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EFFECTS OF SILICA ON THE SURVIVAL OF *COLEOMEGILLA MACULATA LENGI* (COLEOPTERA: COCCINELLIDAE) AND *LEPTINOTARSA DECEMLINEATA* (COLEOPTERA: CHRYSOMELIDAE)

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Larvae of *Coleomegilla maculata lengi* Timberlake and *Leptinotarsa decemlineata* (Say) were unable to moult and died after ingesting colloidal silica with their food. Field trials showed that dry silica can be used to reduce populations of *L. decemlineata* on potato.

Introduction

Inert powders and dusts that come into contact with the integument or are ingested affect growth and survival in various insects. Diatomaceous earths have been used to kill insect pests of grain (Carlson and Ball 1962; Strong and Sbur 1963) and the spruce budworm (Stelzer 1966). Silica aerogel has been used to protect stored seed and cereal products from insects (Cotton and Frankenfeld 1949). Desiccation caused mortality in parasitic Hymenoptera when water-sorbing powders of mineral origin were applied topically (Bartlett 1951). Silica has been included in the diets of insects to increase roughage and bulk. Though a diet with 12% silica was not harmful to crickets, they were unable to survive on diets with more than this proportion of silica (Neville and Luckey 1962). In the present study colloidal silica with a particular size under .012 μ (Cab-O-Sil, H5, Cabot Carbon of Canada, Toronto) was fed to larvae of *Coleomegilla maculata lengi* Timberlake and *Leptinotarsa decemlineata* (Say) to measure their tolerance for silica and to determine the feasibility of using silica to measure food intake by gravimetric analysis of silica in the feces and comparison with the concentration of silica in the diet.

Laboratory Tests

Dry silica and powdered pea aphid, *Acyrthosiphon pisum* (Harr.), in a 1:1 mixture by weight were fed to each of the four larval instars of *C. maculata* by the method of Smith (1965). At least 12 individuals of each instar were reared on this and their survival was compared with those of similar numbers reared on dried *A. pisum*. Food eaten by an individual was measured as the difference in weight of food supplied and of food left after moulting and pupation.

Third-instar larvae of *L. decemlineata* were fed foliage cut from potato plants to which dry silica had been previously applied. Each cutting was supported on an upright paper cone with a hole at the small end through which the plant stem was pushed into water in the flask holding the cup. In a test one larva was released on each of 15 cuttings with silica and 15 similarly arranged without silica. The test was repeated three times and survival of *L. decemlineata* was compared on foliage with and without silica.

To determine whether the toxic effects of silica were caused by contact with the cuticle or by ingestion, three groups each with 12 third-instar larvae of *L. decemlineata* were immersed in dry silica for 2, 4, and 8 hours respectively; they were then reared on untreated potato foliage.

The laboratory tests were conducted at 20.1°C, 60% R.H., and 16 hours of illumination from fluorescent lights followed by 8 hours of darkness. Means of longevity in days are given with standard errors.

No larvae of *C. maculata* moulted after eating food mixed with silica, and death occurred shortly before they were expected to moult. The longevity in days of each instar fed on silica and the longevity of the controls in parentheses were: first instar, 2.40±.51 (4.13±.27); second instar, 3.10±.18 (4.00±.17); third instar, 4.30±.30 (4.18±.42); and fourth instar 6.73±.66 (7.18±.41). The estimated quantities of silica-treated food ingested by all instars except the first are: second instar, .32±.08; third instar, .92±.07; and fourth instar, 3.10±.40 mg.

No larvae of *L. decemlineata* moulted after eating foliage of potato treated with dry silica, and death occurred within 24 hours. No mortality occurred among untreated larvae and all produced adults. External contact with silica for up to 8 hours had no harmful effects and more than 90% of each treatment group reached the adult stage when fed on untreated foliage.

Field Tests

In 1967, 12 plants each about 25 cm high were selected at random in a potato field of about 0.2 ha (hectares). About 0.3 l. of dry silica were shaken on the foliage of six such plants at intervals of 3 days from 17 to 24 July. The six other plants served as controls. Third- and fourth-instar larvae of *L. decemlineata* were counted on all plants before treatment and plant yields expressed as numbers and weights of potatoes per plant for treated and untreated groups were determined. The date on which each plant became defoliated by feeding was recorded.

In 1968, 20 plants each about 25 cm high were selected at random in a field of about 0.2 ha. Each plant was treated with silica and paired with an untreated plant with about 1 m between the members of a pair. Each treated plant was sprayed until all the foliage was wet with a 5% suspension of silica in 5% sucrose solution each week from 2 July to 6 August. The numbers of adults, egg batches, and third- and fourth-instar larvae of *L. decemlineata* were recorded three times weekly for all plants. The date on which each plant became defoliated by feeding was recorded and the potatoes were weighed.

In the 1967 tests, all plants of the control group were defoliated 3–7 days before those of the treated group. The mean yield of the control group was significantly less ($P < 0.05$ by a one-tailed t test) than that of the treated group, i.e., 160.90 g and 312.58 g per plant respectively. The numbers of potatoes produced per plant were not closely related to their weights. Total numbers of third- and fourth-instar larvae on treated plants were less than those on controls in 3 of 7 counts. The mean numbers of larvae per plant in 7 counts were significantly different (t test, $P < .05$) in control and treated groups, i.e. 149.83 ± 14.32 and 97.17 ± 24.20 respectively.

In the 1968 tests, in 11 pairs of plants the control was defoliated 3–12 days before the treated plant; in 3 pairs the control was defoliated at the same time as the treated plant; in 1 pair the treated plant was defoliated before the control plant; and in 5 pairs comparisons were incomplete because of mortality in the plants. The mean yield of the control group did not differ significantly from that of the treated group. The combined yield was 91.27 ± 9.45 g per plant. The numbers of adults, egg batches, and third- and fourth-instar larvae of *L. decemlineata* did not differ significantly in control and treated groups. The means for 14 counts and the groups combined were 5.74 ± 1.65 adults, 5.26 ± 0.55 eggs, and 48.31 ± 5.11 third- and fourth-instar larvae per plant.

Discussion

Dry silica when ingested with the food is highly toxic to the two beetles studied and is of no use for measuring food intake. When wet, as in the spray used in 1968, silica may lose some of its toxicity. Bartlett (1951) reported that when partly wetted some dry powders lost their lethal effects, i.e., water-sorptive capacities. However, the lethal properties of colloidal silica probably do not depend only on its power to desiccate an insect. The mode of action of colloidal silica may depend on the adsorption of a digestive enzyme or on interference with the passage of food. The usefulness of silica in reducing populations of *L. decemlineata* depends on several factors. Unless the material adheres to the foliage the number of applications may be prohibitively high. Assurance that silica in this form is not harmful to humans and other animals is needed. Assessment of the effects should be made in crops with normal yields. The crop of 1968 here described was much below normal in this respect.

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