INVESTIGATIONS ON THE
Control of Hop Pests
1939

by

H. E. Morrison

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H. E. Morrison

Assistant in Entomology

Oregon Agricultural Experiment Station
Oregon State College
Corvallis, Oregon

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Introduction

A detailed report of the life history, description, habits and control measures of fourteen of the more important hop pests is given in the Biennial report of the Department of Entomology for 1937-1938.

Preliminary field work was carried on in 1938 for the control of the common red spider, Tetranychus telarius Linn. and fourteen treatments were tested. One material, dinitro-o-cyclohexylphenol (1%), in walnut shell flour gave promising results. More comprehensive experiments were conducted in the field in 1939 with this material at various dilutions and in combination with various added toxicants. The results of these experiments are described in detail in this report.

In 1938, some preliminary observations were made on the effect of overhead sprinkling to populations of the common red spider, Tetranychus telarius Linn. More detailed studies were made along this line and their results are given in this report.

Seasonal history of Tetranychus telarius Linn.

The seasonal history of the common red spider, Tetranychus telarius Linn., was very erratic during 1939. Detailed seasonal history studies were undertaken at the College Experimental Hop Yard, Corvallis, Oregon, but time did not permit similar studies at other localities. The method of taking population counts is described fully in the Biennial hop pest report for 1937-1938.

Adult red spiders were noted on hop foliage at Corvallis and other localities in the Willamette Valley as early as May 8, 1939. This was fifty-two (52) days earlier than their initial appearance in 1938. They increased very slowly during the months of May and June, but their rate of increase was very rapid during July and August. The seasonal history during these midsummer months closely paralleled that of 1938.

Parasites and predators were again credited with holding red spiders in check. Population counts on the number predators showed that the lady bird beetles var. juliana Muls., Adalia bipunctata Linn., Hippodamia parenthesis Say., californica Mann. Cycloneda munda Say and Coccinella were most abundant respectively, and as many as 26 were found on the lower third of one hop plant. There was considerable evidence of secondary parasitism among these predators. This indicates that their control value may be considerably lessened during 1940.

Red spiders were generally more abundant in 1939 than in 1938 and presented an economic threat to a number of hop yards. Most growers were able to control them satisfactorily and little economic damage resulted. A comparison of populations of the common red spider Tetranychus telarius Linn. between the 1938 and 1939 seasons is shown in the following table.

Comparison of Tetranychus telarius Linn. populations

1938-1939

	Population distribution			Population density		
	Percentage leaves infested			Number of red spiders per leaf		
Date	1938	1939	% difference	1938	1939	% difference
July 11	5	17	71	.005	1.0	99.5
July 27	12	58	79	.013	2.9	99.5
August 1	14	71	81	.015	6.2	99.8

Overhead irrigation versus Tetranychus telarius Linn.

A new irrigation system was installed in 1939 at the Oregon Agricultural Experimental Hop yard, Corvallis, Oregon, and the effect of various kinds of overhead irrigation on yield and abundance of Downy mildew were studied. The results of these investigations will be reported separately by the Department of Farm Crops. Irrigated hops were shown to be more vigorous and produced increased yields over non-irrigated plants. There was little evidence of increases in abundance of Downy mildew under the 1939 seasonal conditions, according to Dr. R. E. Fore, Associate Agronomist, Oregon State College. Overhead irrigation was carried on during severe temperatures throughout the day with no indication of foliage burn.

Studies on the effect of this type of irrigation on red spider populations were prevented at the experimental hop yard because of insufficient numbers of red spiders.

Preliminary observations on this problem were made in 1938 at the Oberson and Gosler Hop Yard near Buena Vista, Oregon. The owners had installed a new overhead sprinkling system and used long arm rotary sprinklers. There were indications that this cultural practice may have contributed toward red spider control, but populations were not sufficiently abundant to make detailed counts. Biological control agents were very active in this yard in 1938 and it was not possible to separate the control value of the biological factors and those produced by overhead irrigation.

The owners of this yard replaced the long arm rotary sprinklers with short arm sprinklers in 1939. Water was directed in an outward and upward manner on the undersurface of the hop leaves at a pressure of fifty pounds. This system provided for ease in pipe movement but plants in the proximity of rotary sprinklers suffered severe mechanical injury.

Detailed population counts were made in this yard on July 17 and July 25. Distribution and density figures were taken on each occasion from nine (9) different points in the yard. The manner of making these counts is described in detail in the Biennial Hop Report for 1937-1938. No check or unirrigated areas were allowed to stand for comparative purposes.

The Northern forty (40) rows of the yard had been irrigated at the time the population counts were first taken on July 17. The data from these counts are tabulated and summarized as follows:

Date - July 17, 1939

Location of count					
Northwest corner*			North central part*		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	40	25	1	10	3
2	30	10	2	60	120
3	40	20	3	50	11
4	70	34	4	80	25
5	30	18	5	20	5
6	30	11	6	20	10
7	30	16	7	100	38
8	20	12	8	80	50
9	50	11	9	60	27
10	30	19	10	40	29
Mean	37 ± 13.45	18±7.15	Mean	51 ± 28.23	32 ± 32.68

Location of count					
Northeast corner*			West central part**		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	10	25	1	100	610
2	0	0	2	100	800
3	20	12	3	100	1000
4	0	0	4	100	1500
5	20	6	5	100	450
6	20	3	6	100	900
7	20	12	7	100	230
8	50	75	8	100	750
9	0	0	9	100	2000
10	20	5	10	100	1200
Mean	16 ± 14.28	14 ± 21.69	Mean	100 ± 0	944 ± 493.63

Location of count					
Central part**			East central part**		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	20	12	1	20	57
2	100	120	2	50	75
3	70	85	3	100	450
4	70	130	4	90	140
5	70	120	5	40	70
6	80	100	6	80	75
7	30	25	7	100	190
8	90	140	8	100	140
9	90	97	9	20	60
10	50	35	10	90	125
Mean	67 ± 24.91	86 ± 13.88	Mean	69 ± 31.03	138 ± 111.99

Note * - All plants had been irrigated when data was taken.
** - Plants were not irrigated when data was taken.

Date - July 17, 1939

Location of count					
Southwest corner**			South central part**		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	50	130	1	70	45
2	100	140	2	80	93
3	70	150	3	50	40
4	90	105	4	20	7
5	90	160	5	90	135
6	100	112	6	60	45
7	50	97	7	90	105
8	70	137	8	50	80
9	100	97	9	60	92
10	90	62	10	100	70
Mean	81 ± 18.68	119 ± 28.26	Mean	67 ± 22.82	71 ± 35.58

Location of count		
Southeast corner**		
Plant No.	% leaves infested	Population per leaf
1	100	160
2	80	97
3	80	75
4	80	70
5	100	115
6	90	120
7	80	85
8	80	110
9	70	90
10	50	45
Mean	81 ± 13.45	97 ± 30.16

Note: ** Plants were not irrigated when data was taken.

Date - July 25, 1939

Location of count					
Northwest corner			North central part		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	40	11	1	30	12
2	40	23	2	50	40
3	40	8	3	40	6
4	50	31	4	40	18
5	20	4	5	40	14
6	30	7	6	30	9
7	40	18	7	30	7
8	20	11	8	20	12
9	20	17	9	20	9
10	20	20	10	30	14
Mean	32 ± 10.77	15 ± 7.88	Mean	33 ± 9.00	14 ± 9.28

Location of count					
Northeast corner			West central part		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	0	0	1	100	1000
2	20	5	2	100	900
3	20	8	3	100	600
4	0	0	4	100	500
5	20	3	5	100	100
6	0	0	6	80	200
7	10	2	7	100	70
8	0	0	8	90	1000
9	10	2	9	100	400
10	10	5	10	100	500
Mean	9 ± 8.30	3 ± 2.64	Mean	97 ± 6.40	527±332.1

Location of count					
Central part			East central part		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	10	3	1	30	9
2	50	35	2	10	3
3	100	88	3	40	6
4	50	63	4	50	12
5	100	57	5	20	8
6	90	78	6	60	15
7	60	40	7	40	13
8	30	12	8	60	25
9	60	14	9	70	30
10	40	36	10	80	14
Mean	59 ± 28.44	44 ± 27.81	Mean	46 ± 21.07	14 ± 7.93

Date - July 25, 1939

Location of count					
Southwest corner			South central part		
Plant No.	% leaves infested	Population per leaf	Plant No.	% leaves infested	Population per leaf
1	90	200	1	80	32
2	90	48	2	60	140
3	100	550	3	40	20
4	90	250	4	90	52
5	100	350	5	90	75
6	80	300	6	100	49
7	60	90	7	100	85
8	90	125	8	80	40
9	80	40	9	50	45
10	60	27	10	70	18
Mean	81 ± 14.87	198 ± 159.30	Mean	76 ± 19.60	56 ± 34.65

Location of count		
Southeast corner		
Plant No.	% leaves infested	Population per leaf
1	100	40
2	100	53
3	30	8
4	100	75
5	40	15
6	80	47
7	30	9
8	100	65
9	30	7
10	40	9
Mean	65 ± 31.70	33 ± 24.91

Summary - Percentage Leaves Infested

Location	Mean (1) 7/17/39	Standard error of Mean (1) ±	Mean(2) 7/25/39	Standard error of Mean (2) ±	Mean (1) minus Mean (2)	** $\frac{\text{Mean(1) minus Mean(2)}}{\sqrt{\text{S.E.M.(1) plus S.E.M.(2)}}}$
North west corner	37	4.25	32	3.40	5	.919
North central part	51	8.93	33	2.84	18	2.02
North east corner	16	4.52	9	2.64	7	1.338
West central part	100	0.00	97	2.02	3	1.48
Central part	67	7.87	59	8.99	8	.669
East central part	69	9.81	46	6.66	23	1.94
South west corner	81	5.90	81	4.70	0	0.00
South central part	67	7.21	76	6.20	- 9	.946
South east corner	81	9.53	65	10.02	16	.954

** - Value necessary for significance -- 2.00 or more

Summary - Number of red spiders per leaf

Location	Mean (1) 7/17/39	Standard error of Mean (1) ±	Mean (2) 7/25/39	Standard error of Mean (2) ±	Mean (1) minus Mean (2)	*** $\frac{\text{Mean(1) minus Mean(2)}}{\sqrt{\text{S.E.M.(1) plus S.E.M.(2)}}}$
North west corner	18	2.26	15	2.49	3	.906
North central part	32	10.33	14	2.93	18	1.68
North east corner	14	13.71	3	.83	11	.801
West central part	944	156.09	527	105.01	417	2.21
Central part	86	4.38	44	8.59	42	4.35
East central part	138	35.41	14	2.50	124	3.49
South west corner	119	8.39	198	50.37	- 79	1.36
South central part	71	11.25	56	10.95	15	.956
South east corner	97	9.53	33	7.87	64	5.18

*** - Value for significance -- 2.00 or more.

Discussion of Results

The results of this study are not conclusive but several interesting points have resulted.

1. Population counts on the northern forty (40) rows were made on July 17 after they had been irrigated. These counts (both density and distribution) were significantly lower than the remainder of the yard. This may have been due to the effect of irrigation and/or lower initial red spider infestation.

2. There was no significant reduction in red spider distribution between the dates July 17 and July 25 when data were considered collectively (hop yard as one unit) or when considered separately (yard divided by sectors).

3. Population density data show no significant reduction between the dates July 17 and July 25 when they were considered collectively (yard as one unit) but four of the nine sectors show a highly significant reduction when data were considered separately.

4. Red spider populations showed the highest rate of increase from July 15 to July 30, at Corvallis, Oregon. Similar increases may have occurred at the Oberson and Gosler hop yard but no check (unirrigated) hops were allowed to stand for comparative purposes. The real value of this modified overhead irrigation system on red spider control is uncertain because of insufficient data.

5. The Oregon Agricultural Experimental Hop Yard is now ably equipped to conduct more detailed and specific studies on this problem. These investigations will be carried on if and when red spiders become available in sufficient numbers for experimental work.

Fig. 1 New field insectary, East Farm, Corvallis, Oregon

Fig. 2 Hop experimental duster for use in small plots

Fig. 3 Dust Mixing Machine at East Farm, Corvallis, Oregon

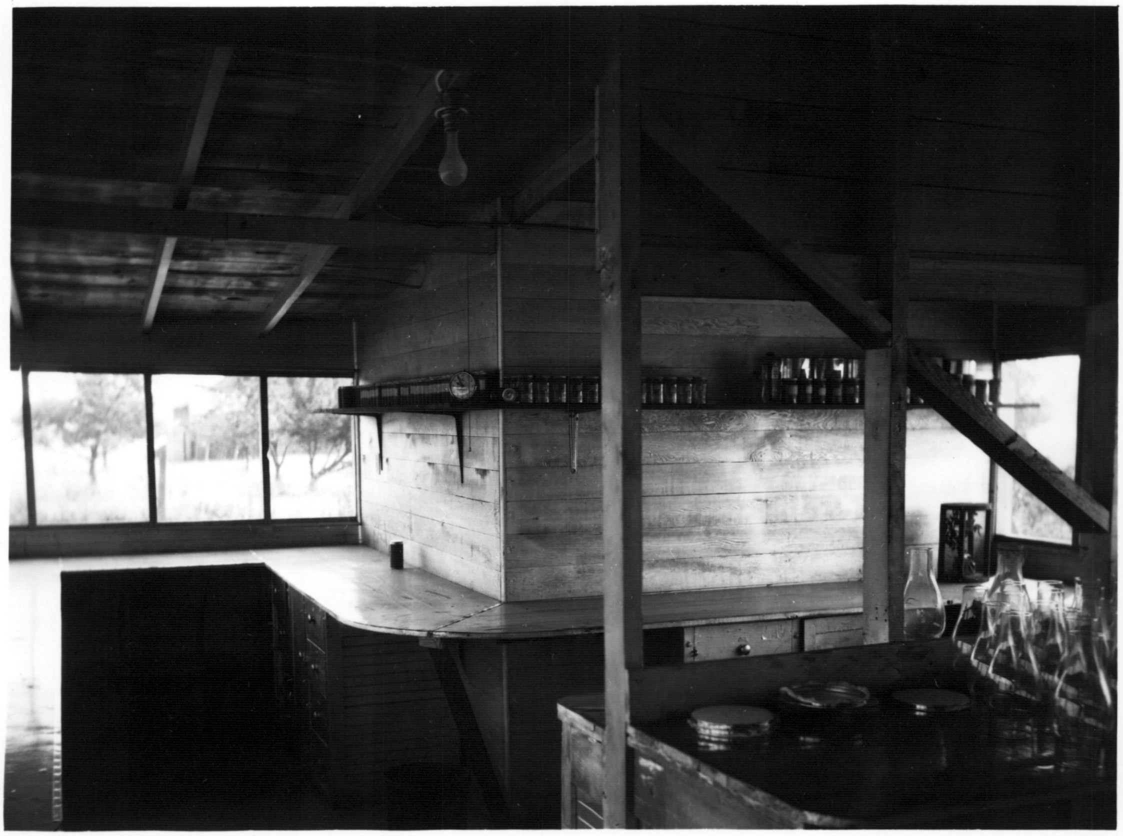


Fig. 4 Interior of Insectary, East Farm, Corvallis, Oregon

Dinitro-o-cyclonexyl-phenol as an Insecticide

Historical review of nitro-phenol compounds

Dinitro-o-cyclohexyl phenol (DNOCHP or DN) belongs to a group of nitrol-phenols which have been known to possess insecticidal properties for many years. In 1892, Harz and Von Miller (2) (19) working in Germany combined and marketed equal parts of potassium 3-5-dinitro-o-cresylate and soap under the trade name "Antinonnine". This combination was harmless to plants at concentrations of .10 to .125 per cent and was reported as toxic to the gooseberry sawfly, Nematus ribesi Thor, the grain thrips, Lophyrus rufus Schoyen, the black arch moth Liparis monaca L., the antler or grass moth, Charaeas gramina and various acari, plant lice, fungi and rodents. It was ineffective against various cochineals and weevils.

Cooper and Walling (6) in 1915-1916 experimented with numerous materials against the blow fly larvae, Calliphora vomitoria and found that o-nitrophenol, p-nitrophenol and trichlorphenol did not act as a deterrent but did possess varying degrees of toxicity, depending upon the concentration of the material and its method of application.

Moore, 1917, (20) found that phenol, o-chlorphenol and o-dinitrophenol were toxic in the gaseous state to the adult of the house fly, Musca domestica L. The following year (21) he learned that p-nitrophenol in combination with creosote and talc were effective on the clothes louse, Pediculus humanus Linn.

In 1917, Jackson and Lefroy (14) tested over 140 different compounds as stomach poisons on the house fly Musca domestica L. and reported that o-dinitro-cresylate, potassium-o-dinitro-cresylate and ammonium-p-dinitro-cresylate were toxic.

Hargreaves in 1924 (11) tested over 140 different compounds on the larvae of the imported cabbage worm Pieris rapae L. and found that dinitrophenol, o-nitrophenol and nitrophenol had some toxicity as a stomach poison.

Tattersfield, Gimingham and Morris (23) in 1925 used the bean aphis, Aphis rumicis, and the eggs of the geometrid moth Selinia tetralunaria for test insects in their investigations of the toxicity of a number of phenol derivatives. They found that 3-5-dinitro-o-cresol and 2-4-dinitrophenol were more toxic than p-nitrophenol, trinitrophenol, m-nitrophenol, o-nitrophenol, phenol, 5-nitro-o-cresol, o and p-anisol, trinitro-m-cresol, 3-5-dinitro-p-cresol and 3-nitro-o-cresol.

In 1930, McAllister and Van Leeuwen (17) investigated the insecticidal properties of 345 compounds on the codling moth, Carpocapsa pomonella L., 2-4-dinitrophenol, 3-5-dinitro-o-cresol, 2-6-dinitro-4 chlorphenol, p-nitrophenol and o-nitrophenol were included in these tests and all but the latter compound showed decided toxicity.

The annual report of the Director of the California Experiment Station 1930-1931 (1) stated that the addition of o-dinitrocresol to oil sprays greatly increased the effectiveness of the spray against the eggs of the mealy plum aphis Hyalopterus arundinid Fabr.

McGovran (18) in 1933 emulsified several dinitrophenols (2-dinitrophenol and 2-5 dinitro-o-cresol) in white oil and found them only slightly more toxic than the oil alone when applied to newly hatch larvae of the codling moth Carpocapsa pomonella L.

2-4-dinitro-6-cyclohexyl-phenol (DNOCHP or DN) was first tested as an insecticide in 1936. Kagy and Richardson (16) conducted laboratory tests and determined the dosage mortality curves of DNOCHP-petroleum oil combinations on the eggs of the plant bug *Lygaeus kalmii* Stal and the adult of the San Jose Scale, *Aspidiotus pernicious* Comst. They concluded that the addition of DNOCHP to the oil increased its toxicity and that the DNOCHP-oil combination had a synergistic effect on both test insects.

Dutton (7) in 1936 carried on field tests using DNOCHP in oil and reported satisfactory control on the San Jose Scale, *Aspidiotus pernicious* Comst. and the eggs of the rosy apple aphis, *Anuraphis roseus* Baker. Less comprehensive tests indicated that satisfactory control was obtained against the eggs of the black cherry aphis *Myzus ceresia* F.

Boyce and Prendergast (3) in 1936 reported that a DNOCHP-petroleum oil combination offered promise against the citrus red mite, *Paratetranychus citri* McG., the black scale, *Saissetia oleae* Bern., the frosted scale, *Lecanium pruniosum* Coq., the codling moth, *Carpocapsa pomonella* Linn., and the orange tortrix, *Tortrix citrana* Fern. THESE INVESTIGATORS WERE THE FIRST TO INCORPORATE DNOCHP IN DUSTS. It was learned that diatomaceous earth was a superior carrier than bentonite, talc, hydrated lime or sulfur. Promising results were obtained with DNOCHP dusts against the green citrus aphis, *Aphis spiraecola* Patch, the melon aphis, *Aphis gossypii* Glov., the nymphs of the black scale, *Saissetia oleae* Bern., the California red scale, *Chrysomphalus aurantii* Mask. and the eggs, active and quiescent stages of the citrus red mite *Paratetranychus citri* MCG.

In the same year (1936) Kagy (15) determined the median lethal dosages of DNOCHP and its calcium, magnesium, lead and copper salts and compared them with acid lead arsenate, calcium 2-4-dinitro-phenylphenate, calcium 2-6-dinitro-4-cyclohexylphenate and lead 2-5-dinitro-o-cresylate on the last instar of the corn ear worm *Heliothis armigera* Hubn. He found that

DNOCHP, its salts and 2-4-dinitro-6-cyclohexylphenate were superior to acid lead arsenate in toxic and speed of toxic action on the army worm *Cirphis unipuncta* Haw. and the imported cabbage worm *Ascia rapae* Linn. Similar tests showed DNOCHP was more effective than arsenic trioxide on the red leggedgrasshopper, *Melanoplus femur-rubrum* DeG., but the calcium salt of DNOCHP was relatively ineffective.

Hansberry and Richardson (10) in 1936 determined the median lethal dosages of many insecticides against the silkworm, *Bombyx mori*, the corn ear worm, *Heliothis armigera* Hubn., the painted lady butterfly, *Vanessa cardui* L. (*Pyralis*), the army worm, *Cirphis unipuncta* Haw., and the imported cabbage worm *Ascia rapae* L. They compared their results with those of other investigators. The toxicity of DNOCHP or its salts was outstanding in all instances.

Hartzell and Moore (12) in 1937 tested various concentrations of oils, tar oils and oils containing DNOCHP against the apple form of the Oyster-shell scale *Lepidosaphes ulmi* Linn. Their results showed that the oil-DNOCHP combinations were superior to other treatments and that a less percentage of oil was necessary for commercial control when DNOCHP was added as a toxicant.

In 1938, Hartzell, Moore and Greenwood (13) conducted field tests against the egg stage of the eye-spotted budmoth and learned that the addition of DNOCHP afforded satisfactory control while a 3 per cent lubricating oil was unsatisfactory. The efficiency of the DNOCHP treatments increased in proportion to the amount of DNOCHP in the mixture.

Garman in 1938 (8) showed that a 4 per cent DNOCHP in lubricating oil emulsion was equally effective in the control of the rosy apple aphis, *Anuraphis roseus* Baker as tar oils and nicotine-oil sprays. The DNOCHP combination also controlled European red mite, Paratetranychus pilosus C. & F. The cost of the DNOCHP-oil spray was higher than the tar oil sprays but cheaper than the nicotine-oil combinations.

Morrison, in 1938 (22) carried on preliminary field tests with a 1 per cent DNOCHP-walnut shell dust against the common red spider, Tetranychus telarius L. on hops. Excellent control was obtained in this test but some burning was noted on baby hops. Later trials with the DNOCHP-redwood flour combination at concentrations of .125, .25, .40, .75 and 1.00 per cent DNOCHP showed very high toxicity and produced no burning.

Hammer, in 1938, (9) conducted field experiments with the scurfy scale Chinoaspis furfura Fitch in the apple orchards of New York State. He found that the addition of DNOCHP to various kinds and concentrations of lubricating oils gave increased toxicity.

In 1939, Boyce, Kagy, Pershing and Hansen (4) reviewed the physical and chemical properties of DNOCHP, and described a chlorometric method of analysis. They studied the distribution of DNOCHP in the oil and aqueous phase of spray emulsions and found that with acidified water 90 per cent of the compound remained in the oil phase while only 5 per cent of the compound remained in the oil phase when alkaline water was used. The phase distribution of the DNOCHP was correlated with insecticidal efficiency (greater kill was obtained with acidified water). Field tests were made and oxalic acid was used to acidify the alkaline waters of California. The use of this acid made it necessary to study various emulsifying and spreading agents. Powdered blood albumen was found to be most satisfactory. It was then learned that the use of acidified waters produced more tree injury.

DNOCHP in oil was sprayed to apricot trees and was apparently instrumental in causing them to break dormancy three weeks in advance of the untreated trees. The application of ½ per cent of no. 3 oil with the addition of .25 per cent was safe to the foliage of oranges and lemons. Slight injury was noted with increases in concentration of DNOCHP from .25 to .50 per cent and severe injury resulted with increases of DNOCHP from .50 to 1 per cent. High temperatures (100° F.) and low relative humidities (25%) apparently accentuated the injury.

The writers gave a summary of available information on the effect of DNOCHP on Public Health. Investigations have revealed that DNOCHP does not stimulate man or higher vertebrates and was lethal to birds and small mammals in very high dosages. DNOCHP in oil was tested in a preliminary way in the field with promising results on the black scale on naval oranges and apricots Saissetia oleae Bern., Citrocola scale on naval oranges, Coccus pseudomagnoliarum Kuw., the citrus red mite, Paratetranychus citri McG., the citrus white fly, Dialeurodes citri Ashm., the European elm scale Gossyparia spurina Mod., the red scale Aonidiella aurantii Mask., the walnut scale on Persian walnuts Aspidiotus juglans-regiae Comst., and the frosted scale on Persian walnuts, Lecanium pruniosum. The nicotine and sodium salts of DNOCHP have offered control of the melon aphis, Aphis gossypii Glov. The sodium salt has also been found toxic to eggs of the citrus red mite Paratetranychus citri McG. and the black scale Saissetia oleae Bern., while the triethanolamine salt of DNOCHP is also effective on S. oleae when used in an aqueous solution.

DNOCHP was found to react with lime, talc, bentonite and certain diatomaceous earths to form nitro phenol salts. The acid carriers walnut shell flour and redwood flour did not react in this manner and for this reason have received more favor. These dusts have shown promise of control of the common red spider, Tetranychus telarius, L., the citrus red spider, Paratetranychus citri McG., citrus thrips, Scirtothrips citri Moult., greenhouse thrips, Heliothrips haemorrhoidalis Bouche, the orange tortrix, Argyrotaenia citrana Fern., the red scale, Aonidiella aurantii Mask., the green citrus aphid, Aphis spiraecola and the melon aphid, Aphis gossypii Glov.

Boyce, Prendergast, Kagy and Hansen in 1939 (5) reported on the method of preparing DNOCHP in dust form. The solvent mix method of preparation was most satisfactory. By this method the DNOCHP is dissolved in toluene (70%) and carbon tetrachloride (30%) and atomized into a special mixing apparatus. This method was found superior to mechanical mixtures. However, a significant difference from the biological point of view could never be demonstrated from tests in the laboratory or in the field between dusts of these two type mixtures.

Field tests showed that there was considerable weathering of DNOCHP dusts over a period of six days. Laboratory tests have shown that this weathering is related to temperature and that sunlight and humidity are of little importance. The toxicity of DNOCHP has been measured to exist from 4 to 5 days after dusting and that mortality is usually accomplished within 24 hours after application. Newly hatched mite larvae are killed after hatching and the DNOCHP is toxic to these larvae for approximately one week. 100 per cent kill on mites is effected when .4 milligrams of 1% dust was applied per square centimeter. A new type of Duster has been constructed for satisfactory field applications. This featured a large volume of air moving at a low velocity (9000 to 10,000 cu. ft. min. at 65 miles hour). Very large fishtails were used to entail greater spread of the dust.

Walnut shell flour and redwood flour have supplanted diatomaceous earch, talc, bentonite, and hydrated lime as carriers for DNOCHP. Other materials which are being investigated and which offer promise include pecan shell flour, almond pit flour, peach pit flour, olive pit flour, apricot pit flour and hardwood flour.

Plants have been injured by DNOCHP dusts when applications were made at high temperatures. Generally speaking, little damage has been noted when temperature forecasts have been followed and applications were not made when temperatures would reach 95° F. or would likely reach this temperature two days in the future.

DNOCHP dusts are compatible with dusting sulfur and may be mixed with it. HCN fumigation can be carried on over freshly dusted trees. Oil sprays may be applied within one week after dust application and vice versa. The compatibility of DNOCHP dusts with cryolite, nicotine, zinc oxide and other zinc compounds are being investigated.

Field tests have been made with apparent safety to oranges, lemons, Persian walnuts, peaches and apricots when care has been taken to watch temperature forecasts.

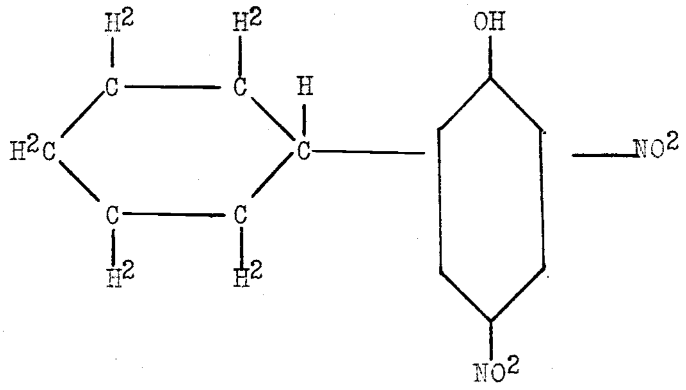
There appears to be no significant Public Health hazard involved in the use of DNOCHP dusts either to the operators who apply the material or to the consumers of the treated fruit. Preliminary laboratory and field tests have been made with DNOCHP dusts and they have been found effective against the cirtus red mite, Paratetranychus citri McG., the common red spider, Tetranychus telarius, Linn., the six spotted mite, Tetranychus sexmaculatus Piley, the Pacific mite, Tetranychus pacificus McG., the clover mite Briobia praetoisa Koch., and the walnut blister mite Eriophyes tristriatus erineous Nal.

Physical properties of Dinitro-o-cyclohexylphenol (4)

DNOCHP is an organic dye which is very active on wool, hair, feathers and other animal products but relatively inactive to cotton and other vegetable fabrics. It is a nearly odorless, yellowish-white crystalline compound with a molecular weight of 266 and a melting point of 106° C. It crystallizes from alcohol, petroleum oils and other solvents in needles and in hexagonal plates from acetone. The technical grade material which is used for insecticidal purposes is slightly impure.

Chemical properties of Dinitro-o-cyclohexylphenol (4)

Dinitro-o-cyclohexylphenol or more specifically 2-4-dinitro-6-cyclohexylphenol (DNOCHP or DN) is formed by the substitution of nitro-groups on o-cyclohexylphenol to give the following structural formula:



An example of the method of synthesis of this nitro-phenol is given as follows: (U.S. Patent No. 1,880,404). Edgar C. Britton and Lindley E. Mills to the Dow Chemical Co. of Midland, Michigan, October 4, 1932.

A mixture of 176 grams (1 mole) of ortho-cyclohexylphenol and 197 grams (approximately 2 moles) of concentrated sulphuric acid (specific gravity 1.665) was heated in a glass lined vessel and agitated at a temperature of 60° to 70° C. for about ¼ hour and then poured into about 700 grams of water contained in a vessel similar to that described above. The solution was warmed to about 70° C. and then 236 grams (about 2 moles) of nitric acid (sp. gr. 1.4) was gradually added with stirring.

The aqueous nitric acid mixture was then further diluted with 3500 grams of water and the temperature of the diluted mixture maintained at 85° to 90° C. for 1½ hours when the formation of the yellow crystals of dinitro-ortho-cyclohexylphenol was complete. The crystals were filtered and thoroughly washed with cold water. A yield of 218 grams of dinitro-ortho-cyclohexylphenol of melting point 104° C. or approximately 82 per cent of the theoretical yield of product, calculated on the quantity of the ortho-cyclohexylphenol used, was obtained. The recrystallized product (from alcohol) had a melting point of 106° C.

Chemical properties of Dinitro-o-cyclohexylphenol (4)

Dinitro-o-cyclohexylphenol is more soluble in aromatic solvents than in aliphatic solvents and the degree of solubility depends largely on the temperature of the solvent. The organic solvents arranged according to their ascending solubility of Dinitro-o-cyclohexylphenol are 95% ethyl alcohol, glacial acetic acid, carbon tetrachloride, acetone, ethyl acetate ethylene dichloride, xylene, toluene, and benzene.

The solubility of Dinitro-o-cyclohexylphenol in petroleum oils varies with the grade and temperature of the solvent and is apparently closely related to the unsulfonatable residue of the solvent.

Dinitro-o-cyclohexylphenol is almost insoluble in water and its degree of solubility is definitely related to the pH of the water. It is most soluble in water when the pH is between 6 and 7. The pH of the water definitely affects the relation of Dinitro-o-cyclohexylphenol in its distribution between the oil in water and water in oil phases. High pH values of water are associated with high percentages of dinitro-o-cyclohexylphenol in the aqueous phase, lower percentages in the oil phase and vice versa. Insecticidal efficiency of dinitro-o-cyclohexylphenol is considerably higher when pH values of the emulsion range between 4 and 6. Increases in pH beyond 6 brings about decided decreases in toxicity.

Preparation of dinitro-o-cyclohexylphenol sprays

It is necessary to combine dinitro-o-cyclohexylphenol in oil for spray purposes. Stock solutions are prepared by dissolving the nitro-phenol in the oil on a percentage weight basis. The grade and concentration of the nitro-phenol-oil mixture depends upon its intended usage. A light-medium oil (No. 3) is satisfactory on citrus foliage while heavy lubricating oils or tar oils are commonly used for dormant applications. The oil-nitrophenol mixture can be emulsified in spray tanks with 1¼ ounces of blood albumen and 3 ounces of oxalic acid per 100 gallons of water. The function of the oxalic acid is to adjust the pH range from 3.5 to 5.0.

Preparation of dinitro-o-cyclohexylphenol dusts

Three methods are employed in the preparation of dusts which contain dinitro-o-cyclohexylphenol; the mechanical method or ball mill method, the solvent-mix method, and the mechanically diluted solvent-mix method.

The mechanical method presents considerable difficulties because nitrophenol does not lend itself readily to this type of mixing. Certain of its physical properties tend to cause the crystalline particles to collect in aggregates. Fairly uniform dusts can be prepared by mixing equal parts of the diluent and dinitro-o-cyclohexylphenol in a ball mill from 12 to 24 hours and then diluting to the desired concentration by an additional 4 hours' mixing.

The solvent mix method is more satisfactory from the standpoint of dispersion of the nitro-phenol through the diluent. Dinitro-o-cyclohexylphenol is dissolved in a suitable solvent (70% toluene and 30% carbon tetrachloride) and then slowly atomized into the diluent which is under constant agitation. Thirty minutes in a special mechanical mixing device produces a satisfactory mix.

The mechanical diluted solvent mix method is also satisfactory from the biological standpoint. The product of the solvent mix method is taken as a base and diluted to the concentration desired with a given diluent. This method was used by the Entomology Department in preparing the Dinitro-o-cyclohexylphenol dusts for use in 1939.

Diluents such as walnut shell flour, redwood flour, talc, diatomaceous earth, bentonite and hydrated lime have been used with dinitro-o-cyclohexylphenol. The walnut shell flour and redwood flour are acidic compounds and as such do not form salts when mixed with the nitro-phenol compound. Talc, bentonite, hydrated lime and certain diatomaceous earths are alkaline in nature. These materials form buffers with the nitro-phenols and subsequently break down, the nitro-phenols into salts and phenates.

Phytocidal action of Dinitro-o-cyclohexylphenol

The phytocidal action of dinitro-o-cyclohexylphenol has been investigated to a limited extent. .25 per cent of the nitro-phenol in a solution of No. 3 oil used at a concentration of .5 per cent is apparently safe to oranges and lemons. Increased nitro-phenol content in the oil from .25 to .50 per cent is slightly toxic to foliage and a 1 per cent nitro-phenol-oil combination causes severe injury. There is apparently a very narrow margin between the insecticidal and phytocidal properties of this material.

Dinitro-o-cyclohexylphenol is also known to be specific for a number of plants and flax and strawberries are severely injured by very low concentrations of the nitro-phenol sprays and dusts. Oranges, lemons, Persian walnuts, peaches, almonds and beans are apparently able to stand repeated applications.

Temperature has been shown to be a limiting factor in the plant tolerance of dinitro-o-cyclohexylphenol. Severe injury is known to occur to foliage when nitro-phenol dusts are applied when temperatures are above 95° F. or are likely to reach this temperature for two days after application.

The insecticidal action of dinitro-o-cyclohexylphenol

The nitro-phenol group has received attention by various workers over a period of forty-seven years, and many claims are made for the insecticidal properties of this group. Limited tests have indicated that these nitrophenols act as fumigants, fungicides, stomach and contact insecticides.

Dinitro-o-cyclohexylphenol has been tested on over thirty different species of insects and it has been found effective as a scalicide, aphisicide, ovicide, acaricide, thripside and as a stomach poison on various lepidoptera and orthoptera. The physiological action of dinitro-o-cyclohexylphenol on insects has not been investigated.

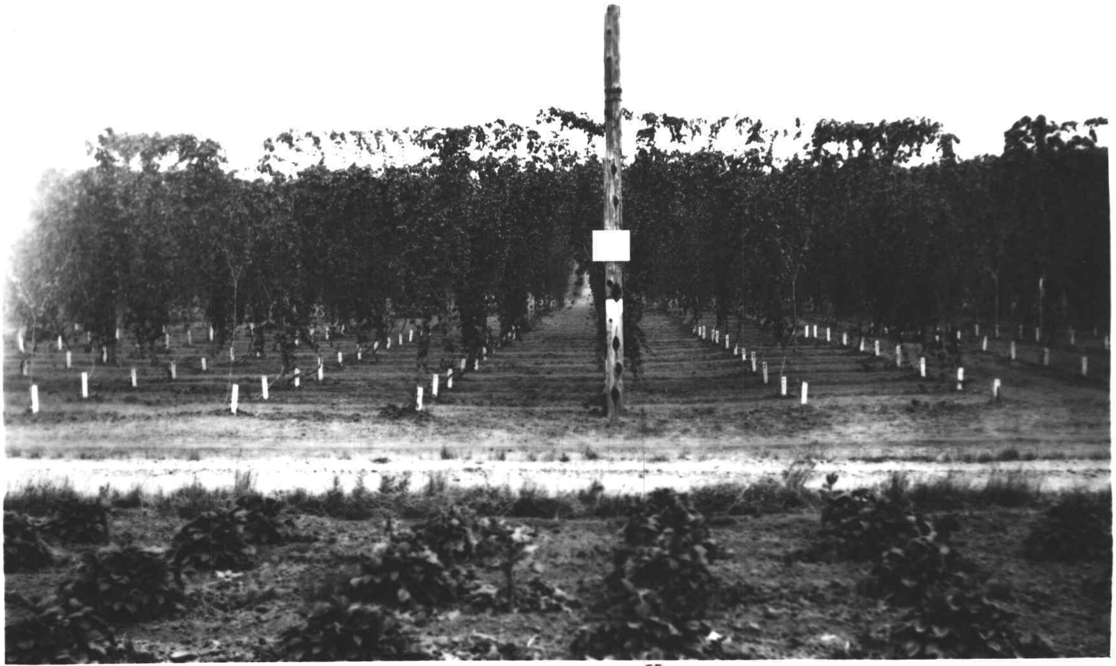


Fig. 5 General View of the Entomology Hop yard which was used for compatibility tests in 1939

Fig. 6 General View of the Entomology hop yard which was used for dosage tests in 1939

1939 Field Experiments with Dinitro-o-cyclohexylphenol

Seven dusts and seven sprays were tested against the common red spider Tetranychus telarius Linn. in 1938. Dinitro-o-cyclohexylphenol (DNOCHP or DN) dust at 1% concentration and walnut shell flour as a carrier was outstanding in control but some foliage injury was noted on baby hop plants. Later trials with this material at concentrations of .125, .25, .50 and 1.% gave promising results with no foliage injury to baby hops.

More comprehensive tests were carried out with DN dusts in 1939 at the Oregon Agricultural Experimental Hop Yard, Corvallis, Oregon, where dosage, compatibility and plant susceptibility trials were undertaken.

Dosage tests were carried on on one-half of the Entomology yard. This block had been used for dusting investigations in 1938. Dusts were applied at concentrations of .03125, .0625, .125, .50, .75 and 1.%. All dilutions were prepared in the mechanical dust mixer from the proprietary 1% DN dust.

Compatibility tests were made on the experimental block which was assigned to spray treatments in 1938. All dusts were prepared mechanically from the proprietary 1% DN dust and concentration of DN was held constant at .25% in all instances. Talc, hydrated lime, bentonite and diatomaceous earth were used as diluents while in other mixtures added toxicants such as 4% nicotine sulfate, .4% pyrethrins I and II, 1.5% loro and .6% rotenone were used.

Plant susceptibility tests were made in the varietal block of the experimental yard on four or more plants from twelve varieties. These varieties included Early clusters, Fuggles, Late clusters, Red vines, Brewer's favorite, Brewer's Gold, Belgian spalt, Kent golding, East Kent Golding and the Russian varieties Serebrianka, Skorospielka and Zimshevii. Treatments were applied to these plants on August 2 when temperatures in the hop yard exceeded 100 degrees F. Dosages approximated 100 pounds per acre. Check or untreated plots were allowed to stand in all experiments for comparative purposes. The toxicity of walnut shell flour was determined by applying it to one plant.

A new mechanical duster was purchased by the Entomology Department for small plot tests. This apparatus worked very satisfactorily and dusts were applied to small plots in a manner similar to that of spraying.

The pursuit of laboratory tests against the common red spider and other hop pests has been severely handicapped in the past because of the lack of an insectary for conducting these tests. This problem has been overcome in 1939 by the constructing of an insectary which measures 16 feet by 32 feet. One section of this building has been enclosed and equipped for the preparation of dusts. Approximately 190 square feet are available for insecticidal tests and the rearing of insects. The insectary is equipped with lights and will be equipped with water in 1940.

Cooperative work with the Department of Agricultural Engineering and the United States Department of Agriculture has been undertaken in the development of a new type of duster for use in hop yards. This duster features low velocity and high volume of air. It was given preliminary trials at the Experimental hop yard late in the season of 1939 and the results were very promising. This duster will be used for demonstration experiments in 1940.

The experimental design used in 1939 was similar to that employed in 1938 but increased plantings of hops made it possible to use eight replications of treatments. The method of measuring acaricidal efficiency was also similar to that of 1938. These methods are discussed fully in the Biennial hop report for 1937-1938. The diagrom of the experimental blocks and the collected data are shown on the following pages:

DIAGRAM OF HOP DUST BLOCK

12	3	3	1	1	2	2	4	4	8	8	7	7	5	5	6	6	2	2	4	4	3	3	1	1	5	5	6	6	8	8	7	7
11	3	3	1	1	2	2	4	4	8	8	7	7	5	5	6	6	2	2	4	4	3	3	1	1	5	5	6	6	8	8	7	7
10	3	3	1	1	2	2	4	4	8	8	7	7	5	5	6	6	2	2	4	4	3	3	1	1	5	5	6	6	8	8	7	7
9	6	6	4	4	7	7	3	3	5	5	1	1	8	8	2	2	7	7	3	3	6	6	4	4	8	8	2	2	5	5	1	1
8	6	6	4	4	7	7	3	3	5	5	1	1	8	8	2	2	7	7	3	3	6	6	4	4	8	8	2	2	5	5	1	1
7	6	6	4	4	7	7	3	3	5	5	1	1	8	8	2	2	7	7	3	3	6	6	4	4	8	8	2	2	5	5	1	1
6	7	7	5	5	1	1	8	8	6	6	2	2	3	3	4	4	1	1	8	8	7	7	5	5	3	3	4	4	6	6	2	2
5	7	7	5	5	1	1	8	8	6	6	2	2	3	3	4	4	1	1	8	8	7	7	5	5	3	3	4	4	6	6	2	2
4	7	7	5	5	1	1	8	8	6	6	2	2	3	3	4	4	1	1	8	8	7	7	5	5	3	3	4	4	6	6	2	2
3	8	8	2	2	6	6	5	5	3	3	4	4	7	7	1	1	6	6	5	5	8	8	2	2	7	7	1	1	3	3	4	4
2	8	8	2	2	6	6	5	5	3	3	4	4	7	7	1	1	6	6	5	5	8	8	2	2	7	7	1	1	3	3	4	4
1	8	8	2	2	6	6	5	5	3	3	4	4	7	7	1	1	6	6	5	5	8	8	2	2	7	7	1	1	3	3	4	4
Row No.	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
	Plot 1				Plot 2				Plot 3				Plot 4				Plot 5				Plot 6				Plot 7				Plot 8			

Fig. 7 Used for dosage tests in 1939

DIAGRAM OF HOP ~~SPRAY~~ DUST BLOCK

12	11	11	9	9	10	10	12	12	16	16	15	15	13	13	14	14	10	10	12	12	11	11	9	9	13	13	14	14	16	16	15	15
11	11	11	9	9	10	10	12	12	16	16	15	15	13	13	14	14	10	10	12	12	11	11	9	9	13	13	14	14	16	16	15	15
10	11	11	9	9	10	10	12	12	16	16	15	15	13	13	14	14	10	10	12	12	11	11	9	9	13	13	14	14	16	16	15	15
9	14	14	12	12	15	15	11	11	13	13	9	9	16	16	10	10	15	15	11	11	14	14	12	12	16	16	10	10	13	13	9	9
8	14	14	12	12	15	15	11	11	13	13	9	9	16	16	10	10	15	15	11	11	14	14	12	12	16	16	10	10	13	13	9	9
7	14	14	12	12	15	15	11	11	13	13	9	9	16	16	10	10	15	15	11	11	14	14	12	12	16	16	10	10	13	13	9	9
6	15	15	13	13	9	9	16	16	14	14	10	10	11	11	12	12	9	9	16	16	15	15	13	13	11	11	12	12	14	14	10	10
5	15	15	13	13	9	9	16	16	14	14	10	10	11	11	12	12	9	9	16	16	15	15	13	13	11	11	12	12	14	14	10	10
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1	16	16	10	10	14	14	13	13	11	11	12	12	15	15	9	9	14	14	13	13	16	16	10	10	15	15	9	9	11	11	12	12
Row No.	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
	Plot 1				**Plot 2**				**Plot 3**				**Plot 4**				**Plot 5**				**Plot 6**				**Plot 7**				**Plot 8**			

Fig. 8 Used for compatibility tests in 1939.

Summary of dosage trials

Treat. No.	Treatment	Per cent	pounds/ acre	Percentage dead red spiders Replications									Total spiders
				1	2	3	4	5	6	7	8	Mean	
1	Check - No treatment	---	---	6.3	7.0	6.1	7.1	3.3	6.1	5.3	5.3	5.8	3977
2	DNOCHP Walnut shell flour	1.00 99.00	124	99.9	100.0	100.0	99.8	99.3	99.8	100.0	100.0	99.8	5131
3	DNOCHP Walnut shell flour	.75 99.25	156	99.7	100.0	99.3	100.0	100.0	99.5	100.0	99.5	99.8	5353
4	DNOCHP Walnut shell flour	.50 99.50	116	99.5	100.0	100.0	99.6	100.0	99.8	97.1	100.0	99.5	4543
5	DNOCHP Walnut shell flour	.25 99.75	136	100.0	99.8	99.7	99.8	99.6	99.5	99.7	100.0	99.8	4880
6	DNOCHP Walnut shell flour	.125 99.875	125	98.8	95.3	97.2	95.6	98.5	98.1	89.3	93.9	95.9	5670
7	DNOCHP Walnut shell flour	.0625 99.9375	119	98.9	99.8	98.8	99.6	98.7	99.9	97.5	96.8	98.7	6419
8	DNOCHP Walnut shell flour	.03125 99.96875	156	98.9	98.7	100.0	96.5	97.3	99.0	98.3	90.8	97.4	6565

Summary of Compatibility Trials

Treat. No.	Treatment	Per cent	Pounds per acre	Percentage dead red spiders Replications									Total spiders
				1	2	3	4	5	6	~~6~~ 7	8	Mean	
9	Check	---	---	14.4	15.9	2.2	6.8	3.9	6.2	7.8	1.7	7.3	4833
10	DNOCHP Walnut shell flour Talc	.25 24.75 75.00	145	92.3	99.4	99.7	97.9	98.3	94.1	97.4	94.8	96.7	4552
11	DNOCHP Walnut shell flour Hydrated lime	.25 24.75 75.00	156	97.5	95.7	90.8	92.6	89.1	84.5	95.9	88.6	91.8	5486
12	DNOCHP Walnut shell flour Bentonite	.25 24.75 75.00	90	77.2	99.5	95.0	94.5	98.9	93.4	97.9	88.7	93.1	4981
13	DNOCHP Walnut shell flour Diatomaceous earth	.25 24.75 75.00	53	46.4	85.2	87.3	96.9	94.6	82.9	96.8	99.8	86.3	4644
14	DNOCHP Walnut shell flour Talc Loro Rotenone	.25 24.75 72.90 1.50 .60	85	90.5	98.9	98.7	98.3	96.6	93.5	98.9	98.1	96.7	4811
15	DNOCHP Walnut shell flour Talc Pyrethrins I and II	.25 24.75 74.60 .40	60	99.6	96.4	98.3	98.9	98.2	97.1	99.6	99.1	98.4	4960
16	DNOCHP Walnut shell flour Hydrated lime Nicotine sulfate (40%)	.25 24.75 71.00 4.00	84	95.4	97.5	90.9	93.0	92.3	86.4	91.7	92.2	92.4	5635

Fig.9 Dinitro-o-cyclohexyl phenol burn on hop foliage of Russian variety-Serebrianka 1939.

Fig.10 Dinitro-o-cyclohexyl phenol burn on hop cones of Russian Variety-Skorospielka 1939.

Discussion of Results

Red spiders were not present in sufficient numbers to cause economic injury to the check or untreated plots but sufficient numbers were counted to justify the following conclusions:

1. DN dusts (mechanically diluted from the proprietary 1% dust) showed no significant differences between concentrations of .03125, .0625, .125, .25, .50, .75 and 1 per cent. All gave a very satisfactory kill (97 to 99 per cent) and all were significantly superior to the check or untreated plot.

2. Nicotine sulfate, pyrethrum, loro and rotenone were found to be compatible with DN dusts but did not increase its pesticidal efficiency. No foliage injury resulted from these combinations.

3. Diatomaceous earth as a diluent was less satisfactory than other materials and gave significantly lower kill.

4. Walnut shell flour had the best physical properties of the various carriers. This material was the only carrier which had the physical property of penetration of the spider web.

5. The hop aphis, Phorodon humuli Schrank and the onion thrips Thrips tabaci Lind. were not present in sufficient numbers for measurement of insecticidal efficiency but it was indicated that none of the DN concentrations or the addition of nicotine sulfate, pyrethrum, loro or rotenone at described concentrations would be satisfactory for their control. These toxicants possess known control value for these insects but it is possible that the combination of DN -walnut shell flour with them produces some unknown buffer action.

6. Great variations were noted in the amount of material applied per acre. This was due in part to differences in wind velocity between the

beginning and completion of the application. Satisfactory coverage on the underside of the hop leaves was the objective of each application. Differences in the physical properties of the diluents also contributed largely to these variations.

7. Considerable progress has been made toward the development of a hop duster which will apply material commercially to the underside of hop leaves. DN dust has shown sufficient promise of red spider control over two years that demonstration trials of its effectiveness are contemplated during 1940.

8. The amount of DN dust per acre which is necessary to control the common red spider has not been determined. It is believed that approximately 100 pounds per acre (1.86 ounces per plant) will be sufficient.

9. DN dust at 1 per cent at the rate of 100 pounds per acre when temperatures exceeded 100 degrees F. was safe on Early clusters, Late clusters, Fuggles, Red Vines, Brewer's favorite, Brewer's gold, Belgian spalt, Zimshevii, Kent golding and East Kent golding. Severe injury occurred to foliage and bracts of cones on the two Russian varieties Skorospielka and Serebrianka.

10. Limited tests on the toxicity of walnut shell flour showed that as such it was of no acaricidal value.

Fig.11 Side view of Experimental hop duster, which features low velocity - heavy volume dust applications.

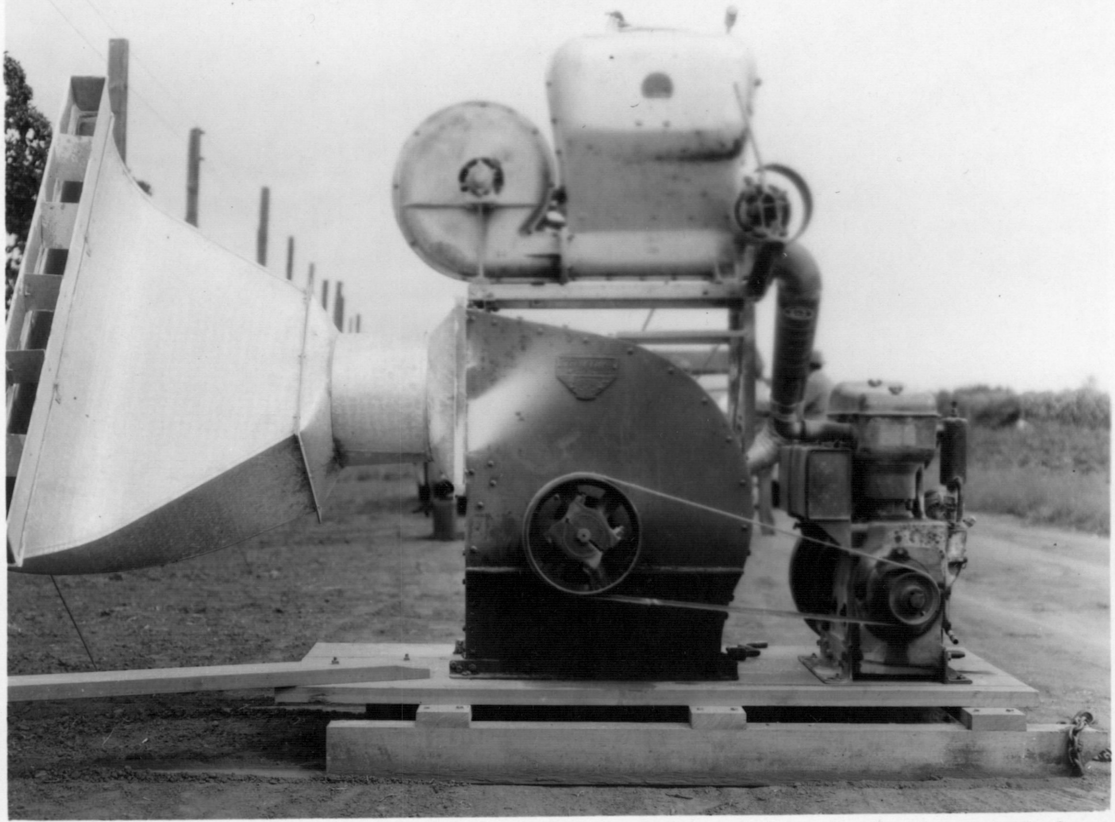

Fig.12 Side view of Experimental hop duster which is to be used for demonstration work in 1940.

Seasonal history of the hop aphis Phorodon humuli Schrank

Seasonal history studies were carried on in the Oregon Agricultural Experimental Hop Yard at Corvallis during 1938 and 1939. The method of conducting these investigations is described in the Biennial Hop report for 1937-1938.

Aphis were first noted in hop yards at Corvallis and other vicinities in the Willamette Valley as early as May 12, 1939. This was 48 days in advance of their initial appearance in 1938. They developed very slowly until the beginning of July when their rate of increase was very rapid. They reached their peak of abundance about the middle of July. This was the critical point of their development and it appeared that they might become an economic problem.

Biological factors became important enough after the middle of July to effect a satisfactory control. Population counts on the numbers of predators showed that as many as 26 lady bird beetles were found on the lower third of one hop plant. The species Hippodamia convergens Guer., Coccinella perplexa var. juliana Mul., Adalia bipunctata Linn., Hippodamia parenthesis Say, Cycloneda munda Say and Coccinella californica Mann. were most abundant in the experimental hop yard. H. convergens Guer. and its varieties were credited as being largely responsible for hop aphis control. There was considerable evidence of secondary parasitism among these predators in 1939 and it is indicated that hop aphis may be of economic importance in 1940.

Hop aphis were more abundant generally in 1939 than in 1938 but they were not sufficiently numerous to become an economic problem. Some slight indications of sooty mold (less than .1%) was found in hop cones at the Experimental hop yard at harvest time. Several other yards in the vicinity of Independence, Oregon, reported mild outbreaks of sooty mold. A comparison of the seasonal development of the hop aphis, Phorodon humuli Schrank, is given in the following table:

Comparison of Phorodon humuli Schrank populations
1938-1939

Date	Population distribution			Population density		
	Percentage of leaves infested			Number of aphis per leaf		
	1938	1939	% difference	1938	1939	% difference
July 11	12	55	78	.038	8.1	99.5
July 27	8	33	76	.015	1.3	98.8
August 1	6	10	40	.007	0.2	96.5

Date of first aphis appearance in 1938 -- June 29
Date of first aphis appearance in 1939 -- May 12
Difference -- 48 days

Control tests with the hop aphis Phorodon humuli Schrank

Hop aphis were not sufficiently abundant in 1939 for testing the efficiency of insecticides. The experimental hop yard was sprayed July 6, 7 and 8, 1939, and the Entomology section of approximately one acre was allowed to stand as unsprayed check. Nicotine sulfate (1-800) with rosin soap (2 gallons per 100 gallons water), Nicotine sulfate (1-800) with commercial soap (1 gallon per 100 gallons water) and Quassia extract (5 gal. from 5 lbs. chips) with commercial soap (1 gallon per 100 gallons water) were used in these applications.

All spray applications effected satisfactory control of the hop aphis but the rate of control of the quassia treatment was decidedly less than the nicotine treatments.

The hop aphis population in the check (untreated) area had been effectively controlled by biological factors by the middle of August and there were no differences in populations between treated and untreated hop plants.

The Aphicidal efficiency of DN dusts at various concentrations and in combination with nicotine sulfate, loro, rotenone and pyrethrum could not be measured because of low populations, but the relative abundance of aphis on the undusted hop plants was approximately equal to that of the dusted plants.

Notes on minor hop pests

The onion thrips Thrips tabaci Lind were more numerous in 1939 than in 1938 and some slight foliage injury resulted during May and June. Decided reductions in thrips abundance was noted after the middle of July. The populations of the onion thrips were apparently not significantly reduced by the application of DN dusts at various concentrations and in combinations with nicotine sulfate, loro, rotenone or pyrethrum. A few of the predaceous thrips Aeolothrips melaleucus Haliday were found in 1939 on both hops and poppy. They were not as abundant in 1939 as in 1938.

The western 12-spotted cucumber beetle Diabrotica soror Lec. were very abundant in hop yards during July, August and September. Their attack was directed in general to feeding on the ripening hop cones and this was rather severe in certain sections of the yard.

The omnivorous leaf tier Cnephasia longana Haw., the hop flea beetle, Psylliodes punctulata Mels, the fall webworm Hyphantria cunea Drury and the hop butterflies Aglais antiopa Linn, Polygonia satyrus Edw., Polygonia interrogationis Fabr., and Polygonia comma Harris were not noted during 1939.

The ant Formica fusca Linn. var. was reported as doing economic damage at the Dickson Hop Yard at Hermiston, Oregon. This yard was visited on July 19

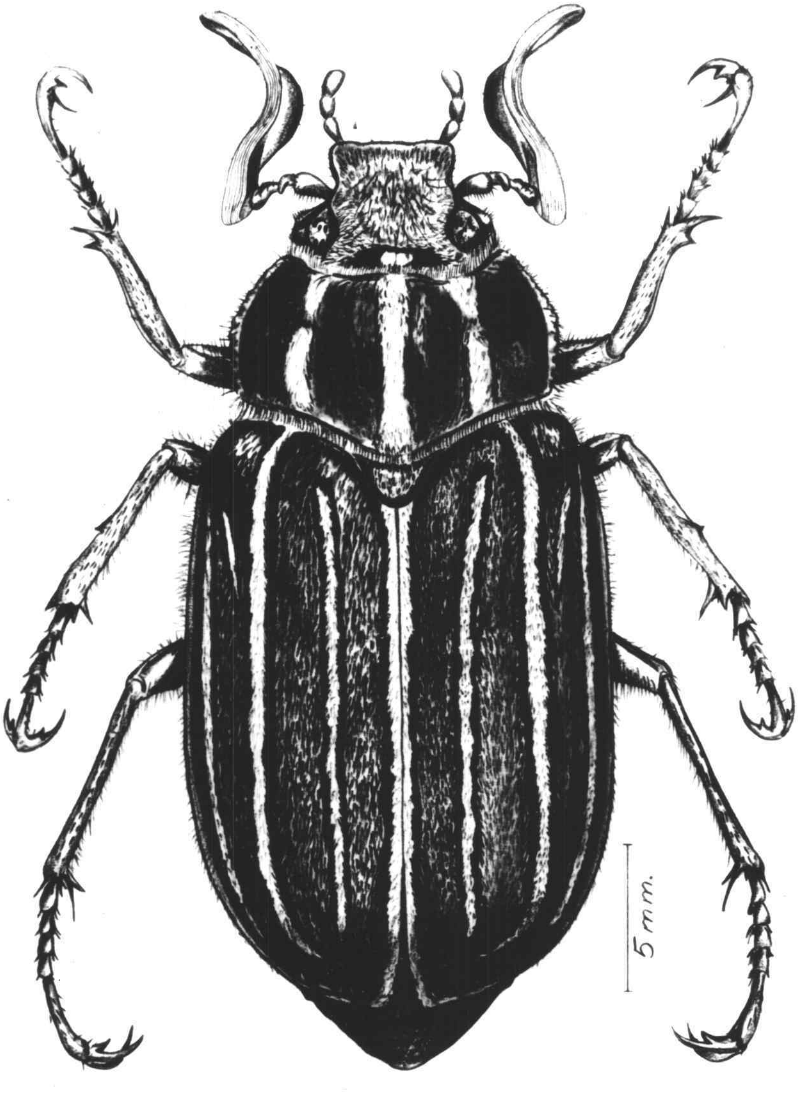

Fig.13 Adult Polyphylla decemlineata Say
(Drawing by Dan Bonnell)

by Dr. Don C. Mote and H. E. Morrison. Few ants could be found and there was no evidence of economic damage by them. One ant was noted attending an undetermined scale insect on a hop vine but after thorough searching no additional scales could be found.

The ten lined June beetle, Polyphylla decemlineata, was described by Say in 1823 (Jour. Ac. N.S. Phila. III, p. 246). See also LeConte (The complete writings of Thomas Say, Vol. II, p. 145-146, S.E. Cassino & Co., Boston, 1883) as follows:

Melolontha (Phyllophyla) 10-lineata. - "Above covered with a yellowish down; thorax trilineate, and elytra quadrilineate with white.

Inhabits Missouri.

Body reddish-brown, covered with a very short spiniform down: clypeus quadrate, slightly wider at tip and truncate, emarginate in the middle; down yellowish, dusky on the tip, and whitish above the eyes: antennae pale yellowish-brown, glabrous: clava elongated, and composed of seven lamina: thorax with yellowish-brown, and three longitudinal lines of white down, of which the lateral ones are interrupted near the anterior tip: scutel with white down, and glabrous margin: elytra with yellowish down; a common sutural line, and three others upon the disk of each elytron of white down; an abbreviated oblique white line from the humerus: pectus and postpectus hairy: feet castaneous, with white down; thighs and intermediate and posterior tibia, hairy behind; venter with white down, more dense upon the margins of the segments and in triangular spots each side.

Length nearly one inch.

A large and beautiful insect, which I first saw above the Pawnee villages on the Platte; several other specimens, however, occurred during our journey to

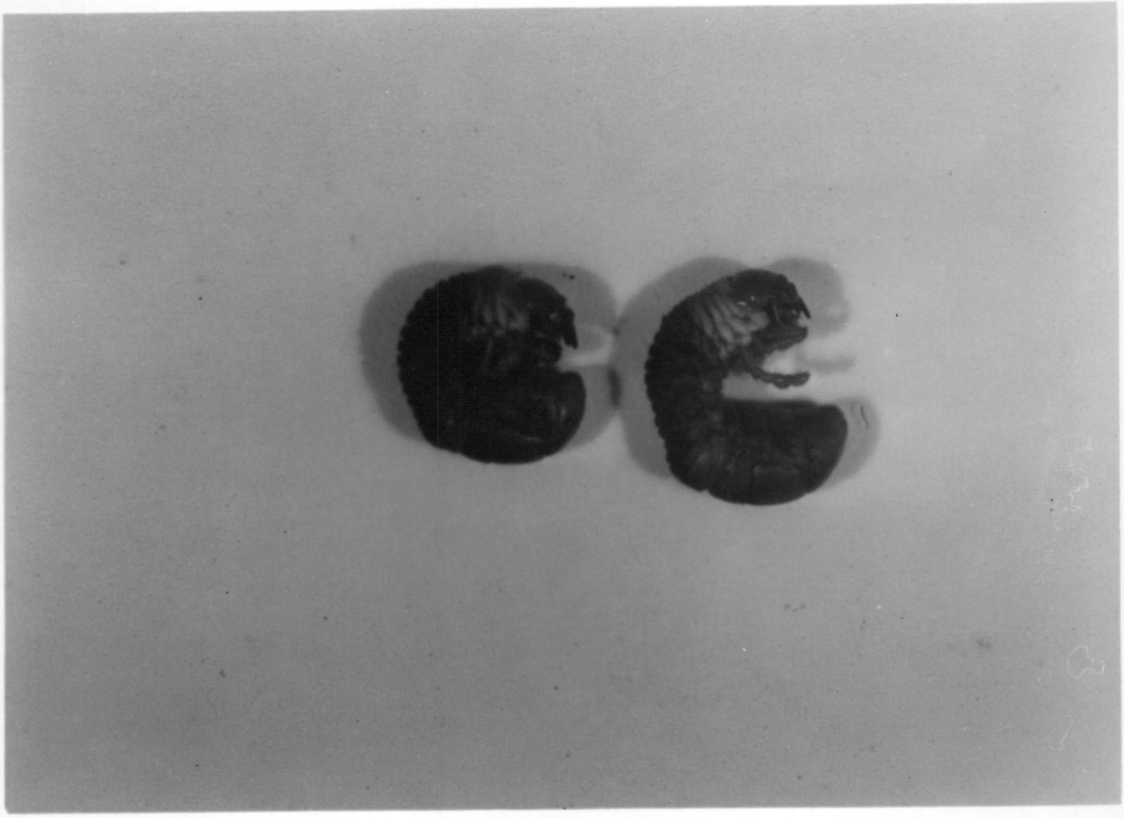

Fig. 14 Larvae of Polyphylla decemlineata Say. This stage of the insect has been found destructive to hop roots.

the mountains. Its color varies from light chestnut to a black; but the downy or spiny vesture is immutable, though it is very deciduous.

It seems to be closely allied to the _M. occidentalis_; but if Oliver's description of that insect be correct, it is sufficiently distinct. According to him, that species has sometimes only 'une ligne longitudinale, blanche, au mileau du corcelet' and the scutel is 'marque de deux taches blanchatres', whereas our insect has always three throacic lines, but a single scutellar spot.

Mr. Nuttall also obtained specimens of this insect on the Arkansas." "(A species of Polyphylla. - Lec.)"

The life history of the ten lined June beetle has not been worked out but it is believed to have a two to three life cycle. It is economically important to strawberries in Oregon. Eleven larva were taken from one hop root in the E. A. Miller hop yard near Salem, Oregon, where it was associated with the California prionid, _Prionus californica_ Mots.

No attempts were made to control these larva because of the lateness of the season and the low soil temperature. Preliminary tests with chloropicrin, carbon disulphide and other soil fumigants are contemplated during 1940.

The California prionid, _Prionus californica_, was described by T. Victor von Motschulsky in 1845. (Die Käfer Russlands, Bull. Moschu XVIII 72 pp. 1845 and Insects de la Siberie Mem. de l' Ac. d. St. Petersb. XIII 274 pp. 1845).

The life history of the California prionid has not been completely worked out. The egg of the insect is about one eighth of an inch long, one sixteenth of an inch in diameter and is decidedly yellowish in color. The larvae or borer when full grown averages about three inches in length and

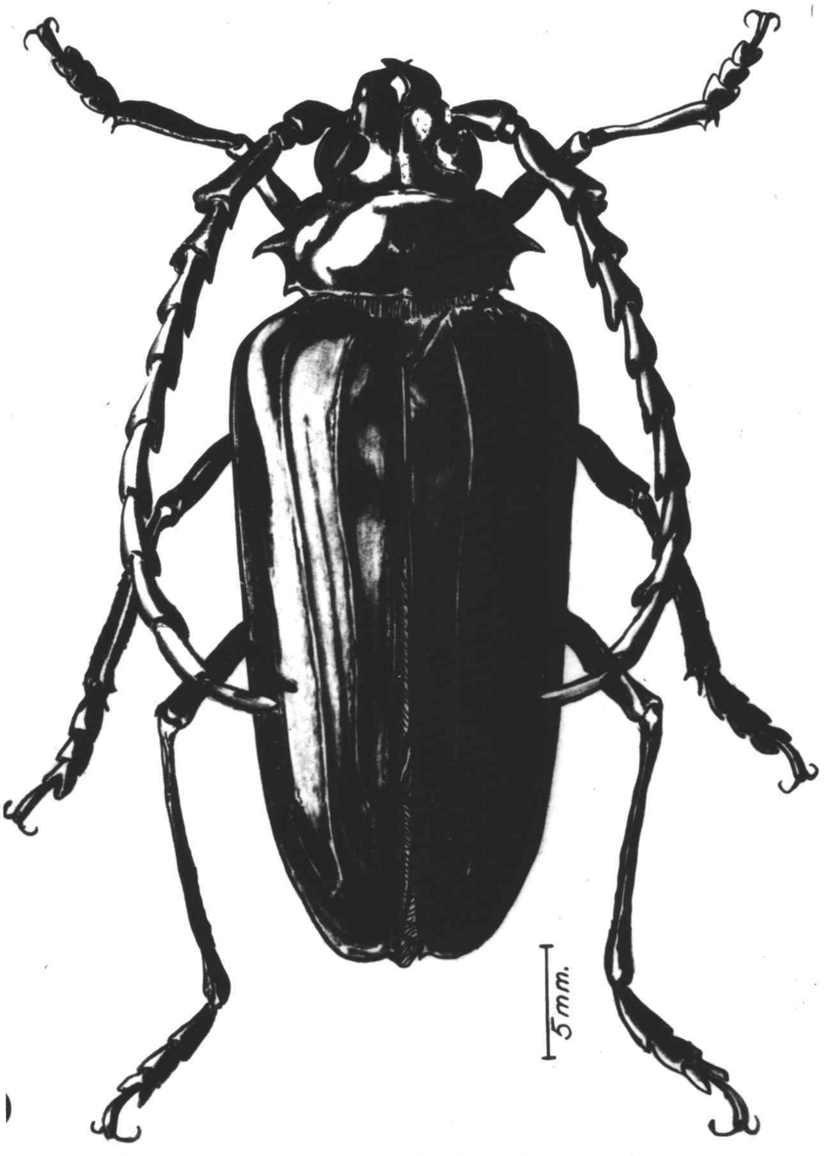

Fig. 15 Adult Prionus Californicus Mots
(Drawing by Dan Bonnell)

Fig. 16 Larvae of Prionus californicus Mots. This stage of the insect attacks hop roots.

Fig.17 Injury to hop roots by Prionus californicus Mots.

about one inch in diameter. The color is nearly always a rich creamy yellow but occasionally specimens are found with a reddish brown hue beneath the surface of the skin. This is believed to be caused by the feeding on dark colored wood or bark. Younger larvae are in all respects except size similar to the mature larvae. The jaws are black in color and very powerful. The pupae is colored similarly to that of the borer and is about 1.75 inches long and 1.50 inches in diameter.

The adults are dark brown beetles which vary from 1 to 1.50 inches in length. There are several large, sharp teeth or spines on the lateral margins of the prothorax. The antennae are twelve-jointed.

The winter is spent in the larval stage and adults do not appear until July and August at which time eggs are deposited. Two or more years are necessary to complete the life cycle of this insect.

The California prionid was found causing damage to a hop yard belonging to Mr. E. A. Miller which was located southwest of Salem, Oregon. Approximately 1% of the hop plants from an eight-acre field were destroyed. No control work was carried on in this yard in 1939 but tests using chloropicrin, carbon disulphide and other fumigants are contemplated in 1940.

DN dusts on beans

An infestation of the common red spider Tetranychus telarius Linn. occurred on a bean planting adjacent to the experimental hop yard, East farm, Corvallis, Oregon.

DN dusts were mechanically diluted from the 1% proprietary mixture to concentrations of 0.1, 0.2 and 0.4% with walnut shell flour as the diluent.

The above materials were applied on July 24 to several rows of the bean varieties - Tennessee Green Pod, Stringless Red Valentine, Dark Red Kidney and Giant Stringless Green Pod.

The efficiency of these dusts was measured on July 28 and decided kill was effected by all dusts. There was no significant difference between any of the treatments.

The applications of the DN dusts were safe to the foliage of the four different varieties of beans. Data on this experiment are tabulated and summarized on the following pages:

DN Tests on Beans

Treatment No. 0.4% DN in walnut shell flour. Date July 28, 1939

Number of Tetranychus telarius L.

Leaf No.	Dead	Alive	Total	% Dead
1	32	0	32	100
2	50	1	51	98
3	53	0	53	100
4	55	0	55	100
5	50	0	50	100
6	48	0	48	100
7	34	0	34	100
8	31	0	31	100
9	44	0	44	100
10	36	0	36	100
11	46	0	46	100
12	35	0	35	100
13	20	0	20	100
14	33	0	33	100
15	43	0	43	100
Total	610	1	611	99.9±.574

DN Tests on Beans

Treatment No. Check (No treatment) Date July 28, 1939

Number of *Tetranychus telarius* L.

Leaf No.	Dead	Alive	Total	% Dead
1	3	32	35	9
2	7	53	60	12
3	6	22	28	22
4	0	47	47	0
5	2	60	62	3
6	1	18	19	5
7	4	42	46	9
8	2	37	39	5
9	0	22	22	0
10	0	18	18	0
11	3	66	69	4
12	0	44	44	0
13	0	21	21	0
14	1	51	52	2
15	0	27	27	0
Total	29	508	537	5± 5.96

DN Tests on Beans

Treatment No. <u>0.2% DN in walnut shell flour</u> Date <u>July 28, 1939</u>

Number of *Tetranychus telarius* L.

Leaf No.	Dead	Alive	Total	% Dead
1	66	15	81	81
2	54	2	56	96
3	76	4	79	95
4	28	0	28	100
5	18	18	36	50
6	37	9	46	80
7	38	1	39	97
8	63	0	63	100
9	20	0	20	100
10	28	3	31	90
11	53	5	58	91
12	10	0	10	100
13	53	1	54	98
14	22	1	23	96
15	14	3	17	82
Total	579	62	641	90 ± 12.92

DN Tests on Beans

Treatment No. 0.1% DN in Walnut Shell Flour Date July 28, 1939

Number of Tetranychus telarius L.

Leaf No.	Dead	Alive	Total	% Dead
1	24	27	51	47
2	52	2	54	96
3	22	0	22	100
4	18	10	28	64
5	38	2	40	95
6	25	2	27	92
7	80	0	80	100
8	56	2	58	97
9	65	0	65	100
10	30	3	33	91
11	5	19	24	21
12	67	0	67	100
13	52	3	55	95
14	24	10	34	71
15	32	9	41	78
Total	590	89	679	83± 22.54

Summary of DN dusts on Beans

Treatment	Percent red spiders dead	Percent control*
Check - No treatment	5	0
DN dust - 0.1% in walnut shell flour	83	94
DN dust - 0.2% in walnut shell flour	90	94
DN dust - 0.4% in walnut shell flour	99.9	95

*From Formula:

$$\% \text{ control} -- \frac{\% \text{ dead treatment} - \% \text{ dead check}}{\% \text{ dead treatment}} \times 100$$

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