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EFFECT OF CALCIUM SILICATE ON FEEDING AND DEVELOPMENT OF TROPICAL SOD WEBWORMS (LEPIDOPTERA: PYRALIDAE)

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The tropical sod webworm (TSW), *Herpetogramma phaeopteralis* Guenee, has a wide tropical distribution and is considered to be one of the most destructive turfgrass pests in Florida. This webworm is common throughout most of Florida, although it probably does not survive the winter in the northern part of the state. TSW larvae cause damage to many turfgrass species by feeding on grass foliage. Damage appears as patches that become yellowish, then brown. Turf adjacent to flower beds and shrubs usually shows the first sign of damage, since adults rest in such foliage and moths lay more eggs in nearby turf (Kerr 1955).

Silicon (Si) is the second most common element on earth, but it is not considered to be an essential element for plant growth (Arnon & Stout 1939). However, there is a growing body of evidence that Si can enhance plant resistance to insect pests. The solid silica that is associated with the plant cell walls may constitute a mechanical barrier to penetration of the mandibles of insects (Jones & Handreck 1967). Applied Si and higher available soil Si have improved the resistance of rice to several economically important rice insect pests (Savant et al. 1997). Recently, Carvalho et al. (1999) reported that Si reduced the feeding and reproduction of greenbug (*Schizaphis graminum* Rond.), a sorghum herbivore. Also, Saigusa et al. (1999) reported reduced insect feeding in turf treated with calcium silicate. The objective of this study was to determine if calcium silicate applications to turf plants increase silicon in the plants and affect feeding and development of TSW.

Tests were conducted from August to December 2003. In the first test, five species of turfgrasses were used. Each species received two treatments: one with calcium silicate slag (Calcium Silicate Corporation, Inc., Lake Harbor, FL) at 10 MT/ha of slag mixed into a soil mix and one treatment without slag. The rate of 10 MT/ha of calcium silicate slag was selected based on previous research on pest control in rice and sugarcane (Seebold 1998; Savant et al. 1999) to ensure a high concentration of Si within plant tissue. The turfgrasses used were Tifdwarf Bermudagrass (*Cynodon dactylon* (L.) Pers. × *Cynodon transvaalensis* Burtt-Pavy), SeaIsle Seashore paspalum (*Paspalum vagintium* Swartz), NUF-76 St. Augustinegrass (*Stenotaphrum secudatum* (Walt) Kuntze), Meyers Zoysiagrass (*Zoysia japonica* Steud) and Centennial Centipedegrass (*Eremochloa ophiuroides* (Munro) Hack). All plants were grown in 225-cm^3 pots with 1:1 volume sand and Farfard #2 soil mix (Conrad Fafard, Agawam, MA). One fifth instar TWS (range = 4 to 8 mg) was weighed and placed on each host plant and the plant set inside a one liter polypropylene container and covered with mesh cloth. After four days larvae were recovered and weighed to determine weight gain. During the experiment, larvae and plants were maintained in an insectary at 28°C and 12-h photoperiod. Five host plants × the two treatments were set up at the same time to be one replication and ten replications were conducted.

In the second test, the same turf grass species and treatments were used as in the first test. Two moist filter papers were placed on the bottom of a 9-cm diameter petri dish. Excised leaves from one potted host plant were placed into a dish and a newly hatched TSW larvae (neonate) was placed upon the excised leaves. Neonates were not weighed because they are very small and fragile averaging less than 0.001 g per larva. Leaves were added "ad libitum" as needed. Petri dishes were stored in the previously mentioned insectary. Because the larvae are sensitive to dehydration, petri dishes were placed in plastic bags to maintain high humidity. Larvae were weighed after 7 days and returned to petri dishes until adults had emerged. Petri dishes were examined daily to insure fresh leaves and to note pupation and adult emergence date. Kerr (1955) reported that TSW took about 7 days from pupation to adult emergence at 26°C. We waited 14 days at 28°C before considering pupae dead. Five host plants × the two treatments were again set up at the same time to be one replication and 15 replications were conducted. Leaves from seven plants of each treatment in each of the five host plant species were randomly selected to determine the concentration of Si in the leaves. Silicon analysis of plant tissue was made according to methods for autoclave-induced digestion and colorimetric determination of Si as described by Elliott & Snyder (1991).

Our experimental design in both tests was a 5 × 2 factorial experiment with five levels of plant factor and two levels of treatment (= plus or minus slag) factor. Hence, a two way Analysis of Variance by the GLM procedure (SAS 1996) was used to analyze our data.

In the first test with potted plants, plant species and treatment were not significant factors ($P > 0.05$) in larval initial weights and there was no interaction ($P > 0.05$) between the two factors (Table 1). F values were 1.3 (4 *df*) for plant species,

TABLE 1. GROWTH OF TROPICAL SOD WEBWORMS ON DIFFERENT HOST PLANTS TREATED WITH CALCIUM SILICATE SLAG.

Plant	Slag	Mean ± SD[1] Initial wt (mg)	Final wt (mg)	% Growth
Bermudagrass	–	5.7 ± 0.8	44.7 ± 10.6	784
	+	5.4 ± 1.3	42.2 ± 12.9	781
Centipedegrass	–	6.0 ± 1.1	30.8 ± 14.2	513
	+	5.8 ± 1.6	24.9 ± 6.2	429
Seashore paspalum	–	5.5 ± 1.5	34.8 ± 10.3	632
	+	5.5 ± 1.5	37.5 ± 15.4	681
St. Augustinegrass	–	5.6 ± 1.3	27.1 ± 11.9	483
	+	5.8 ± 0.8	29.9 ± 11.9	515
Zoysiagrass	–	5.0 ± 1.0	17.2 ± 6.2	344
	+	5.6 ± 1.3	15.9 ± 6.5	283

[1]A two way Analysis of Variance with the GLM procedure (SAS 1996) was used to analyze the data. See text for discussion of results.

0.1 (1 *df*) for treatment, and 0.9 (4 *df*) for plant-treatment interaction. The lack of statistical significance was expected since larval weights were selected initially to be similar in all treatments. After four days, plant species was a factor ($P < 0.0001, F = 15.2$, 4 *df*) in larval weights and treatment was not ($P > 0.05$. $F = 0.3$, 1 *df*). No interaction ($P > 0.05$, $F = 0.7$, 4 *df*) was observed. Percentage survival of larvae after four days in all 10 groups averaged 94.0 ± 7.0% (SD), with some larvae surviving in all 10 groups.

In the second test with excised leaves, plant species was again a factor in larval weights ($P < 0.0001$, $F = 11.8$, 4 *df*), days to pupation ($P < 0.0001$, $F = 17.0$, 4 *df*), and days to emergence ($P < 0.0001$, $F = 15.6$, 4 *df*) (Table 2). Treatment was not a factor in larval weights ($P > 0.05$, $F = 2.1$, 1 *df*), days to pupation ($P > 0.05$, $F = 3.9$, 1 *df*), or days to emergence ($P > 0.05$, $F = 0.5$, 1 *df*). No interaction was observed in larval weights ($P > 0.05$, $F = 0.5$, 4 *df*), days to pupation, ($P > 0.05$, $F = 0.1$, 4 *df*) or days to emergence ($P > 0.05$, $F = 1.5$, 4 *df*). Percentage survival of neonate larvae to adult emergence in all 10 groups averaged 66.0 ± 18.2% (SD), with some larvae surviving in all 10 groups. Leaf tissue analysis showed that treatment was a factor ($P < 0.0001$, $F = 35.5$, 1 *df*) in % Si in leaf tissue. This is corroborated by noting that all five plant species had more Si in leaves after slag applications than controls with no slag application. Plant species was also a factor ($P < 0.05$, $F = 2.7$, 4 *df*) in % Si in leaves for reasons not fully understood. No interaction ($P > 0.05$, $F = 1.0$, 4 *df*) was observed.

As noted earlier, increased Si in plant tissue has been shown to reduce insect feeding damage. However, our data consistently showed that using two different testing methods (whole plant and

TABLE 2. GROWTH AND DEVELOPMENT OF TROPICAL SOD WEBWORMS IN DIFFERENT HOST PLANTS TREATED WITH CALCIUM SILICATE SLAG AND PERCENTAGE OF SILICON IN LEAVES OF HOST PLANTS.

Plant	Slag	Mean ± SD[1] Larval wt[2]	Days to Pupation	Days to emergence	Si (%)[3]
Bermudagrass	–	33.2 ± 13.2	10.5 ± 0.7	16.5 ± 0.5	0.7 ± 0.2
	+	29.4 ± 10.0	10.7 ± 0.9	16.6 ± 1.3	1.4 ± 0.5
Centipedegrass	–	23.0 ± 13.0	12.7 ± 1.8	18.7 ± 1.7	0.8 ± 0.3
	+	16.9 ± 11.7	13.2 ± 2.8	20.0 ± 2.5	1.4 ± 0.6
Seashore paspalum	–	39.4 ± 15.8	10.1 ± 0.9	15.5 ± 1.0	0.7 ± 0.2
	+	37.0 ± 16.5	10.8 ± 0.9	16.3 ± 1.2	0.9 ± 0.2
St. Augustinegrass	–	30.0 ± 15.3	11.0 ± 0.9	17.3 ± 1.2	0.5 ± 0.07
	+	22.3 ± 20.3	11.4 ± 1.6	17.2 ± 2.0	0.9 ± 0.3
Zoysiagrass	–	12.8 ± 9.6	12.7 ± 1.4	19.0 ± 1.3	0.5 ± 0.2
	+	15.3 ± 12.1	13.3 ± 1.7	18.0 ± 1.3	1.2 ± 0.6

[1]A two way Analysis of Variance by the GLM procedure (SAS 1996) was used to analyze the data.
[2]Weight (mg) of neonates held seven days at 28°C.
[3]Si (%) in dry weight of plant tissue.

excised leaves) on five different species of turf grasses, increased Si in plant tissue from calcium silicate applications did not affect growth and development of TSW. Reasons for the lack of response of TSW to Si in leaves is not known. However, the insect-plant-silicon response is complex and not always predictable. For example, Peterson et al. (1988) showed that high levels of silica decreased digestibility in *Spodoptera eridania* (Cramer) and promoted increased consumption rates. However, larval growth rates were not different from the control at the highest level of silica (20% dry weight). Also, it has been shown that certain plant genotypes are more efficient than others in their accumulation of Si, thus making them more resistant (Savant 1997). Our study, like other studies, shows application of elements to plants may affect insects in different and not always predictable ways.

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Summary

The objective of this study was to determine if the calcium silicate applications to turf plants increase silicon concentration within the plants and affect feeding and development of tropical sod webworms. Five species of host plants were used with each species receiving two treatments: one with calcium silicate slag (10 MT/ha) and one without. Higher concentrations of silicon found in slag treated plants did not affect tropical sod webworm feeding or development.

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