pm 0.45 a
2. 2 liters	3.0 \pm 0.00 b
3. 4 liters	3.0 \pm 0.45 b
4. 6 liters	2.2 \pm 0.45 b
5. 8 liters	2.2 \pm 0.45 b
6. 10 liters	1.2 \pm 0.45 c

*Index of leaf mite damage, plus or minus standard error of the mean, according to Smith-Meyer [18]: 0 = absence of damage; 1 = up to 20% of the leaf area with damage; 2 = 21% - 40% of leaf area with damage; 3 = 41% - 60% of leaf area with damage; 4 = 61% - 80% of leaf area with damage and 5 = more than 80% of leaf area with damage. The mean values of damage index followed by the same letter in the column did not differ by Dunn's test ($p = 0.05$).

Table 6. Tannins and lignin contents (mean \pm SE) in coffee leaves without and with potassium silicate applied by leaf spraying.

Treatments	Tannins (%)*	Lignin (%)*
Without Si (control)	22.60 \pm 0.31 b	8.53 \pm 0.30 b
With Si (10 liters/ha)	24.42 \pm 0.24 a	9.40 \pm 0.53 a

*Means followed by the same letter in the column do not differ by Tukey's test ($P \leq 0.05$).

treatment 6, 10 liters of potassium silicate/ha, the lowest (1.2) (Table 5).

3.5. Tannins and Lignin Contents in Coffee Leaves after Leaf Spraying

The leaves of the coffee trees sprayed with potassium silicate, represented by the highest applied dose, 10 liters/ha, presented a higher percentage of tannins and lignin than the plants without Si (control treatment) (Table 6).

4. Discussion

Potassium silicate in leaf spraying, at all doses analyzed, provided a reduction of

O. ilicis mite infestation in coffee plants, similar to that already verified by other authors and other pests; for example, silicon application negatively affected the number of nymphs and the growth of the *S. graminum* aphid population in rice plants [23] [24].

In this study it was observed that protective effect of silicon can be associated with chemical and physical changes of the plant, such as hardening of the leaf tissue, causing a reduction in the pest mite feeding and in the mite population (immatures, adults and eggs), consequently reduction of the damage caused in leaf coffee plants.

It has also been observed that there was the induction of plant defense compounds such as tannins and lignin. The increase of lignin in leaf tissues of coffee plants fertilized with sodium or calcium silicate has already been reported [25], but no increase in lignin content was observed with the application of silicon in the soybean [*Glycine max* (L.) Merrill, Fabaceae] [26]. The secondary metabolites produced by the plants can be toxic or deterrents of feeding to the herbivores, causing nutritional limitation [27]. The most important group of secondary defensive compounds is tannins, since they act as food deterrents [28]. The synthesis and accumulation of tannins in coffee leaves may have contributed to the induction of coffee resistance to the *O. ilicis* mite in this work. Lignin is a complex polymer that when deposited on the cell wall is responsible for its hardness and increased resistance to attack by external agents [29], thus causing a mechanical barrier, making the cell wall more resistant.

It has also been reported that the resistance conferred by the leaf silicon application causes chemical and physical changes in three varieties of Poaceae (*Deschampsia caespitosa* L., *Festuca ovina* and *Lolium perenne* L.) such as reduced digestibility, increased tissue stiffness and increased abrasiveness [30]. However, with application of calcium silicate in the soil, it was already observed in coffee that the mealybug, *P. citri*, reached the phloem feeding place without problems, indicating that in this study, no mechanical barrier was performed to avoid the penetration of the buccal stylets [31].

Evidence for feeding deterrence to herbivorous arthropods in maize plants (*Z. mays*) were observed to the fall armyworm, *Spodoptera frugiperda* Smith & Abbot (Lepidoptera: Noctuidae), with inhibition of feeding in plants treated with sodium silicate, where the caterpillars presented wear out of the jaws on the incisor region when in contact with leaves with higher silicon content, high mortality and cannibalism due to the increase of resistance to this species [32]. Applications of calcium silicate in sugarcane (*Saccharum officinarum* L., Poaceae) were also correlated with the reduction of damage caused by *Eldana saccharina* Walker (Lepidoptera: Pyralidae) [33] [34].

In corn, bean, cucumber and eggplant the application of potassium silicate increased the resistance of these plants against the two-spotted spider mite, *T. urticae*, infestation, causing reduction of their feeding [13]. Also in common bean, *P. vulgaris*, it was verified that the duration of developmental stage of *T. urticae* was significantly affected by Si doses. The longest immature period, the shortest longevity of females and the shortest oviposition period were obtained

with 2 ppm of Si, affected population growth parameters and a better potential for decreasing the population of this mite. So the application of Si in this case can be used in the mite integrated pest management programs [35].

In the present study were observed a reduction the number of eggs laid by *O. ilicis* in the coffee leaves sprayed with Si, probably due the mite feeding difficulty that caused a reduction of the fecundity of the population. For the aphid, *S. graminum*, it has been demonstrated that the application of Si reduces its fecundity, preference and longevity in rice leaves (*Oyza sativa* L, Poaceae), treated with sodium silicate [36].

The application by leaf spraying of different doses of potassium silicate allow to demonstrate that the concentration of Si in the coffee leaves increased according to the increase of the applied dose, indicating that there was absorption by the plant, even though the coffee tree was a dicotyledonous plant. A similar result was observed also in coffee plants in other studies [37]. In results obtained with leaf application of Si in potato plants (*Solanum tuberosum* L., Solanaceae), it was observed that silicon acts as a resistance inducer to aphids *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) [24], despite these plants being classified as non-accumulators of this mineral [38].

In the present study no significant difference was observed in the infestation of coffee plants with *O. ilicis* in relation to the different doses of Si used in leaf spraying. Also, no difference was observed in the number of eggs and in the development time of the mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) with the increase of Si rates in citrus (*Citrus* spp., Rutaceae) [39], which indicates the importance of the application of Si.

Concerning the damage avoided with the use of Si in leaf spraying, it has already been found that *Diabrotica speciosa* (Germar) (Coleoptera: Chrysomelidae) causes twice as many lesions in the control as in plants of potato (*S. tuberosum*) treated with silicic acid [40]. It has also been found that the application of potassium silicate in cocoa plants (*Theobroma cacao* L., Malvaceae) reduced the incidence and level of damage caused by insect pests [41].

In the development of this work, the application of potassium silicate increased resistance to damage caused by the mite *O. ilicis*, which was confirmed by the decrease in the value of the damage index found when Si was applied in leaf spraying.

The applications of potassium silicate as a source of silicon (Si) result in a positive effect in reducing the population of *O. ilicis* mites and in the damage caused by it in coffee leaves, even if it is a dicotyledonous plant. Therefore, the applications of potassium silicate by leaf spraying can be used in programs of integrated management of the southern red mite in coffee plants, with a view to sustainable management and environmental protection.

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