

destructive numbers in many localities in California from Imperial Valley to the central part of the state. In one instance at least it is reported to have been successfully controlled by a 6% nicodust.

COMBINATIONS OF NICODUST

There has also been collected a great deal of miscellaneous data on the various combinations of sulfur, arsenic compounds and fungicides on insect control. The use of lime instead of kaolin to produce a more efficient dust by liberating pure nicotine to be further fortified by the addition of dry sulfur at the time of mixing for nicosulfur dusts appears from many experiments conducted under widely different conditions upon various insects, to be more efficacious than nicodust of the same strength without the sulfur. When sulfur alone is treated with "Blackleaf 40" it appears to increase the efficiency of the nicotine over lime alone, but because of its weight it is not as easily handled in the dusting machines as is the regular nicodust.

Mixtures of nicodust and powdered arsenate of lead were very efficient in controlling caterpillars and flea beetles, particularly the latter on tomatoes.

Dusting for the control of the codling moth has received a considerable impetus and a large number of experiments are under way, mostly conducted by orchardists or insecticide manufacturers. We are contemplating a definite series of experiments along this line next year.

The revival of tobacco dust is also to be noticed and many mysterious "kill all" mixtures are being put on the market as rapidly as possible.

In conclusion I feel certain that there is a great future for dust spraying. As yet it has hardly been touched. The development of new machinery is also uncertain. The two must go hand in hand. As entomologists we should take an impartial view and do all in our power to bring about the very best possible conditions for the profitable production of clean and wholesome agricultural products by the elimination of insect pests by the most efficient and economical means.

NOTES ON THE USE OF NICOTINE DUSTS

By A. W. MORRILL

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During the past few months the writer has given considerable time to investigations of nicotine dusts for the California Sprayer Company, manufacturers of a well known dusting machine and of a brand of nicotine insecticides. Work has been done with many species of insects but the

results which I have to offer at this time are for the most part fragmentary. However, it is hoped that the miscellaneous observations here recorded may prove of some value to others.

OBSERVATIONS ON THE USE OF NICOTINE DUSTS AGAINST THE GRAPE LEAF-HOPPERS

It was found by various investigators in the season of 1920 that the grape leaf-hoppers were susceptible to the effects of nicotine dusts but to what extent these insects were actually killed seems not to have been definitely determined. Reports in regard to the effectiveness of nicotine dusts against the leaf-hoppers became rather conflicting early in the present season and field tests were consequently undertaken in the Imperial Valley and later in the San Joaquin valley to discover the facts in regard to this question.

As a basis for work against the grape leaf-hoppers it was considered necessary to make a study of the methods of checking results of nicotine dust applications in vineyards. The method in common use consisted in spreading papers or canvas under the vines to be dusted and observing the hoppers which dropped on these comparatively smooth surfaces. Other observers modified this method by dumping the dead and stupefied insects from papers or canvas into pasteboard boxes or glass jars together with the dust which had dropped from the vine with the insects. By these methods an element of uncertainty was introduced by the assumption that the dusts which had dropped from the treated vines had lost all toxicity.

Among the methods tested by the writer were: (1) observing hoppers which dropped onto papers and canvas spread under the vines (2) observing hoppers which dropped into an old galvanized bucket with rough bottom (3) observing hoppers picked up with forceps from papers and canvas within five minutes after applying dust to the vines and kept in glass jars or vials (4) observing hoppers which dropped into a galvanized bucket within five minutes from the application of dust to the vine and which were dumped into a wire sifter to separate from dust and then into a glass jar for observation (5) observing hoppers which dropped onto a fine wire screen (about 50 mesh) through which most of the dust immediately passed and (6) observing hoppers which were left lying as they fell on the ground under the vines.

The last mentioned method was the most tedious but was necessarily the standard. The use of a fine wire screen (the inverted top of an insect breeding cage was used in this observation) appeared to give results which approximated those obtained by the standard method and the

insects were much easier to locate and keep under observation. When the insects dropped onto papers spread on the ground even a slight breeze had a tendency to blow the insects and dust together in depressions giving far from normal conditions. One would naturally suppose that by carefully picking up adults which had fallen onto canvas and dropping these into glass jars the insects would be under conditions as favorable for recovery as though they were lying on the ground under the plant. This however, does not appear to be the case. When collected in a bucket placed under the dusted plant and the dust sifted from the mass of insects a very noticeable difference in the percentage of recovery was noted in tests with different lots of dust. It has not been determined whether this is entirely due to a difference in toxicity or is partly due to other factors, such as air movement affecting the amount of dust adhering to the insects.

In order to determine whether field results from different lots of dust corresponded with the nicotine content two sample dusts which apparently were of low toxicity were analysed¹ for comparison with two other lots of similar dusts of apparently high toxicity. The analyses and field results are shown in the following table:

Lot no.	1	2	3	4	aver. 1&2	aver. 3&4
Percentage adult leaf hoppers recovered	14.3	25.	1.5	0	19.6	.72
Nicotine shown by analysis of sample	1.95	1.76	1.30	1.25	1.85	1.27

Field tests of lots 2, 3 and 4 were made on June 16 in the same vineyard near Fresno within a period of 1 hour, using exactly the same methods. All conditions were supposedly practically identical. The test of lot 1 was made in another vineyard on the preceding day. No difference was noted in temperature or wind conditions which could account for the difference in killing effects as compared with the other three samples. In these tests the insects dropped into a bucket and were separated from the dust by means of a sieve, then kept in closed Mason jars for observations.

In another field test using a nicotine dust which analysed 2.23% nicotine the field tests showed results strikingly inferior to those with a dust of exactly the same composition but with only 1.55% nicotine. These tests were made near Holtville in the Imperial Valley, one application immediately following the other and all conditions supposedly practically identical. The insects were collected on canvas spread under the vines, picked up carefully with forceps and kept in vials for observation. Eleven

¹Analyses made through cooperation of Prof. Gray, Chief Div. of Chemistry, Cal. Dept of Agric.

out of 40 adults recovered within two hours in case of the vine dusted with the 2.23 dust whereas with the 1.55% dust only one adult out of 75 under observation recovered during a period of 7 hours.

No conclusions should be drawn from the foregoing observations except to the effect that either the nicotine content does not necessarily indicate the relative toxicity of nicotine dusts of otherwise practically identical chemical composition or that the methods described for securing the results are of very questionable dependability.

As already noted the standard method of checking results of dust applications consists in observing the insects on the ground under the treated plant. On June 18, Mr. A. J. Flebut of the U. S. Bureau of Entomology, and the writer undertook to determine the difference in the percentage of recovery of adult leaf-hoppers left on the ground under dusted vines, on screens and in buckets. Of 109 adults under observation 56 were in buckets and none of these recovered, 40 were on fine wire screens and of these 28 recovered while 13 were on the ground where they fell from the vines and of these 11 recovered. Of 21 nymphs under observation in the same tests, all on the screens, 7 recovered. These figures do not necessarily indicate the value of dusting for the leaf-hoppers since many of the insects, both nymphs and adults, drop onto the upper surfaces of leaves where they remain in contact with dust and apparently are under as unfavorable conditions as the adults which were under observation in the bucket. Furthermore many or most of the nymphs which recover on the ground probably fail to get back on to the plants. This probably explains the reason why satisfactory results were reported by many vineyard owners who used the dusting method early in the season. In the tests above mentioned dusts were used in which $7\frac{1}{2}\%$ and 10% of Blackleaf 40 were used in manufacture, the analysis showing 2.4 and 3.8% of nicotine respectively; the former with 90% hydrated lime and 10% sulphur as a carrier and the latter with a carrier composed of approximately 75% sulphur and 25% lime.

From the writers observation it appears that the use of ordinary nicotine dusts against the grape leaf-hopper is of little value against the adults.

Against the nymphs the value appears to consist in stupefying a large percentage causing them to drop. Early in the season before the vines have runners lying on the ground or in the case of trellised vines, this probably is equivalent to killing a large percentage of the insects.

In certain experiments in which a second application of dust was made to vines from one to 24 hours after the first, it was estimated that the first application caused 100 per cent of the nymphs to drop in the first

experiment, 95% in the second, and 95.2% in the third. The number of nymphs counted in the three experiments was 46, 106, and 681 respectively. The foregoing tests were somewhat less dependable in the case of the adults since some of those which did not drop from the first application may have left the plants. In one test however in which a square block of 16 vines was dusted, a second thorough dusting 24 hours after the first showed that about 55% of the adults had been killed or had disappeared from the central block of four vines. Nine hundred and seventy-four adults were included in this count. Only those which dropped from each vine into a bucket within five minutes after the dust was applied were included, the estimated total for the average plant being about 1700.

OBSERVATIONS ON THE USE OF NICOTINE DUSTS AGAINST THE MELON APHIS

Investigations of the writer in the Imperial valley and other points in Southern California have not developed much of practical value to add to the discussion of melon aphid control presented by Mr. Roy Campbell in Circular 154 of the U. S. Dept. of Agriculture. For scattering infestations the writer advises nicotine dusts with not less than 2.4% nicotine. This requires about 7½% of Blackleaf 40 in manufacture. The expense in this case is partly for insurance of the uninfested plants against the spread of the insects. When the infestation is general throughout the field and the problem has become one of reasonable control for the purpose of maturing a marketable crop, with no consideration for restriction of spread, a dust with about 1.5% of nicotine, or 4 or 5% Blackleaf 40 used in manufacture, is to be preferred.

The need of early season scouting or patrolling of the melon fields to locate incipient aphid colonies cannot be too strongly emphasized. Paradoxical as it may seem, the most expensive treatment on a basis of cost per hill is the most economical. Growers can better afford to spend \$4.00 a day for patrolling in early season when a man can find only one or two infested plants each day, at a cost of two to four dollars per hill for labor alone, than he can afford 5c a hill for both labor and material in dealing with a general infestation when the melons are beginning to mature. If a commercial melon field were so generally infested throughout as to require treatment of all the vines with an insecticide to save the crop, the cost of dusting would be prohibitive. Such a condition seldom if ever occurs however, since ordinarily by the time such a widespread infestation has developed a large percentage of the plants are already dead.

An attempt was made to overcome the interference of high winds and to reduce the amount of material needed per plant by using a canvas cover to confine the dust. Areas about three feet square were covered with eight ounce duck held 2 to 4 inches above the leaves of the vines and with side pieces extending to the ground. From one-fifth to one-fourth of the amount of dust normally required was used per plant, discharging the dust at different parts of the enclosure in different tests. These results did not encourage the belief that the use of covers could be used to advantage with the dusting process.

In the Imperial Valley late in May and early in June, with maximum daily temperatures ranging between 93 degrees and 103 degrees, nicotine dusts containing approximately 75% sublimed sulphur caused burning of canteloupe plants.

A single infested watermelon plant treated with such a dust May 29th showed no injury, the aphids being completely eradicated. Pure sulphur applied as a check to canteloupe plants on June 1 had caused no noticeable damage two days later but on June 5 it was noted that the dusted vines were badly burned. While nicotine sulphur dusts may not cause any damage to canteloupes where the temperatures are more moderate than in the Imperial Valley it appears safer to avoid the use of dusts on this crop containing more than 10% sulphur.

Special mention should be made of the relation between nicotine dusts for the melon aphid and the natural enemies of this pest. During the period mentioned above, adult lady bugs were very abundant in the melon fields but there were very few eggs and larvae present. Hymenopterous parasites were remarkably scarce. The most active natural enemy was a species of syrphus fly. A similar situation with regard to melon aphid natural enemies was noted at Burbank near Los Angeles, during July. The adults and larvae of lady birds (*Hippodamia convergens*) and the larvae of the syrphus flies (species unknown) were apparently unaffected by the nicotine dusts used in the experiments.

In tests of nicotine dusts against the melon aphid near Los Mochis, Sinaloa, Mexico in March 1921 it was noted that the adults of hymenopterous parasites (*Aphidius testaceipes*) were apparently not affected by dusts which were satisfactory against the aphid. The aphids which survived the dust, located mostly in curled leaves, received the concentrated attack of the parasites resulting in almost complete eradication of the pests.

OBSERVATION ON NICOTINE DUSTS AGAINST THE WOOLLY APPLE APHIS

Prof. P. J. Parrott has reported¹ nicotine dusts as strikingly ineffective against the woolly apple aphid in his experiments. This is as would be expected but for some reason the writers preliminary tests have shown remarkable susceptibility of this species to nicotine sulphur dusts averaging about 1.6% nicotine² and somewhat less susceptibility to a dust containing over 2% nicotine with a carrier composed of 90% lime. Although only a few infested trees have been available for this work, repeated applications have given uniformly good results. The writer has had experience in the use of nicotine soap solutions against the woolly aphid but in the preliminary dusting experiments here referred to, obtained better results with less effort than previously with the wet applications.

Using the dusts mentioned above colonies of the aphids were frequently completely eradicated on small trees with dust blown from a distance of three or four feet with not enough air pressure to disarrange the waxy covering of the insects and with so little dust remaining attached to the wax as to be scarcely noticeable to the naked eye. The difference in the results obtained by Professor Parrott and the writer may be due to the difference in nicotine content of the dusts tested or perhaps to the dusting machine used by the writer being better adapted for the work. The applications here recorded were made with temperatures ranging from 75 to 85 degrees but no relation between the temperatures and the results was noted.

TWO MECHANICAL DEVICES FOR CONTROLLING WESTERN CUCUMBER BEETLES

By ROY E. CAMPBELL, *Assistant Entomologist*, and WALTER H. NIXON³

In the State of California the western twelve-spotted cucumber beetle (*Diabrotica soror* Lec.) known locally as well as somewhat generally as *the* "Diabrotica," and erroneously as the "green ladybird", causes considerable damage each year.

The beetle is a very voracious and universal feeder, the number of its food plants being placed at over five hundred. From a commercial standpoint, the injury is confined mostly to crops such as beans, cucumber, alfalfa, beets, pumpkin and melons. The injury of cucurbits is to the stems and leaves of the young plants; of alfalfa and beets it is to the

¹Jour. Econ. Ent. Vol. 14, p. 211.

²The writers statements of nicotine content refers to the results of analyses of the manufactured dust and not to the amount of nicotine added to the carrier.

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