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THE EFFECT OF ORCHARD DUST ON THE BIOLOGICAL CONTROL OF AVOCADO PESTS

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Dust—field deposits of inert dust—may be one of the avocado growers' worst enemies. The presence of inert dust deposits on avocado trees inhibits the activity of all species of beneficial insects. In many instances the beneficial insects are quickly killed by inert dusts. When the effectiveness of beneficial insects is thus reduced the uncontrolled pest species may soon increase to numbers sufficient to cause commercial damage.

Why is it that dust deposits which kill or incapacitate beneficial insects may be relatively innocuous to pest species? This question is easily answered when the mode of action of the dust and the habits and structures of the insects are considered.

Inert dusts may be lethal to insects either directly or indirectly. They may cause death directly through desiccation, or indirectly by reducing the insects' ability to find food.

Dust deposits may facilitate the desiccation of insects by increasing the permeability of the cuticle (or skin), by exposing the permeable intersegmental membranes and by, in effect, increasing the evaporative area of the body. In general, the lethal effects of dust increase with the aridity of the environment or with the amount, adhesiveness, and fineness of the dust particles. Inert dusts such as clays with marked water-absorptive powers are especially lethal. Such materials may quickly kill insects that are constantly exposed to them, especially if the insects must perforce move about actively over or through the deposits.

Inert dusts may bring about starvation of insects by forming a mechanical barrier to their food supply, by impeding their movement or by clogging their digestive systems.

With this information in mind let us now examine the habits of harmful and beneficial insects found in avocado orchards to see why the beneficial species are so much more seriously impaired by dust deposits than the pest species.

HABITS AND STRUCTURE OF PEST INSECTS

First let us consider the harmful species or the insect pests. As we review the list of avocado pests we readily see that most of them are relatively sessile; that is, they move about over the avocado tree very little, if any at all. Moreover, some of the pests, for example all scale insects and mealybugs, are well protected from dust deposits by wax covers or by hard, thick body walls. Thus they have relatively little, if any, contact with dust deposits in the orchards. Further, all of the pests are in constant contact with a

food supply of living plant material which is high in moisture content. In addition, most of the pest species—all scale insects, mealybugs, aphids and mites— have piercing mouth-parts which penetrate the plant cuticle, so that these pests feed on clean, dust-free plant sap. It should also be pointed out that all mite pests of avocados (technically mites are not insects) are apparently immune to the desiccating effects of inert dusts. Thus we see that because of their habits and body structures, pests in avocado orchards are either immune to inert dusts or live relatively free of the harmful effects of such deposits.

HABITS AND STRUCTURE OF BENEFICIAL INSECTS

Now let us examine the habits and structure of the beneficial insects on the same basis and in the same order. We found that the harmful insects were relatively sessile. Just the opposite is true, however, of the searching stages of the beneficial insects. The adult parasites and adults and larvae of predators must search incessantly over the leaves and fruits of avocado trees if they are to control the pest species satisfactorily. The more efficient the beneficial insect is in this respect, the lower will be the population of its host and the greater will be the surface area of the host plant traversed by the beneficial insect. Thus the beneficial species are constantly and severely subjected to the detrimental influence of any dust deposit present in the orchards.

It has been pointed out that some of the harmful insects are shielded from dust deposits by protective covers. None of the beneficial species are protected in such a manner.

Insofar as the supply of food and water was concerned, we found that both were constantly available to the pest species. This is far from true, however, in the case of beneficial insects. Adult parasites, in general, depend on the chance supply of natural sugars (honeydew or nectar) in the orchard as their only food source and as one of their important sources of water. At times a major portion of the adult parasites' time must be spent in search of food and water. The adults of insect predators may feed either on their insect hosts or on honeydew or nectar. Larval stages of predatory insects depend almost entirely on the capture of their prey for both food and moisture requirements. In all of these cases the beneficial insects have relatively poor contact with their nutrient supplies. Here again (as in the search for their hosts) the beneficial insects must travel almost continuously over the surface of the trees, this time in search of food and moisture. In this instance, also, they are forced into constant contact with any dust deposit that may be present on the trees. This condition becomes especially critical when the dust has a desiccating effect on the beneficial insects, as there is little opportunity for them to replenish the water so vitally needed.

While most insect and mite pests pierce the plant cuticle with their mouth-parts to feed on plant juices, the adult parasites, as has already been shown, must feed on honeydew and nectar found exposed on plant surfaces. Such foods may be so covered by dust deposits that they are unavailable to beneficial insects, or they may be so contaminated with dust particles that, should they be ingested, they could impair the digestion of the beneficial species. These same conditions hold true for predators insofar as their feeding on honeydew and nectar is concerned. Such dust deposits, while having no detrimental effect on pest species, could readily result in death by

starvation for beneficial insects.

Dust may also adversely affect the efficiency of beneficial insects in several other ways. It may dull their senses, agitate them and cause them to depart from a dusty area, or slow down their rate of travel so that their searching capacity will be reduced.

Beneficial insects utilize delicate sensory organs, predominantly in the antennae, for locating and recognizing food and host insects. These sensitive organs must be kept relatively free of foreign particles if the insect is to function normally. Most beneficial insects have special structures on their legs and mouth-parts to cleanse the antennae and other body structures. By this means foreign particles adhering to the antennae are removed frequently enough to keep them clean and in proper working order. When dust particles that adhere readily to the antennae are present in sufficient quantity, much (possibly most) of the beneficial insect's valuable searching time must be spent in cleansing itself. Despite these efforts certain types of dust deposits may, in time, so dull the senses of the beneficial insects that they can no longer detect food materials or host insects. Such instances usually result in a quick death of the parasite or predator.

Beneficial insects are annoyed by the presence of dust on orchard trees. Commonly, when beneficial insects capable of flight encounter dusty trees they become agitated and leave before they have been seriously injured. If such insects should subsequently encounter clean trees they may free themselves of any accumulated dust and continue their searching activities. If, however, each tree that is visited in turn is dusty the beneficial insects may soon become incapacitated or die of desiccation. In either case dusty trees lose the protective services of beneficial insects.

Repeated studies have shown that some kinds of dust deposits (relatively few) will not directly cause the death of certain beneficial insects, regardless of the quantity of dust present or the length of time the insects are exposed to it. However, such nonlethal dust deposits may so markedly reduce the searching speed of a beneficial insect that it may starve to death in the midst of a relatively high host population In addition such dusts may contaminate the sensitive antennae of beneficial insects and render them useless so that neither food nor host can be detected.

LABORATORY STUDIES ON THE EFFECT OF INERT DUST DEPOSITS ON BENEFICIAL INSECTS

A predator and a parasite species were used experimentally in the laboratory in a study of the effects of various inert dusts of known physical properties on the efficiency of beneficial insects. The predator was **Stethorus picipes** a tiny black lady beetle that preys on all stages of the avocado brown mite, the six-spotted mite and other plant-feeding mites. Both the adult and larval stages of **Stethorus** were used in these studies. The parasite was the very small wasp, **Trichogramma minutum**, which, in avocado orchards, parasitizes the eggs of **Amorbia** and the omnivorous looper.

From these studies it was learned that both **Stethorus** (larvae and adult) and **Trichogramma** (adults) were quickly killed when exposed to light deposits of number of different dusts of mineral origin. Of the various materials tested, several types finely powdered clays gave the quickest kills. In general, the smaller the particle size of a

given mineral dust the more quickly it killed. It was also learned that when he mineral materials were applied as a spray, or when they were exposed in a mist chamber or wetted in any other manner before the experimental animals were placed on them, their lethal effect was greatly reduced.

Bartlett (1) obtained similar data using as test insects **Aphytis chrysomophali** (a, parasite of the California red scale) and **Metaphycus luteolus** (a parasite of the black scale).

Results from these laboratory experiments indicate that under field condition, fresh daily deposits of dry, finely powdered dusts would be especially lethal; older deposits that had been exposed to dew, fog, rain, etc., would be relatively innocuous.

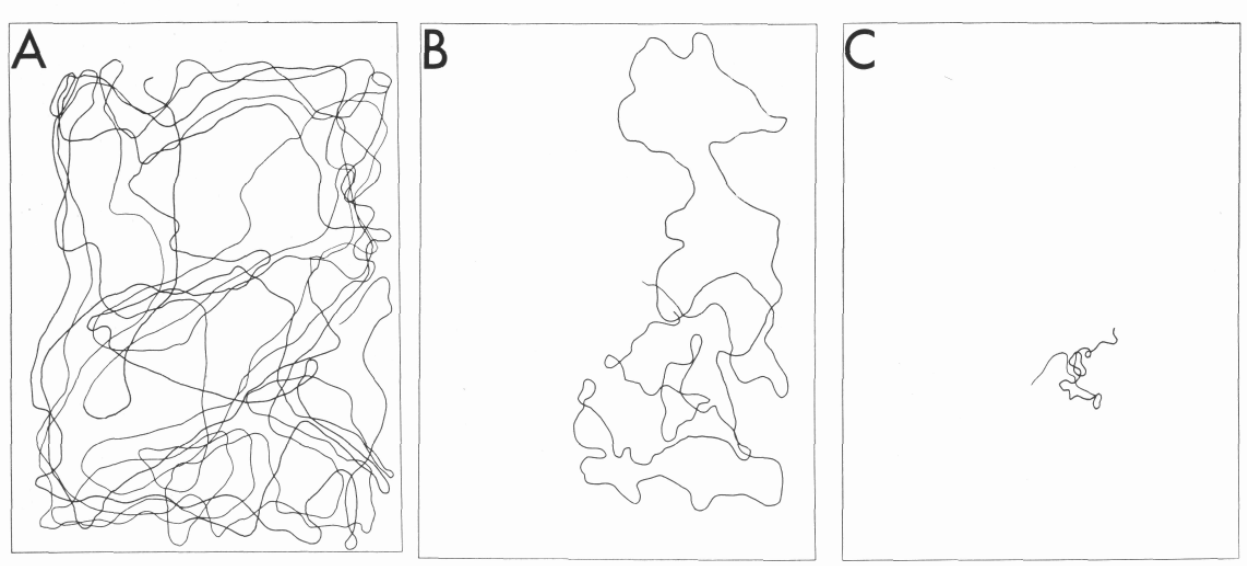
It was mentioned earlier that certain dust deposits not directly lethal to beneficial insects might seriously inhibit their efficiency in an indirect manner. This proved to be the case when **Stethorus** larvae were exposed to deposits of a dust made from finely ground kapok fibers.

Stethorus larvae confined in heavy deposits of this inert dust completed their development in the normal period of time when supplied with an abundance of mites in their immediate vicinity, thus demonstrating that the dust was not directly lethal to the larvae. However, a comparison of illustrations A, B, and C in Figure 1 will readily show how lights deposits of kapok dust markedly reduced the searching capacity of **Stethorus** larvae. Each of these illustrations depicts a 15-minute searching pattern of illustration A is a picture of the searching pattern of a larva on a “check” or untreated sheet of paper. Illustration B shows the pattern on a sheet of paper treated with a deposit of approximately 320 particles of kapok dust per square inch. Illustration C shows the pattern on a sheet of paper treated with approximately 1600 particles of kapok dust per square inch. The larva traveled 259 inches in a 15-minute period on the “check” or untreated sheet of paper; on the sheet with 320 particles per square inch the larva traveled 53 inches; and on the paper with 1600 particles per square inch in traveled 8 inches in 15 minutes.

In the presence of dust deposits such as these, **Stethorus** would be relatively ineffective in controlling populations of plant-feeding mites. The results of this experiment help to explain why (as frequently occurs in the field) **Stethorus** may become established on dusty avocado trees where mites are very abundant and yet be incapable of reducing the mites below the point of economic importance.

FIELD-LABORATORY EXPERIMENTS

In order to obtain field dust deposits from various areas, opened culture dishes placed on special stands in the field were exposed for given time intervals. After having thus collected deposits of air-borne dusts, the culture dishes were brought into the laboratory and the effects of the deposits on **Stethorus** and **Trichogramma** were observed.



Illustrations of a 15-minute searching pattern of a last-instar larva of Stethorus picipes on three differently treated sheets of typing paper. A. Check sheet free of a dust deposit. B. A deposit of approximately 320 particles of finely ground kapok per square inch. C. A deposit of approximately 1600 particles of finely ground kapok per square inch.

From these experiments it was learned that a culture dish exposed near an unpaved road in Riverside collected a lethal dust deposit from clouds of dust produced by the passing of 10 automobiles. Similarly, lethal dust deposits were collected within a five-day period in culture dishes exposed in the first row of avocado trees bordered by an unpaved road in Encinitas. Also, culture dishes exposed six feet from the lee side of a home incinerator during the burning of several days' accumulation of household trash collected a deposit of ash particles that killed most of the beneficial insects within seven hours. It was found that certain industrial dusts may be injurious to beneficial insects; culture dishes exposed for 24-hour periods at varying distances from several dust-producing industrial plants collected inert deposits that killed **Stethorus** and **Trichogramma** in a relatively short time.

GENERAL OBSERVATION

It has been observed that biological upsets have occurred in avocado orchards following the accumulation of dust deposits arising from the following sources: unpaved roads, turkey ranches, ditch-digging activities, incineration and a developing housing project.

From the foregoing studies and observations it is clear that almost any type of dust deposit in avocado orchards will inhibit the activity of beneficial insects and consequently increase the damage from pests. Therefore, precautions taken to keep trees clean and free from fresh dust deposits will help in the maintenance of a satisfactory biological control of insect and mite pests. However, since the daily deposit of dry dust particles is the most serious offender, the logical approach to dust prevention is the elimination of the dust source.

LITERATURE CITED

1. Bartlett, Blair R. The action of certain "inert" dust materials on parasitic Hymenoptera. Jour. Econ. Ent. 44(6): 891-6. 1951.